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Final
December 2012

Remedial Investigation Report for Groundwater (Covering TNT Areas and Red Water Pond Areas)

Former Plum Brook Ordnance Works
Sandusky, Ohio

FUDS Project No. G05OH001826

US Army Corps of Engineers
Nashville District

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U.S. Army Engineer District, Nashville
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Submittal of the Remedial Investigation Report for Groundwater
(Covering TNT and Red Water Pond Areas)
Former Plum Brook Ordnance Works, Sandusky, Ohio
Contract No. W912P5-12-D-0001; Shaw Project Number 146394

Dear Ms. McClanahan:

In accordance with the requirements of Delivery Order No. DO02 of Contract No. W912P5-12-D-0001, Shaw is pleased to submit this Final Remedial Investigation (RI) Report for Groundwater Covering the TNT and Red Water Pond Areas Groundwater at the Former Plum Brook Ordnance Works (PBOW) located in Sandusky, Ohio. This RI report represents the full compilation and summary for the DERP-FUDS Project No. G05OH001826 RI. It was prepared consistent with the following: the 2004 Groundwater Data Summary and Evaluation Report and the Baseline Human Health Risk Assessment (BHHRA) Report that were previously finalized and submitted; the agreements among PBOW Project Delivery Team (PDT) members; and communications with the U.S. Army Corps of Engineers regarding the scope of this report. This Final RI report incorporates the comments/direction of the Corps on the previously submitted November 8, 2012 draft, including those provided during the November 29, 2012 PDT meeting held at the National Aeronautics and Space Administration (NASA) Plum Brook Station.

Enclosed for your records are four hard copies of this report, and a complete electronic copy is attached to each hard copy on compact disk (CD). As agreed during the PDT meeting, the appendices to the RI Report are included on the CD only. Copies of this deliverable have also been sent to those on the distribution list as indicated for their records.

Should you have any questions or require additional information regarding this submittal, please do not hesitate to contact me at (865) 694-7496.

Sincerely,

Steven T. Downey, PE, PMP
Project Manager

Enclosures

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Client Name: U.S. Army Engineer District, Nashville; CELRN-EC-E

Project Description: Remedial Investigation Report for TNT and Red Water Pond Areas Groundwater
Former Plum Brook Ordnance Works, Sandusky, Ohio

Contract No. W912P5-12-D-0001 Delivery Order No. DO02

Project No. 146394 Task/Phase Number: 03000000

Document Type		Identify specific section or segment covered by this checkprint	Document Origin
☐	Technical / Cost Proposal		X Originator Developed
☐	RFP		☐ Edited Standard
☐	Contract / Subcontract		☐ Client Furnished
☐	Work Plans		
X	Report	Remedial Investigation Report	**Document Status**
☐	Risk Assessment / Evaluation		☐ Preliminary
☐	Specifications & Plans		☐ Internal Draft
☐	Design Calculations		☐ Draft
☐	Tables		☐ Draft Final
☐	Drawings / Figures		X Final
☐	Other:		☐ Other:

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Remedial Investigation Report
For Groundwater
(Covering TNT Areas and Red Water Pond Areas)

Former Plum Brook Ordnance Works,
Sandusky, Ohio

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Shaw Project Number 146394

December 2012

Final

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G05OH001826_03.10_1023_a

Table of Contents

Page

List of Tables iii
List of Figures iv
List of Acronyms v
Executive Summary ES-1
1.0 Introduction 1-1
1.1 Report Organization 1-1
1.2 Facility Location and Description 1-2
1.3 Facility History and Background 1-3
2.0 Physical Setting 2-1
2.1 Geography, Topography, and Surface Drainage 2-1
2.2 Geology 2-1
2.2.1 Regional Geology 2-1
2.2.2 Local Geology 2-2
2.2.3 Regional Hydrogeology 2-2
2.2.4 Local Hydrogeology 2-2
2.2.5 Influence of Precipitation on Water Levels 2-3
2.3 Groundwater Quality and Use 2-4
2.3.1 Groundwater Quality 2-4
2.3.2 Groundwater Use 2-6
2.4 Site Conceptual Model 2-7
3.0 Site Characterization 3-1
3.1 Samples and Analyses 3-1
3.2 Summary of Analytical Results 3-3
3.2.1 TNTA 3-4
3.2.2 TNTB 3-5
3.2.3 TNTC 3-7
3.2.4 PPRWP Area 3-7
3.2.5 WARWP Area 3-9
3.2.6 Downgradient Perimeter 3-10
4.0 Baseline Human Health Risk Assessment 4-1
4.1 Identification of COPCs 4-2
4.2 Exposure Assessment 4-3
4.3 Risk Characterization 4-4

Table of Contents *(continued)*

Page

4.3.1 Cancer Risk 4-5
4.3.2 Noncancer Effects of Chemicals 4-5
4.3.3 Risk Characterization Results 4-6
4.3.3.1 Overall and Site-Related TNTA Groundwater Risk Results 4-6
4.3.3.2 Overall and Site-Related TNTB Groundwater Risk Results 4-7
4.3.3.3 Overall and Site-Related TNTC Groundwater Risk Results 4-7
4.3.3.4 Overall and Site-Related PRRWP Groundwater Risk Results 4-7
4.3.3.5 Overall and Site-Related WARWP Groundwater Risk Results 4-8
4.3.3.6 Overall and Site-Related Downgradient Areas Groundwater Risk Results 4-8
4.3.3.7 Modeled Future Groundwater Risk Results 4-9
4.4 BHHRA Conclusions 4-11
5.0 DERP-FUDS Project No. G05OH001826 Recommendations 5-1
6.0 References 6-1
Tables
Figures
Appendix A – 2004 Groundwater Data Summary and Evaluation Report
Appendix B – Baseline Human Health Risk Assessment of Groundwater

List of Tables

Table	Title	Follows Tab
4-1	Statistical Summary and COPC Selection of Chemicals Detected in Bedrock Groundwater, TNT Area A	
4-2	Statistical Summary and COPC Selection of Chemicals Detected in Bedrock Groundwater, TNT Area B	
4-3	Statistical Distribution and COPC Selection of Chemicals Detected in Bedrock Groundwater, TNT Area C	
4-4	Statistical Summary and COPC Selection of Chemicals Detected in Bedrock Groundwater, Pentolite Road Red Water Pond Area	
4-5	Statistical Summary and COPC Selection of Chemicals Detected in Bedrock Groundwater, West Area Red Water Ponds Area	
4-6	Statistical Summary and COPC Selection of Chemicals Detected in Bedrock Groundwater, Downgradient Areas at the Facility Boundary	
4-7	Summary of Overall and Site-Related Hazard Indices and Cancer Risks TNT Areas and Red Water Pond Areas	

List of Figures

Figures	Title	Follows Tab
1-1	PBOW Vicinity Map	
1-2	Locations of TNT Areas and Red Water Pond Areas	
2-1	Overburden/Shale Groundwater Elevation Contour Map (August 2004)	
2-2	Delaware Limestone Bedrock Groundwater Elevation Contour Map (August 2004)	
2-3	Generalized PBOW Block Diagram	
3-1	Regional Geologic Map with Well Locations and Topography	
3-2	Groundwater Sampling Locations – TNT Area A	
3-3	Groundwater Sampling Locations – TNT Area B	
3-4	Groundwater Sampling Locations – TNT Area C	
3-5	Groundwater Sampling Locations – Pentolite Road Red Water Pond Area	
3-6	Groundwater Sampling Locations – West Area Red Water Ponds Area	

List of Acronyms

AOC	area of concern
BHHRA	baseline human health risk assessment
BSC	background screening concentration
COPC	chemical of potential concern
DERP	Army Defense Environmental Restoration Program
D&M	Dames & Moore, Inc.
DNT	dinitrotoluene
DoD	U.S. Department of Defense
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
FS	feasibility study
FUDS	Formerly Used Defense Sites
gpm	gallons per minute
GSA	General Services Administration
HI	hazard index
HQ	hazard quotients
ILCR	incremental lifetime cancer risk
IT	IT Corporation
LRD	Great Lakes and Rivers Division
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
NASA	National Aeronautics and Space Administration
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
ODNR	Ohio Department of Natural Resources
OEPA	Ohio Environmental Protection Agency
PBOW	Plum Brook Ordnance Works
PBS	Plum Brook Station
ppm	parts per million
PRRWP	Pentolite Road Red Water Pond
QAPP	quality assurance project plan
RBSC	risk-based screening concentration
RfD	reference dose
RI	remedial investigation
RWP	Red Water Pond

List of Acronyms *(Continued)*

SDWR	Secondary Drinking Water Regulations
Shaw	Shaw Environmental, Inc.
SVOC	semivolatile organic compound
TDS	total dissolved solids
TNT	trinitrotoluene
TNTA	TNT Area A
TNTB	TNT Area B
TNTC	TNT Area C
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
VOC	volatile organic compound
WARWP	West Area Red Water Pond

Executive Summary

A remedial investigation (RI) was conducted for groundwater associated with five sites at Plum Brook Ordnance Works (PBOW). These sites are TNT Area A (TNTA), TNT Area B (TNTB), TNT Areas C (TNTC), the Pentolite Road Red Water Pond (PRRWP) Area, and the West Area Red Water Pond (WARWP) Area. This investigation and evaluation also includes areas downgradient of the TNT Areas and Red Water Pond (RWP) Areas, as represented by monitoring wells near the downgradient PBOW facility boundary. Both the upper, overburden/shale groundwater unit and the underlying bedrock groundwater have been investigated and evaluated as part of this RI.

The results of the RI have been previously reported in the 2004 Groundwater Data Summary and Evaluation Report (2004 Groundwater Report) and the baseline human health risk assessment (BHHRA). This RI report summarizes the information from these sites presented in the 2004 Groundwater Report and the BHHRA and includes recommendations based on their findings. No additional investigation results, evaluation, or information is presented in this RI report. Thus, the purpose of this RI report is to consolidate the investigative and evaluation information for groundwater associated with these sites into one report.

2004 Groundwater Report. RI activities were conducted by Shaw Environmental, Inc. (Shaw) at to investigate the groundwater associated with the TNT and RWP Areas. The RI samples include those collected from the groundwater monitoring wells and temporary piezometers from November 1997 through August 2004. These samples were evaluated in the 2004 Groundwater Report. The types of wells/piezometers sampled for the RI are summarized as follows:

- ***TNTA*** – overburden temporary piezometers (9 in 2000; 2 in 2001), overburden/shale monitoring wells (5 wells), and bedrock monitoring wells (2 wells)
- ***TNTB*** – overburden temporary piezometers (2 in 2001), overburden/shale monitoring wells (2 wells), and bedrock monitoring wells (4 wells)
- ***TNTC*** – overburden temporary piezometers (9 in 2000; 2 in 2001), overburden/shale monitoring wells (3 wells), and bedrock monitoring wells (2 wells)
- ***PRRWP*** – overburden temporary piezometers (20 in 1998) and bedrock wells (2 wells)
- ***WARWP*** – overburden temporary piezometers (14 in 1998) and bedrock wells (2 wells)

- ***Downgradient Perimeter*** – bedrock wells (8 wells).

A summary of the evaluation of groundwater in each area is presented in the following paragraphs. This summary focuses on nitroaromatics, because these are the main contaminants that were generated by the TNT Areas. Please note that based on sampling results from PBOW as well as other sites, analytical results from direct-push groundwater samples tend to be biased high for metals and nitroaromatics. This has been attributed both to the higher turbidity in direct-push groundwater samples and to contamination from overlying soil being dragged down into the groundwater. For these reasons, direct-push groundwater samples are not regarded as being of adequate quality for quantitative evaluation of groundwater contamination.

TNTA Overburden/Shale Groundwater. A total of 11 nitroaromatics were detected at concentrations above risk-based screening concentration (RBSC) levels in the overburden/shale temporary piezometer and monitoring well groundwater samples at TNTA. The maximum nitroaromatic concentration in the piezometer samples was trinitrotoluene (TNT) at 32,400 micrograms per liter (µg/L),and the maximum concentration among nitroaromatics detected in overburden/shale monitoring wells was TNT at 110 µg/L.

Benzene, toluene, and chloroform were the only volatile organic compounds (VOC) detected in the groundwater above RBSC or applicable background screening concentration (BSC) values. Three semivolatile organic compounds (SVOC) were detected as SVOCs above RBSC levels: bis(2-ethylhexyl)phthalate and the nitroaromatics 2,4-dinitrotoluene (DNT) and 2,6-DNT. Unfiltered metals aluminum, arsenic, iron, and manganese have been most commonly detected in the overburden/shale groundwater above both RBSC and BSC values during both the wet and dry seasons. Filtration removed most of the metals above RBSC and BSC values.

TNTA Delaware Limestone Bedrock. Nine nitroaromatic compounds were detected at concentrations above RBSC levels in the bedrock groundwater at TNTA. The maximum detected concentration was that of 2,6-DNT, which was detected only once in TNTA bedrock groundwater at a concentration of 3.6 µg/L.

VOCs have consistently been detected in all site wells since 1997 with benzene, toluene, ethylbenzene, and xylenes (BTEX) and methylene chloride commonly above RBSC and (for BTEX) BSC values. SVOCs exceeding the RBSCs are bis(2-ethylhexyl)phthalate and the polycyclic aromatic hydrocarbons naphthalene, chrysene, dibenzofuran, and phenanthrene. The

BTEX and polycyclic aromatic hydrocarbons parameters appear to be naturally occurring free-phase petroleum hydrocarbons.

The following metals were detected at concentrations exceeding both the RBSCs and BSCs: aluminum, arsenic, barium, iron, manganese, and nickel. Of these, only barium concentrations exceeded the screening values in the filtered samples, indicating that the metals were associated with suspended particulates.

TNTB Overburden/Shale. Nitroaromatic compounds have consistently been present in the overburden/shale groundwater in monitoring well MK-MW17 during all sampling events, with five at concentrations exceeding the RBSCs. The nitroaromatic detected at the maximum concentration was TNT (68 µg/L); TNT was the only nitroaromatic detected in the direct-push piezometer groundwater but was detected at a concentration less that the RBSC.

VOCs have not been detected at concentrations above RBSC or BSC values in TNTB overburden/shale groundwater. The SVOC parameter indeno(1,2,3-cd)pyrene was detected at a concentration above the RBSC value, and the two nitroaromatics 2,4-DNT and 2,6-DNT likewise were detected as SVOCs. Metals typically present in unfiltered groundwater samples at concentrations above RBSC and BSC levels include aluminum, arsenic, cobalt, iron, manganese, and nickel. In the filtered groundwater samples, iron, manganese, and nickel concentrations have fairly consistently been above the RBSC and BSC values.

TNTB Shale Bedrock. Nitroaromatic compounds have not been detected in the groundwater from the shale bedrock monitoring wells at TNTB.

The BTEX compound benzene was detected at concentrations exceeding the BSC and the RBSC. The SVOC naphthalene was detected once above the RBSC but was not detected in any of the other TNTB bedrock groundwater samples. Detections of metals in unfiltered samples exceeding both RBSCs and BSCs include aluminum, arsenic, iron, and manganese. Filtration of the groundwater generally removed much of the metals from all of the wells. Remaining metals in filtered samples above both the RBSC and BSC are iron and manganese. The benzene and naphthalene are likely related to naturally occurring petroleum hydrocarbons that are common in the Delaware Limestone.

TNTC Overburden/Shale. Nine nitroaromatics were detected above the RBSCs, but only in temporary piezometer samples. The maximum detected concentration in the direct-push piezometer samples was TNT at 20,100 µg/L. In the same event, the nitroaromatics 2,4-DNT

(37,600 µg/L) and 2,6-DNT (1,130 µg/L) were detected as SVOCs in the piezometer samples. TNT was detected once among the wells samples but at a concentration less than the RBSC.

Benzene was the only VOC detected above the RBSC and BSC values in groundwater. The metals aluminum, arsenic, cobalt, copper, iron, nickel, manganese, and zinc have been detected in the overburden/shale groundwater at concentrations above both RBSC and BSC values. Manganese and nickel are the only metals that were detected above the RBSC and BSC in any of the unfiltered samples.

TNTC Delaware Limestone Bedrock. No nitroaromatic compounds were detected in the bedrock groundwater samples from TNTC.

BTEX compounds have been detected consistently above BSCs and RBSCs in both TNTC wells. Methylene chloride was detected in one sample at a concentration exceeding the RBSC. The SVOCs bis(2-ethylhexyl)phthalate, 2-methylnaphthalene, and naphthalene were detected at concentrations above RBSCs in every sampling event. No metals exceeded both the RBSC and BSC values. The BTEX, naphthalene, and 2-mentylnaphthalene are likely related to naturally occurring petroleum hydrocarbons that are common in the Delaware Limestone.

PRRWP Area Overburden/Shale. A total of nine nitroaromatic compounds were detected above RBSC levels in the 20 groundwater samples collected from temporary piezometers during the wet season of June 1998. The maximum detected concentration of any compound detected as a nitroaromatic explosive was that of 2,4-DNT at 6,900 µg/L. The nitroaromatic 4,6-dinitro-2-methylphenol was detected as an SVOC at 20,000 µg/L.

The VOCs detected at concentrations exceeding the RBSC values at the PRRWP Area are tetrachloroethene and trichloroethene. The SVOC naphthalene was detected in one sample at a concentration that exceeded the RBSC. Most of the metals were detected above the RBSCs and BSCs in one or more of the unfiltered samples. The metals most frequently detected at concentrations above both RBSC and BSC values in the unfiltered samples included aluminum, iron, and manganese. Filtering removed most of the exceedances in most samples, indicating that the metals are mostly associated with suspended particulates associated with the direct-push sampling method. Total cyanide and nitrate were also detected above the RBSC in the groundwater.

PRRWP Area Delaware Limestone Bedrock. A total of four nitroaromatic compounds (4-amino-2,6-DNT, 2,4-DNT, 2,6-DNT, and nitrobenzene) were detected at concentrations

exceeding the RBSCs. The highest concentration of nitroaromatics found in the PRRWP Area bedrock well samples was TNT at a concentration of 1.6 µg/L.

BTEX parameters were consistently found exceeding the screening RBSC and BSC values in both wells. Acetone was the only other VOC detected at a concentration that exceeded the RBSC value during both sampling events in well BED-MW23. The SVOCs 2-methylnaphthalene, naphthalene, 4-methylphenol, and bis(2-ethylhexyl)phthalate were detected at concentrations that exceeded the RBSCs. Iron and manganese are the only metals that exceeded the RBSCs and BSC values in the unfiltered samples and in the filtered samples.

WARWP Area Overburden/Shale. A total of seven nitroaromatic compounds were detected at concentrations above RBSC levels in the 14 groundwater samples from temporary piezometers during the wet season of June 1998. The maximum detected concentration of nitroaromatics among the overburden/shale groundwater samples was 2,4-DNT at 950 µg/L (660 µg/L as an SVOC).

Tetrachloroethene is the only VOC detected above the RBSC value. Half (i.e., 11) of the metals were detected above the RBSCs and BSCs in one or more of the unfiltered samples. The unfiltered metals most frequently detected at concentrations above both RBSC and BSC values included aluminum, arsenic, iron, and manganese. Among the filtered samples, only arsenic and manganese were detected at concentrations above both the RBSC and BSC values. This indicates that most of the metals are present in suspended particulates. In addition, nitrate was detected above the RBSC in this area.

WARWP Area Delaware Limestone Bedrock. Five nitroaromatic compounds (4,6-dinitro-2-methylphenol, 2,4-DNT, 2,6-DNT, 2,4-dinitrophenol, and 3-nitroaniline), all detected as SVOCs, were found to be above RBSC levels during the wet season of May 1998. The highest concentration among the nitroaromatics was that of 3-nitroaniline at 150 µg/L.

The only VOC detected at a concentration that exceeds the RBSC is benzene, a BTEX compound. No SVOCs other than the nitroaromatics were detected at a concentration that exceeds the RBSC. Arsenic, cobalt, and nickel were each detected at concentrations exceeding the respective RBSC and BSC values. Each of the exceedances of RBSCs/BSCs for arsenic, cobalt, and nickel was observed in both the unfiltered and associated filtered groundwater samples at similar respective concentrations (i.e., filtered versus unfiltered); this indicates that these analytes are in the dissolved phase. Nitrate was also detected above the RBSC.

Downgradient Perimeter Overburden/Shale. No downgradient, perimeter overburden/shale monitoring wells were scheduled to be sampled during any of the RI sampling events.

Downgradient Perimeter Delaware Limestone Bedrock. In samples from the downgradient perimeter wells, four nitroaromatic compounds (nitrobenzene, 2,4-DNT, 2,6-DNT, and 2-nitrotoluene) were detected at concentrations that exceeded the RBSC. 2,4-DNT had the highest detected concentration among the nitroaromatics and was detected at a maximum detected concentration of 1.5 µg/L.

A number of VOC compounds (acetone, benzene, chlorobenzene, ethylbenzene, methylene chloride, toluene, and total xylenes) were detected at concentrations above RBSCs and BSCs. In particular, the BTEX compounds (individually or in various combinations) exceeded the RBSCs and BSCs consistently throughout all sampling events in all of the monitoring wells. Three SVOCs were detected above the RBSCs: bis(2-ethylhexyl)phthalate, naphthalene, and 2-methylnaphthalene. The BTEX compounds, naphthalene, and 2-methylnaphthalene are likely associated with naturally occurring petroleum hydrocarbons that are common to the Delaware Limestone. The metals detected above RBSCs and BSCs in the unfiltered samples were arsenic, iron, and manganese. Two metals, arsenic and manganese, were detected at concentrations above RBSC and BSCs in at least one of the filtered groundwater samples. Total cyanide was detected above the RBSC only one time in a groundwater sample collected in the 1997 dry season sampling event.

Baseline Human Health Risk Assessment. The BHHRA quantitatively evaluated exposure to chemicals in bedrock groundwater associated with the TNT Areas and RWP Areas. Groundwater in the overlying overburden/shale was found to be spatially discontinuous and of very low yield. Therefore, this unit was evaluated qualitatively and used as a source in a chemical fate and transport model. The following hypothetical receptors were evaluated for exposure to chemicals of potential concern (COPC) in bedrock groundwater as a potable source: off-site resident at the downgradient boundary, hypothetical future on-site worker, and future on-site resident. These receptors are regarded as hypothetical because the groundwater is not currently used as a potable source and is highly unlikely to be used in the future for reasons including poor natural quality and widespread availability of municipal water. Two separate evaluations were performed for each receptor: one based on concentrations of COPCs measured in bedrock groundwater wells, and the other based on modeled future concentrations that assume leaching of COPCs from soil to overburden/shale groundwater and transport of contaminants from the overburden/shale groundwater to the bedrock groundwater unit, as well as transport within the bedrock unit.

Risks were characterized for each COPC identified in each area for the relevant receptors. The resulting overall noncancer hazard index (HI) was compared to the noncancer hazard criterion (HI≤1). The incremental lifetime cancer risk (ILCR) values were compared to the PBOW cancer risk goal (ILCR>1E-5) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) risk management range (1E-6 to 1E-4). These comparisons are characterized by area in the bulleted statements that follow. The BHHRA reported both overall risks (including naturally occurring chemicals in groundwater) and site-related risks (resulting from former U.S. Department of Defense activities).

TNTA

- Site-related cancer risks for the future on-site worker do not exceed the PBOW risk goal and are within the NCP risk management range.
- Site-related risks for the resident exceed the PBOW risk goal but are within the NCP risk management range.
- Site-related noncancer hazards exceed the noncancer HI goal for all receptors.
- Overall cancer risks exceed the NCP risk management range for all receptors.
- Overall noncancer hazards exceed the HI goal for all receptors.

TNTB

- No site-related COPCs were identified for TNTB; site-related cancer risks and noncancer hazards are regarded as negligible.
- Overall cancer risks for the resident exceed the NCP risk management range; overall cancer risks for the worker are within the NCP risk management range but exceed the PBOW goal.
- Overall noncancer hazards for the resident exceed the HI goal; those for the worker do not.

TNTC

- No site-related COPCs were identified for TNTC; site-related cancer risks and noncancer hazards are regarded as negligible.
- Overall cancer risks for the resident exceed the NCP risk management range; overall cancer risks for the worker are within the NCP risk management range but exceed the PBOW goal.
- Overall noncancer hazards for the resident exceed the HI goal; those for the worker do not.

PRRWP Area

- Site-related cancer risks for the future on-site worker workers do not exceed the PBOW risk goal and are within the NCP risk management range.
- Site-related risks for the resident exceed the PBOW risk goal but are within the NCP risk management range.
- Site-related noncancer hazards are less than the noncancer HI goal for all receptors.
- Overall cancer risks exceed the NCP risk management range for all receptors.
- Overall noncancer hazards exceed the HI goal for all receptors.

WARWP Area

- Site-related cancer risks for the future on-site worker exceed the PBOW risk goal but are within the NCP risk management range.
- Site-related risks for the resident exceed the PBOW risk goal and the NCP risk management range.
- Site-related noncancer hazards exceed the noncancer HI goal for all receptors.
- Overall cancer risks exceed the NCP risk management range for the resident but do not exceed the NCP risk management range for the worker.
- The overall cancer risks for the worker exceed the PBOW cancer risk goal.
- Overall noncancer hazards exceed the HI goal for all receptors.

Downgradient Boundary (resident only)

- Site-related cancer risks for the future resident exceeds the PBOW risk goal but are within the NCP risk management range.
- Site-related noncancer hazards are less than the noncancer HI goal for all receptors.
- Overall cancer risks exceed the NCP risk management range for the resident.
- Overall noncancer hazards exceed the HI goal for the resident.

As discussed above, the receptors were also evaluated based on modeled future groundwater concentrations. This modeling effort and evaluation included only TNT, 2,4-DNT, and 2,6-DNT, which are the three primary contaminants in TNT Area and RWP Areas soil and groundwater.

Therefore, all modeled risks are site related. The BHHRA results of this evaluation are presented below for each area.

TNTA (based on modeled concentrations)

- Site-related cancer risks for the future on-site worker exceed the PBOW risk goal and are within the NCP risk management range.
- Site-related risks for the resident exceed the PBOW risk goal and the NCP risk management range.
- Site-related noncancer hazards exceed the noncancer HI goal for the resident but not for the worker.

TNTB (based on modeled concentrations)

- Site-related cancer risks for the future on-site worker are less than the PBOW risk goal and are within the NCP risk management range.
- Site-related risks for the resident exceed the PBOW risk goal but are within the NCP risk management range.
- Site-related noncancer hazards are less than the noncancer HI goal for the resident and the worker.

TNTC (based on modeled concentrations)

- Site-related cancer risks for the future on-site worker and the resident exceed both the PBOW risk goal and the NCP risk management range.
- Site-related noncancer hazards for the worker do not exceed the HI goal.
- Site-related noncancer hazards for the resident exceed the noncancer HI goal.

PRRWP Area (based on modeled concentrations)

- Site-related cancer risks for the future on-site worker exceed the PBOW risk goal but are within the NCP risk management range.
- Site-related risks for the resident exceed both the PBOW risk goal and the NCP risk management range.
- Site-related noncancer hazards are less than the noncancer HI goal for the resident and the worker.

WARWP Area (based on modeled concentrations)

- Site-related cancer risks for the future on-site worker exceed the PBOW risk goal but are within the NCP risk management range.
- Site-related risks for the resident exceed both the PBOW risk goal and the NCP risk management range.
- Site-related noncancer hazards are less than the noncancer HI goal for the resident and the worker.

Boundary Area Downgradient from TNTA (based on modeled concentrations – resident only)

- Site-related cancer risks are less than the PBOW risk goal and the NCP risk management range.
- Site-related noncancer hazards are less than the noncancer HI goal.

Boundary Area Downgradient from TNTB/TNTC/PRRWP Area (based on modeled concentrations – resident only)

- Site-related cancer risks exceed the PBOW risk goal but are within the NCP risk management range.
- Site-related noncancer hazards are less than the noncancer HI goal.

Boundary Area Downgradient from WARWP Area (based on modeled concentrations – resident only)

- Site-related cancer risks are less than the PBOW risk goal and are within the NCP risk management range.
- Site-related noncancer hazards are less than the noncancer HI goal.

BHHRA Conclusion. At each area, except the WARWP Area, the non-site-related COPCs dominate both the cancer risk and noncancer hazards; at the WARWP Area, residential and worker ILCR values associated with non-site-related arsenic also exceed the target ILCR. The following COPCs are dominant with respect to cancer risk and/or noncancer hazard for the five areas of concern and the downgradient areas; site-related COPCs are specifically noted as such:

- TNTA – Naturally occurring petroleum-related organic compounds
- TNTB – Inorganics and naturally occurring petroleum-related organic compounds
- TNTC – Naturally occurring petroleum-related organic compounds
- PRRWP – Naturally occurring petroleum-related organic compounds

- WARWP – Site-related nitroaromatics and naturally occurring arsenic
- Downgradient – Naturally occurring petroleum-related organic compounds.

For each of these areas, even if no site-related COPCs were present, noncancer hazards associated with residential groundwater use, cancer risk associated with residential groundwater use, and cancer risks associated with worker use would result in respective HI and ILCR values that would exceed the target HI criterion (1) and Ohio Environmental Protection Agency target cancer risk (1E-5).

Recommendations for TNT Areas and RWP Areas Groundwater.

Based on the findings of this RI, development of an FS for TNT and RWP Areas groundwater is recommended.

1.0 Introduction

The U.S. Army is conducting studies of environmental impacts attributable to releases associated with historical operations of a property previously owned by the U.S. Department of Defense (DoD), the former Plum Brook Ordnance Works (PBOW) in Sandusky, Erie County, Ohio. PBOW is an Army Defense Environmental Restoration Program (DERP) project under the Great Lakes and Rivers Division (LRD) Formerly Used Defense Sites (FUDS) program. The Louisville District office of the U.S. Army Corps of Engineers (USACE) is the program management district for the LRD FUDS program. Management support is for PBOW is provided by the USACE Huntington District office and technical oversight is provided by the USACE Nashville District office.

This remedial investigation (RI) has been performed to determine if any DoD-related environmental impacts have resulted in unacceptable risks to human health or the environment pertaining to chemicals in groundwater underlying and/or originating from the following PBOW sites, which comprise DERP-FUDS Project No. G05OH001826:

- TNT Area A (TNTA)
- TNT Area B (TNTB)
- TNT Area C (TNTC)
- Pentolite Road Red Water Pond (PRRWP) Area
- West Area Red Water Pond (WARWP) Area.

The results of the RI have been previously reported in the 2004 Groundwater Data Summary and Evaluation Report, referred to hereinafter as the 2004 Groundwater Report (Shaw Environmental, Inc. [Shaw], 2005a,b), and the baseline human health risk assessment (BHHRA) (Shaw, 2006). This RI report summarizes the information from these sites presented in the 2004 Groundwater Report and the BHHRA and includes recommendations based on their findings. No additional investigation results, evaluation, or information is presented in this RI report. Thus, the purpose of this RI report is to consolidate the investigative and evaluation information for groundwater associated with these sites into one report.

The 2004 Groundwater Report and the BHHRA are both included in the PBOW Administrative Record (AR). The documents and the AR document numbers are as follows:

- 2004 Groundwater Data Summary and Evaluation Report (Shaw, 2005a) Vol. 1, Part 1: AR No. G05OH001826_03.10_1020_a

- 2004 Groundwater Data Summary and Evaluation Report (Shaw, 2005b) Vol. 1, Part 2: AR No. G05OH001826_03.10_1019_a

- Baseline Human Health Risk Assessment of Groundwater (Shaw, 2006): AR No. G05OH001826_03.11_1001_a

This RI report, which includes only groundwater that is associated with the former 2,4,6-trinitrotoluene (TNT) manufacturing areas (TNT Areas) and the red water pond (RWP) areas (RWP Areas), was conducted under Delivery Order No. DO02 of Contract No. W912P5-12-D-0001. Please note that other environmental media associated with these sites were previously investigated and evaluated, as documented in other reports (e.g., IT Corporation [IT], 2000a,b,c,d; 2001a,b,c) under other DERP-FUDS projects.

1.1 Report Organization

As part of the RI effort, each of the five sites listed above in Section 1.0 was previously investigated and evaluated in the 2004 Groundwater Report and the BHHRA. The 2004 Groundwater Report and the BHHRA are appended to this report in their entirety (Appendices A and B, respectively) in electronic format on compact disk. No ecological risk assessments were performed specifically for groundwater because each of the TNT and RWP Areas were interpreted to be groundwater recharge areas; thus, ecological exposure to groundwater was determined to be an incomplete pathway. Please note the other environmental media, including soils, sediment, and surface water have been evaluated for ecological receptors (e.g., IT, 2000c,d; 2001c).

The remainder of this chapter provides a description and history of the PBOW facility and of the TNT and RWP Areas. Additional information on these sites can be found in the appended 2004 Groundwater Report, the BHHRA, and documents referenced therein. Chapter 2.0 of this report summarizes the physical setting of PBOW and specifically addresses the five site areas associated with this groundwater RI. This discussion of physical setting includes the geography, topography, drainage, and geology, including hydrogeology and natural groundwater quality.

Chapters 3.0 and 4.0 summarize the 2004 Groundwater Report and BHHRA analytical results, evaluation, and conclusions. Chapter 5.0 presents site-specific recommendations for site management decisions. These recommendations primarily discuss whether or not a remedial action is warranted. These recommendations do not identify a specific technological approach, but are provided to help site managers form a basis for determining whether a feasibility study (FS) is required or if proceeding to a no-action proposed plan is the appropriate course for a given site. References used in the RI are provided in Chapter 6.0.

Additional details pertaining to the 2004 Groundwater Report and BHHRA for the various site areas are provided in the previously submitted final reports, which are included on compact disk as Appendices A and B.

1.2 Facility Location and Description

The former PBOW is located approximately 4 miles south of Sandusky, Ohio, and 59 miles west of Cleveland. It is currently operated and maintained by the National Aeronautics and Space Administration (NASA) as Plum Brook Station (PBS), a satellite to NASA John H. Glenn Research Center at Lewis Field, Cleveland, Ohio. Although located primarily in Perkins and Oxford Townships, the eastern edge of the site extends into Huron and Milan Townships. PBOW is in general bounded on the north by Bogart Road, on the south by Mason Road, on the west by Patten Tract Road, and on the east by U.S. Highway 250. Public access to PBOW is prohibited except during the annual deer hunting season, which is by permit only. The area surrounding PBOW is mostly agricultural and residential. Figure 1-1 shows the geographical location of the former PBOW site.

1.3 Facility History and Background

The PBOW facility was built on property totaling 9,009 acres in early 1941 as a manufacturing plant for TNT, 2,4-dinitrotoluene (DNT), and pentolite (International Consultants Incorporated, 1995). Production of explosives at PBOW began in December 1941 and continued until 1945. It is estimated that more than 1 billion pounds of nitroaromatic explosives were manufactured during the 4-year operating period. The three TNT manufacturing areas were designated TNTA, TNTB, and TNTC. Twelve process lines were used in the manufacture of TNT: four lines at TNTA, three lines at TNTB, and five lines at TNTC. The PBOW facility also included infrastructure such as power plants and waste water treatment plants. The manufacturing areas consisted of widely scattered wood-frame buildings with asbestos and sheet metal coverings. These areas also included a series of buried and/or overhead flumes and pipes used to transport various liquids associated with the manufacturing process. Some of these waste liquids were transported to the PRRWP or WARWP, either prior to or subsequent to treatment. The locations of the three TNT Areas and two RWP Areas are shown on Figure 1-2.

After plant operations ceased, the manufacturing lines were decontaminated by the War Department in late 1945. During decontamination, all structures, equipment, and manufacturing debris were either removed and salvaged or removed and burned. After decontamination, the property was initially transferred to the Ordnance Department, then to the War Assets Administration after it was certified by the U.S. Army to be decontaminated. In 1949, PBOW was transferred to the General Services Administration (GSA). In 1955, the GSA completed

further decontamination within the TNT manufacturing areas. This effort included removal of contaminated surface and subsurface soil around the buildings and wooden and ceramic waste disposal lines containing TNT. Thousands of pounds of TNT were discovered in catch basins; this TNT was removed and burned at the burning grounds.

RIs for environmental media other than groundwater were completed for TNTB and the PRRWP Area in 2000 and for TNTA and TNTC in 2003. Decision Documents have been signed for soil remediation at the three TNT areas, with remediation either completed (TNTB) or ongoing (TNTA and TNTC). Please note that the TNTC Decision Document also addresses contaminated sediment along a limited area of a drainage ditch. Remediation was also performed at the PRRWP Area as part of a non-time-critical removal action completed in 2008, and additional remediation is anticipated for the PRRWP Area to address soil contamination that still remains at the site. It has been determined that no remediation is necessary at the WARWP Area (IT, 2002).

Two property use agreements were entered into by the National Advisory Committee of Aeronautics, the predecessor of NASA, and the Army in 1956 and 1958, respectively. On March 15, 1963, NASA obtained accountability and custody for the remaining PBOW property, approximately 6,030 acres that had been under the accountability and custody of the Department of the Army. NASA performed further decontamination efforts in the TNT Areas during 1964. The NASA decontamination process included removing contaminated surface soil above the drain tiles, flumes, etc.; destruction of buildings by fire; then removal of all soil, debris, sumps, and above-grade portions of concrete foundations. Portions of the concrete foundations located below grade were left buried, and some that had been previously slightly above grade were likewise buried. All materials, including the soil in those areas, were flashed; the area was then rough-graded. The decontamination process was also to have included the burning of nitroaromatic-filled flumes that were excavated (Dames & Moore, Inc. [D&M], 1997a).

NASA has operated and maintained PBOW since 1963, and the facility is currently the NASA Glenn Research Center, Plum Brook Station. NASA operates the former PBOW property as a space research facility in support of their John H. Glenn Research Center at Lewis Field, Cleveland, Ohio. Most of the aerospace testing facilities built in the 1960s at the site are presently on standby or inactive status. On April 18, 1978, NASA declared approximately 2,152 acres of PBOW as excess. The Perkins Township Board of Education acquired 46 acres of the excess acreage and uses this area as a bus transportation area. The GSA retains ownership of the remaining excess acreage and currently has a use agreement with the Ohio National Guard for 604 acres of this land. NASA presently controls approximately 6,400 acres. The details of land

transactions are listed in the site management plan (International Consultants Incorporated, 1995).

Nitroaromatic compounds (i.e., explosives) are generally the contaminants in impacted TNT and RWP Areas groundwater that have resulted from past DoD activities. The presence of nitroaromatic groundwater contamination has resulted from spills on the surface; leaks from holding areas, flumes, and pipelines; and leaching from soils and materials that have infiltrated from process water associated with former manufacturing operations. Section 2.4 presents a site conceptual model that includes these source types and migration mechanism in the context of the site geology, hydrogeology, and other physical characteristics of the PBOW area.

2.0 Physical Setting

2.1 Geography, Topography, and Surface Drainage

PBOW is located within the Eastern Lake Region of the Central Lowland Province (Soil Conservation Service, 1971). The facility is on a plain with a slight slope to the north-northeast toward Lake Erie at approximately 25 feet per mile. Elevations across the PBOW facility range from 680 feet above mean sea level at the intersection of Taylor Road and Patrol Road on the southwestern side of the site to 625 feet above mean sea level at the northern portion of the installation (Figure 1-2). In general, the topography of PBOW is characterized by a flat ground surface with occasional low hummocks caused primarily by glacial scouring and deposition. A low escarpment trends from the western to the northeastern portion of the site (Shaw, 2005a).

PBOW lies in the eastern region of the Pickeral Creek-Pipe Creek Basin, which is part of the St. Lawrence River drainage basin (D&M, 1997b). Eleven streams exist within PBOW and flow north-northeast toward Lake Erie, which is located approximately 3.5 miles north of the site. The site is part of four drainage areas: (1) Sawmill Creek (southern PBOW); (2) Plum Brook (central PBOW); (3) Pipe Creek (western PBOW); and (4) Storrs-Hemminger Ditch (north-central PBOW). All four drainage areas flow into Sandusky Bay (D&M, 1997b). Four discharge points at PBOW (Lindsley Ditch, Ransom Brook, Kuebler Ditch, and Plum Brook) are monitored by NASA PBS under a National Pollutant Discharge Elimination System outfall permit (Ohio Environmental Protection Agency [OEPA], 2007). In addition to the streams, 17 isolated ponds and reservoirs and former red water ponds are located at PBOW (U.S. Geological Survey [USGS], 1992; D&M, 1997b).

2.2 Geology

2.2.1 Regional Geology

The bedrock in northern Ohio and found at PBOW consists of Devonian and Silurian carbonates (limestone and dolomite) and clastics (shale, siltstone, and sandstone). These units unconformably overlie older sedimentary sequences of Ordovician and Cambrian Age rocks, which in turn unconformably overlie pre-Cambrian basement rocks (D&M, 1997b). The local bedrock is situated on the eastern flank of the Findlay Arch. In the Devonian and Silurian of northern and western Erie County, weathering of the carbonates has produced cavernous porosity and karst topography.

2.2.2 Local Geology

Three bedrock units have been encountered during well installation at PBOW: the Delaware Limestone, the Olentangy Shale, and the Ohio Shale. The Delaware Limestone is the lowermost formation screened by site wells. It is characterized as a hard, dense, finely crystalline limestone and dolomite. The unit is typically buff colored, hard, and massive and usually is described as fossiliferous with pyrite crystals. In the vicinity of PBOW, quarries (Hanson Aggregates to the north, Hanson-Sandusky Crushed Stone to the southwest, and abandoned Castalia quarry to the west) mine limestone from the Delaware. Traces of natural petroleum-derived hydrocarbons and hydrogen sulfide are common in all three quarries. Overlying the Delaware Limestone is the Olentangy Shale. Two members of the Olentangy Shale have been characterized at the site: the Plum Brook Shale and the overlying Prout Limestone. The Plum Brook Shale is interpreted to consist of approximately 35 feet of bluish-gray, soft, fossiliferous shale containing thin layers of dark, hard, fossiliferous limestone. The Prout Limestone has been described as an approximate 15- to 50-foot-thick unit which occasionally outcrops in a 1,000- to 2,000-foot-wide, northeast-striking band across the middle portion of PBOW. It is described as a dark-gray to blue, very hard, siliceous, fossiliferous limestone or dolomitic mudstone. The Olentangy Shale of PBOW dips to the southeast at a slope of approximately 21 feet per mile. The uppermost formation at PBOW is the Ohio Shale. Geographic Information System data show that the Ohio Shale dips to the southeast at a slope of approximately 26 feet per mile (Shaw, 2005a). Only one member of the Ohio Shale is present in the PBOW area, the Huron Shale. This unit is described as black and thinly bedded, with abundant carbonaceous matter. Some large pyrite/carbonate concretions are also present in the Huron Shale, some as large as 6 feet in diameter (D&M, 1997a).

2.2.3 Regional Hydrogeology

Regional groundwater flow is to the north-northeast towards Lake Erie, although local flow may vary due to local topography. Water in the limestone typically occurs in joints and along bedding planes or in solutionally enlarged openings. Although some limestone in the middle of the county provide well yields of up to 500 gallons per minute (gpm), the overburden and the majority of the other formations can sustain groundwater pumping of only 10 gpm or less (D&M, 1997b). A hydrogeological study conducted by the USGS on the glacial deposits in Sandusky in 1990 reported a horizontal hydraulic conductivity of 0.046 feet per day and a vertical hydraulic conductivity of 1.2 feet per day (USGS, 1992).

2.2.4 Local Hydrogeology

From domestic groundwater wells outside of PBOW boundaries, the bedrock groundwater has been divided into three horizontal zones based on location and yield. Zone 1 occurs in the north

and northwestern portion of PBOW. It is characterized as yielding from 100 to 500 gpm from karstic limestone approximately 100 feet below grade. Zone 2 is in the northern portion of PBOW and has yields of 15 gpm or less from limestone approximately 300 feet below grade. Zone 3 is located in the eastern and southern portion of the site in predominantly shale bedrock. In addition to being found in the shale, groundwater is located in thin sand and gravel horizons interbedded with silt and clay deposits. Most Zone 3 wells are poor yielding, many of them providing less than 3 gpm (D&M, 1997b). TNTA and TNTB lie within Zone 3, the PRRWP Area lies within Zone 2, TNTC appears to lie within Zones 1 and 3, and the WARWP is within Zone 1.

Two main water-bearing zones are present underlying PBOW: one in the overburden/shale and one in the Delaware Limestone bedrock. The overburden and shale groundwater units exhibit similar water levels, suggesting substantial vertical communication, and are thus considered one hydrogeologic unit. Groundwater in the overburden/shale is in discontinuous pockets during dry time periods, exemplified by monitoring wells that are typically dry or areas in which wells could not be installed due to a lack of water in the overburden soil at the time of drilling. Only limited lateral migration of contaminants would typically occur in the overburden due to the lack of water. During a wet period, the general flow direction in the overburden/shale water-bearing zone (where present) is to the north-northeast, largely mirroring surface topography (Figure 2-1). The flow also corresponds somewhat to the topography of the top of the bedrock.

In contrast, the limestone bedrock water-bearing zone is saturated year-round. The conceptual model of the site shows that groundwater flow in the Delaware Limestone water-bearing zone migrates and is influenced by the frequency, orientation, density, and connectivity of fractures in the Delaware. Groundwater flow in the Delaware Limestone bedrock is only indicated by wells screened in the Delaware Limestone. Similar to the overburden/shale flow direction, groundwater in the Delaware Limestone flows to the north-northeast. A more detailed discussion of hydrogeological information is presented in the 2004 Groundwater Report (Appendix A). Groundwater flow in the limestone bedrock is depicted on Figure 2-2. Although this figure shows flow during a wet period (August 2004), general flow patterns during dry periods appear to be essentially the same, although specific localized flow may differ for a specific PBOW site. These differences in wet season and dry season do not appear to apply to the TNT and RWP Areas (Appendix A).

2.2.5 Influence of Precipitation on Water Levels

Although earlier investigations have indicated that there is a strong connection between precipitation and groundwater elevations, no clear correlation exists between monthly

precipitation rates and water level elevations in site wells (refer to Section 6.2 of Appendix A). The lack of observed correlation is probably influenced by the amount of precipitation and the runoff rate. For example, summer thunderstorms that produce short periods of heavy precipitation may result in more surface runoff and less infiltration. Conversely, constant periods of precipitation at a lower rate over a period of days may result in more infiltration. Freezing rain or snow will also not result in an immediate recharge to groundwater. From review of local monthly precipitation data, evapotranspiration and rainfall runoff rates calculations, and a comparison table of sitewide monitoring well groundwater elevations verses aquifer recharge rates, a seasonal correlation was determined. During the months of January through June, a greater volume of groundwater in the overburden/shale monitoring wells was present as compared to the months of July through December, when a lesser amount of water was present. Therefore, the time period of January through June is termed the "wet" time period, while July through December is termed the "dry" time period.

2.3 Groundwater Quality and Use

2.3.1 Groundwater Quality

Two groundwater aquifer systems are utilized for drinking water in the region: a carbonate aquifer to the west and a shale aquifer to the east. PBOW is located within the transition of the two systems. As described in Section 2.2.4, the overburden and shale are regarded as one unit, thus, this water-bearing zone is referred to as the overburden/shale unit. The limestone unit typically yields an adequate volume of groundwater for a drinking water source but is regionally regarded by the Ohio Department of Natural Resources as being of low quality because of high mineral content (D&M, 1997a).

Overburden/Shale Groundwater. Groundwater in the overburden is in discontinuous pockets during dry time periods. Also, the shallow overburden generally has low yields over most of PBOW due to the high percentage of silt and clay. Because of these conditions, the overburden/shale groundwater yields insufficient volume for potable use in many areas of the underlying PBOW. Additionally, groundwater from background wells in competent shale bedrock was found to have elevated concentrations of chloride, sulfate, iron, manganese, and total dissolved solids (TDS) (Shaw, 2006). Some of these concentrations, especially those of sulfate and TDS, were found at levels that far exceed the respective U.S. Environmental Protection Agency (EPA) Office of Groundwater Secondary Drinking Water Regulations (SDWR) or health advisories (EPA, 2012). The SDWRs are nonenforceable levels that are based on aesthetic properties (e.g., taste, odor, or color) or cosmetic effects (e.g., skin or tooth discoloration). The following list compares concentrations of these analytes in samples from off-

site upgradient background shale unit groundwater wells to the respective Office of Drinking Water SDWRs or health advisories.

- ***Chloride*** – Fifty percent of the background wells exceeded the chloride SDWR of 250 milligrams per liter or parts per million (ppm). The maximum background concentration (3,540 ppm) was 14 times higher than the SDWR.

- ***Sulfate*** – Eleven percent of the background wells exceeded the sulfate SDWR of 250 ppm. The maximum background concentration (514 ppm) was approximately twice the SDWR.

- ***Iron*** – Thirty-two percent of the background wells exceeded the iron SDWR of 0.3 ppm. The maximum background concentration (1.55 ppm) was approximately 5 times higher than the SDWR.

- ***Manganese*** – Sixty-one percent of the background wells exceeded the manganese SDWR of 0.05 ppm. The maximum background concentration (0.728 ppm) was over 14 times higher than the SDWR.

- ***Sodium*** – One hundred percent of the background wells exceeded the sodium health advisory level of 20 ppm. The maximum background concentration (1,390 ppm) was approximately 70 times higher than the sodium health advisory level. (Note that no SDWR exists for sodium.)

- ***TDS*** – Eighty-two percent of the background wells exceeded the TDS SDWR of 500 ppm. The maximum background concentration (6,850 ppm) was nearly 14 times higher than the SDWR.

Based on naturally occurring high TDS and other analytes as described above, this groundwater unit is consistent with the EPA guidelines for Class III nonpotable groundwater. Therefore, overburden/shale groundwater is not a suitable drinking water source based on both low yield and naturally poor quality.

Limestone Bedrock Groundwater. The limestone bedrock water-bearing zone yields groundwater year round, although specific locations may not produce water due to limited bedrock fractures in some areas. During periods of low precipitation, only limited migration of contaminants would occur in the overburden due to reduced infiltration. Limestone bedrock groundwater underlying most of PBOW is of poor natural quality largely due to naturally occurring petroleum hydrocarbons and hydrogen sulfide gas emissions.

As mentioned in Section 2.2.2, the presence of natural petroleum-derived hydrocarbon seeps are common along the walls of area quarries. Petroleum hydrocarbons were observed at depth during

the drilling of all TNT and RWP Area bedrock wells except TNTC well BED-MW18. This well was completed across the contact of the Olentangy Shale and Delaware Limestone. Evidence of naturally occurring petroleum included petroleum stains on rock cores, visible petroleum on drilling bits, free product detected during groundwater sampling, and detectable levels of hydrogen sulfide in boreholes and monitoring wells. The petroleum encountered during drilling was always only in the limestone bedrock unit and typically at depth, although petroleum hydrocarbon was detected throughout the limestone drilling process. Groundwater from all of the wells completed in the limestone (including BED-MW18) had reportable concentrations of petroleum-related compounds. In total, 68 percent of samples collected from eight limestone bedrock wells exceed the maximum contaminant level for benzene. Note that nitroaromatics were not present in most of the limestone groundwater samples; this observation provides additional evidence that the petroleum is not site-related. Subsequent petroleum hydrocarbon analysis by NASA (Science Applications International Corporation, 2007) of several groundwater samples, including one associated with TNTA (TNTA-BEDGW-001) and one associated with the PRRWP Area (BED-MW23), verified that the observed petroleum hydrocarbons in these samples were naturally occurring.

Naturally elevated concentrations of sulfate were observed in three limestone wells (in TNTA, TNTC, and the WARWP Area), and off-gassing of hydrogen sulfide was observed in several wells. The maximum sulfate concentration (2,660 ppm) among these wells was over 10 times the SDWR of 250 ppm. Additionally, all limestone wells except one exhibited the presence of naturally occurring petroleum, and more than two-thirds of limestone groundwater samples were found to have benzene (a natural petroleum component) concentrations that exceed the drinking water standard (see Section 2.6 of the groundwater FS). The limestone groundwater within the TNT and RWP Areas also meets the EPA guidelines for Class III nonpotable groundwater based on elevated concentrations of naturally occurring TDS, hydrogen sulfide, metals, and petroleum compounds. In summary, the limestone unit generally provides an adequate quantity of groundwater, but the natural quality of this water would fail drinking water standards. Therefore, groundwater from the limestone unit underlying the TNT and RWP Areas is nonpotable due to naturally poor quality that is unrelated to former site activities. This is consistent with the findings of the Ohio Department of Natural Resources (D&M, 1997a), which, as mentioned, regards this unit as being of low quality because of high mineral content.

2.3.2 Groundwater Use

The majority of residents in Erie County receive water from public utilities whose sources are surface water. Residences to the north and east of PBOW are connected to city, county, or rural services. Approximately 170 private drinking water wells permitted by the Erie County Health

Department are located within 4 miles of PBOW. USACE conducted a private well survey for the area within 1 mile of the downgradient PBOW boundary. Only five private wells were identified within the 1-mile radius. Two of these were identified as being used for the irrigation of lawns and gardens and washing cars, and the other three were not used at all (please see Appendix A of the BHHRA, which is attached as Appendix B). These wells were samples, and none were found to have detections of nitroaromatics. Groundwater is not used within the PBOW facility.

2.4 Site Conceptual Model

Figure 2-3 presents a generalized block diagram or conceptual model of PBOW showing the possible contaminant sources and migration transport routes, the overburden/shale and bedrock water-bearing units, the geologic units, and the interrelationship between the water-bearing zones. Groundwater sampling investigations and groundwater monitoring well measurement events have found that groundwater in the overburden may be limited to discrete areas during dry time periods of little rainfall. During these periods of low precipitation, only limited migration of contaminants would occur due to less infiltration of rainwater. The site conceptual model illustrates this seasonal, discontinuous nature of the overburden/shale groundwater.

The site conceptual model also illustrates groundwater flow in the Delaware bedrock water-bearing zone through fractures. Groundwater flowpaths and velocity are dictated by the frequency, orientation, density, fracture size, and connectivity of these bedrock fractures. In addition to fractures, some solutional cavities may be present in the limestone bedrock. Generally, groundwater in the bedrock flows to the north-northeast.

3.0 Site Characterization

This chapter provides a summary of the sampling, analyses, results, and evaluation of the TNT Area groundwater, RWP Area groundwater, and downgradient perimeter groundwater previously presented in the 2004 Groundwater Report, which is included as Appendix A. The 2004 Groundwater Report was part of the groundwater RI activities for TNTA, TNTB, TNTC, the PRRWP Area, the WARWP Area, and the associated perimeter area under DERP-FUDS Project No. G05OH001826. The 2004 Groundwater Report also presented the results of 6 years of background well sampling as well as groundwater analytical results for several other PBOW sites (e.g., Acid Areas, Garage Maintenance Area), each of which is being addressed under other PBOW projects. This chapter summarizes only groundwater information related to the TNT and RWP Areas, including the downgradient perimeter areas.

The 2004 Groundwater Report summarized field activities and evaluation of groundwater associated with the TNT and RWP Areas. These field activities, described in detail in the 2004 Groundwater Report, include monitoring well installation, monitoring well development, monitoring well and temporary piezometer sampling, hydraulic conductivity testing, decontamination procedures, land survey, and management of investigation-derived waste. This chapter summarizes only the analytical results of groundwater samples, which include both monitoring well and temporary piezometer samples that were collected between November 1997 and August 2004. Samples from this time period are evaluated in the 2004 Groundwater Report (Appendix A) as the groundwater RI samples. Please note that groundwater analytical results for these site areas dating back as early as 1994 are included in the 2004 Groundwater Report historical tables but are not evaluated in the report. The 2004 Groundwater Report also includes historical tables that present the analytical results for soil, sediment, and surface water from the TNT and RWP Areas; likewise, these results are not evaluated in the 2004 Groundwater Report. The historical groundwater analytical results for groundwater and the other environmental media are presented in Tables 3-1 through 3-20 of Appendix A.

Please note that this chapter provides no data or other information that has not been previously presented and evaluated in the 2004 Groundwater Report (Appendix A).

3.1 Samples and Analyses

The RI samples were collected consistent with the applicable quality assurance project plan (QAPP) (IT, 1996) and sampling and analysis plans (Shaw, 2003; IT, 1996). The groundwater

wells and piezometers were sampled and analyzed as described below as part of the RI effort. The types of wells/piezometers sampled for the RI are summarized as follows:

- ***TNTA*** – overburden temporary piezometers (9 in 2000; 2 in 2001), overburden/shale monitoring wells (5 wells), and bedrock monitoring wells (2 wells)
- ***TNTB*** – overburden temporary piezometers (2 in 2001), overburden/shale monitoring wells (2 wells), and bedrock monitoring wells (4 wells)
- ***TNTC*** – overburden temporary piezometers (9 in 2000; 2 in 2001), overburden/shale monitoring wells (3 wells), and bedrock monitoring wells (2 wells)
- ***PRRWP Area*** – overburden temporary piezometers (20 in 1998) and bedrock wells (2 wells)
- ***WARWP Area*** – overburden temporary piezometers (14 in 1998) and bedrock wells (2 wells)
- ***Downgradient Perimeter*** – bedrock wells (8 wells).

The wells were sampled in November 1997, May 1998, September/October 2001, and April 2002. Each of these well samples was analyzed for filtered metals, unfiltered metals, volatile organic compounds (VOC), semivolatile organics compounds (SVOC), explosives, and water quality parameters, unless sufficient water volume was not available for each analysis. Also, the piezometer samples collected in the RWP Areas were analyzed for this same suite of analytes if adequate water volume was available; please note that most of these had insufficient volume for water quality parameter analysis.

The 2000 piezometer samples from the TNT Areas were analyzed for filtered metals, nonfiltered metals, VOCs, SVOCs, and explosives. A total of 135 piezometer samples were planned in the TNT Areas in 2001 for analysis of filtered metals, nonfiltered metals, VOCs, SVOCs, and explosives. However, this effort was abandoned due to a lack of water; only 6 of 32 piezometers was found to have water, and none of these 6 samples had adequate water volume to analyze for all parameters. Groundwater monitoring well locations, including those for the TNT Area, RWP Area, and downgradient wells, are shown on Figure 3-1, along with the regional geology and site topography as presented in the 2004 Groundwater Report.

All analytical data from these samples were reviewed for accuracy and completeness. One hundred percent of the data analyzed were subjected to data validation following the guidelines in the EPA *Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review* (EPA, 1999) and EPA *Contract Laboratory Program National*

Functional Guidelines for Inorganic Data Review (EPA, 2002), the QAPP (IT, 1996), and specific analytical method requirements. Data were evaluated against specific criteria to verify the achievement of precision, accuracy, representativeness, completeness, and comparability goals established to meet the project data quality objectives. The criteria for blank evaluation were based on those detailed in *Region 3 Modifications to National Functional Guidelines for Evaluating Organic Analyses* (EPA, 1994) and *Region 3 Modifications to the Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* (EPA, 1993). Additional information on data evaluation, data validation, and data quality are provided in the 2004 Groundwater Report and information attached therein (Appendix A).

3.2 Summary of Analytical Results

The analytical results of the RI samples, described in Section 3.1, are summarized in this section, with more information provided for nitroaromatics, which are the historical contaminants generated at the TNT Areas and associated with the RWP Areas. Please note that based on sampling results from PBOW as well as other sites, analytical results from direct-push groundwater samples tend to be biased high for metals and nitroaromatics. This has been attributed both to the higher turbidity in direct-push groundwater samples and contamination from overlying soil being dragged down into the groundwater. For these reasons, direct-push groundwater samples are not regarded as being of adequate quality for quantitative evaluation of groundwater contamination.

Groundwater sampling locations of the TNT Areas and RWP Areas are shown on Figures 3-2 through 3-6, respectively. Groundwater monitoring wells for the TNT and RWP Areas are also shown on Figure 3-1 in the context of all PBOW monitoring wells and off-site wells that had been sampled prior to and during the RI sampling events described in the 2004 Groundwater Report. Perimeter boundary monitoring wells identified as being downgradient of one or more of the TNT or RWP Areas are shown on Figure 3-1 only.

As part of RI evaluation, analytes detected in the respective environmental media were compared to risk-based screening concentrations (RBSC) and background screening concentrations (BSC) as points of reference only. These comparisons to BSC and RBSC values are presented in Tables 7-1 through 7-18 of the 2004 Groundwater Report (Appendix A). RBSCs do not infer a regulatory limit or mandated cleanup level, nor is the identification of an exceedance intended to indicate an unacceptable human health risk or a need for remedial action. Formal evaluation of human health risks was performed in the BHHRA (Appendix B), which is summarized in Chapter 4.0 of this RI report.

The RBSCs were derived from EPA Region 9 preliminary remediation goals (EPA, 2004) as described in the BHHRA (Appendix B). The groundwater RBSCs are based on a generalized residential drinking water scenario, assumed to be the most restrictive use of groundwater, and they correspond to a one-in-one-million (1E-6) incremental lifetime cancer risk (ILCR) or a noncancer hazard quotient (HQ) of 0.1, whichever results in a lower concentration. The evaluation of the analytical results of the samples and analyses (Section 3.2.1), as presented in the 2004 Groundwater Report, are summarized below for groundwater at each TNT Area, RWP Area, and downgradient perimeter.

3.2.1 TNTA

Overburden/Shale. Eleven nitroaromatics were detected at concentrations above RBSC levels in the overburden/shale temporary piezometer and monitoring well groundwater samples at TNTA during both the wet and the dry season. Two nitroaromatics were detected above RBSC levels in November 1997, three in 1998, nine in 2000, seven in 2001, and three in 2002. The maximum nitroaromatic concentration in the piezometer samples was TNT at 32,400 micrograms per liter (µg/L) and the maximum concentration among nitroaromatics detected in overburden/shale monitoring wells was TNT at 110 µg/L.

Benzene, toluene, and chloroform were the only VOCs detected in the groundwater above RBSC or applicable BSC values. Benzene was detected in the groundwater during October 2000 direct-push operations at one boring (GW01), toluene was detected in May 1998 (2 wells) and October 2000 (2 direct-push points), and chloroform was detected in the groundwater during August 2001 direct-push operations from boring DP01. Three SVOCs were detected above RBSC levels. Bis(2-ethylhexyl)phthalate was detected during May 1998 sampling from well MK-MW23 and one or both of the nitroaromatics 2,4-DNT and 2,6-DNT were detected in seven direct-push samples in October 2000. Unfiltered metals aluminum, arsenic, iron, and manganese have been most commonly detected in the overburden/shale groundwater above both RBSC and BSC values during both the wet and dry seasons. Filtration removed most of the metals above RBSC and BSC values, but manganese was still detected above the RBSC and BSC value in 5 of the 18 filtered groundwater samples. Iron was also found in the groundwater above RBSCs and BSCs at MK-MW24 and TNTA-MW10 and arsenic was detected in the groundwater from MK-MW23 at concentrations above both the RBSC and BSC. Sulfate was the dominant anion in most of the overburden/shale wells, with the exception of TNTA-MW11. The dominant anion in well TNTA-MW11 varied over the sampling period from sulfate to chloride.

Delaware Limestone Bedrock. Nine nitroaromatic compounds were detected at concentrations above RBSC levels in the bedrock groundwater at TNTA during both the wet and the dry seasons. Concentrations of nitroaromatic compounds 1,3-dinitrobenzene, 2,4-DNT, 2,6-DNT, and nitrobenzene exceeded RBSC values in BED-MW18 during the dry and wet seasons of 1997 and 1998. 4A-2,6-DNT concentrations exceeded the RBSC in well TNTA-BEDGW-001 during October 2001 (dry season) and April 2002 (wet season). The maximum detected concentration was that of 2,6-DNT, which was detected only once at a concentration of 3.6 µg/L.

VOCs have consistently been detected in all site wells since 1997 with benzene, toluene, ethylbenzene, and xylenes (BTEX) parameters and methylene chloride commonly above RBSC and (for BTEX) BSC values. Bis(2-ethylhexyl)phthalate exceeded the RBSC value in TNTA-BEDGW-001. Naphthalene exceeded the RBSC value during each sampling event from wells BED-MW18 and TNTA-BEDGW-001. The polycyclic aromatic hydrocarbon compounds chrysene, dibenzofuran, and phenanthrene were detected above the RBSC value in well TNTA-BEDGW-001 during the October 2001 dry season.

Barium was the only metal to be detected in both the unfiltered and filtered samples from both wells during all sampling events. The following metals were detected at concentrations exceeding both the RBSCs and BSCs: aluminum (April 2002), arsenic (October 2001 and November 2002), iron (April 2002), manganese (October 2001 and April 2002), and nickel (October 2001). Each of these exceedances was detected in well TNTA-BEDGW-001. None of the metals in the filtered samples for the TNTA bedrock groundwater samples, including those from TNTA-BEDGW-001, exceeded both RBSCs and BSCs in the unfiltered groundwater samples. BTEX constituents in monitoring well TNTA-BEDGW-001 remained above RBSC and BSC levels during both sampling events, likely due to the free-phase hydrocarbon in the groundwater. Anions were dominated by chloride in both bedrock wells during all sampling events. The concentration of chloride was as much as two orders of magnitude greater than the concentration of sulfate.

3.2.2 TNTB

Overburden/Shale. Nitroaromatic compounds have consistently been present in the overburden/shale groundwater in monitoring well MK-MW17 during all sampling events, with five at concentrations exceeding the RBSCs. The nitroaromatic detected at the maximum concentration was TNT (68 µg/L); TNT was the only nitroaromatic detected in the direct-push piezometer groundwater, but was detected at a concentration less than the RBSC.

VOCs have not been detected at concentrations above RBSC or BSC values. Three SVOC parameters have been detected above RBSC levels during three of the four sampling events. The SVOC parameter indeno(1,2,3-cd)pyrene was detected in well MK-MW17 at a concentration above the RBSC value; the nitroaromatics 2,4-DNT and 2,6-DNT likewise were detected as SVOCs in well MK-MW17. Since sampling in November 1997, unfiltered metals typically present in both overburden wells at concentrations above RBSC and BSC levels have included iron, manganese, and nickel. Aluminum and cobalt were detected above RBSC and BSC levels in well MK-MW17 during two of the four sampling events, and arsenic was detected above both the RBSC and BSC during only the wet season sampling event. In the filtered groundwater samples from both wells, iron, manganese, and nickel concentrations have fairly consistently been above the RBSC and BSC values. Sulfate was the dominant anion present in overburden groundwater. The sulfate concentrations are approximately two orders of magnitude greater than the chloride concentrations.

Shale Bedrock. Nitroaromatic compounds have not been detected in the groundwater from the shale bedrock monitoring wells at TNTB. Benzene concentrations above both the RBSC and BSC values were detected in the groundwater from well TNTB-BEDGW-003. Benzene was also above the BSC value in groundwater from well TNTB-BEDGW-003, but only during the November 1997 sampling event. The SVOC naphthalene was detected once in the groundwater sample from TNTB-BEDGW-003 at an estimated concentration above the RBSC, but was not detected in any of the other TNTB bedrock groundwater samples. Well TNTB-BEDGW-003 showed the largest number of unfiltered metals above RBSC and BSC levels. Detections exceeding the both RBSCs and BSCs during both sampling events included aluminum, arsenic, and iron. Manganese was also detected above the RBSC and BSC only during October 2001. Monitoring well TNTB-BEDGW-001 exhibited iron concentrations above RBSC and BSC values during both sampling events as well as arsenic during the wet sampling season of May 1998 and manganese during the dry sampling season of November 1997. The unfiltered groundwater sample from well TNTB-BEDGW-004 displayed iron and manganese concentrations above both the respective RBSC and BSC values. Filtration of the groundwater removed many of the metals from all of the wells. Remaining metals above both the RBSC and BSC are iron and manganese in well TNTB-BEDGW-001 (November 1997) and well TNTB-BEDGW-004 (October 2001 and April 2002). The four bedrock wells showed greater variability in terms of anion concentrations. Wells TNTB-BEDGW-001 and TNTB-BEDGW-003 were chloride-dominant for all but one sampling event. The remaining two wells (TNTB-BEDGW-002 and TNTB-BEDGW-004) were sulfate-dominant. Differences of up to two orders of magnitude were observed in the chloride and sulfate concentrations.

3.2.3 TNTC

Overburden/Shale. Nitroaromatics were detected in the overburden/shale groundwater at TNTC only during the dry seasons of 2000 (10 temporary piezometers) and 2001 (1 temporary piezometer). The maximum detected concentration in the direct-push piezometer samples was TNT at 20,100 µg/L. In the same event, the nitroaromatics 2,4-DNT (37,600 µg/L) and 2,6-DNT (1,130 µg/L) were detected as SVOCs in the piezometer samples. Only TNT was detected (once) among the wells samples, and at a concentration of 0.61 µg/L.

Benzene was the only VOC detected above RBSC and BSC values in the groundwater, and this occurred during the dry season of 2000. The unfiltered metals aluminum, arsenic, iron, and manganese have been the analytes most commonly detected in the overburden/shale groundwater at concentrations above both RBSC and BSC values during both the wet and dry seasons. Cobalt, copper, nickel, and zinc were detected above the RBSC and BSC values in dry season samples. Manganese was one of two metals detected at concentrations above the RBSC and BSC values in filtered samples. The other metal was nickel, which was detected in the 1997 dry season sample from TNTC-MW03. In addition, chloride was detected at concentrations at least one order of magnitude greater than the corresponding sulfate concentrations in the groundwater from overburden/shale monitoring wells.

Delaware Limestone Bedrock. No nitroaromatic compounds were detected in the dry season or wet season bedrock groundwater samples from TNTC. VOCs have been detected consistently in both site wells (BED-MW13 and TNTC-BEDGW-001) since 1997. BTEX parameters are commonly above RBSC and BSC values in the Delaware Limestone screened monitoring wells. Reported concentrations of methylene chloride (a common laboratory contaminant) consistently exceeded the RBSC in both wells, although one sample was B qualified. The SVOCs bis(2-ethylhexyl)phthalate, 2-methylnaphthalene, and naphthalene were detected at concentrations above RBSCs in every sampling event, the first two compounds exclusively in BED-MW13, and naphthalene in all wells. No metals exceeded both the RBSC and BSC values. The detected anions varied in the bedrock wells at the site. In well BED-MW13, chloride is the dominant anion, while sulfate is the dominant anion in well TNTC-BEDGW-001.

3.2.4 PRRWP Area

Overburden/Shale. As many as nine nitroaromatic compounds were detected (as explosives or SVOCs) above RBSC levels in the 20 groundwater samples collected from temporary piezometers during the wet season of June 1998. Two of these (2,4-DNT and 2,6-DNT) were

detected as both SVOCs and explosives. The maximum detected concentration of any compound detected as a nitroaromatic explosive was 6,900 µg/L. The nitroaromatic 4,6-dinitro-2-methylphenol was detected as an SVOC at 20,000 µg/L.

VOC compounds above RBSC values at the PRRWP Area included tetrachloroethene from five locations. Trichloroethene was detected at two direct-push locations at concentrations that exceeded the RBSCs. The SVOC naphthalene was detected at in one direct-push sample at a concentration that exceeded the RBSC. Most of the metals were detected above the RBSC and BSC in one or more of the unfiltered samples; this is to be expected with the direct-push sampling method. The metals most frequently detected at concentrations above both RBSC and BSC values in the unfiltered samples included aluminum, iron, and manganese. Filtering removed most of the exceedances in most samples, indicating that the metals are mostly associated with suspended particulates in the direct-push samples. Manganese was the filtered metal most frequently detected at concentrations above both the RBSC and BSC. It was detected at concentrations ranging from 818 µg/L to a maximum concentration of 62,500 µg/L. Total cyanide was also detected above the RBSC in the groundwater at two locations, and nitrate was detected above the RBSC at two locations. In addition to nitrate, sulfate is the dominant anion in this area. No temporary piezometers were drilled and no overburden/shale wells were sampled during the dry season.

Delaware Limestone Bedrock. A total of four nitroaromatic compounds (4A-2,6-DNT, 2,4-DNT, 2,6-DNT, and nitrobenzene) were detected above RBSC levels during the wet seasons of May 1998 and April 2002 from well BED-MW15. The highest concentration of nitroaromatics detected in the PRRWP Area bedrock well samples was TNT at a concentration of 1.6 µg/L.

BTEX parameters were consistently detected exceeding the screening RBSC and BSC values in both wells during both the wet and dry seasons. Acetone, a common laboratory contaminant, exceeded the RBSC value during both sampling events in well BED-MW23. The SVOC bis(2-ethylhexyl)phthalate, a common laboratory contaminant, was detected above the RBSC value in well BED-MW15 during one (dry season) sampling event and was reported above the RBSC in another sampling event at well BED-MW23 (dry season). The concentrations of the SVOCs 2-methylnaphthalene and naphthalene exceeded the RBSCs in both wells during all sampling events. The SVOC 4-methylphenol was detected above the RBSC during both sampling events from well BED-MW23. Iron was detected above the RBSC and BSC values once in well BED-MW15, and iron and manganese concentrations were usually above both values in the unfiltered and filtered samples from well BED-MW23. Chloride is the dominant

anion in the bedrock, detected at concentrations one to two orders of magnitude greater than the concentrations of sulfate.

3.2.5 WARWP Area

Overburden/Shale. Seven nitroaromatic compounds were detected (as explosives or SVOCs) at concentrations above RBSC levels in the 14 groundwater samples from temporary piezometers during the wet season of June 1998. The maximum detected concentration of nitroaromatics among the overburden/shale groundwater samples was 2,4-DNT at 950 µg/L (660 µg/L as an SVOC).

The VOC tetrachloroethene was detected above the RBSC value at the WARWP and may not be related to former DOD operations. Nitroaromatic detections are indicative of former DoD site activities. Half (i.e., 11) of the metals were detected above the RBSC and BSC in one or more of the unfiltered samples; this is to be expected with the direct-push sampling method. The unfiltered metals most frequently detected at concentrations above both RBSC and BSC values included aluminum, arsenic, iron, and manganese. Among the filtered samples, only arsenic and manganese remained above both RBSC and BSC values. This indicates that most of the metals are suspended in particulates. Sulfate was the dominant anion present. In addition, nitrate was detected above the RBSC in this area. No temporary piezometers were drilled and no overburden/shale wells were sampled during the dry season.

Delaware Limestone Bedrock. Five nitroaromatic compounds (4,6-dinitro-2-methylphenol, 2,4-DNT, 2,6-DNT, 2,4-dinitrophenol, and 3-nitroaniline), all detected as SVOCs, were found to be above RBSC levels during the wet season of May 1998. The nitroaromatics 3-nitroaniline and 2,4-DNT, detected as SVOCs, were also present above RBSC levels during the April 2002 wet season. The highest concentration among the nitroaromatics was that of 3-nitroaniline, at 150 µg/L.

Benzene was detected only once (November 1997 dry season) at a concentration above the RBSC value. Arsenic, cobalt, and nickel were each detected at concentrations exceeding the respective RBSC and BSC values. The single exceedance by arsenic occurred during the April 2002 wet season. Cobalt and nickel were the inorganics most commonly detected at concentrations that exceeded screening levels. Both analytes were above RBSC and BSC values during the dry season (September 2001) and wet season (April 2002) sampling events. Each of the exceedances of RBSCs/BSCs for arsenic, cobalt, and nickel was observed in both the unfiltered and associated filtered groundwater samples at similar respective concentrations (i.e.,

filtered vs. unfiltered); this indicates that these analytes are in the dissolved phase. Nitrate was detected above the RBSC in all four of the sampling events. Anions in the bedrock groundwater are dominated by sulfate, which was detected at concentrations up to two orders of magnitude greater than the concentrations of chloride in all sampling events except September 2001. In this latter event, no sulfate data were available.

3.2.6 Downgradient Perimeter

Overburden/Shale. No downgradient, perimeter overburden/shale monitoring wells were scheduled to be sampled during the 1997 dry season, 1998 wet season, 2001 dry season, or 2002 wet season sampling events.

Delaware Limestone Bedrock. In samples from the downgradient perimeter wells, four nitroaromatic compounds (nitrobenzene, 2,4-DNT, 2,6-DNT, and 2-nitrotoluene) were detected at concentrations that exceeded the RBSC. 2,4-DNT had the highest detected concentration among the nitroaromatics and was detected at a maximum detected concentration of 1.5 µg/L. Each detection of 2,4-DNT was from well BED-MW27. This well was subsequently abandoned because of hydrogen sulfide emissions that were due to naturally occurring groundwater chemistry. In the 1997 dry season sampling event (November), nitrobenzene was detected above the RBSC. 2,4-DNT was detected in BED-MW27 in the 2001 dry season event (October). In this same event, 2,6-DNT concentrations were above the RBSC in BED-MW17 and BED-MW27, respectively. In the 2002 wet season sampling event (April), 2-nitrotoluene was detected above the RBSC in BED-MW17. In the same event, the concentration of 2,4-DNT was above the RBSC in BED-MW27. The compound 2,6-DNT was also detected above the RBSC in BED-MW24 and BED-MW27. In the 2002 dry season sampling event (October), 2,4-DNT and 2,6-DNT concentrations were above the RBSCs. The compound 2-nitrotoluene was detected at a concentration above the RBSC in BED-MW30.

A number of VOC compounds (acetone, benzene, chlorobenzene, ethylbenzene, methylene chloride, toluene, and total xylenes) were detected at concentrations above RBSCs and BSCs. In particular, the BTEX compounds (individually or in various combinations) exceeded the RBSCs and BSCs consistently throughout all sampling events in all of the monitoring wells. Three SVOCs were detected above the RBSCs. The SVOC bis(2-ethylhexyl)phthalate was detected in the samples from BED-MW19 in the 1997 dry season sampling event (November) and BED-MW19 in the 2002 wet season sampling event (April). With the exception of the 2004 wet season sampling event (March), naphthalene was detected at concentrations above the RBSC in all sampling events, particularly in BED-MW17, BED-MW-19, BED-MW24, BED-MW27, and

BED-MW30. Another SVOC (2-methylnaphthalene) was detected at concentrations above the RBSC in the 1998 wet season event (May), 2001 dry season event (October), 2002 wet season event (April), and 2002 dry season event (October). These detections above the RBSC were always in BED-MW17 and BED-MW27. Various metals were detected above screening criteria in every well throughout all sampling events. The metals detected above RBSCs and BSCs in the unfiltered samples were arsenic (well BED-MW30 during the wet season) iron (six wells during both the wet and dry sampling seasons), and manganese (well BED-MW27 in all three sampling events). The most prevalent above the screening criteria was iron. Two metals, arsenic and manganese, were detected at concentrations above RBSC and BSCs in at least one of the filtered groundwater samples. Arsenic was detected in well BED-MW17during the wet season (May 1998), well BED-MW30 during the wet season (May 2004), and in well BED-MW33 during both the wet and dry season (May and August 2004). Manganese was detected in the unfiltered and filtered samples from the 2002 wet and dry period sampling events from well BED-MW27. Total cyanide was detected above the RBSC only one time in a groundwater sample from BED-MW17, collected in the 1997 dry season sampling event. In general, chloride was detected at higher concentrations than sulfate in all wells except BED-MW17 and private well PT-5912.

4.0 Baseline Human Health Risk Assessment

The BHHRA evaluated potential human health risks associated with exposure to groundwater associated with the following PBOW sites:

- TNTA
- TNTB
- TNTC
- PRRWP Area
- WARWP Area
- Downgradient areas at the facility boundary.

It is important to note that site-specific risk assessment for groundwater was included to satisfy administrative requirements.

This chapter summarizes the BHHRA. It identifies the chemicals of potential concern (COPC), summarizes the receptors, evaluated exposure pathways, summarizes the risk characterization, and presents the BHHRA conclusions for bedrock groundwater. The final BHHRA, submitted previously, is attached as Appendix B. The BHHRA was performed consistent with EPA guidance and with the procedures established in the BHHRA for TNTA and TNTC soil (IT, 2001b) and, most specifically, the BHHRA work plan for groundwater underlying the TNT and RWP Areas (Shaw, 2005c). It is noted that the scope of work for the BHHRA required the summation of groundwater risks with those of other environmental media from the respective sites that had been evaluated previously. However, because soil/sediment remediation of the various TNT and RWP Areas is either completed or ongoing under different DERP-FUDS projects, these aggregate risks discussed in the BHHRA (Chapter 8 of Appendix B) are no longer relevant to site conditions and are, thus, not further discussed in the body of this RI report.

This BHHRA used as input the RI analytical results described in the 2004 Groundwater Report (Appendix A) and summarized in Chapter 3.0 of this RI report. Because of very low groundwater yield in the overburden/shale unit of the TNT and RWP Areas, the Project Delivery Team agreed that only a qualitative evaluation was necessary in the BHHRA for this groundwater unit. Please note that the PRRWP Area and WARWP Area overburden/shale monitoring well analytical data that are included in the "historical" data tables of the 2004 Groundwater Report were not identified in that report as RI data. Thus, for purposes of the qualitative evaluation in the BHHRA, the "historical" data from the PRRWP Area (Appendix A, Table 3-20) and WARWP Area (Appendix A, Table 3-16) overburden/shale analytical data were included in the BHHRA.

4.1 Identification of COPCs

A screening procedure was conducted on the analytical data from the bedrock groundwater unit for each site (i.e., TNT, RWP, and downgradient) area. This screening process is used to identify COPCs, which are the detected chemical analytes carried through the full risk assessment process. The objectives of COPC screening are to focus the risk assessment on those chemicals that may contribute significantly to overall risk and to remove from quantification those chemicals whose contribution is clearly inconsequential. COPC screening includes a risk-based screen which also considers status as a human nutrient, a frequency-of-detection evaluation, and a background screen.

The COPC screening process resulted in the generation of a COPC identification and data summary table for each detected analyte in the bedrock groundwater underlying each site which was subsequently quantitatively evaluated in the BHHRA. The areas and corresponding tables are as follows:

- TNTA bedrock groundwater (Table 4-1)
- TNTB bedrock groundwater (Table 4-2)
- TNTC bedrock groundwater (Table 4-3)
- PRRWP Area bedrock groundwater (Table 4-4)
- WARWP Area bedrock groundwater (Table 4-5)
- Downgradient boundary well bedrock groundwater (Table 4-6).

These tables provide the following information for each detected chemical in each bedrock groundwater data set:

- Chemical name
- Frequency of detection
- Range of detected concentrations
- Range of detection limits
- Arithmetic mean of site concentrations
- 95th percent upper confidence limit on the arithmetic mean (for COPCs only)
- Appropriate RBSC
- Appropriate BSC
- Selection/exclusion of chemical as a COPC
- Exposure point concentration (EPC) (for COPCs only).

Additional details of this data summary, including the estimation of the upper confidence limit values and EPCs for COPCs, are discussed in the BHHRA (Appendix B). Please note that a similar screening process was conducted for overburden/shale groundwater samples, but that as mentioned in Section 4.0, the Project Delivery Team agreed that only a qualitative evaluation

was necessary for this unit because it does not represent a usable volume of water (please see Section 2.3 and Tables 2-10 through 2-19 in Appendix B).

4.2 Exposure Assessment

Exposure is the contact of a receptor with a chemical or physical agent. An exposure assessment estimates the type and magnitude of potential exposure of a receptor to COPCs found at or migrating from a site (EPA, 1989). The BHHRA characterizes potential exposures to COPCs in groundwater.

The elements of an exposure model include the following:

- Source
- Source media (i.e., initially contaminated environmental media)
- Contaminant release mechanisms
- Contaminant transport pathways
- Intermediate or transport media
- Exposure media
- Receptors
- Routes of exposure.

Contaminant release mechanisms and transport pathways are not relevant for direct receptor contact with a contaminated source medium (e.g., ingestion or dermal contact).

Groundwater is not currently being used at PBOW, and there are no current uses in the vicinity of the facility boundary. Therefore, the BHHRA addresses only exposure pathways associated with potential future uses. The off-site residents are serviced by municipal water from surface water sources. During a groundwater survey conducted by USACE in 2003, owners of five of the off-site wells identified as downgradient agreed to have their wells sampled; no nitroaromatics were detected in any of these wells. Naturally occurring petroleum hydrocarbons and hydrogen sulfate are prevalent in the limestone bedrock; thus, use of this groundwater unit may not be plausible. Section 2.3 includes further discussion of groundwater quality and use in the area.

Regardless of concerns regarding the questionable potential for groundwater use, given its naturally poor quality (Section 2.3.1), exposure associated with the bedrock groundwater was evaluated in the BHHRA using the long-term receptors to represent the upper bound on bedrock groundwater exposure for all exposed groups of people at the respective TNT Area sites, RWP area sites, and the facility boundary that are listed below.

- ***Current/Future Off Site.*** Data for all six downgradient wells are combined into a single evaluation, assuming a resident who obtains his water from the facility boundary. It is emphasized that groundwater at the facility boundary is not currently used, but such use may be plausible in the future.

- ***Future On Site.*** Five separate evaluations for the five TNT/RWP Areas based on analyses from bedrock wells within the respective areas. Both the on-site worker and on-site resident were evaluated.

- ***Modeled Future On Site.*** Based on modeled future concentrations of TNT, 2,4-DNT, and 2,6-DNT in bedrock groundwater assuming on-site groundwater would be used as a drinking water source. Both the on-site worker and on-site resident were evaluated. This model is presented and discussed in the BHHRA (Appendix B). Section 4.3.3.7 includes for additional information on this model.

- ***Modeled Future Off Site.*** Based on modeled concentrations of 2,4-DNT, 2,6-DNT, and TNT, assuming that the resident obtains tap water from the downgradient PBOW boundary. It is based on the location exhibiting the highest concentrations of these analytes. Three downgradient areas were identified and evaluated based on groundwater flow directions: the area downgradient of TNTA, The area downgradient of the WARWP Area, and the shared area downgradient of TNTB, TNTC, and the area downgradient of the PRRWP Area (Appendix B). Section 4.3.3.7 includes additional information on this model.

These scenarios and receptors were selected based on current usage of the PBOW facility (industrial) and much of the surrounding area (residential/agricultural) to be protective of all receptors (e.g., shorter-term construction workers, visitors, etc.,). Only the residential scenario is evaluated for downgradient bedrock groundwater for the following reasons:

1) Future land use cannot be restricted off site.

2) Current land use downgradient of the PBOW sites is generally residential.

3) The residential scenario is the most protective.

The equations for the calculations of intake values for each exposure pathway, exposure assumptions, and the calculation of EPCs of COPCs for modeled pathways are presented in the BHHRA (Appendix B).

4.3 Risk Characterization

Risk characterization is the process of applying numerical methods and professional judgment to determine the potential for adverse human health effects to result from the presence of site-specific chemicals. This is done by combining the intake rates estimated during the exposure

assessment with the appropriate toxicity information identified in the toxicity assessment (Chapter 4.0 of the BHHRA [Appendix B]). Noncancer hazards and cancer risks are characterized separately, including COPCs that induce both types of effects.

Quantitative expressions are calculated during risk characterization that describe the probability of developing cancer (i.e., ILCRs), or the nonprobabilistic comparison of estimated dose with a reference dose (RfD) for noncancer effects (i.e., HQs and hazard indices [HI]). Quantitative estimates are developed for individual chemicals, exposure pathways, and exposure media for each receptor. These quantitative risk characterization expressions, in combination with qualitative information, are used to guide risk management decisions. Risk characterization is applied only to COPCs. Please note that modeled risks include only those associated with TNT, 2,4-DNT, and 2,6-DNT.

4.3.1 Cancer Risk

The risk from exposure to potential chemical carcinogens is estimated as the probability of an individual developing cancer over a lifetime and is called the ILCR. Equations for calculating the ILCR are presented in the BHHRA (Appendix B).

Total ILCRs in the range of 1E-6 to 1E-4 are regarded as acceptable (EPA, 1990); this range is referred to as the "National Oil and Hazardous Substances Pollution Contingency Plan (NCP) risk management range." Risks less than this range are regarded as negligible. A target cancer risk goal of 1E-5 is used by OEPA and was selected by the PBOW Project Delivery Team as a basis to consider remedial action. Use of this 1E-5 goal represents a departure from the Army's practice of generally using a cancer risk exceeding a value of 1E-4 (the upper end of the NCP risk management range) to trigger remedial action considerations.

4.3.2 Noncancer Effects of Chemicals

The hazards associated with noncancer effects of chemicals are evaluated by comparing an exposure level or intake with an RfD. The HQ, defined as the ratio of intake to RfD, is estimated by dividing the intake of a chemical by the RfD as described in the BHHRA (Appendix B).

Chemical noncancer hazards are evaluated using chronic RfD values. An HQ of unity indicates that the estimated intake equals the RfD. If the HQ is greater than unity, there may be concern for potential adverse health effects. In the case of simultaneous exposure of a receptor to multiple chemicals or to a given chemical by multiple pathways, an HI is calculated as the sum of the HQs.

A total HI is calculated as the sum of all HI values, including all media and all COPCs, for a given receptor. Calculating a total HI as the sum of HQ values is based on the assumption that the potential for noncancer effects is additive. EPA (1989), however, acknowledges that the assumption of additivity is probably appropriate only for chemicals that induce adverse effects by the same mechanism. Therefore, if the total HI for a receptor exceeds 1, individual HI values may be calculated for each target organ, as described in Appendix B.

4.3.3 Risk Characterization Results

The risk characterization process described in Sections 4.3.1 and 4.3.2 was applied to the COPCs identified in Section 4.1 for bedrock groundwater underlying each of the areas evaluated in this BHHRA, as described in Section 4.2. The cancer risks and noncancer hazards are presented for each receptor in Tables 6-1 through 6-47 of Appendix B. Overall risks and hazards associated with groundwater are presented in Table 4-7.

The resultant HI and ILCR values are summarized in bulleted form in the following sections. These sections describe the overall risks/hazards (i.e., combining those which are site-related and background-related) and the site-related risk/hazards. The site-related risk results should be interpreted in light of the associated uncertainties of the site-relatedness selection process as described in the uncertainties analysis (Section 7.2.3 of Appendix B). Please note that unless otherwise specified, the HI and ILCR values refer to the "total" HI and "total" ILCR in each case, as opposed to chemical-specific HQ or ILCR values. In the following bulleted subsections, exceedances of the PBOW cancer risk goal (ILCR>1E-5) are shown in italics, and exceedances of the noncancer hazard criterion (HI>1) or the NCP risk management range (1E-6 to 1E-4) are shown in bold italics.

4.3.3.1 Overall and Site-Related TNTA Groundwater Risk Results

- Site Worker:
  - Overall: ***ILCR = 3E-4***; ***HI = 10***
  - Site-related: ILCR = 1E-5; HI = 0.2. All of the ILCR is associated with 2,6-DNT and 2,4-DNT.

- On-Site Resident Child:
  - Overall: ***HI = 347***
  - Site-related: ***HI = 2;*** associated with nitrobenzene, 2,4-DNT, and 2,6-DNT.

- On-Site Resident Adult:
  - Overall: ***HI = 149***
  - Site-related: HI = 1.

- On-Site Child/Adult Resident:
  - Overall: ***ILCR = 3E-3***
  - Site-related: *ILCR = 4E-5***;** associated with 2,6-DNT, 2,4-DNT, and 2-nitrotoluene.

4.3.3.2 Overall and Site-Related TNTB Groundwater Risk Results

- Site Worker:
  - Overall: *ILCR = 7E-5*; HI = 2 (Maximum target organ-specific HI of 0.8 does not exceed criterion of 1)
  - Site-related: None.

- On-Site Resident Child:
  - Overall: ***HI = 18***
  - Site-related: None.

- On-Site Resident Adult:
  - Overall: ***HI = 8***
  - Site-related: None.

- On-Site Child/Adult Resident:
  - Overall: ***ILCR = 3E-4***
  - Site-related: None.

4.3.3.3 Overall and Site-Related TNTC Groundwater Risk Results

- Site Worker:
  - Overall: *ILCR = 9E-5*; HI = 1
  - Site-related: None.

- On-Site Resident Child:
  - Overall: ***HI = 65***
  - Site-related: None.

- On-Site Resident Adult:
  - Overall: ***HI = 28***
  - Site-related: None.

- On-Site Child/Adult Resident:
  - Overall: ***ILCR = 1E-3***
  - Site-related: None.

4.3.3.4 Overall and Site-Related PRRWP Groundwater Risk Results

- Site Worker:
  - Overall: ***ILCR = 5E-4***; ***HI = 15***

- Site-related: ILCR = 4E-6; HI = 0.07

- On-Site Resident Child:
  - Overall: ***HI = 235***
  - Site-related: HI = 0.6

- On-Site Resident Adult:
  - Overall: ***HI = 101***
  - Site-related: HI = 0.3

- On-Site Child/Adult Resident:
  - Overall: ***ILCR = 7E-3***
  - Site-related: *ILCR = 2E-5*; associated with 2,4-DNT and 2,6-DNT.

4.3.3.5 Overall and Site-Related WARWP Groundwater Risk Results

- Site Worker:
  - Overall: *ILCR = 1E-4*; ***HI = 9***
  - Site-related: *ILCR = 6E-5*; ***HI = 9***

- On-Site Resident Child:
  - Overall: ***HI = 63***
  - Site-related: ***HI = 61***

- On-Site Resident Adult:
  - Overall: ***HI = 27***
  - Site-related: ***HI = 26***

- On-Site Child/Adult Resident:
  - Overall: ***ILCR = 5E-4***
  - Site-related: ***ILCR = 2E-4***; associated with 2,4-DNT and 3-nitroaniline.

4.3.3.6 Overall and Site-Related Downgradient Areas Groundwater Risk Results

- On-Site Resident Child:
  - Overall: ***HI = 100***
  - Site-related: HI = 0.4

- On-Site Resident Adult:
  - Overall: ***HI = 43***
  - Site-related: HI = 0.2

- On-Site Child/Adult Resident:
  - Overall: ***ILCR = 4E-4***
  - Site-related: *ILCR = 3E-5*, associated with 2,4-DNT, 2,6-DNT, and 2-nitrotoluene.

4.3.3.7 Modeled Future Groundwater Risk Results

Potential future concentrations of the major site-related contaminants 2,4-DNT, 2,6-DNT, and TNT were modeled, based on soil and overburden groundwater concentrations, as discussed in Section 3.2.4 of Appendix B. Modeling simulated contaminant leaching from the soil into groundwater and groundwater transport of contaminants. It should be understood that this model has considerable associated uncertainties, and it generally defaults to conservative assumptions that tend to overestimate the resulting concentrations. These overestimated concentrations add an accordingly high bias to the risk and hazard estimates.

Since preparation of the groundwater model, remediation of several thousand cubic yards has taken place and/or is ongoing at TNTA, TNTC, and the PRRWP Area under other DERP-FUDS projects based on protection of direct contact with soil. Because the groundwater model does not account for the improvement of soil conditions associated with these remediation activities, the output from the BHHRA model is outdated and likely overly conservative with respect to soil concentration inputs at these sites, as well as the boundary locations that are downgradient from these sites.

It was determined that the downgradient flow from TNTB, TNTC, and the PRRWP Areas would meet at approximately the same area along the northern facility boundary, and this migration was modeled in a single model run. Migrations from the TNTA and the WARWP areas would affect separate downgradient areas and were modeled separately.

The modeled risks for each of the five areas of concern (AOC) and the three downgradient boundary areas are based on the year in which the combined modeled concentrations of these three nitroaromatics are expected to be at a maximum in that AOC or at that downgradient location.

The resulting cancer risks and noncancer hazards associated with the modeled concentrations are described in bulleted format for each downgradient receptor scenario. Similar to the risk characterization results presented in Sections 4.3.3.1 through 4.3.3.6 for the measured concentrations, exceedances of the PBOW cancer risk goal (ILCR>1E-5) are shown in italics, and exceedances of the noncancer hazard criterion (HI>1) or the NCP risk management range (1E-6 to 1E-4) are shown in bold italics.

Modeled TNTA Groundwater Risk Results

- Site Worker: *ILCR = 1E-4*; HI = 0.5
- On-Site Resident Child: ***HI = 4***

- On-Site Resident Adult: ***HI = 2***
- On-Site Child/Adult Resident: ***ILCR = 5E-4***.

Modeled TNTB Groundwater Risk Results

- Site Worker: ILCR = 6E-6; HI = 0.02
- On-Site Resident Child: HI = 0.1
- On-Site Resident Adult: HI = 0.05
- On-Site Child/Adult Resident: *ILCR = 2E-5*.

Modeled TNTC Groundwater Risk Results

- Site Worker: ***ILCR = 4E-4***; HI = 1
- On-Site Resident Child: ***HI = 8***
- On-Site Resident Adult: ***HI = 4***
- On-Site Child/Adult Resident: ***ILCR = 2E-3***.

Modeled PRRWP Area Groundwater Risk Results

- Site Worker: *ILCR = 4E-5*; HI = 0.1
- On-Site Resident Child: HI = 0.7
- On-Site Resident Adult: HI = 0.3
- On-Site Child/Adult Resident: ***ILCR = 2E-4*** (1.5E-5 prior to rounding).

Modeled WARWP Area Groundwater Risk Results

- Site Worker: *ILCR = 4E-5*; HI = 0.09
- On-Site Resident Child: HI = 0.6
- On-Site Resident Adult: HI = 0.2
- On-Site Child/Adult Resident: ***ILCR = 2E-4***.

Modeled Groundwater Risk Results – Area Downgradient from TNTA

- On-Site Resident Child: HI = 0.002
- On-Site Resident Adult: HI = 0.0009
- On-Site Child/Adult Resident: ILCR = 4E-7.

Modeled Groundwater Risk Results – Area Downgradient from TNTB

- On-Site Resident Child: HI = 0.08
- On-Site Resident Adult: HI = 0.04
- On-Site Child/Adult Resident: *ILCR = 2E-5*.

Modeled Groundwater Risk Results – Area Downgradient from the WARWP Area

- On-Site Resident Child: HI = 0.006
- On-Site Resident Adult: HI = 0.002

- On-Site Child/Adult Resident: ILCR = 1E-6.

4.4 BHHRA Conclusions

Currently, there are no groundwater users on the site or at the facility boundary. Based on measured groundwater concentrations, the hypothetical residential use of groundwater at each TNT Area and RWP Area and the downgradient boundary was found to result in unacceptable cancer risks, exceeding both the NCP acceptable range (1E-6 to 1E-4) and the PBOW cancer risk criterion (1E-5). Residential use of groundwater would also result in a level of exposure that would have the potential to produce adverse noncancer health effects at each TNT and RWP Area (i.e., HI>1). The BHHRA results also show that long-term worker use of site groundwater would results in levels of exposure that would exceed the OEPA target level at each TNT and RWP Area, and would also exceed the NCP acceptable range at TNTA and the PRRWP Area. Additionally, exposure to TNTA and the PRRWP Area groundwater would result in a noncancer HI that exceeds a value of 1 for the long-term on-site worker.

At each area, except the WARWP Area, the non-site-related COPCs dominate both the cancer risk and noncancer hazards; at the WARWP Area, residential and worker ILCR values associated with non-site-related arsenic also exceed the target ILCR. The following COPCs are dominant with respect to cancer risk and/or noncancer hazard for the five AOCs and the downgradient areas; site-related COPCs are specifically noted as such:

- TNTA – Naturally occurring petroleum-related organic compounds
- TNTB – Inorganics and naturally occurring petroleum-related organic compounds
- TNTC – Naturally occurring petroleum-related organic compounds
- PRRWP – Naturally occurring petroleum-related organic compounds
- WARWP – Site-related nitroaromatics and naturally occurring arsenic
- Downgradient – Naturally occurring petroleum-related organic compounds.

For each of these areas, even if no site-related COPCs were present, noncancer hazards associated with residential groundwater use, cancer risk associated with residential groundwater use, and cancer risks associated with worker use would result in respective HI and ILCR values that would exceed the target HI criterion (1) and OEPA target cancer risk (1E-5). Site-related risks associated with groundwater are specifically summarized in the following paragraphs.

Site-Related Risk/Hazard Results Based on Measured Concentrations. Based on hypothetical residential groundwater use, TNTA, the PRRWP Area, the WARWP Area, and the downgradient boundary would result in a risk from site-related chemicals that exceeds the PBOW cancer risk criterion; the ILCR exceedance for the PRRWP Area is marginal. Of these, only the WARWP Area site-related risks would also exceed the NCP acceptable cancer risk

range. Only TNTA and the WARWP Area had noncancer HI values that exceed the threshold criterion of 1 for the resident. With respect to a worker scenario for groundwater use, only the WARWP Area had an ILCR value that exceeds the PBOW cancer risk goal, but this value is less than the NCP acceptable cancer risk range. Likewise, only the WARWP Area had an HI value for worker groundwater use that exceeds a value of 1.

No site-related COPCs were identified for TNTB or TNTC groundwater. Therefore, site-related risks and hazards are acceptable for these two areas with respect to all receptors.

Site-Related Risk/Hazard Results Based on Modeled Concentrations. Based on the model results, each of the TNT and RWP areas have ILCRs that exceed the PBOW cancer risk goal under residential use; each of these areas except for TNTB also exceed the NCP acceptable range for residential use. The noncancer hazard criterion is exceeded only for the resident, and only for TNTA and TNTC. The ILCRs for the worker cancer risk exceed the PBOW risk goal for TNTA, TNTC, the PRRWP Area, and the WARWP Area; of these worker risks based on groundwater modeling, only the ILCR for TNTC exceeds the NCP acceptable risk range. It is noted that TNTB is the only area where soil remediation actions were included in the model. In the off-site perimeter areas, only residential groundwater use at the single boundary area downgradient of TNTB, TNTC, and PRRWP resulted in an ILCR that exceeds the PBOW cancer risk goal , albeit marginally (2E-5). Noncancer HI values were all less than a value of 1 for all downgradient areas, indicating that adverse noncancer health effects are unlikely.

As stated in Section 4.3.3.7, the groundwater model has considerable uncertainties and generally defaults to conservative assumptions. Also, the groundwater model includes the contamination associated with thousands of cubic feet of contaminated soil that have been subsequently removed and remediated and/or are planned for removal or remediation from TNTA, TNTC, and the PRRWP Area. Therefore, the soil-to-groundwater leaching component of the groundwater model greatly overestimates current soil contamination, adding an additional high bias to the modeled concentrations and the associated risk estimates.

5.0 DERP-FUDS Project No. G05OH001826 Recommendations

The purpose of the RI is to gather information concerning the site characteristics so that appropriate remedial alternatives may be developed in the FS. However, it is unnecessary to perform an FS if the BHHRA indicates that the human health risk goals are met under baseline conditions, and the ecological risk assessment indicates a lack of adverse ecological effects (DoD, 2004; 2012). Please note that no ecological risk assessment was required for this RI because no complete ecological exposure pathways were identified pertaining to groundwater.

Based on the findings of this RI, development of an FS for TNT and RWP Areas groundwater is recommended.

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TABLES

Table 4-1

Statistical Summary and COPC Selection of Chemicals Detected in Bedrock Groundwater
TNT Area A, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of Concentration Values, µg/L: Detected Concentrations Minimum	Detected Concentrations Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Units	Statistical Distribution [a]	Mean µg/L	95% UCL µg/L b	BSC [c] µg/L	RBSC [d] µg/L	COPC? [e,f]	Exposure Point Concentration [g] µg/L
Inorganics														
Aluminum	3 / 5	60	79.2	8300	200	200	µg/L	NP	1.77E+03	8.30E+03	3.09E+02	3.65E+03	Y	8.30E+03
Arsenic	2 / 6	33	10.8	17.3	10	200	µg/L	L	3.14E+01	5.31E+02	7.40E+00	4.48E-02	Y	1.73E+01
Barium	6 / 6	100	471	1290	200	200	µg/L	N	9.19E+02	1.14E+03	1.18E+04	2.55E+02	N (b)	---
Beryllium	1 / 5	20	1.1	1.1	5	5	µg/L	NP	2.22E+00	2.50E+00		7.30E+00	N (a)	---
Cadmium	1 / 6	17	1.2	1.2	5	5	µg/L	NP	2.28E+00	2.50E+00		1.82E+00	N (a)	---
Calcium	6 / 6	100	724000	12000000	50000	500000	µg/L	L	3.01E+06	1.93E+07	3.16E+05	Nutrient	N (c)	---
Chromium	1 / 6	17	37.2	37.2	10	10	µg/L	NP	1.04E+01	3.72E+01		1.09E+01 h	Y	3.72E+01
Cobalt	2 / 6	33	6.4	12.7	50	50	µg/L	NP	1.99E+01	2.50E+01	1.21E+01	7.30E+01	N (a)	---
Copper	2 / 6	33	3.2	53.1	25	25	µg/L	L	1.77E+01	8.43E+01	1.98E+01	1.46E+02	N (a)	---
Iron	4 / 5	80	40	33400	100	100	µg/L	NP	6.76E+03	3.34E+04	1.55E+03	1.09E+03	Y	3.34E+04
Lead	1 / 6	17	18.4	18.4	3	60	µg/L	N	1.23E+01	2.14E+01		1.50E+01 i	Y	1.84E+01
Magnesium	6 / 6	100	384000	943000	5000	50000	µg/L	L	6.53E+05	1.02E+06	2.17E+05	Nutrient	N (c)	---
Manganese	6 / 6	100	36.8	11700	15	15	µg/L	L	2.30E+03	5.15E+07	6.36E+02	8.76E+01	Y	1.17E+04
Mercury	2 / 6	33	0.067	1	0.2	0.2	µg/L	NP	2.45E-01	1.00E+00		1.09E+00	N (a)	---
Nickel	2 / 6	33	48.8	75.7	40	40	µg/L	NP	3.41E+01	7.57E+01	8.60E+00	7.30E+01	Y	7.57E+01
Potassium	6 / 6	100	94200	334000	5000	50000	µg/L	L	1.78E+05	2.84E+05	1.16E+05	Nutrient	N (c)	---
Sodium	6 / 6	100	442000	4050000	5000	200000	µg/L	N	2.40E+06	3.48E+06	1.39E+06	Nutrient	N (c)	---
Vanadium	1 / 6	17	36.9	36.9	50	50	µg/L	NP	2.70E+01	3.69E+01		3.65E+00	Y	3.69E+01
Zinc	4 / 6	67	31	425	20	20	µg/L	L	1.37E+02	1.90E+04	5.07E+02	1.09E+03	N (a)	---
Explosives														
1,3,5-Trinitrobenzene	1 / 6	17	1.5	1.5	0.2	0.2	µg/L	NP	3.33E-01	1.50E+00		1.09E+02	N (a)	---
1,3-Dinitrobenzene	1 / 6	17	1	1	0.2	0.36	µg/L	NP	2.74E-01	1.00E+00		3.65E-01	Y	1.00E+00
2,4-Dinitrotoluene	1 / 6	17	0.49	0.49	0.2	1.8	µg/L	N	3.56E-01	6.21E-01		9.89E-02 j	Y	4.90E-01
2,6-Dinitrotoluene	1 / 6	17	3.6	3.6	0.2	1.1	µg/L	NP	7.64E-01	3.60E+00		9.89E-02 j	Y	3.60E+00
2-Amino-4,6-dinitrotoluene	2 / 4	50	0.33	0.55	0.2	0.2	µg/L	NA	2.70E-01	NA		7.30E-01 k	N (a)	---
2-Nitrotoluene	1 / 6	17	0.31	0.31	0.2	8.1	µg/L	NP	8.13E-01	4.05E+00		4.87E-02	Y	3.10E-01
3-Nitrotoluene	1 / 6	17	0.3	0.3	0.2	0.27	µg/L	NP	1.40E-01	3.00E-01		1.22E+01	N (a)	---
4-Amino-2,6-dinitrotoluene	2 / 6	33	1.3	1.3	0.2	1.8	µg/L	NP	6.33E-01	1.30E+00		7.30E-01 k	Y	1.30E+00
Nitrobenzene	1 / 6	17	2	2	0.2	1.9	µg/L	NP	5.62E-01	2.00E+00		3.40E-01	Y	2.00E+00
Semivolatile Organic Compounds														
2,4-Dimethylphenol	6 / 6	100	5.1	18	10	100	µg/L	N	1.11E+01	1.48E+01		7.30E+01	N (a)	---
2-Methylnaphthalene	6 / 6	100	1.6	470	10	100	µg/L	L	8.85E+01	4.07E+05		6.20E-01 l	Y	4.70E+02
2-Methylphenol	5 / 6	83	2.6	12	10	100	µg/L	L	1.25E+01	1.44E+02		1.82E+02	N (a)	---
4-Methylphenol	6 / 6	100	1.2	15	10	100	µg/L	L	6.20E+00	3.14E+01		1.82E+01	N (a)	---
Bis(2-ethylhexyl)phthalate	2 / 5	40	3.5	8.6	10	100	µg/L	L	5.42E+00	8.15E+00		4.80E+00	Y	8.15E+00
Chrysene	2 / 6	33	0.62	15	10	100	µg/L	NP	5.94E+00	1.50E+01		9.21E+00	Y	1.50E+01
Dibenzofuran	1 / 6	17	12	12	10	100	µg/L	NP	6.17E+00	1.20E+01		1.22E+00	Y	1.20E+01
Fluorene	2 / 6	33	1.9	28	10	100	µg/L	NP	8.32E+00	2.80E+01		2.43E+01	Y	2.80E+01
Naphthalene	6 / 6	100	3.1	170	10	100	µg/L	L	3.93E+01	2.50E+03		6.20E-01	Y	1.70E+02
Phenanthrene	2 / 6	33	3.4	74	10	100	µg/L	NP	1.62E+01	7.40E+01		1.83E+01 m	Y	7.40E+01
Phenol	5 / 6	83	1.4	27	10	100	µg/L	L	1.18E+01	1.57E+02		1.09E+03	N (a)	---
Volatile Organic Compounds														
Acetone	3 / 3	100	34	290	50	1000	µg/L	NA	1.37E+02	NA		5.48E+02	N (a)	---
Benzene	5 / 6	83	5.7	700	5	200	µg/L	L	2.12E+02	5.12E+05		3.54E-01	Y	7.00E+02
Carbon disulfide	3 / 6	50	4.8	32	5	200	µg/L	N	4.08E+01	6.96E+01		1.04E+02	N (a)	---

Table 4-1

Statistical Summary and COPC Selection of Chemicals Detected in Bedrock Groundwater
TNT Area A, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of Concentration Values, µg/L: Detected Concentrations Minimum	Detected Concentrations Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Units	Statistical Distribution [a]	Mean µg/L	95% UCL µg/L b	BSC [c] µg/L	RBSC [d] µg/L	COPC? [e,f]	Exposure Point Concentration [g] µg/L
Chloromethane	1 / 6	17	35	35	10	400	µg/L	L	5.83E+01	1.10E+04		1.58E+01	Y	3.50E+01
Ethylbenzene	6 / 6	100	32	240	5	200	µg/L	L	1.17E+02	5.53E+02		1.34E+02	Y	2.40E+02
Methylene chloride	3 / 5	60	47	330	5	400	µg/L	L	1.11E+02	1.45E+07		4.28E+00	Y	3.30E+02
Toluene	5 / 6	83	21	730	5	200	µg/L	L	2.60E+02	1.40E+04		7.23E+01	Y	7.30E+02
Xylenes, total	6 / 6	100	150	1400	5	200		L	6.27E+02	3.60E+03		2.06E+01	Y	1.40E+03
Miscellaneous														
Chloride	5 / 5	100	1200	12900	0.1	200	mg/L	N	7.05E+03	1.13E+04		Nutrient	N (d)	1.13E+04
Sulfate	4 / 4	100	16	388	0.01	100	mg/L	NA	1.20E+02	NA		5.00E+05 n	N (a)	---

COPC - Chemical of potential concern; UCL - Upper confidence limit; BSC - Background screening criterion; RBSC - Risk-based screening concentration
ND - No data; µg/L - Micrograms per liter; mg/L - Milligrams per liter.

[a] Statistical Distribution: N = Normal distribution; L = Lognormal distribution; NP = Nonparametric distribution; NA = Not applicable, distribution not determined for sample sets less than 5.

[b] Method of estimation based on statistical distribution (please see Section 3.2.1 of the BHHRA).

[c] Background screening criteria are presented in the ***2004 Data Summary and Evaluation Report*** (Shaw, 2005).

[d] Risk-Based Screening Concentrations based on EPA Region 9 Preliminary Remediation Goals (PRGs [EPA, 2004]) for tap water.
PRGs were adjusted to provide an Hazard Index of 0.1 and an Incremental Lifetime Cancer Range of 1E-6.

[e] N - Chemical is not chosen as a COPC:
(a) - maximum detected concentration is less than the RBSC.
(b) - maximum detected concentration is less than the BSC.
(c) - essential nutrient.
(d) - essential nutrient with no toxicity value available.

[f] Y - Chemical is chosen as COPC.

[g] Exposure point concentration is chosen based on criteria described in section 3.2.1 of the BHHRA.

[h] Based on PRG for chromium VI.

[i] Screening criteria for lead based on the action level of 15 µg/L (EPA, 1996, *Drinking Water Regulations and Health Advisories*, Office of Water, Washington, DC, October).

[j] Based on PRG for dinitrotoluene mixture.

[k] Based on PRG for aminodinitrotoluene.

[l] Based on PRG for naphthalene.

[m] Based on PRG for pyrene.

[n] Screening criteria for sulfate based on the *Drinking Water Advisory (EPA, 1996)*.

Source: Baseline Human Health Risk Assessment (BHHRA)of Groundwater (Shaw, 2006).

Table 4-2

Statistical Summary and COPC Selection of Chemicals Detected in Bedrock Groundwater
TNT Area B, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of Concentration Values, µg/L: Detected Conc Minimum	Detected Conc Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Units	Statistical Distribution [a]	Arithmetic Mean µg/L	95% UCL [b] µg/L	BSC [c] µg/L	RBSC [d] µg/L	COPC? [e,f]	Exposure Point Concentration [g] µg/L
Metals														
Aluminum	7 / 7	100	53.1	16900	200	200	µg/L	L	3.77E+03	1.54E+06	3.09E+02	3.65E+03	Y	1.69E+04
Arsenic	3 / 8	38	12.5	22.7	10	10	µg/L	NP	9.14E+00	1.29E+01	7.40E+00	4.48E-02	Y	1.29E+01
Barium	7 / 8	88	39.9	1780	200	200	µg/L	N	8.80E+02	1.36E+03	1.18E+04	2.55E+02	N (b)	---
Calcium	8 / 8	100	76500	217000	5000	5000	µg/L	L	1.20E+05	1.64E+05	3.16E+05	Nutrient	N (c)	---
Chromium	3 / 8	38	1.3	32.3	10	10	µg/L	L	9.18E+00	3.03E+01		1.09E+01 h	Y	3.03E+01
Cobalt	2 / 8	25	10.1	18.7	50	50	µg/L	NP	2.24E+01	2.50E+01	1.21E+01	7.30E+01	N (a)	---
Copper	5 / 7	71	10.9	99.2	25	25	µg/L	L	4.28E+01	1.79E+02	1.98E+01	1.46E+02	N (a)	---
Iron	7 / 8	88	132	41700	100	100	µg/L	N	1.52E+04	2.56E+04	1.55E+03	1.09E+03	Y	2.56E+04
Lead	4 / 8	50	3.9	15.7	3	3	µg/L	L	4.85E+00	1.54E+01		1.50E+01 i	Y	1.54E+01
Magnesium	8 / 8	100	22800	72500	5000	5000	µg/L	N	4.80E+04	6.22E+04	2.17E+05	Nutrient	N (c)	---
Manganese	8 / 8	100	32.65	1140	15	15	µg/L	N	5.18E+02	7.91E+02	6.36E+02	8.76E+01	Y	7.91E+02
Mercury	1 / 8	13	0.079	0.079	0.2	0.2	µg/L	NP	9.74E-02	1.00E-01		1.09E+00	N (a)	---
Nickel	4 / 8	50	5.1	71.2	40	40	µg/L	L	2.95E+01	7.48E+01	8.60E+00	7.30E+01	N (a)	---
Potassium	8 / 8	100	851	136000	5000	50000	µg/L	L	4.95E+04	5.15E+06	1.16E+05	Nutrient	N (c)	---
Selenium	2 / 8	25	5.6	14.4	5	5	µg/L	NP	4.38E+00	5.60E+00		1.82E+01	N (a)	---
Sodium	8 / 8	100	6660	849000	5000	50000	µg/L	N	3.60E+05	5.71E+05	1.39E+06	Nutrient	N (c)	---
Vanadium	3 / 8	38	2.3	48.6	50	50	µg/L	NP	2.49E+01	2.50E+01		3.65E+00	Y	2.50E+01
Zinc	8 / 8	100	3.8	184	20	20	µg/L	L	7.27E+01	9.41E+02	5.07E+02	1.09E+03	N (a)	---
Semivolatile Organic Compounds														
2-Methylnaphthalene	1 / 8	13	4.8	4.8	10	14.5	µg/L	NP	5.26E+00	5.00E+00		6.20E-01 j	Y	4.80E+00
Bis(2-ethylhexyl)phthalate	2 / 7	29	2	3.6	10	14.5	µg/L	N	4.69E+00	5.87E+00		4.80E+00	N (a)	---
Naphthalene	1 / 8	13	2.8	2.8	10	14.5	µg/L	NP	5.01E+00	5.00E+00		6.20E-01	Y	2.80E+00
Phenanthrene	1 / 8	13	0.73	0.73	10	14.5	µg/L	NP	4.75E+00	5.00E+00		1.83E+01 k	N (a)	---
Phenol	2 / 8	25	1.6	2.2	10	14.5	µg/L	N	4.51E+00	5.71E+00		1.09E+03	N (a)	---
Volatile Organic Compounds														
1,1-Dichloroethane	2 / 8	25	0.19	0.4	1	5	µg/L	L	7.93E-01	1.80E+00		8.11E+01	N (a)	---
2-Butanone	2 / 4	50	69	75	5	25	µg/L	N	3.73E+01	8.46E+01		6.97E+02	N (a)	---
2-Hexanone	1 / 6	17	0.56	0.56	5	25	µg/L	L	4.47E+00	3.54E+01		1.99E+02 l	N (a)	---
4-Methyl-2-pentanone	1 / 8	13	0.7	0.7	5	25	µg/L	L	3.99E+00	1.04E+01		1.99E+02	N (a)	---
Acetone	3 / 3	100	38	110	10	50	µg/L	N	7.77E+01	NA		5.48E+02	N (a)	---
Benzene	5 / 8	63	0.14	17	1	5	µg/L	L	4.38E+00	1.53E+02		3.54E-01	Y	1.70E+01
Carbon disulfide	4 / 8	50	0.37	8	1	5	µg/L	NP	2.39E+00	7.20E+00		1.04E+02	N (a)	---
Ethylbenzene	1 / 8	13	0.52	0.52	1	5	µg/L	NP	8.46E-01	1.00E+00		1.34E+02	N (a)	---
Toluene	3 / 7	43	1.25	5.2	1	5	µg/L	L	1.95E+00	1.01E+01		7.23E+01	N (a)	---
Xylenes, total	2 / 7	29	0.945	2.3	1	5	µg/L	L	1.18E+00	2.79E+00		2.06E+01	N (a)	---
Miscellaneous														
Chloride	8 / 8	100	2800	3720000	1000	1000	mg/L	L	9.18E+05	1.21E+10		Nutrient	N (d)	---
Nitrate	1 / 7	14	48	48	1000	1000	mg/L	NP	4.35E+02	5.00E+01		1.00E+02 m	N (a)	---
Sulfate	8 / 8	100	31100	160000	1000	1000	mg/L	N	9.64E+04	1.29E+05		5.00E+05 n	N (a)	---

Table 4-2

Statistical Summary and COPC Selection of Chemicals Detected in Bedrock Groundwater
TNT Area B, Former Plum Brook Ordnance Works
Sandusky, Ohio

COPC - Chemical of potential concern; UCL - Upper confidence limit; BSC - Background screening criterion; RBSC - Risk-based screening concentration;
ND - No data; µg/L - Micrograms per liter; mg/L - Milligrams per liter.

[a] Statistical Distribution: N - Normal distribution; L - Lognormal distribution; NP - Nonparametric distribution; NA - Not applicable, distribution 1not determined for sample sets less than 5.
[b] Method of estimation based on statistical distribution (please see Section 3.2.1 of the BHHRA).
[c] Background screening criteria are presented in the ***2004 Data Summary and Evaluation Report*** (Shaw, 2005).
[d] Risk-Based Screening Concentrations based on EPA Region 9 Preliminary Remediation Goals (PRGs [EPA, 2004]) for tap water.
PRGs were adjusted to provide an Hazard Index of 0.1 and an Incremental Lifetime Cancer Range of 1E-6.
[e] N - Chemical is not chosen as a COPC:
(a) - maximum detected concentration is less than the RBSC.
(b) - maximum detected concentration is less than the BSC.
(c) - essential nutrient.
(d) - essential nutrient with no toxicity value available.
[f] Y - Chemical is chosen as COPC.
[g] Exposure point concentration is chosen based on criteria described in section 3.2.1 of the BHHRA.
[h] Based on PRG for chromium VI.
[i] Screening criteria for lead based on the action level of 15 µg/L (EPA, 1996, *Drinking Water Regulations and Health Advisories* , Office of Water, Washington, DC, October).
[j] Based on PRG as for naphthalene.
[k] Based on PRG as for pyrene.
[l] Based on PRG as for 4-methyl-2-pentanone.
[m] Based on PRG for nitrite.
[n] Screening criteria for sulfate based on the *Drinking Water Advisory (EPA, 1996)* .

Source: Baseline Human Health Risk Assessment (BHHRA)of Groundwater (Shaw, 2006).

Table 4-3

Statistical Distribution and COPC Selection of Chemicals Detected in Bedrock Groundwater
TNT Area C, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Detection Frequency	Percent Hits	Range of Concentration Values,µg/L: Detected Concentrations Minimum	Detected Concentrations Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Units	Statistical Distribution [a]	Mean µg/L	95% UCL [b] µg/L	BSC [c] µg/L	RBSC [d] µg/L	COPC? [e,f]	Exposure Point Concentration [g] µg/L
Metals														
Aluminum	1 / 3	33	96.8	96.8	200	200	µg/L	NA	9.89E+01	NA	3.09E+02	3.65E+03	N (a)	---
Arsenic	1 / 6	17	4.1	4.1	10	10	µg/L	NP	4.74E+00	5.00E+00	7.40E+00	4.48E-02	N (b)	---
Barium	5 / 6	83	16.5	2680	200	200	µg/L	L	9.28E+02	5.49E+06	1.18E+04	2.55E+02	N (b)	---
Calcium	6 / 6	100	125000	439000	5000	5000	µg/L	NP	3.48E+05	4.34E+05	3.16E+05	Nutrient	N (c)	---
Copper	1 / 6	17	6.1	6.1	25	25	µg/L	NP	1.16E+01	1.25E+01	1.98E+01	1.46E+02	N (a)	---
Iron	4 / 6	67	55.1	335	100	100	µg/L	L	1.37E+02	4.59E+02	1.55E+03	1.09E+03	N (a)	---
Magnesium	6 / 6	100	9250	334000	5000	5000	µg/L	N	1.67E+05	2.43E+05	2.17E+05	Nutrient	N (c)	---
Manganese	6 / 6	100	5.1	271	15	15	µg/L	L	9.17E+01	2.84E+03	6.36E+02	8.76E+01	N (b)	---
Nickel	1 / 6	17	2.3	2.3	40	40	µg/L	NP	1.75E+01	2.00E+01	8.60E+00	7.30E+01	N (a)	---
Potassium	5 / 6	83	9610	101000	5000	5000	µg/L	L	4.89E+04	1.46E+06	1.16E+05	Nutrient	N (c)	---
Sodium	6 / 6	100	29500	1330000	5000	50000	µg/L	NP	5.52E+05	1.19E+06	1.39E+06	Nutrient	N (c)	---
Zinc	3 / 6	50	5.6	47.2	20	20	µg/L	NP	1.43E+01	1.00E+01	5.07E+02	1.09E+03	N (a)	---
Semivolatile Organic Compounds														
2,4-Dimethylphenol	4 / 6	67	13	22	10	10	µg/L	N	1.24E+01	1.84E+01		7.30E+01	N (a)	---
2-Methylnaphthalene	6 / 6	100	3.2	34	10	10	µg/L	N	1.67E+01	2.66E+01		6.20E-01 h	Y	2.66E+01
2-Methylphenol	4 / 6	67	3.3	6.6	10	10	µg/L	N	5.00E+00	5.87E+00		1.82E+02	N (a)	---
4-Methylphenol	4 / 6	67	3.3	6.9	10	10	µg/L	N	5.10E+00	5.97E+00		1.82E+01	N (a)	---
Bis(2-ethylhexyl)phthalate	4 / 6	67	5.2	55	10	10	µg/L	NP	1.95E+01	5.50E+01		4.80E+00	Y	5.50E+01
Fluorene	2 / 6	33	1	1.4	10	10	µg/L	NP	3.91E+00	5.00E+00		2.43E+01	N (a)	---
Isophorone	1 / 6	17	2.7	2.7	10	10	µg/L	NP	4.67E+00	5.00E+00		7.08E+01	N (a)	---
Naphthalene	6 / 6	100	2.5	34	10	10	µg/L	L	1.38E+01	8.66E+01		6.20E-01	Y	3.40E+01
Phenanthrene	2 / 6	33	1.3	1.9	10	10	µg/L	NP	4.03E+00	5.00E+00		1.83E+01 i	N (a)	---
Phenol	4 / 6	67	11	69	10	10	µg/L	NP	2.41E+01	6.20E+01		1.09E+03	N (a)	---
Volatile Organic Compounds														
Acetone	1 / 6	17	53	53	200	200	µg/L	NA	5.30E+01	NA		5.48E+02	N (a)	---
Benzene	6 / 6	100	8.4	410	20	100	µg/L	L	1.34E+02	3.55E+03		3.54E-01	Y	4.10E+02
Bromomethane	1 / 6	17	13	13	2	200	µg/L	L	4.41E+01	3.88E+03		8.66E-01	Y	1.30E+01
Carbon disulfide	1 / 6	17	5.8	5.8	1	100	µg/L	L	2.55E+01	8.87E+01		1.04E+02	N (a)	---
Ethylbenzene	6 / 6	100	12	130	20	100	µg/L	L	6.26E+01	2.87E+02		1.34E+02	N (a)	---
Methylene chloride	4 / 5	80	19	160	1	200	µg/L	L	5.03E+01	2.73E+05		4.28E+00	Y	1.60E+02
Toluene	6 / 6	100	8.8	300	20	100	µg/L	L	1.34E+02	3.46E+03		7.23E+01	Y	3.00E+02
Xylenes, total	6 / 6	100	90	1300	20	100	µg/L	L	5.76E+02	3.48E+03		2.06E+01	Y	1.30E+03
Miscellaneous														
Chloride	5 / 6	83	242000	4290000	50	1000000	mg/L	L	2.00E+06	6.96E+07		Nutrient	N (d)	---
Sulfate	6 / 6	100	5000	1340000	10	250000	mg/L	L	4.22E+05	6.91E+09		5.00E+05 j	Y	1.34E+06

Table 4-3

Statistical Distribution and COPC Selection of Chemicals Detected in Bedrock Groundwater
TNT Area C, Former Plum Brook Ordnance Works
Sandusky, Ohio

COPC - Chemical of potential concern; UCL - Upper confidence limit; BSC - Background screening criterion; RBSC - Risk-based screening concentration;
ND - No data; µg/L - Micrograms per liter; µg/L - Milligrams per liter

[a] Statistical Distribution: N - Normal distribution; L - Lognormal distribution; NP - Nonparametric distribution; NA - Not applicable, distribution not determined for sample sets less than 5.
[b] Method of estimation based on statistical distribution (please see Section 3.2.1).
[c] Background screening criteria are presented in the ***2004 Data Summary and Evaluation Report*** (Shaw, 2005).
[d] Risk-Based Screening Concentrations based on EPA Region 9 Preliminary Remediation Goals (PRGs [EPA, 2004]) for tap water.
PRGs were adjusted to provide an Hazard Index of 0.1 and an Incremental Lifetime Cancer Range of 1E-6.
[e] N - Chemical is not chosen as a COPC:
(a) - maximum detected concentration is less than the RBSC.
(b) - maximum detected concentration is less than the BSC.
(c) - essential nutrient.
(d) - essential nutrient with no toxicity value available.
[f] Y - Chemical is chosen as COPC.
[g] Exposure point concentration is chosen based on criteria described in section 3.2.1.
[h] Based on PRG for naphthalene.
[i] Based on PRG as for pyrene.
[j] Screening criteria for sulfate based on the *Drinking Water Advisory*.

Table 4-4

Statistical Summary and COPC Selection of Chemicals Detected in Bedrock Groundwater
Pentolite Road Red Water Pond Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of Concentration Values, µg/L: Detected Concentrations Minimum	Detected Concentrations Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Units	Statistical Distribution [a]	Mean µg/L	95% UCL [b] µg/L	BSC [c] µg/L	RBSC [d] µg/L	COPC? [e,f]	Exposure Point Concentration [g] µg/L
Metals														
Aluminum	2 / 3	67	350	513	200	200	µg/L	N	3.21E+02	6.72E+02	3.09E+02	3.65E+03	N (a)	---
Barium	6 / 6	100	64.2	1710	200	200	µg/L	L	6.37E+02	1.46E+04	1.18E+04	2.55E+02	N (b)	---
Calcium	6 / 6	100	199000	859000	5000	50000	µg/L	L	4.43E+05	9.13E+05	3.16E+05	Nutrient	N (c)	---
Chromium	3 / 6	50	6.1	20.6	10	10	µg/L	NP	9.45E+00	2.06E+01		1.09E+01 h	Y	2.06E+01
Cobalt	1 / 6	17	5.9	5.9	50	50	µg/L	NP	2.18E+01	2.50E+01	1.21E+01	7.30E+01	N (a)	---
Copper	2 / 6	33	4.8	39.5	25	25	µg/L	L	1.57E+01	4.08E+01	1.98E+01	1.46E+02	N (a)	---
Iron	5 / 6	83	142	7280	100	100	µg/L	L	3.14E+03	1.97E+07	1.55E+03	1.09E+03	Y	7.28E+03
Magnesium	6 / 6	100	169000	591000	5000	50000	µg/L	L	2.73E+05	4.63E+05	2.17E+05	Nutrient	N (c)	---
Manganese	6 / 6	100	5.6	1170	15	15	µg/L	L	2.61E+02	1.06E+06	6.36E+02	8.76E+01	Y	1.17E+03
Nickel	3 / 6	50	3.8	13.6	40	40	µg/L	N	1.41E+01	2.00E+01	8.60E+00	7.30E+01	N (a)	---
Potassium	6 / 6	100	58800	96000	5000	50000	µg/L	L	7.20E+04	8.56E+04	1.16E+05	Nutrient	N (c)	---
Sodium	6 / 6	100	559000	1810000	5000	50000	µg/L	NP	8.40E+05	1.81E+06	1.39E+06	Nutrient	N (c)	---
Thallium	1 / 6	17	50.8	50.8	10	50	µg/L	NP	1.26E+01	5.08E+01		2.41E-01	Y	5.08E+01
Zinc	3 / 5	60	3	30.6	20	20	µg/L	L	1.43E+01	1.05E+02	5.07E+02	1.09E+03	N (a)	---
Explosives														
2,4,6-Trinitrotoluene	2 / 6	33	1.3	1.6	0.2	2	µg/L	N	8.63E-01	1.30E+00		1.82E+00	N (a)	---
2,4-Dinitrotoluene	1 / 6	17	0.89	0.89	0.2	2	µg/L	N	5.97E-01	9.33E-01		9.89E-02 i	Y	8.90E-01
2,6-Dinitrotoluene	1 / 6	17	0.89	0.89	0.4	6	µg/L	L	1.49E+00	2.55E+00		9.89E-02 i	Y	8.90E-01
4-Amino-2,6-dinitrotoluene	1 / 6	17	0.97	0.97	0.2	2.6	µg/L	N	7.63E-01	1.11E+00		7.30E-01 j	Y	9.70E-01
Nitrobenzene	1 / 6	17	0.35	0.35	0.2	2	µg/L	L	3.76E-01	1.92E+00		3.40E-01	Y	3.50E-01
RDX	1 / 6	17	0.51	0.51	0.5	5	µg/L	L	8.77E-01	4.42E+00		6.11E-01	N (a)	---
Semivolatile Organic Compounds														
2,4-Dimethylphenol	6 / 6	100	5.6	51	10	10	µg/L	L	2.04E+01	1.32E+02		7.30E+01	N (a)	---
2-Methylnaphthalene	6 / 6	100	22	37	10	10	µg/L	L	2.90E+01	3.45E+01		6.20E-01 k	Y	3.45E+01
2-Methylphenol	6 / 6	100	3	37	10	10	µg/L	L	1.32E+01	1.24E+02		1.82E+02	N (a)	---
4-Methylphenol	6 / 6	100	3.9	43	10	10	µg/L	L	1.42E+01	8.51E+01		1.82E+01	Y	4.30E+01
Bis(2-ethylhexyl)phthalate	5 / 5	100	1.8	37	10	10	µg/L	L	1.03E+01	4.06E+02		4.80E+00	Y	3.70E+01
Butyl benzyl phthalate	1 / 6	17	1.5	1.5	10	10	µg/L	NP	4.42E+00	5.00E+00		7.30E+02	N (a)	---
Diethyl phthalate	2 / 6	33	0.68	1.2	10	10	µg/L	NP	3.65E+00	5.00E+00		2.92E+03	N (a)	---
Di-n-butyl phthalate	1 / 6	17	1.1	1.1	10	10	µg/L	NP	4.35E+00	5.00E+00		3.65E+02	N (a)	---
Fluorene	2 / 6	33	1.4	1.7	10	10	µg/L	NP	3.85E+00	5.00E+00		2.43E+01	N (a)	---
Isophorone	2 / 6	33	3.8	4.2	10	10	µg/L	NP	4.67E+00	5.00E+00		7.08E+01	N (a)	---
Naphthalene	6 / 6	100	21	31	10	10	µg/L	L	2.57E+01	2.99E+01		6.20E-01	Y	2.99E+01
n-Nitrosodiphenylamine	1 / 6	17	0.64	0.64	10	10	µg/L	NP	4.27E+00	5.00E+00		1.37E+01	N (a)	---
Phenanthrene	6 / 6	100	0.98	2.4	10	10	µg/L	L	1.70E+00	2.51E+00		1.83E+01 l	N (a)	---
Phenol	6 / 6	100	12	150	10	10	µg/L	L	5.12E+01	3.57E+02		1.09E+03	N (a)	---
Volatile Organic Compounds														
1,1,2-Trichloroethane	1 / 6	17	4.9	4.9	20	200	µg/L	L	4.83E+01	9.88E+02		2.00E-01	Y	4.90E+00
Acetone	4 / 4	100	87	1600	200	2000	µg/L	L	8.14E+02	5.03E+06		5.48E+02	Y	1.60E+03
Benzene	6 / 6	100	570	2500	20	200	µg/L	L	1.20E+03	3.07E+03		3.54E-01	Y	2.50E+03

Table 4-4

Statistical Summary and COPC Selection of Chemicals Detected in Bedrock Groundwater
Pentolite Road Red Water Pond Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of Concentration Values, µg/L: Detected Concentrations Minimum	Detected Concentrations Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Units	Statistical Distribution [a]	Mean µg/L	95% UCL [b] µg/L	BSC [c] µg/L	RBSC [d] µg/L	COPC? [e,f]	Exposure Point Concentration [g] µg/L
Carbon disulfide	1 / 6	17	3.1	3.1	20	200	µg/L	L	4.97E+01	1.47E+03		1.04E+02	N (a)	---
Chlorobenzene	1 / 6	17	5.5	5.5	20	200	µg/L	L	4.84E+01	8.45E+02		1.06E+01	N (a)	---
Ethylbenzene	6 / 6	100	130	230	20	200	µg/L	L	1.62E+02	2.02E+02		1.34E+02	Y	2.02E+02
Methylene chloride	4 / 4	100	31	160	40	400	µg/L	N	1.03E+02	1.66E+02		4.28E+00	Y	1.60E+02
Toluene	6 / 6	100	460	1000	20	200	µg/L	L	6.73E+02	9.46E+02		7.23E+01	Y	9.46E+02
Xylenes, total	6 / 6	100	880	1600	20	200	µg/L	L	1.10E+03	1.40E+03		2.06E+01	Y	1.40E+03
Miscellaneous														
Chloride	6 / 6	100	1400000	6400000	50	100000	mg/L	L	2.75E+06	5.13E+06		Nutrient	N (d)	---
Sulfate	5 / 6	83	82000	218000	5	50000	mg/L	N	9.63E+04	1.54E+05		5.00E+05 [m]	N (a)	---

COPC - Chemical of potential concern; UCL - Upper confidence limit; BSC - Background screening criterion; RBSC - Risk-based screening concentration;
ND - No data; µg/L - Micrograms per liter; mg/L - Milligrams per liter.

[a] Statistical Distribution: N - Normal distribution; L - Lognormal distribution; NP - Nonparametric distribution; NA - Not applicable, 1distribution not determined for sample sets less than 5.

[b] Method of estimation based on statistical distribution (please see Section 3.2.1).

[c] Background screening criteria are presented in the ***2004 Data Summary and Evaluation Report*** (Shaw, 2005).

[d] Risk-Based Screening Concentrations based on EPA Region 9 Preliminary Remediation Goals (PRGs [EPA, 2004]) for tap water.
PRGs were adjusted to provide an Hazard Index of 0.1 and an Incremental Lifetime Cancer Range of 1E-6.

[e] N - Chemical is not chosen as a COPC:
(a) - maximum detected concentration is less than the RBSC.
(b) - maximum detected concentration is less than the BSC.
(c) - essential nutrient.
(d) - essential nutrient with no toxicity value available.

[f] Y - Chemical is chosen as COPC.

[g] Exposure point concentration is chosen based on criteria described in section 3.2.1.

[h] Based on PRG for chromium VI.

[i] Based on PRG for dinitrotoluene mixture.

[j] Based on PRG for aminodinitrotoluene.

[k] Based on PRG for naphthalene.

[l] Based on PRG for pyrene.

[m] Screening criteria for sulfate based on the *Drinking Water Advisory* .

Table 4-5

Statistical Summary and COPC Selection of Chemicals Detected in Bedrock Groundwater
West Area Red Water Ponds Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of Concentration Values, µg/L: Detected Concentrations Minimum	Detected Concentrations Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Units	Statistical Distribution [a]	Mean µg/L	BSC [b] µg/L	RBSC [c] µg/L	COPC? [d,e]	Exposure Point Concentration [f] µg/L
Metals													
Arsenic	2 / 3	67	6.1	9.5	10	100	µg/L	NA	2.19E+01	7.40E+00	4.48E-02	Y	9.50E+00
Barium	2 / 3	67	49.5	51.4	200	200	µg/L	NA	6.70E+01	1.18E+04	2.55E+02	N (a)	--
Calcium	3 / 3	100	99000	325000	5000	5000	µg/L	NA	2.13E+05	3.16E+05	Nutrient	N (c)	--
Chromium	2 / 3	67	1.6	3.4	10	10	µg/L	NA	3.33E+00		1.09E+01 g	N (a)	--
Cobalt	2 / 3	67	102	267	50	50	µg/L	NA	1.31E+02	1.21E+01	7.30E+01	Y	2.67E+02
Copper	2 / 3	67	30.7	94.8	25	25	µg/L	NA	4.60E+01	1.98E+01	1.46E+02	N (a)	--
Iron	3 / 3	100	164	438	100	100	µg/L	NA	3.43E+02	1.55E+03	1.09E+03	N (a)	--
Lead	1 / 3	33	3.6	3.6	3	30	µg/L	NA	6.70E+00		1.50E+01 h	N (a)	--
Magnesium	3 / 3	100	59700	230000	5000	5000	µg/L	NA	1.45E+05	2.17E+05	Nutrient	N (c)	--
Manganese	3 / 3	100	32	136	15	15	µg/L	NA	7.77E+01	6.36E+02	8.76E+01	N (b)	--
Nickel	3 / 3	100	45.5	278	40	40	µg/L	NA	1.45E+02	8.60E+00	7.30E+01	Y	2.78E+02
Potassium	3 / 3	100	42100	56800	5000	5000	µg/L	NA	4.93E+04	1.16E+05	Nutrient	N (c)	--
Selenium	2 / 3	67	5.5	7.8	5	50	µg/L	NA	1.28E+01		1.82E+01	N (a)	--
Sodium	3 / 3	100	269000	1020000	5000	50000	µg/L	NA	6.39E+05	1.39E+06	Nutrient	N (c)	--
Vanadium	1 / 2	50	5.5	5.5	50	50	µg/L	NA	1.53E+01		3.65E+00	Y	5.50E+00
Zinc	2 / 2	100	10.8	64.8	20	20	µg/L	NA	3.78E+01	5.07E+02	1.09E+03	N (a)	--
Semivolatile Organic Compounds													
2,4-Dinitrotoluene	2 / 4	50	16	19	10	1000	µg/L	NA	1.65E+02		9.89E-02 i	Y	1.90E+01
4,6-Dinitro-2-methylphenol	1 / 4	25	28	28	50	5000	µg/L	NA	7.88E+02		3.65E-01	Y	2.80E+01
2,4-Dinitrophenol	1 / 4	25	14	14	50	5000	µg/L	NA	7.85E+02		7.30E+00	Y	1.40E+01
3-Nitroaniline	1 / 4	25	150	150	50	5000	µg/L	NA	8.19E+02		1.09E+00	Y	1.50E+02
Nitrobenzene	1 / 4	25	5.8	5.8	10	1000	µg/L	NA	1.59E+02		3.40E-01	Y	5.80E+00
Volatile Organic Compounds													
Benzene	1 / 4	25	1.1	1.1	1	5	µg/L	NA	1.65E+00		3.54E-01	Y	1.10E+00
Carbon disulfide	2 / 4	50	0.25	1.3	1	5	µg/L	NA	1.64E+00		1.04E+02	N (a)	--
Ethylbenzene	1 / 4	25	0.59	0.59	1	5	µg/L	NA	1.52E+00		1.34E+02	N (a)	--
Xylenes, total	1 / 4	25	3.9	3.9	1	5	µg/L	NA	2.35E+00		2.06E+01	N (a)	--
Miscellaneous													
Chloride	4 / 4	100	3000	79000	50	20000	mg/L	NA	5.75E+04		Nutrient	N (d)	--
Cyanide, total	3 / 4	75	16	44	10	10	mg/L	NA	2.58E+01		7.30E+01	N (a)	--
Nitrate	3 / 3	100	22000	79300	2000	10000	mg/L	NA	4.18E+04		1.00E+03	Y	7.93E+04
Nitrate-Nitrite	1 / 1	100	300	300	0.1	0.1	mg/L	NA	3.00E+02		1.00E+02 j	Y	3.00E+02
Sulfate	4 / 4	100	610000	2660000	500	1000000	mg/L	NA	1.34E+06		5.00E+05 k	Y	2.66E+06

Table 4-5

Statistical Summary and COPC Selection of Chemicals Detected in Bedrock Groundwater
West Area Red Water Ponds Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

COPC - Chemical of potential concern; BSC - Background screening criterion; RBSC - Risk-based screening concentration;
ND - No data; µg/L - Micrograms per liter; mg/L - Milligrams per liter.

[a] Statistical Distribution: NA - Not applicable, distribution not determined for sample sets less than 5.
[b] Background screening criteria are presented in the ***2004 Data Summary and Evaluation Report*** (Shaw, 2005).
[c] Risk-Based Screening Concentrations based on EPA Region 9 Preliminary Remediation Goals (PRGs [EPA, 2004]) for tap water.
PRGs were adjusted to provide an Hazard Index of 0.1 and an Incremental Lifetime Cancer Range of 1E-6.
[d] N - Chemical is not chosen as a COPC:
(a) - maximum detected concentration is less than the RBSC.
(b) - maximum detected concentration is less than the BSC.
(c) - essential nutrient.
(d) - essential nutrient with no toxicity value available.
[e] Y - Chemical is chosen as COPC.
[f] Exposure point concentration is equal to the maximum detected.
[g] Based on PRG for chromium VI.
[h] Screening criteria for lead based on the action level of 15 µg/L (EPA, 1996, *Drinking Water Regulations and Health Advisories* , Office of Water, Washington, DC, October).
[i] Based on PRG for dinitrotoluene mixture.
[j] Based on PRG for nitrite.
[k] Screening criteria for sulfate based on the *Drinking Water Advisory* .

Table 4-6

Statistical Summary and COPC Selection of Chemicals Detected in Bedrock Groundwater Downgradient Areas at the Facility Boundary, Former Plum Brook Ordnance Works Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of Concentration Values, µg/L: Detected Concentrations Minimum	Detected Concentrations Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Units	Statistical Distribution [a]	Mean µg/L	95% UCL [b] µg/L	BSC [c] µg/L	RBSC [d] µg/L	COPC? [e,f]	Exposure Point Concentration [g] µg/L
Metals														
Aluminum	16 / 19	84	35.7	1171	200	200	µg/L	L	2.44E+02	4.30E+02	3.09E+02	3.65E+03	N (a)	---
Arsenic	3 / 25	12	4.5	6.1	10	20	µg/L	NP	5.24E+00	5.00E+00	7.40E+00	4.48E-02	N (b)	---
Barium	28 / 28	100	86.2	1860	200	200	µg/L	N	8.72E+02	1.03E+03	1.18E+04	2.55E+02	N (b)	---
Cadmium	2 / 28	7	0.25	1.1	5	10	µg/L	NP	2.46E+00	2.50E+00		1.82E+00	N (a)	---
Calcium	28 / 28	100	117500	462000	5000	5000	µg/L	NP	2.12E+05	2.55E+05	3.16E+05	Nutrient	N (c)	---
Chromium	5 / 28	18	1.6	24.4	10	10	µg/L	NP	5.76E+00	5.00E+00		1.09E+01 h	Y	2.44E+01
Cobalt	5 / 28	18	1.2	10.9	50	50	µg/L	NP	2.14E+01	2.50E+01	1.21E+01	7.30E+01	N (a)	---
Copper	7 / 27	26	13.3	94.45	25	25	µg/L	NP	1.99E+01	1.25E+01	1.98E+01	1.46E+02	N (a)	---
Iron	16 / 27	59	48.3	257000	100	100	µg/L	NP	1.25E+04	2.51E+02	1.55E+03	1.09E+03	Y	2.57E+05
Lead	1 / 28	4	6.8	6.8	3	14	µg/L	NP	2.26E+00	1.50E+00		1.50E+01 i	N (a)	---
Magnesium	28 / 28	100	34600	279000	5000	5000	µg/L	NP	1.10E+05	8.45E+04	2.17E+05	Nutrient	N (c)	---
Manganese	25 / 27	93	2	4660	15	15	µg/L	NP	2.69E+02	3.04E+01	6.36E+02	8.76E+01	Y	4.66E+03
Mercury	1 / 28	4	0.035	0.035	0.2	0.2	µg/L	NP	9.77E-02	1.00E-01		1.09E+00	N (a)	---
Nickel	7 / 27	26	3.5	17.7	40	40	µg/L	NP	1.76E+01	2.00E+01	8.60E+00	7.30E+01	N (a)	---
Potassium	28 / 28	100	2365	67200	5000	5000	µg/L	N	3.28E+04	3.89E+04	1.16E+05	Nutrient	N (c)	---
Sodium	28 / 28	100	18550	685000	5000	5000	µg/L	NP	1.76E+05	1.06E+05	1.39E+06	Nutrient	N (c)	---
Thallium	1 / 22	5	3.7	3.7	10	20	µg/L	NP	5.17E+00	5.00E+00		2.41E-01	N (d)	---
Vanadium	1 / 28	4	7.8	7.8	50	50	µg/L	NP	2.44E+01	2.50E+01		3.65E+00	N (d)	---
Zinc	20 / 25	80	3.9	139.5	20	20	µg/L	L	2.97E+01	4.81E+01	5.07E+02	1.09E+03	N (a)	---
Explosives														
1,3-Dinitrobenzene	1 / 29	3	0.22	0.22	0.2	0.41	µg/L	NP	1.08E-01	1.00E-01		3.65E-01	N (a)	---
2,4,6-Trinitrotoluene	2 / 29	7	0.081	0.27	0.2	0.53	µg/L	NP	1.17E-01	1.00E-01		1.82E+00	N (a)	---
2,4-Dinitrotoluene	3 / 29	10	0.58	1.5	0.2	0.41	µg/L	NP	1.99E-01	1.00E-01		9.89E-02 j	Y	1.50E+00
2,6-Dinitrotoluene	5 / 29	17	0.3	1.4	0.2	0.44	µg/L	NP	2.26E-01	1.00E-01		9.89E-02 j	Y	1.40E+00
2-Amino-4,6-dinitrotoluene	1 / 25	4	0.19	0.19	0.2	0.2	µg/L	NP	1.04E-01	1.00E-01		7.30E-01 k	N (a)	---
2-Nitrotoluene	2 / 29	7	0.16	0.55	0.2	6.3	µg/L	NP	2.81E-01	1.00E-01		4.87E-02	Y	5.50E-01
3-Nitrotoluene	1 / 29	3	0.62	0.62	0.2	2.2	µg/L	NP	1.58E-01	1.00E-01		1.22E+01	N (a)	---
4-Nitrotoluene	1 / 25	4	0.23	0.23	0.2	4	µg/L	NP	1.91E-01	1.00E-01		6.59E-01	N (a)	---
Nitrobenzene	3 / 29	10	0.32	0.34	0.2	2.8	µg/L	NP	1.94E-01	1.00E-01		3.40E-01	Y	3.40E-01
RDX	2 / 29	7	0.17	0.22	0.5	6.5	µg/L	NP	4.45E-01	2.50E-01		6.11E-01	N (a)	---
Semivolatile Organic Compounds														
2,4-Dimethylphenol	8 / 30	27	0.76	5.1	5	100	µg/L	NP	5.88E+00	5.00E+00		7.30E+01	N (a)	---
2-Methylnaphthalene	25 / 30	83	1.4	24	5	100	µg/L	L	9.27E+00	1.31E+01		6.20E-01 l	Y	2.40E+01
2-Methylphenol	2 / 30	7	0.89	1.1	5	100	µg/L	NP	6.15E+00	5.00E+00		1.82E+02	N (a)	---
4-Methylphenol	3 / 30	10	1.1	2	5	100	µg/L	NP	6.07E+00	5.00E+00		1.82E+01	N (a)	---
Bis(2-ethylhexyl)phthalate	6 / 27	22	2.3	9.7	5	100	µg/L	NP	6.46E+00	5.00E+00		4.80E+00	Y	9.70E+00
Chrysene	1 / 30	3	1	1	5	100	µg/L	NP	6.28E+00	5.00E+00		9.21E+00	N (a)	---
Naphthalene	21 / 30	70	2.1	18	5	100	µg/L	L	8.54E+00	1.06E+01		6.20E-01	Y	1.80E+01
Phenanthrene	8 / 30	27	0.74	1.4	5	100	µg/L	NP	5.34E+00	5.00E+00		1.83E+01 m	N (a)	---
Phenol	10 / 30	33	1.2	55	5	100	µg/L	NP	7.14E+00	5.00E+00		1.09E+03	N (a)	---

Table 4-6

Statistical Summary and COPC Selection of Chemicals Detected in Bedrock Groundwater Downgradient Areas at the Facility Boundary, Former Plum Brook Ordnance Works Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of Concentration Values, µg/L: Detected Concentrations Minimum	Detected Concentrations Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Units	Statistical Distribution [a]	Mean µg/L	95% UCL [b] µg/L	BSC [c] µg/L	RBSC [d] µg/L	COPC? [e,f]	Exposure Point Concentration [g] µg/L
Volatile Organic Compounds														
2-Butanone	3 / 5	60	8.1	130	5	500	µg/L	L	4.60E+01	7.95E+02		6.97E+02	N (a)	---
Acetone	8 / 14	57	19	230	5	1800	µg/L	L	1.20E+02	7.77E+02		5.48E+02	N (a)	---
Benzene	26 / 30	87	0.195	130	1	180	µg/L	NP	3.22E+01	3.60E+01		3.54E-01	Y	1.30E+02
Bromomethane	1 / 28	4	13.95	13.95	2	360	µg/L	L	3.35E+01	1.17E+02		8.66E-01	N (d)	---
Carbon disulfide	15 / 29	52	0.59	40	1	180	µg/L	L	1.57E+01	3.95E+01		1.04E+02	N (a)	---
Chlorobenzene	2 / 30	7	2.2	11	1	180	µg/L	L	1.45E+01	4.17E+01		1.06E+01	Y	1.10E+01
Chloromethane	1 / 30	3	1.3	1.3	2	360	µg/L	L	3.22E+01	9.70E+01		1.58E+01	N (a)	---
Ethylbenzene	27 / 30	90	1	120	1	180	µg/L	L	3.20E+01	8.71E+01		1.34E+02	N (a)	---
Methylene chloride	12 / 26	46	5.95	98	1	360	µg/L	L	2.01E+01	5.95E+01		4.28E+00	Y	9.80E+01
Toluene	25 / 28	89	1.2	180	1	180	µg/L	NP	5.25E+01	7.30E+01		7.23E+01	Y	1.80E+02
Xylenes, total	27 / 30	90	6.4	560	1	180	µg/L	NP	1.66E+02	1.80E+02		2.06E+01	Y	5.60E+02
Miscellaneous														
Chloride	30 / 30	100	33400	2790000	1000	1000	mg/L	NP	5.76E+05	2.60E+05		Nutrient	N (e)	---
Cyanide, total	2 / 28	7	16	320	1000	1000	mg/L	NP	4.76E+02	5.00E+00		7.30E+01	Y	3.20E+02
Sulfate	25 / 30	83	11300	1280000	1000	1000	mg/L	NP	1.38E+05	4.27E+04		5.00E+05 [n]	Y	1.28E+06

COPC - Chemical of potential concern; UCL - Upper confidence limit; BSC - Background screening criterion; RBSC - Risk-based screening concentration; ND - No data; µg/L - Micrograms per liter; mg/L - Milligrams per liter.

[a] Statistical Distribution: N - Normal distribution; L - Lognormal distribution; NP - Nonparametric distribution.

[b] Method of estimation based on statistical distribution (please see Section 3.2.1).

[c] Background screening criteria are presented in the ***2004 Data Summary and Evaluation Report*** (Shaw, 2005).

[d] Risk-Based Screening Concentrations based on EPA Region 9 Preliminary Remediation Goals (PRGs [EPA, 2004]) for tap water. PRGs were adjusted to provide an Hazard Index of 0.1 and an Incremental Lifetime Cancer Range of 1E-6.

[e] N - Chemical is not chosen as a COPC:
- (a) - maximum detected concentration is less than the RBSC.
- (b) - maximum detected concentration is less than the BSC.
- (c) - essential nutrient.
- (d) - frequency of detection is less than 5 percent.
- (e) - essential nutrient with no toxicity value available.

[f] Y - Chemical is chosen as COPC.

[g] Because the downgradient wells are in various areas, the maximum detected concentration was selected as the exposure point concentration.

[h] Based on PRG for chromium VI.

[i] Screening criteria for lead based on the action level of 15 µg/L (EPA, 1996, *Drinking Water Regulations and Health Advisories*, Office of Water, Washington, DC, October).

[j] Based on PRG for dinitrotoluene mixture.

[k] Based on PRG for aminodinitrotoluene.

[l] Based on PRG for naphthalene.

[m] Based on PRG for pyrene.

[n] Screening criteria for sulfate based on the *Drinking Water Advisory*.

Table 4-7

Summary of Overall and Site-Related Hazard Indices and Cancer Risks
TNT Areas and Red Water Pond Areas
Plum Brook Ordnance Works, Sandusky, Ohio

PBOW Site and Receptors	Site-Related (Measured Conc)[a]		Site-Related (Modeled Future Conc)[b]		Overall (Measured Conc)[c]	
	Total HI[d]	Total ILCR[e]	Total HI	Total ILCR	Total HI	Total ILCR
TNTA						
Resident	***2***	*4.E-05*	***4***	***5.E-04***	***347***	***3.E-03***
Worker	0.2	1.E-05	0.5	*1.E-04*	***10***	***3.E-04***
TNTB						
Resident	NA[f]	NA[f]	0.1	*2.E-05*	***18***	***3.E-04***
Worker	NA[f]	NA[f]	0.02	6.E-06	0.8	*7.E-05*
TNTC						
Resident	NA[f]	NA[f]	***8***	***2.E-03***	***65***	***1.E-03***
Worker	NA[f]	NA[f]	1	***4.E-04***	1	*9.E-05*
PRRWP Area						
Resident	0.6	*2.E-05*	0.7	***2.E-04***	***235***	***7.E-03***
Worker	0.07	4.E-06	0.1	*4.E-05*	***15***	***5.E-04***
WARWP Area						
Resident	***61***	***2.E-04***	0.6	***2.E-04***	***63***	***5.E-04***
Worker	***9***	*6.E-05*	0.09	*4.E-05*	***9***	*1.E-04*
Downgradient Areas[g]						
Resident	0.4	*3.E-05*	NA[h]	NA[h]	***100***	***4.E-04***
Areas Downgradient from TNTA						
Resident	NA[i]	NA[i]	0.002	4.E-07	NA[i]	NA[i]
Areas Downgradient from TNTB, TNTC, and PRRWP Area						
Resident	NA[i]	NA[i]	0.08	*2.E-05*	NA[i]	NA[i]
Areas Downgradient from WARWP Area						
Resident	NA[i]	NA[i]	0.006	1.E-06	NA[i]	NA[i]

[a]Based on measured groundwater concentrations.
[b]Based on modeled potential future groundwater concentrations.
[c]Based on measured groundwater concentrations. Calculated from BHHRA as the total risk/hazard minus the site-related risk/hazard.
[d]The hazard index (HI) is a measure of noncancer hazard for an exposed individual. For conservativeness, value shown for the resident is based on childhood exposure.
[e]The incremental lifetime cancer risk (ILCR) is the estimated extra cancer risk which an individual encounters based on exposure to a site.
[f]Not applicable because no site-related chemicals of potential concern were identified in limestone bedrock groundwater in the risk assessment (Shaw, 2006).
[g]Downgradient HI and ILCR values based on measured groundwater concentrations combined all downgradient locations, using the highest concentrations among these.
[h]Not applicable because separate downgradient areas were evaluated for the HI and ILCR using the modeled concentrations.
[i]Not applicable because separate downgradient areas were not evaluated for the HI and ILCR using the measured concentrations. Please refer to footnote f.

Notes:
1. HI values equal to or less than 1 are unlikely to result in adverse noncancer human health effects for any member of the exposed population and are regarded as accepta
2. ILCR values equal to or less than 1E-5 (1 in 100,000) are generally regarded by the Ohio Environmental Protection Agency (OEPA) as acceptable
3. The NCP identifies ILCR values less than 1E-6 (1 in 1,000,000) as negligible, and ILCR values of 1E-6 (1 in 1,000,000) through 1E-4 (1 in 10,000) are within the NCP acceptabl range. It is noted that the average lifetime cancer risk of the general U.S. population is approximately 40,000 in 100,00
4. *Italics* (non-bolded) apply only to cancer risks and indicate that the value exceeds the the 1E-5 value that is regarded as acceptable by the OEF
5. ***Bold intalics*** indicates that the noncancer hazard is unacceptable, or that the cancer risk value exceeds the NCP acceptable range (1E-6 to 1E-4

FIGURES

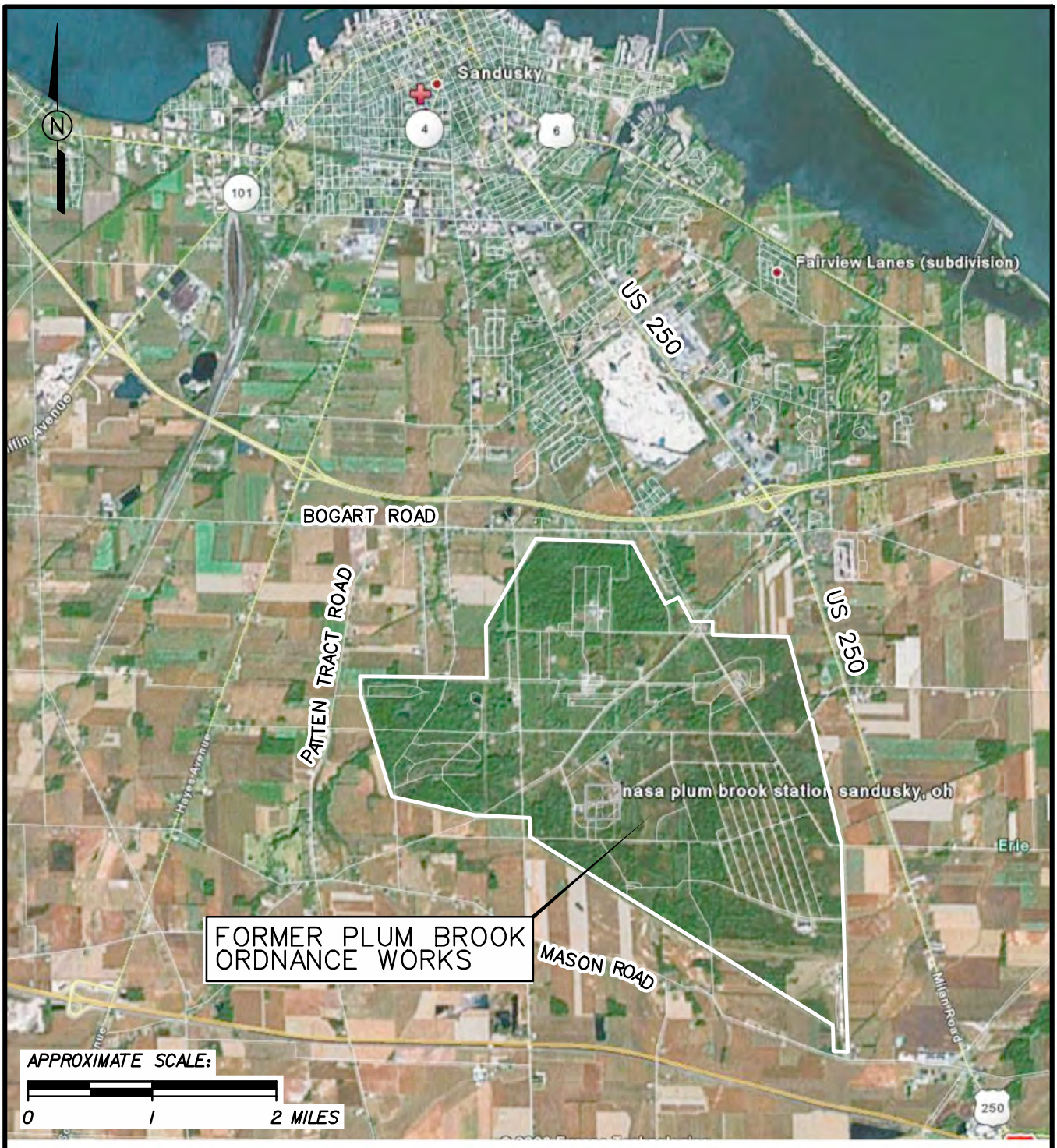

FIGURE 1-1
PBOW VICINITY MAP

RI REPORT - GROUNDWATER COVERING THE TNT AREAS AND RED WATER POND AREAS
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

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LEGEND:

- AREA OF CONCERN
- APPROXIMATE LOCATION OF SEWER LINES
- POND
- CREEK, DITCH, CONVEYANCE
- FORMER RAILROAD
- ROAD
- FENCE
- FACILITY BOUNDARY

NOTES:

1. SNAKE ROAD BURNING GROUND AREA WAS ALSO REFERRED TO AS "SNAKE ROAD BURN PIT", "SCHEID ROAD BURNING GROUNDS", AND "DISPOSAL AREA THREE".
2. REACTOR FACILITY CONSTRUCTED BY NASA POST WWII AND IS IDENTIFIED FOR LOCATION PURPOSES ONLY.

PENTOLITE AREA
NASA's REACTOR FACILITY AREA
PENTOLITE ROAD RED WATER PONDS
ACID AREA No.3
COAL YARD No.2
POWERHOUSE No. 2 ASH PITS
WASTE WATER TREATMENT PLANT No.2
WASTE WATER TREATMENT PLANT No.3
GARAGE MAINTENANCE AREA
WASTE WATER TREATMENT PLANT No.1
TNTA/WWTP1 SEWER LINES
ACID AREA No.2
ASH PIT No.3
COAL YARD No.3
ACID AREA No.1
WWTPs STEEL SEWER LINE
ASH PIT No.1
COAL YARD No.1
UPPER TOLUENE TANKS AREA
TNT MANUFACTURING AREA A
WEST AREA RED WATER PONDS
TNTC/WWTP2 SEWER LINES
RESERVOIR No.2 BURNING GROUND
ADDITIONAL BURNING GROUND AREA
MIDDLE TOLUENE TANKS AREA
TNTB/WWTP1 SEWER LINES
TNT MANUFACTURING AREA C
LOWER TOLUENE TANKS AREA
TAYLOR ROAD BURNING GROUND AREA
G-8 BURNING GROUND AREA
TNT MANUFACTURING AREA B
SNAKE ROAD BURNING GROUND AREA

PATROL ROAD
BOGART ROAD
EAST BOGART ROAD
SCHENK ROAD
PIPE CREEK
CAMPBELL ROAD
RANSOM ROAD
COLUMBUS AVENUE
PLUM BROOK
TAYLOR ROAD
BOYAT ROAD
DITCH
LINDSLEY
SANDUSKY - NORWALK ROAD
PENTOLITE ROAD
PATTEN TRACT ROAD
MAINTENANCE ROAD
BUOY ROAD
FOX ROAD
SHORT CUT ROAD
SCHLESSMAN DITCH
U.S. 250
NORTH MAGAZINE ROAD
SCHEID DITCH
CENTER MAGAZINE ROAD
EAST SCHEID ROAD
WEST SCHEID ROAD
TAFT ROAD
SOUTH MAGAZINE ROAD
KUEBELAR DITCH
OLENACHER DITCH
THOMAS ROAD
MASON ROAD
80/90 TURNPIKE TOLL ROAD

SCALE:
0 1500 3000 FEET

FIGURE 1-2
LOCATION OF THE TNT AREAS AND RED WATER POND AREAS

RI REPORT - GROUNDWATER COVERING THE TNT AREAS AND RED WATER POND AREAS
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

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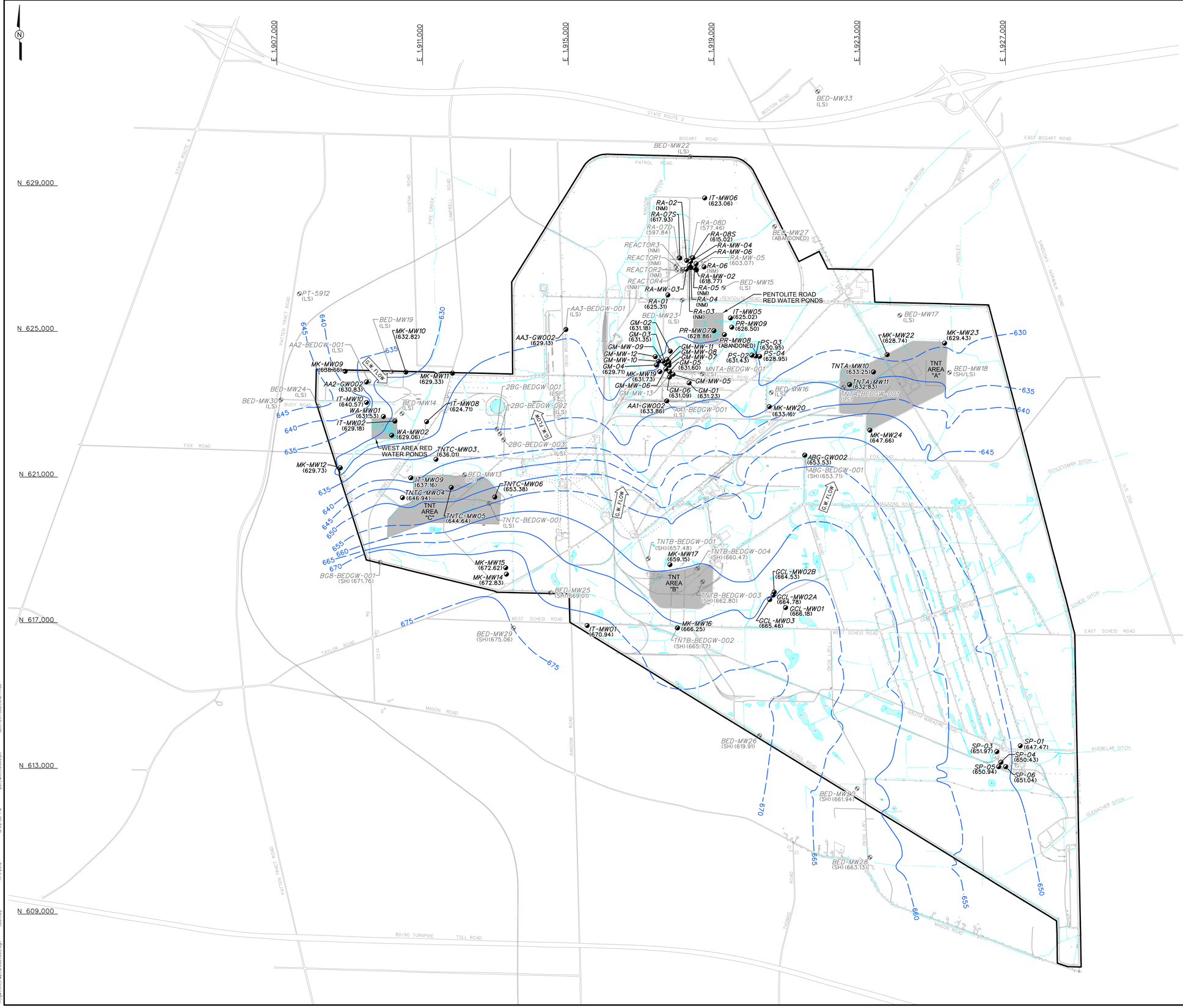

LEGEND:

ABG-GW002	OVERBURDEN/SHALE MONITORING WELL
TNTC-BEDGW-001 (LS)	BEDROCK MONITORING WELL SCREENED IN LIMESTONE
ABG-BEDGW-001 (SH)	BEDROCK MONITORING WELL SCREENED IN SHALE
	BUILDING
	RAILROAD
	SURFACE WATER
	DITCH
	FENCE (PBOW BOUNDARY)
(630.45)	GROUNDWATER ELEVATION (FT-MSL)
630	GROUNDWATER ELEVATION CONTOUR (FT-MSL) (DASHED WHERE INFERRED)
G.W. FLOW	GROUNDWATER FLOW DIRECTION
(NM)	NOT MEASURED

NOTES:

1. MONITORING WELLS PB-MW01, PB-MW02, PB-MW03, AND PB-MW04 ARE NOT SHOWN (SURVEY COORDINATES NOT AVAILABLE).
2. GROUNDWATER ELEVATION CONTOURS REFLECT THE INFLUENCE OF TOPOGRAPHY, INCLUDING DITCHES AND STREAMS; HOWEVER, TOPOGRAPHIC ELEVATION CONTOURS HAVE BEEN OMITTED FOR CLARITY.
3. MONITORING WELL BED-MW26 WAS NOT USED FOR GROUNDWATER ELEVATION CONTOURING.
4. BEDROCK MONITORING WELLS WITH (SH) DESIGNATION INDICATE THAT WELL IS SCREENED IN SHALE BEDROCK. GROUNDWATER LEVELS FROM (SH) WELLS AND OVERBURDEN WELLS USED IN CONTOUR MAP CONSTRUCTION.
5. LINES DASHED WHERE OVERBURDEN GROUNDWATER EXISTENCE OR LOCATION IS UNCERTAIN.
6. GROUNDWATER LEVELS WERE MEASURED ON AUGUST 10 AND 11, 2004.
7. THIS MAP IS BASED ON INFORMATION FROM AUGUST 2004. IT DOES NOT INCLUDE INFORMATION FROM MONITORING WELLS INSTALLED SUBSEQUENTLY.

FIGURE 2-1
OVERBURDEN/SHALE
GROUNDWATER ELEVATION
CONTOUR MAP (AUGUST 2004)

RI REPORT - GROUNDWATER COVERING THE TNT AREAS AND RED WATER POND AREAS
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

SCALE:
0 1200 2400 FEET

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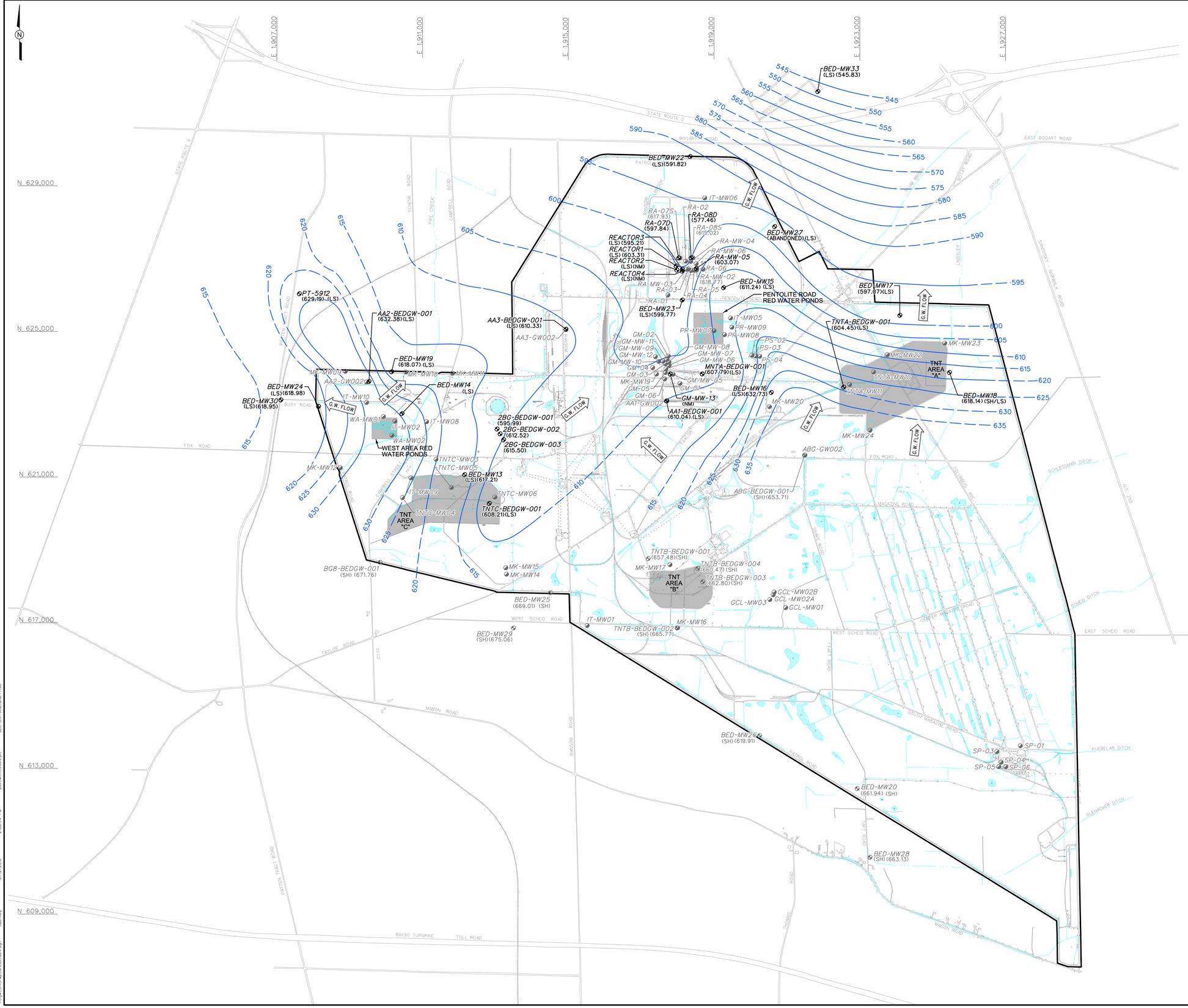

LEGEND:

ABG-GW002	OVERBURDEN/SHALE MONITORING WELL
TNTC-BEDGW-001 (LS)	BEDROCK MONITORING WELL SCREENED IN LIMESTONE
ABG-BEDGW-001 (SH)	BEDROCK MONITORING WELL SCREENED IN SHALE
	BUILDING
	RAILROAD
	SURFACE WATER
	DITCH
	FENCE (PBOW BOUNDARY)
(630.45)	GROUNDWATER ELEVATION (FT-MSL)
630	GROUNDWATER ELEVATION CONTOUR (FT-MSL) (DASHED WHERE INFERRED)
G.W. FLOW	GROUNDWATER FLOW DIRECTION
(NM)	NOT MEASURED

NOTES:

1. MONITORING WELLS PB-MW01, PB-MW02, PB-MW03, AND PB-MW04 ARE NOT SHOWN. (SURVEY COORDINATES NOT AVAILABLE).
2. MONITORING WELLS REACTOR2 AND REACTOR4 WERE NOT USED FOR GROUNDWATER ELEVATION CONTOURING.
3. TYPE OF BEDROCK MONITORING WELLS ARE SCREENED IN IS INDICATED BY (SH) - SHALE AND (LS) - LIMESTONE.
4. MONITORING WELLS WITH (SH) DESIGNATION NOT INCLUDED IN CONTOURING.
5. DASHED LINES INDICATE UNCERTAIN GROUNDWATER LEVEL ELEVATION.
6. STATIC GROUNDWATER LEVELS WERE MEASURED AUGUST 10 AND 11, 2004 UNLESS OTHERWISE INDICATED.
7. WATER LEVELS IN MONITORING WELLS 2BG-BEDGW-001, -002, AND -003 WERE NOT IN STATIC CONDITIONS, THEREFORE GROUNDWATER ELEVATIONS WERE NOT USED IN CONTOUR MAP CONSTRUCTION.
8. DEPTH TO GROUNDWATER IN WELL PT-5912 WAS MEASURED AUGUST 24, 2004, AND COMPARED TO BED-MW19 AND BED-MW30 AUGUST 10, 2004 DEPTH TO WATER MEASUREMENTS. 0.9 FEET WAS SUBTRACTED FROM THE AUGUST 24, 2004 MEASUREMENT.
9. DEPTH TO GROUNDWATER IN WELLS REACTOR1 AND REACTOR3 WERE MEASURED AUGUST 17, 2004 AND COMPARED TO RA-01 AUGUST 10, 2004 DEPTH TO WATER MEASUREMENTS. 0.6 FEET WAS ADDED TO THE AUGUST 17, 2004 MEASUREMENT.
10. WATER LEVEL ELEVATION OF TNTA-BEDGW-001 NOT USED IN CONTOUR MAP CONSTRUCTION DUE TO ERRATIC WATER LEVEL CHANGES ASSOCIATED WITH >14 FEET OF NATURAL PETROLEUM.
11. THIS MAP IS BASED ON INFORMATION FROM AUGUST 2004. IT DOES NOT INCLUDE INFORMATION FROM MONITORING WELLS INSTALLED SUBSEQUENTLY.

FIGURE 2-2
DELAWARE LIMESTONE BEDROCK GROUNDWATER ELEVATION CONTOUR MAP (AUGUST 2004)

RI REPORT - GROUNDWATER COVERING THE TNT AREAS AND RED WATER POND AREAS
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

SCALE: 0 1200 2400 FEET

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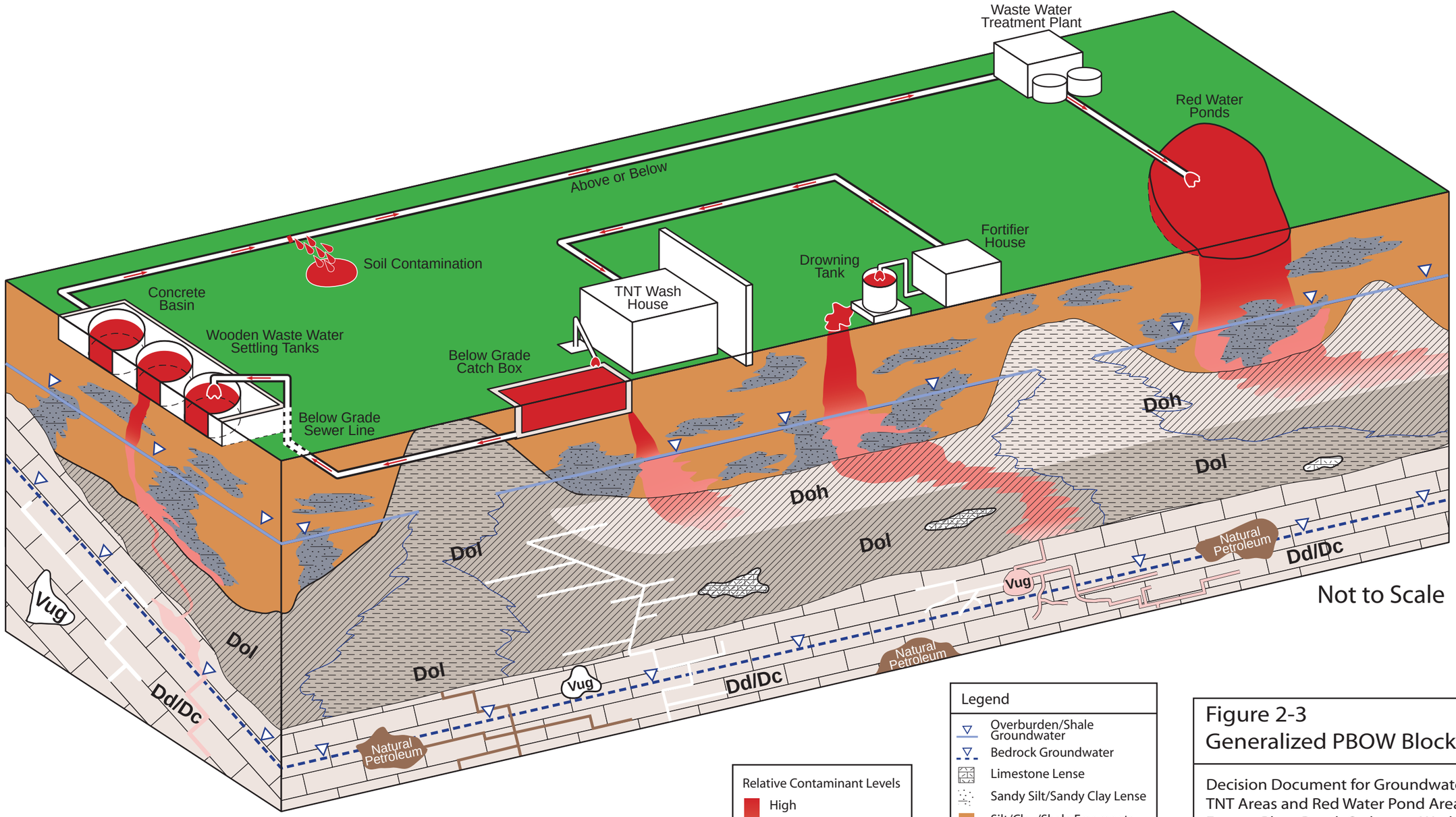

Relative Contaminant Levels

High

Low

Legend

- Overburden/Shale Groundwater
- Bedrock Groundwater
- Limestone Lense
- Sandy Silt/Sandy Clay Lense
- Silt/Clay/Shale Fragments
- Weathered Shale

Doh - Ohio Shale
Dol - Olentangy Shale (Prout and Olentangy Shale Members)
Dd- Delaware Limestone
Dc- Columbus Limestone
Vug - Void area in rock

Figure 2-3
Generalized PBOW Block Diagram

Decision Document for Groundwater
TNT Areas and Red Water Pond Areas
Former Plum Brook Ordnance Works
Sandusky, Ohio

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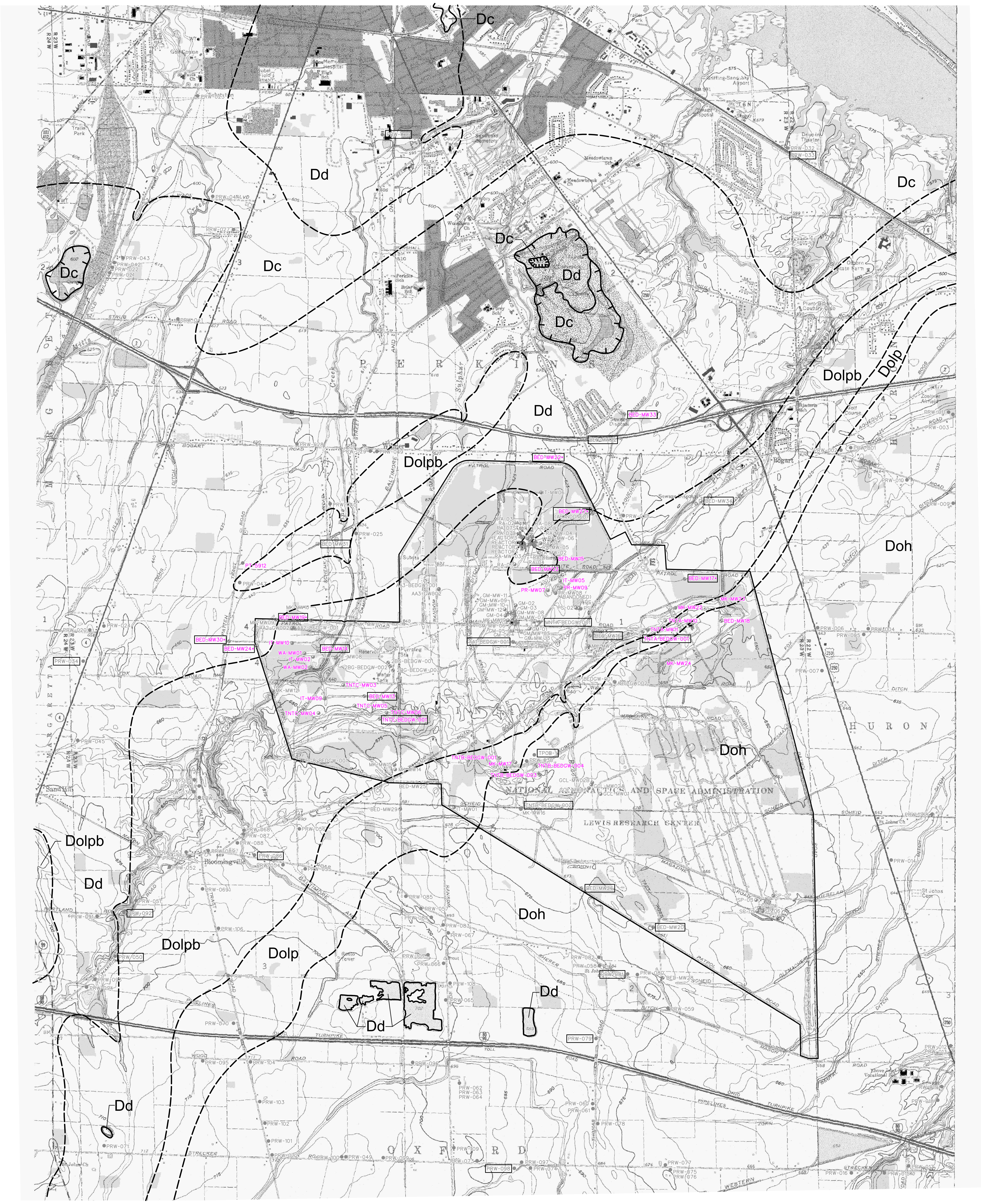

LEGEND:

- PRIVATE WELL LOCATION
- OVERBURDEN WELL LOCATION
- BEDROCK WELL LOCATION
- SOIL BORING LOCATION
- H_2S AND/OR NATURAL GAS, AND/OR PETROLEUM HYDROCARBON WERE NOTED DURING DRILLING
- CONTACT SOLID LINE WHERE EXPOSED; DASHED WHERE CONCEALED BY SEDIMENTS

AGE	FORMATION/GROUP	ROCK DESCRIPTION
DEVONIAN	Doh - Ohio Shale	Shale: black, thin-bedded with bituminous and carboneous material, pyrite, natural gas pockets.
	Dolp - Prout Limestone Member (Olentangy Shale)	Limestone: light gray, calcareous.
	Dolpb - Plum Brook Member (Olentangy Shale)	Shale: dark gray, thin-bedded.
	Dd - Delaware Limestone	Limestone: buff, earthy, interbedded with brown crystalline dolomite, fossiliferous, hydrogen sulfide, petroleum hydrocarbon.
	Dc - Columbus Limestone	Limestone: brown to gray, fine crystalline, fossiliferous with tan to buff gray, partly sandy dolomite at base.

REFERENCES:

PRELIMINARY BEDROCK GEOLOGY OF THE KIMBALL AND SANDUSKY, OHIO, QUADRANGLES, STATE OF OHIO, DEPARTMENT OF NATURAL RESOURCES, DIVISION OF GEOLOGICAL SURVEY, 1995.

BASE MAPS (COMBINED BY SHAW) FROM KIMBALL AND SANDUSKY QUADRANGLES, 7.5 MINUTE SERVICES, (TOPOGRAPHIC), 1969. SANDUSKY MAP WAS PHOTOREVISED 1979.

NOTES:

1. CONTACT LINES WERE ADJUSTED BASED ON 2004 MONITORING WELLS/SOIL BORING AND GIS DATA AND PRESENTED IN THE 2004 GROUNDWATER DATA SUMMARY AND EVALUATION REPORT. FURTHER UPDATES TO THE GEOLOGIC INTERPRETATION ARE PRESENTED IN MORE RECENT REPORTS (E.G. WASTEWATER TREATMENT PLANT No.3 SITE CHARACTERIZATION REPORT [SHAW, 2011]).
2. TNT AREA WELLS, RED WATER POND AREA WELLS, AND DOWNGRADIENT WELLS EVALUATED IN THE 2004 GROUNDWATER REPORT ARE SHOWN IN COLOR.
3. BEDROCK WELLS BED-MW17*, BED-MW19*, BED-MW22*, BED-MW24*, BED-MW27*, AND BED-MW30* WERE EVALUATED IN THE BASELINE HUMAN HEALTH RISK ASSESSMENT (APPENDIX B) AS DOWNGRADIENT BOUNDARY WELLS.

SCALE: 0 1250 2500 FEET

FIGURE 3-1
REGIONAL GEOLOGIC MAP WITH WELL LOCATIONS AND TOPOGRAPHY

RI REPORT - GROUNDWATER COVERING THE TNT AREAS AND RED WATER POND AREAS
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

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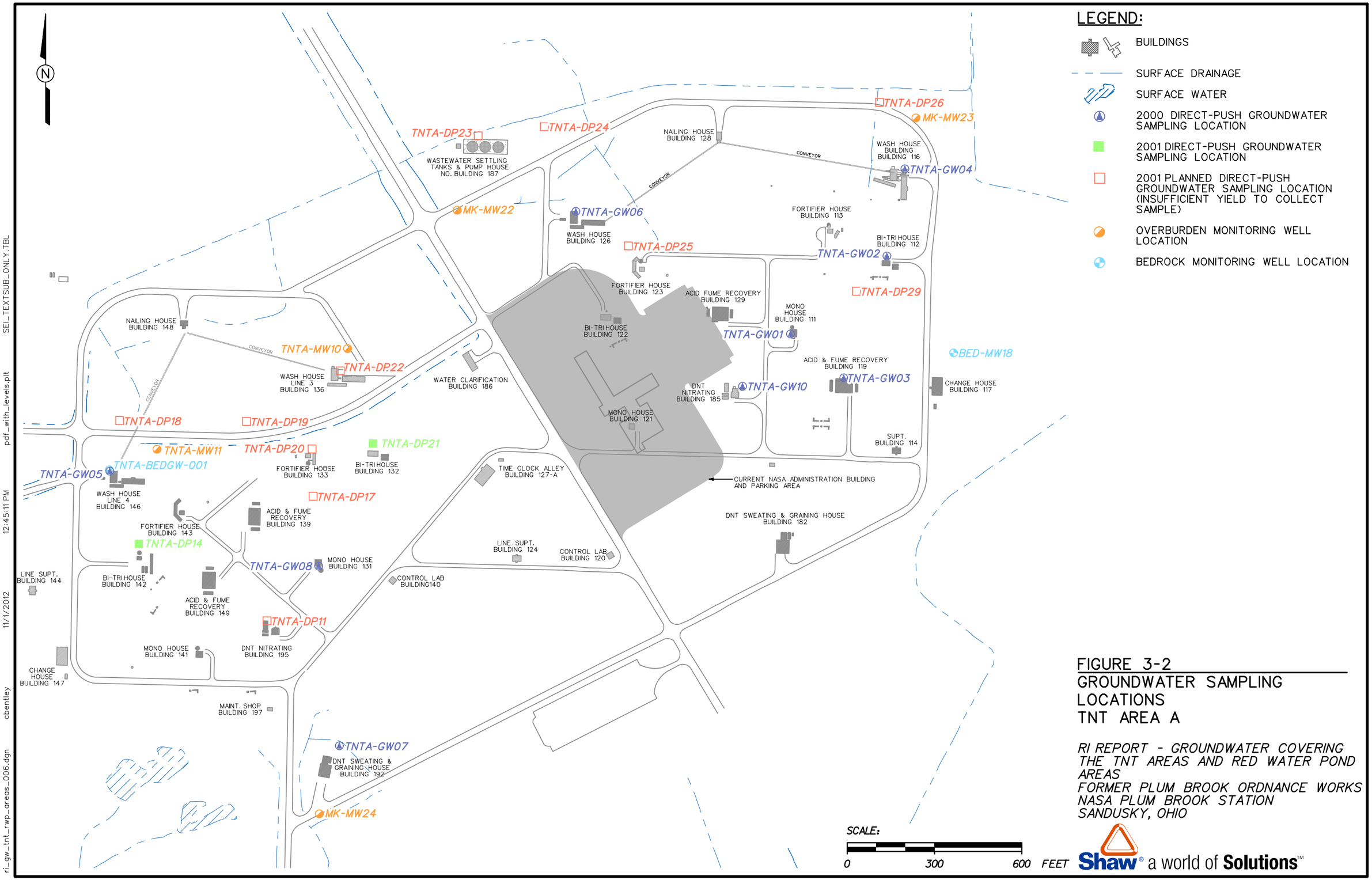

FIGURE 3-2
GROUNDWATER SAMPLING LOCATIONS
TNT AREA A

RI REPORT - GROUNDWATER COVERING THE TNT AREAS AND RED WATER POND AREAS
FORMER PLUM BROOK ORDNANCE WORKS
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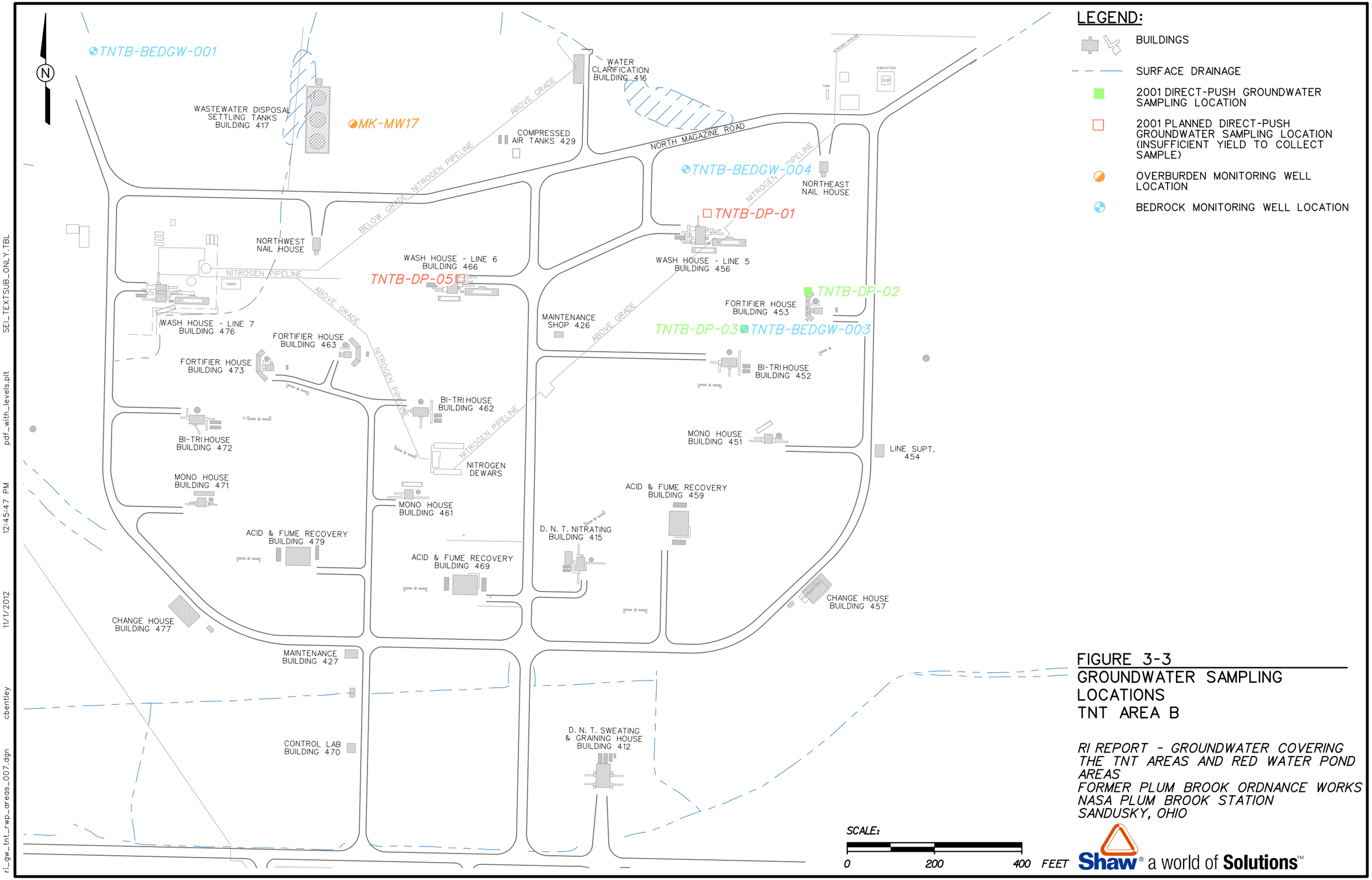

FIGURE 3-3
GROUNDWATER SAMPLING LOCATIONS
TNT AREA B

RI REPORT - GROUNDWATER COVERING THE TNT AREAS AND RED WATER POND AREAS
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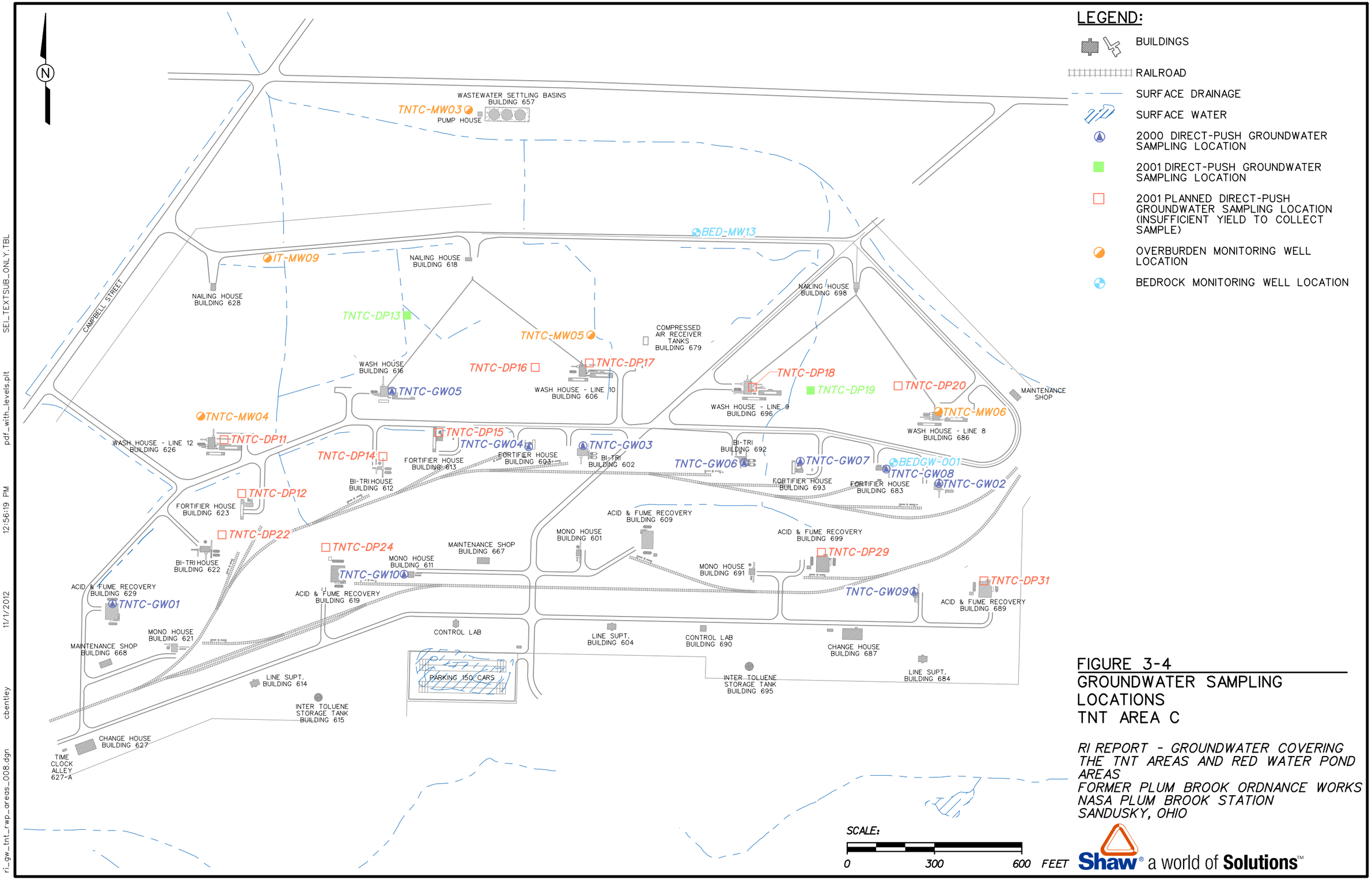

FIGURE 3-4
GROUNDWATER SAMPLING LOCATIONS
TNT AREA C

RI REPORT - GROUNDWATER COVERING THE TNT AREAS AND RED WATER POND AREAS
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

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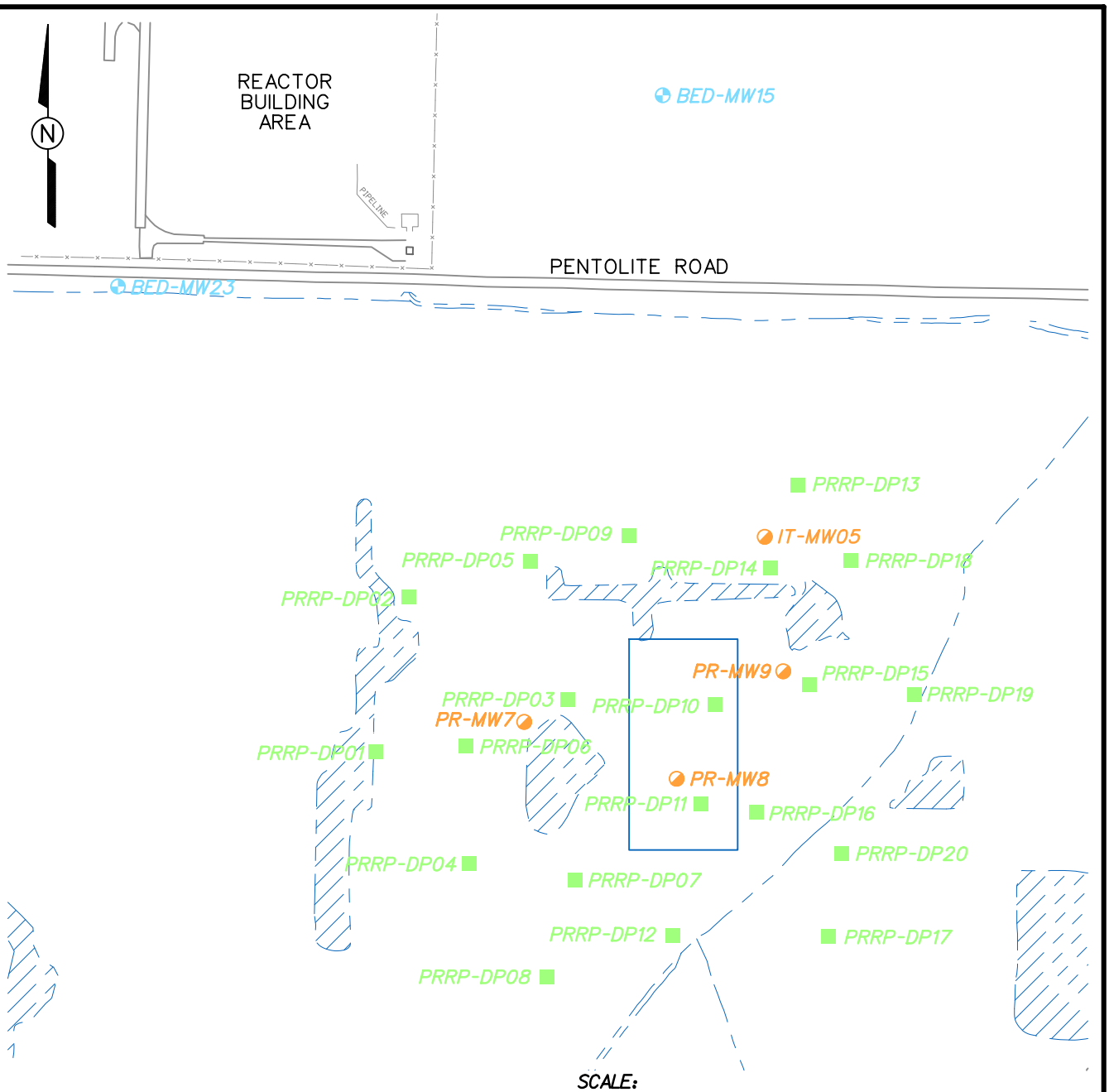

LEGEND:

- BUILDINGS
- PAVED ROADS
- SURFACE WATER
- SURFACE WATER DRAINAGE
- APPROXIMATE HISTORICAL LOCATION OF PONDS
- FENCE (PBOW BOUNDARY)
- DIRECT-PUSH GROUNDWATER SAMPLING LOCATION
- OVERBURDEN MONITORING WELL LOCATION (NON-RI DATA; EVALUATED ONLY IN THE BHHRA)
- BEDROCK MONITORING WELL LOCATION

FIGURE 3-5
GROUNDWATER SAMPLING LOCATIONS PENTOLITE ROAD RED WATER POND AREA

RI REPORT - GROUNDWATER COVERING THE TNT AREAS AND RED WATER POND AREAS
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

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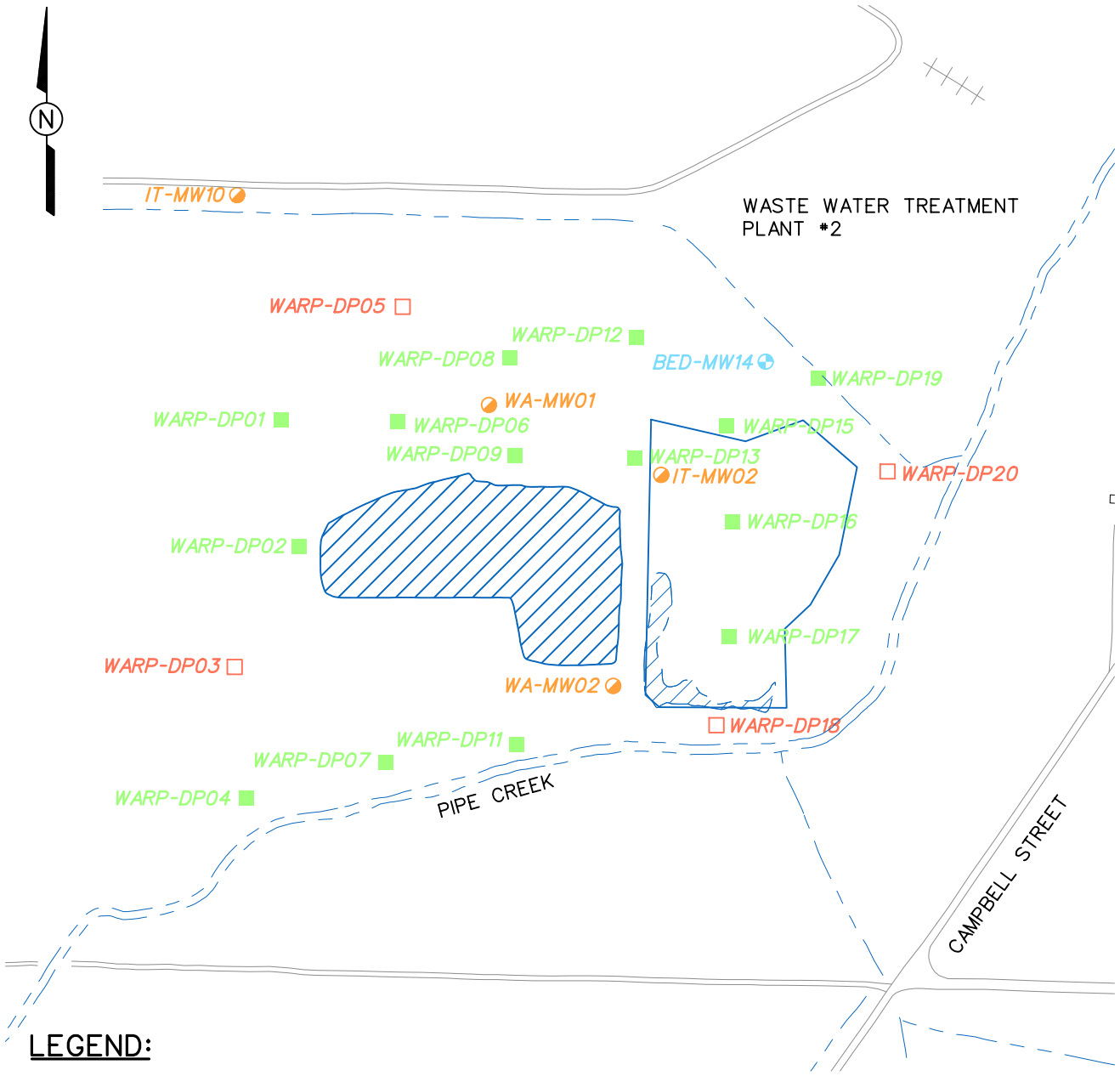

LEGEND:

- RAILROAD
- SURFACE WATER
- SURFACE DRAINAGE
- APPROXIMATE HISTORICAL LOCATION OF PONDS
- UNPAVED ROADS/DRIVES
- PAVED ROADS
- DIRECT-PUSH GROUNDWATER SAMPLING LOCATION
- PLANNED DIRECT-PUSH GROUNDWATER SAMPLING LOCATION (INSUFFICIENT YIELD TO COLLECT SAMPLE)
- OVERBURDEN MONITORING WELL LOCATION (NON-RI DATA; EVALUATED ONLY IN THE BHHRA)
- BEDROCK MONITORING WELL LOCATION

SCALE:

0 300 600 FEET

FIGURE 3-6
GROUNDWATER SAMPLING LOCATIONS
WEST AREA RED WATER PONDS AREA

RI REPORT - GROUNDWATER COVERING THE TNT AREAS AND RED WATER POND AREAS
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

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APPENDIX A

2004 GROUNDWATER DATA SUMMARY AND EVALUATION REPORT (ELECTRONIC DELIVERABLE)

2004 Groundwater Data Summary and Evaluation Report

Former Plum Brook Ordnance Works Sandusky, Ohio

Volume 1, Part 1 of 2

Text, Tables, and Figures

Prepared for:

U.S. Army Corps of Engineers, Nashville District
P. O. Box 1070
Nashville, Tennessee 37202-1070

Prepared by:

Shaw Environmental, Inc.
312 Directors Drive
Knoxville, Tennessee 37923

Shaw Project No. 843656

Revision 1

April 2005

Table of Contents

Page

List of Appendices vi
List of Tables vii
List of Figures ix
List of Acronyms xii
Executive Summary ES-1
1.0 Introduction 1-1
1.1 Scope of Work and Project Objectives 1-3
1.2 Report Organization 1-4
1.3 Facility Location and Description 1-4
1.4 Site History and Potential for Contamination 1-5
2.0 Physical Setting 2-1
2.1 Geography, Topography, and Surface Drainage 2-1
2.2 Geology and Soils 2-1
2.2.1 Regional Geology 2-1
2.2.2 Local Geology 2-2
2.2.3 Local Soils 2-3
2.2.4 Hydrogeology 2-4
2.2.4.1 Current Groundwater Usage 2-4
2.2.4.2 Regional Hydrogeology 2-4
2.2.4.3 General Site Hydrogeology 2-4
2.3 Climatological Setting 2-5
2.4 Site Conceptual Model 2-6
3.0 Summary of Previous Environmental Studies 3-1
3.1 TNT Areas 3-1
3.1.1 TNT Area A 3-1
3.1.2 TNT Area B 3-6
3.1.3 TNT Area C 3-11
3.2 Red Water Pond Areas 3-15
3.2.1 West Area Red Water Ponds 3-15
3.2.2 Pentolite Road Red Water Ponds 3-19
3.3 Background Area 3-21
3.3.1 Soil 3-21
3.3.2 Groundwater 3-22

Table of Contents *(Continued)*

Page

4.0 Field Activities 4-1
4.1 Introduction 4-1
4.2 Monitoring Well Installation 4-2
4.3 Monitoring Well Development 4-5
4.4 Monitoring Well Abandonment 4-6
4.5 Groundwater Sampling 4-6
4.6 Hydraulic Conductivity Testing 4-10
4.7 Decontamination Procedures 4-12
4.8 Land Survey 4-12
4.9 IDW Management 4-12
5.0 Analytical Program and Data Review Methodologies 5-1
5.1 Analytical Program Methodologies 5-1
5.1.1 Sample Analysis and Data Validation 5-1
5.1.2 Analytical Methods 5-2
5.1.3 Data Quality Evaluation 5-2
5.1.4 Blank Evaluation 5-2
5.2 Comparison to Screening Criteria 5-3
5.2.1 Derivation and Use of RBSCs in the BHHRA 5-3
5.2.2 Background Screening 5-4
6.0 Investigation Results 6-1
6.1 Quarterly Groundwater Level Measurements 6-1
6.2 Geologic and Hydrogeologic Investigation Results 6-1
6.2.1 Hydrogeology of Overburden/Shale Water-Bearing Zone 6-2
6.2.2 Geology and Hydrogeology of Delaware Limestone Water-Bearing Zone 6-5
6.2.3 Hydraulic Connection Between Zones 6-7
6.2.4 Influence of Precipitation on Water Levels 6-7
7.0 Groundwater Sampling Events 7-1
7.1 Areas and Water-Bearing Units Sampled 7-1
7.2 Areas of Concern Analytical Results 7-3
7.2.1 TNT Manufacturing Area A 7-4
7.2.1.1 Overburden Temporary Piezometers 7-4
7.2.1.2 Overburden/Shale 7-5

Table of Contents *(Continued)*

Page

7.2.1.3 Delaware Limestone Bedrock 7-8
7.2.1.4 Summary of Sampling Events, TNT Manufacturing Area A 7-10
7.2.2 TNT Manufacturing Area B 7-11
7.2.2.1 Temporary Piezometers 7-11
7.2.2.2 Overburden/Shale 7-12
7.2.2.3 Shale Bedrock 7-14
7.2.2.4 Summary of Sampling Events, TNT Manufacturing Area B 7-17
7.2.3 TNT Manufacturing Area C 7-18
7.2.3.1 Temporary Piezometers 7-18
7.2.3.2 Overburden/Shale 7-19
7.2.3.3 Delaware Limestone Bedrock 7-22
7.2.3.4 Summary of Sampling Events, TNT Manufacturing Area C 7-24
7.2.4 West Area Red Water Ponds Area 7-25
7.2.4.1 Temporary Piezometers 7-25
7.2.4.2 Overburden/Shale 7-26
7.2.4.3 Delaware Limestone Bedrock 7-26
7.2.4.4 Summary of Sampling Events, West Area Red Water Ponds ... 7-28
7.2.5 Pentolite Road Red Water Ponds Area 7-29
7.2.5.1 Temporary Piezometers 7-29
7.2.5.2 Overburden/Shale 7-30
7.2.5.3 Delaware Limestone Bedrock 7-30
7.2.5.4 Summary of Sampling Events, Pentolite Road Red Water Ponds 7-32
7.2.6 Acid Areas and Maintenance Shop Area 7-33
7.2.6.1 Acid Area No. 1 7-33
7.2.6.1.1 Overburden/Shale 7-33
7.2.6.1.2 Delaware Limestone Bedrock 7-33
7.2.6.1.3 Summary of Sampling Events, Acid Area No. 1 ... 7-35
7.2.6.2 Acid Area No. 2 7-36
7.2.6.2.1 Overburden/Shale 7-36
7.2.6.2.2 Delaware Limestone Bedrock 7-36
7.2.6.2.3 Summary of Sampling Events, Acid Area No. 2 ... 7-39

Table of Contents *(Continued)*

Page

7.2.6.3 Acid Area No. 3 7-40
7.2.6.3.1 Overburden/Shale 7-40
7.2.6.3.2 Delaware Limestone Bedrock 7-40
7.2.6.3.3 Summary of Sampling Events, Acid Area No. 3 7-41
7.2.6.4 Maintenance Area 7-42
7.2.6.4.1 Overburden/Shale 7-42
7.2.6.4.2 Delaware Limestone Bedrock 7-42
7.2.6.4.3 Summary of Sampling Events, Maintenance Area 7-44
7.2.7 Additional Burning Ground Area 7-44
7.2.7.1 Overburden/Shale 7-44
7.2.7.2 Shale Bedrock 7-44
7.2.7.3 Summary of Sampling Events, Additional Burning Ground Area 7-46
7.2.8 Upper Toluene Tanks Area 7-46
7.2.8.1 Overburden/Shale 7-46
7.2.8.2 Delaware Limestone Bedrock 7-47
7.2.8.3 Summary of Sampling Events, Upper Toluene Tanks Area 7-48
7.3 Downgradient Perimeter Wells Analytical Results 7-50
7.3.1 Overburden/Shale 7-50
7.3.2 Delaware Limestone Bedrock 7-50
7.3.3 Summary of Sampling Events, Downgradient Perimeter Wells 7-57
7.4 Background Monitoring Wells Analytical Results 7-59
7.4.1 Overburden/Shale 7-59
7.4.2 Shale Bedrock 7-61
7.4.3 Summary of Sampling Events, Background Monitoring Wells 7-62
8.0 Conclusions 8-1
8.1 Overburden/Shale Water-Bearing Zone 8-1
8.1.1 Nitroaromatic Compounds 8-2
8.1.2 Organic Compounds 8-2
8.1.3 Inorganic Compounds 8-3
8.1.4 Geologic and Hydrogeological Conclusions 8-4

Table of Contents *(Continued)*

Page

8.2 Delaware Limestone Bedrock Water-Bearing Zone 8-5
8.2.1 AOC Well Samples 8-5
8.2.1.1 Nitroaromatic Compounds 8-5
8.2.1.2 Organic Compounds 8-6
8.2.1.3 Inorganic Compounds 8-7
8.2.2 Downgradient Perimeter Well Samples 8-7
8.2.2.1 Nitroaromatic Compounds 8-8
8.2.2.2 Organic Compounds 8-8
8.2.2.3 Inorganic Compounds 8-9
8.2.3 Background Well Samples 8-9
8.2.3.1 Nitroaromatic Compounds 8-9
8.2.3.2 Organic Compounds 8-10
8.2.3.3 Inorganic Compounds 8-10
8.2.3.4 Background Screening Concentrations 8-11
8.2.3.5 Geochemical Evaluation of Elevated Inorganics 8-12
8.3 Geologic and Hydrogeological Conclusions 8-12
9.0 Recommendations 9-1
10.0 References 10-1
Tables
Figures

List of Appendices

Appendix A – Groundwater Sample Collection Logs
Appendix B – Soil Boring and Monitoring Well HTRW Drill Logs/Well Construction Diagrams
Appendix C – Photographs
Appendix D – Well Development Logs
Appendix E – Hydraulic Conductivity Data
Appendix F – Land Survey Data
Appendix G - IDW Waste Manifests (August 2003 – August 2004)
Appendix H – Data Validation Summaries
Appendix I – Chemical Analytical Data Summary
Appendix J – Detected Hits Summary Excluding "B" Qualifiers
Appendix K – Data Quality Evaluations
Appendix L - Chains-of-Custody
Appendix M – Methods Related to the Evaluation of Background
Appendix N – Teleconference Notes on BTEX in Quarry/E-Mail Message on Active Oil/Gas Field
Appendix O – Recharge Calculations
Appendix P – Comments and Responses

List of Tables

Table	Title	Follows Text
2-1	Summary of Off-Site Drinking Water Wells	
3-1	TNTA - Historical Surface Water Analytical Results	
3-2	TNTA - Historical Sediment Analytical Results	
3-3	TNTA - Historical Soil Analytical Results	
3-4	TNTA - Historical Groundwater Analytical Results	
3-5	TNTB - Historical Surface Water Analytical Results	
3-6	TNTB - Historical Sediment Analytical Results	
3-7	TNTB - Historical Soil Analytical Results	
3-8	TNTB - Historical Groundwater Analytical Results	
3-9	TNTC - Historical Surface Water Analytical Results	
3-10	TNTC - Historical Sediment Analytical Results	
3-11	TNTC - Historical Soil Analytical Results	
3-12	TNTC - Historical Groundwater Analytical Results	
3-13	WARWP - Historical Surface Water Analytical Results	
3-14	WARWP - Historical Sediment Analytical Results	
3-15	WARWP - Historical Soil Analytical Results	
3-16	WARP - Historical Groundwater Analytical Results	
3-17	PRRWP - Historical Surface Water Analytical Results	
3-18	PRRWP - Historical Sediment Analytical Results	
3-19	PRRWP - Historical Soil Analytical Results	
3-20	PRRWP - Historical Groundwater Analytical Results	
4-1	Summary of Background Investigations	
4-2	Monitoring Well Construction Details	
4-3	Summary of Groundwater Samples Collected	
4-4	Final Field Measurements of Groundwater Samples	
5-1	Summary of Analytical Parameters and Methods	
6-1	Summary of Groundwater Elevation Measurements	
6-2	Detected Hydrocarbons in Bedrock Drilling	
6-3	Summary of Hydraulic Conductivity Testing Results	
6-4	Well Pair Vertical Hydraulic Gradients	
7-1	Detected Constituents in Overburden/Shale Temporary Piezometer Sampling Locations, TNT Manufacturing Areas A, B, and C	

List of Tables *(Continued)*

Table	Title	Follows Tab
7-2	Detected Constituents in Overburden/Shale Monitoring Wells, TNT Manufacturing Area A	
7-3	Detected Constituents in Bedrock Monitoring Wells, TNT Manufacturing Area A	
7-4	Detected Constituents in Overburden/Shale Monitoring Wells, TNT Manufacturing Area B	
7-5	Detected Constituents in Bedrock Monitoring Wells, TNT Manufacturing Area B	
7-6	Detected Constituents in Overburden/Shale Monitoring Wells, TNT Manufacturing Area C	
7-7	Detected Constituents in Bedrock Monitoring Wells, TNT Manufacturing Area C	
7-8	Detected Constituents in Overburden/Shale Temporary Piezometer Sampling Locations, Red Water Pond Areas	
7-9	Detected Constituents in Bedrock Monitoring Well, West Area Red Water Ponds	
7-10	Detected Constituents in Bedrock Monitoring Wells, Pentolite Road Red Water Ponds	
7-11	Detected Constituents in Bedrock Monitoring Wells, Acid Area No. 1	
7-12	Detected Constituents in Bedrock Monitoring Wells, Acid Area No. 2	
7-13	Detected Constituents in Bedrock Monitoring Well, Acid Area No. 3	
7-14	Detected Constituents in Bedrock Monitoring Well, Maintenance Shop Area	
7-15	Detected Constituents in Bedrock Monitoring Well, Additional Burning Ground Area	
7-16	Detected Constituents in Bedrock Monitoring Well, Upper Toluene Tanks Area	
7-17	Detected Constituents in Bedrock Monitoring Wells, Downgradient Perimeter Wells	
7-18	Detected Constituents in Bedrock Monitoring Wells, Background Monitoring Wells	

List of Figures

Figure	Title	Follows Tab
1-1	Vicinity Map	
1-2	Locations of Areas of Concern with Site Topography	
2-1	Regional Geologic Map with Well Locations	
2-2	Site Map with Wells and Lines of Cross-Section	
2-3	Geologic Cross-Section A-A'	
2-4	Geologic Cross-Section B-B'	
2-5	Geologic Cross-Section C-C'	
2-6	Geologic Cross-Section D-D'	
2-7	Geologic Cross-Section E-E'	
2-8	Geologic Cross-Section F-F'	
2-9	Top-of-Shale Elevation Contour Map	
2-10	Top-of-Delaware Limestone Elevation Contour Map	
2-11	Overburden Thickness Contour Map	
2-12	Overburden Groundwater Isopach Map (August 2001)	
2-13	Generalized PBOW Block Diagram	
3-1	TNT Area A - General Site Features and Monitoring Well Location Map	
3-2	TNT Area B - General Site Features and Monitoring Well Location Map	
3-3	TNT Area C - General Site Features and Monitoring Well Location Map	
3-4	West Area Red Water Ponds and TNT Area C – General Site Features and Monitoring Well Location Map	
3-5	Pentolite Road Red Water Ponds – General Site Features and Monitoring Well Location Map	
3-6	Background Soil Boring Locations (1994)	
5-1	Protocol for Screening and Risk Evaluation	
6-1	Active/Inactive Natural Oil and Gas Wells of Erie County, Ohio	
6-2	Overburden/Shale Groundwater Elevation Contour Map (May 2004)	
6-3	Overburden/Shale Groundwater Elevation Contour Map (August 2004)	
6-4	Delaware Limestone Groundwater Elevation Contour Map (May 2004)	
6-5	Delaware Limestone Groundwater Elevation Contour Map (August 2004)	
6-6	Groundwater Elevation Contour Map, Reactor Facility Area (November 2001)	
6-7	Groundwater Elevation Contour Map, Reactor Facility Area (August 2004)	
6-8	Typical Groundwater Elevation Fluctuation, Overburden/Shale Wells	

List of Figures *(Continued)*

Figure	Title	Follows Tab
6-9	Typical Groundwater Elevation Fluctuation, Overburden/Ohio Shale	
6-10	Typical Groundwater Elevation Fluctuation, Overburden/Olentangy Shale	
6-11	Typical Groundwater Elevation Fluctuation, Delaware Limestone	
6-12	Typical Groundwater Elevation Fluctuation, Reactor Wells, 1, 2, 3 and BED-MW13	
6-13	Monthly Precipitation Data, January 1994 through June 2004	
6-14	Calculated Monthly Recharge Rates at PBOW	
7-1	Detected Constituents at TNT Area A Above RBSCs or BSCs in Overburden/Shale and Bedrock Groundwater (November 1997 through April 2002)	
7-2	Detected Constituents at TNT Area B Above RBSCs or BSCs in Overburden/Shale and Bedrock Groundwater (November 1997 through April 2002)	
7-3	Detected Constituents at TNT Area C Above RBSCs or BSCs in Overburden/Shale and Bedrock Groundwater (November 1997 through April 2002)	
7-4	Detected Constituents at West Area Red Water Ponds Above RBSCs or BSCs in Overburden/Shale Groundwater (June 1998)	
7-5	Detected Constituents at West Area Red Water Ponds Above RBSCs or BSCs in Bedrock Groundwater (November 1997 through April 2002)	
7-6	Detected Constituents at Pentolite Road Red Water Ponds Above RBSCs or BSCs in Overburden/Shale Groundwater (June 1998)	
7-7	Detected Constituents at Pentolite Road Red Water Ponds Above RBSCs or BSCs in Bedrock Groundwater (November 1997 through April 2002)	
7-8	Detected Constituents at Acid Area No. 1/Maintenance Shop Area Above RBSCs or BSCs in Bedrock Groundwater (November 1997 through April 2002)	
7-9	Detected Constituents at Acid Area No. 2 Above RBSCs or BSCs in Bedrock Groundwater (November 1997 through April 2002)	
7-10	Detected Constituents at Acid Area No. 3 Above RBSCs or BSCs in Bedrock Groundwater (November 1997 through April 2002)	
7-11	Detected Constituents at Additional Burning Ground Area Above RBSCs or BSCs in Bedrock Groundwater (November 1997 through April 2002)	
7-12	Detected Constituents at Upper Toluene Tanks Area Above RBSCs or BSCs in Bedrock Groundwater (November 1997 through April 2002)	

List of Figures *(Continued)*

Figure	Title	Follows Tab
7-13	Detected Constituents at Downgradient Areas Above RBSCs or BSCs in Bedrock Groundwater (November 1997 through April 2002)	
7-14	Detected Constituents at Background Areas in Overburden/Shale Groundwater (November 1997 through April 2002)	

List of Acronyms

AA1	Acid Area 1
AA2	Acid Area 2
AA3	Acid Area 3
ABG	Additional Burning Ground
AOC	area of concern
BCF	bioconcentration factor
BERA	baseline ecological risk assessment
bgs	below ground surface
BHHRA	baseline human health risk assessment
BSC	background screening concentration
BTEX	benzene, toluene, ethyl benzene, and total xylenes
CLP	Contract Laboratory Program
COC	chemical of concern
D&M	Dames and Moore, Inc.
DNB	dinitrobenzene
DNT	dinitrotoluene
DO	delivery order
DOD	U.S. Department of Defense
DQO	data quality objective
DRO	diesel range organics
EPA	U.S. Environmental Protection Agency
ºF	degrees Fahrenheit
FFS	focused feasibility study
FS	feasibility study
ft	foot (feet)
gpm	gallons per minute
GIS	geographic information system
GRO	gasoline range organics
HI	hazard index
H_2S	hydrogen sulfide
HQ	hazard quotient
HTRW	hazardous, toxic, and radiological waste

List of Acronyms *(Continued)*

ICI	International Consultants, Inc.
ID	inside diameter
IDW	investigation-derived waste
ILCR	incremental lifetime cancer risk
IT	IT Corporation
MCL	maximum contaminant level
MDC	maximum detected concentration
MK	Morrison Knudsen Corporation
ml/min	milliliters per minute
MNTA	Maintenance Shop Area
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
NASA	National Aeronautics and Space Administration
OD	outside diameter
ODNR	Ohio Department of Natural Resources
OEPA	Ohio Environmental Protection Agency
PAH	polynuclear aromatic hydrocarbon
PBOW	Plum Brook Ordnance Works
PBS	Plum Brook Station
PCB	polychlorinated biphenyl
PETN	pentolite
ppm	parts per million
PRRWP	Pentolite Road Red Water Ponds
PVC	polyvinyl chloride
QAPP	quality assurance project plan
RBSC	risk-based screening concentration
RDX	cyclotrimethylenetrinitramine
RGO	remedial goal option
RI	remedial investigation
SAIC	Science Applications International Corporation
SAP	sampling and analysis plan
SCS	Soil Conservation Service
Shaw	Shaw Environmental, Inc.
SLERA	screening level ecological risk assessment

List of Acronyms (Continued)

SOW	scope of work
SVOC	semivolatile organic compound
TNB	trinitrobenzene
TNT	trinitrotoluene
TNTA	TNT Area A
TNTB	TNT Area B
TNTC	TNT Area C
USGS	U.S. Geological Survey
UTT	Upper Toluene Tanks
VOC	volatile organic compound
USACE	U.S. Army Corps of Engineers
WARWP	West Area Red Water Ponds
yd^3	cubic yards

Executive Summary

The U.S. Army is conducting studies of the environmental impact of suspected hazardous waste sites at properties previously owned by the U.S. Department of Defense (DOD). The former Plum Brook Ordnance Works (PBOW), located in Sandusky, Erie County, Ohio, is currently being investigated under the Defense Environmental Restoration Program for Formerly Used Defense Sites. This 9,000-acre facility was used for the manufacture of explosives during World War II. The site is currently owned by the National Aeronautics and Space Administration (NASA) and is operated as the Plum Brook Station (PBS) of the John Glenn Research Center, located in Cleveland, Ohio.

The investigation is being managed and technically overseen by the Nashville, Tennessee and Huntington, West Virginia District Offices of the U.S. Army Corps of Engineers (USACE). Shaw Environmental, Inc. (Shaw) (formerly IT Corporation [IT]) was contracted by the USACE, Nashville District to conduct a groundwater remedial investigation (RI) for the following site areas:

- TNT Area A (TNTA)
- TNT Area B (TNTB)
- TNT Area C (TNTC)
- West Area Red Water Ponds (WARWP)
- Pentolite Road Red Water Ponds (PRRWP).

This report assimilates data that was generated during the 2003 off-site, background monitoring well installation, 4 phases of 2004 field activities, data from the 10th quarterly background groundwater sampling event, and data from 2 downgradient groundwater quarterly sampling events. Also included in this report are the background bedrock groundwater screening concentrations for benzene, toluene, ethyl benzene, and total xylenes (BTEX) and inorganics that were generated from analytical results of the background monitoring wells. (Note: BTEX concentrations are interpreted to be from natural sources and not site related. Regardless, BTEX and polynuclear aromatic hydrocarbons will not be eliminated in the sitewide groundwater risk assessment. Information concerning the origin of natural hydrocarbons found in the groundwater in the Delaware Limestone bedrock monitoring wells is located in Sections 6.2, 6.2.2, and 8.3 in this report.) Groundwater analytical results from 4 site-wide sampling events along with 2 downgradient groundwater sampling events are compared to October 2004 risk-based screening concentrations (RBSC) and calculated background screening concentrations (BSC). Specific field activities that are documented in this report include: installation of 2 background and 2

downgradient monitoring wells; development, groundwater sampling and aquifer testing of the newly installed wells; and, 1 round of quarterly background groundwater sampling and 2 rounds of downgradient well groundwater sampling. Field activities were conducted pursuant to the following documents: Site-Specific Sampling and Analysis Plan, Site-Specific Safety and Health Plan, the Site-Wide Sampling and Analysis Plan (SAP), Quality Assurance Project Plan (QAPP), and Site-Wide Safety and Health Plan.

From rainfall precipitation data and water run-off and groundwater recharge calculations, time periods have been established to determine when the greatest volume of groundwater may be expected in the monitoring wells at PBOW. January through June was determined to be the period when the greatest amount of groundwater is present at the PBOW site and is, thus, referred to as the "wet season". July through December was determined to be the time period when the least amount of groundwater would be present; therefore, this time period is called the "dry season". Sampling events at PBOW were scheduled to collect groundwater from monitoring wells during the wet and dry seasons to determine if any seasonal trends may be present. Using groundwater sampling analytical results from 10 rounds of background groundwater sampling during "wet and dry" time periods along with associated water quality parameters, no seasonal trends were evident.

Groundwater samples were collected over a 6-year period from six bedrock wells in assumed background locations. These wells were BED-MW20, BED-MW24, BED-MW25, BED-MW28, BED-MW29, and BG8-BEDGW-001. Review of analytical data, field observations, and groundwater flow direction indicated that two of these wells were either downgradient of potential source areas (BED-MW24) or were impacted by anomalous natural gas (BED-MW20). Therefore, groundwater analytical results from the remaining background wells BG8-BEDGW-001, BED-MW25, BED-MW28, and BED-MW29 were used to establish background concentrations for naturally occurring BTEX and for inorganic constituents.

BSC values were developed for PBOW groundwater using the analytical results only from unfiltered background groundwater samples that were collected by the low-flow sampling methodology. Either upper tolerance limit or the maximum detected concentration, whichever was lower, of each analyte reported compound was selected as the BSC value. The respective BTEX and inorganics BSC values are listed below.

VOCs	BSC (µg/L)
Benzene	2.4
Ethyl benzene	0.87
Toluene	1.7
Total Xylenes	5.5

Metals – Unfiltered	BSC (µg/L)	Metals – Unfiltered	BSC (µg/L)
Aluminum	309	Iron	1,550
Arsenic	7.4	Magnesium	217,000
Barium	11,800	Manganese	636
Calcium	316,000	Nickel	8.6
Cobalt	12.1	Potassium	116,000
Copper	19.8	Sodium	1,390,000
		Zinc	507

µg/L – Micrograms per liter.

Overburden/Shale Water-Bearing Zone

Analytical results from 104 groundwater samples from the overburden/shale at 6 areas of concern (AOC) have been evaluated against RBSC and BSC values. Groundwater samples were collected from monitoring wells and direct-push operations during previous investigations. The sporadic, discontinuous, seasonally dependant shallow water-bearing zone at PBOW has been impacted as described in the following paragraphs.

Nitroaromatic Compounds. Nitroaromatic compounds were consistently in the overburden/shale groundwater above RBSC values at TNTA, TNTB, TNTC, PRRWP, and WARWP during both wet and dry time periods. Based on the nitroaromatic detections of 2A-4,6-dinitrotoluene (DNT) and 4A-2,6-DNT, site conditions indicate that a natural biodegradation of 2,4,6-TNT, 2,4-DNT, and 2,6-DNT may be taking place.

Organic Compounds. Organic compounds were consistently detected in the overburden/shale groundwater above RBSC and/or BSC values at TNTA, TNTB, TNTC, PRRWP, and WARWP during both wet and dry time periods. Most common organic detections at the 4 AOCs were nitroaromatics, detected as semivolatile organic compounds (SVOC). Tetrachloroethene and trichloroethene were detected in the groundwater at PRRWP, WARWP, and the Additional Burning Ground Area (ABG) during wet season direct-push activities. Three polynuclear aromatic hydrocarbons benzo(a)pyrene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene were detected at the ABG above RBSCs during dry season well sampling. These compounds are indicative of previous burning activities and may be attributable to site contamination.

Inorganic Compounds. Inorganic compounds were consistently detected above RBSC and/or BSC values in the overburden/shale groundwater at TNTA, TNTB, TNTC, PRRWP, and WARWP. In the unfiltered phase, inorganics included aluminum, arsenic, copper, chromium, iron, lead, manganese, thallium, and vanadium. Many of the metals were removed during the field filtration process but several metals (arsenic, iron, lead, manganese, and thallium) remained above the RBSC and/or BSC values in the groundwater at many of the AOCs. Lead was detected above the RBSC during the wet season at TNTB and PRRWP. Both lead detections may be indicative of site contamination, typically a result from former lead lined building floors.

The shallow water table extends into the upper severely to moderately weathered shale from the central portion of the facility to the south-central and southwestern areas. In the southeastern portion of the site, overburden/shale groundwater flow appears to have a relatively uniform horizontal hydraulic gradient to the east-northeast. Overburden/shale groundwater in the central portion of the facility generally flows to the north and discharges to both Ransom and Plum Brook. On the north side of the site, the flow is toward Ransom Brook and a wetland area located southwest of the Reactor Facility Area. Groundwater in the western panhandle of PBOW flows to the north-northwest and discharges to Pipe Creek. In the far northwest corner of PBOW, a groundwater divide is present (marked by Pipe Creek) where overburden/shale groundwater is interpreted to flow in a southwest direction, toward Pipe Creek. Since the initial water level measurements taken in December 1994 (applicable only to wells installed at that time), groundwater elevations in the overburden/shale wells have had variable water level elevations. The minimum change was seen in shale bedrock background well BED-MW29 with a change of 1.21 feet while the maximum change was 25.03 feet in well TNTC-MW04 (at TNTC) (Table 6-1). The average fluctuation of water levels in the overburden/shale monitoring wells was 6.65 feet. Groundwater elevations in the overburden fluctuate seasonally, irrespective of the area of the site. Consistent fluctuations in other overburden wells may imply a significant horizontal connectivity across the overburden water-bearing zone and that water levels are controlled by regional fluctuations in the bedrock groundwater elevations.

Delaware Limestone Water-Bearing Zone

Analytical results from 46 groundwater samples collected from the Delaware Limestone at 10 AOCs have been evaluated against RBSC and BSC values. Bedrock groundwater samples were collected from monitoring wells during previous investigations. The Delaware Limestone water-bearing zone at PBOW has also been impacted by nitroaromatic, organic, and inorganic contaminants to different extents by past site activities, although to a lesser degree than the overburden/shale water-bearing zone.

Nitroaromatic Compounds. No nitroaromatics were detected in the groundwater of monitoring wells located on properties outside of the PBOW facility. Nitroaromatic compounds were consistently detected in the bedrock groundwater above RBSC values at TNTA, TNTB, and PRRWP during both wet and dry time periods. Nitroaromatics were detected at AOCs Acid Area 1 (AA1), Acid Area 2 (AA2), Maintenance Shop Area (MNTA), and the Upper Toluene Tanks (UTT) Area during previous investigations, but were encountered during only 1 sampling event. Additional sampling at these AOCs should be conducted to determine the presence or absence of any nitroaromatic contamination.

As noted in the overburden/shale water-bearing zone, nitroaromatic detections of 2A-4,6-DNT and 4A-2,6-DNT indicate that a natural biodegradation of 2,4,6-TNT, 2,4-DNT, and 2,6-DNT may be taking place.

Organic Compounds. Organic compounds were consistently detected in the Delaware Limestone groundwater above RBSC and/or BSC values at nearly all of the AOCs investigated (TNTA, TNTC, PRRWP, WARWP, AA1, AA2, Acid Area 3 (AA3), MNTA, and UTT) during both wet and dry time periods. BTEX compounds, methylene chloride, naphthalene, and 2-methylnaphthalene at concentrations above RBSC and/or BSC values were encountered in nearly all of the bedrock monitoring wells sampled at the AOCs, except at WARWP. However, these compounds are typically found in the Delaware Limestone groundwater due to the presence of naturally occurring petroleum hydrocarbon in the Delaware Limestone bedrock formation. Benzene concentrations above the RBSC and BSC ranged from 5.7 µg/L (TNTA well BED-MW18, November 1997 dry season) to 2,500 µg/L (PRRWP well BED-MW23, April 2002 wet season).

At the WARWP, monitoring well BED-MW14 exhibited SVOCs that may be site related. Five nitroaromatics recorded as SVOCs (2,4-DNT [May 1998], 4,6-dinitro-2-methylphenol [May 1998], 2,4-dinitrophenol [May 1998 and April 2002], nitrobenzene [May 1998], and 3-nitroaniline [April 2002]) may have impacted the bedrock groundwater as a result of past site activities. Other organics exceeding screening levels that may be considered related to former DOD site activities are chloromethane (AA2), bromomethane (AA2 and AA3), trichloroethene (MNTA), 1,1,2-trichloroethane (PRRWP), and toluene (UTT). The SVOC detected most frequently above RBSCs at all AOCs except the WARWP was bis(2-ethylhexyl)phthalate, a common laboratory contaminant.

Inorganic Compounds. Inorganic compounds were consistently detected in the Delaware Limestone groundwater above RBSC and/or BSC values at the AOCs investigated. In the unfiltered phase, inorganics included aluminum, arsenic, barium, chromium, iron, manganese, nickel, and thallium. Many of the metals were removed during the field filtration process but several metals (arsenic, barium, iron, manganese, and thallium) remained above the RBSC and/or BSC values in the groundwater at many of the AOCs.

Groundwater flow direction in the Delaware Limestone bedrock is predominantly to the northeast in the eastern half of PBOW and to the northwest in the far western corner and central western section. Groundwater exits PBOW northeast of the reactor facility and flows in a north-northeast direction toward Lake Erie. Groundwater flow on the western side of PBOW is thought to be influenced by sump pumps at the reactor facility and structure of the Delaware Limestone.

Wells monitoring the Delaware Limestone showed significant variability in hydraulic conductivity. Hydraulic conductivity from slug tests completed in wells screened in the range from 0.002 (former well BED-MW27) to 1.84 feet per day (ft/day) (BED-MW24). A downward vertical gradient is present between the overburden/shale water-bearing zone and the Delaware bedrock.

Three quarries mining the Delaware Limestone in the vicinity north of PBOW are reported to have encountered naturally occurring petroleum hydrocarbons and knowingly have encountered hydrogen sulfide (H_2S) gas. Free-phase hydrocarbons and ethyl benzene BTEX compounds detected in the groundwater of PBOW bedrock monitoring wells are interpreted to have the same origin based on the following observations:

- The majority of wells with hydrocarbons detections are screened in the Delaware Limestone.
- Hydrocarbon-contaminated monitoring wells are widespread throughout PBOW, rather than being limited to only specific site areas.
- Drilling bore log notes indicate that hydrocarbons were encountered while drilling in the Delaware Limestone bedrock.
- Photographs show petroleum hydrocarbon on Delaware Limestone rock cores.
- The detection of hydrogen sulfide associated with the hydrocarbon that is found in the Delaware Limestone.

Discussions with the Ohio Department of Natural Resources, Division of Geological Survey, indicated there are producing oil wells in Erie County. These oil wells reportedly are pumping from the Delaware Limestone and the Columbus Limestone.

Based upon conclusions from groundwater analytical results during this investigation, the following are recommended:

- Toluene was detected at elevated concentrations in well MK-MW20 in the UTT area. Based on the relative absence of other aromatic hydrocarbons, the source of the contamination is interpreted to be from toluene storage used in the production of nitroaromatics. Based on these findings, further evaluation is warranted.

- Monitoring wells have not been installed at the Middle Toluene Tanks Area. Based upon the results from the UTT Area, consideration should be given to the installation of overburden water-bearing zone wells at the Middle Toluene Tank Area (assessment of possible toluene contamination in overburden groundwater) and bedrock wells at the Middle and Lower Toluene Tank Areas (assessment of possible toluene contamination in bedrock groundwater), if deemed necessary.

- Installation of one additional bedrock monitoring well in the PRRWP Area to monitor bedrock contamination.

- With consistent nitroaromatic contamination in overburden/shale well MK-MW17, the location of the well at the mouth of Ransom Brook, additional surface water samples should be collected in Ransom Brook during periods of groundwater discharge to verify no impact to the stream.

- During the 2000 RI soil sampling activities, a total of 9 open manholes (3 at TNTA and 6 at TNTC) were discovered. Several open manholes were also discovered in AA3 during recent investigations. For health and safety reasons, Shaw recommends a sitewide sweep of PBOW be conducted to identify the location of all former DOD open manholes followed by proper abandonment.

Planned Activities

- Complete site-wide groundwater model (2005).
- Complete site-wide groundwater risk assessment (2005).

1.0 Introduction

The U.S. Army is conducting studies of the environmental impact of suspected hazardous waste sites at properties previously owned by the U.S. Department of Defense (DOD). The former Plum Brook Ordnance Works (PBOW), located in Sandusky, Erie County, Ohio, is currently being investigated under the Defense Environmental Restoration Program for Formerly Used Defense Sites. Figure 1-1 shows the geographical location of the former PBOW site. This 9,000-acre facility was used for the manufacture of explosives during World War II. The site is currently owned by the National Aeronautics and Space Administration (NASA) and is operated as the Plum Brook Station (PBS) of the John Glenn Research Center.

The investigation is being managed and technically overseen by the Nashville, Tennessee and Huntington, West Virginia District Offices of the U.S. Army Corps of Engineers (USACE). Shaw Environmental, Inc. (Shaw), (formerly IT Corporation [IT]) was contracted by the USACE, Nashville District to conduct a groundwater remedial investigation (RI) at two red water pond areas and three former trinitrotoluene (TNT) manufacturing areas. The two red water pond areas are the West Area Red Water Ponds (WARWP) and the Pentolite Road Red Water Ponds (PRRWP). The three former TNT manufacturing areas are TNT Area A (TNTA), TNT Area B (TNTB), and TNT Area C (TNTC).

Initial work was performed under Delivery Order (DO) 0010 of Contract Number DACA62-00-D-0002 while reporting was conducted under DO 0014 of the same contract number. In January 2003, DO 0021 was issued under the same contract number which expanded the investigation relative to the TNT manufacturing areas and Red Water Ponds to areas beyond NASA's PBS boundaries in both the upgradient and downgradient groundwater flow direction. RI reporting for this work is conducted under DO 0021.

This document (2004 Groundwater Data Summary and Evaluation Report) is Volume 1 of 2 planned volumes. Volume 1 consists of 2 parts; text, tables, and figures are included in Part 1 and Appendices A through O are included in Part 2. This volume (Volume 1) presents final evaluations, conclusions, and recommendations for the RI and background evaluation from data attributable to the TNT manufacturing areas and Red Water Ponds at both on-site and off-site areas. It also presents background screening concentrations (BSC) for PBOW bedrock groundwater and their derivation. These BSCs will be used as a comparison and evaluation tool for on-site and off-site analytical results. Volume 2 will be the Baseline Human Health Risk Assessment (BHHRA) of groundwater, which will be submitted under a separate cover. The

BHHRA report will be prepared by Shaw and will describe all points and findings of the BHHRA with respect to the TNT manufacturing areas and Red Water Ponds.

Background groundwater analytical results are included in tables of this report; however, full data dumps are not included because they have been provided with previously issued quarterly reports. Data collected from 2001 (first quarterly background sampling event) through 2004 (ninth quarterly background groundwater sampling event) as well as discussion of field activities and quarterly background groundwater analytical can be found in the reports as identified below. Note that the quarterly background groundwater sampling was timed to monitor seasonal changes in groundwater quality. Precipitation data of the Sandusky area were used to determine two general seasons of groundwater recharge (Chapter 6.0): a wet season (January through June) and a dry season (July through December). Reports identifying field activities and analytical results completed in 2001 through 2004 are listed below:

- 2001 Groundwater Remedial Investigation (IT, 2002a). Background bedrock monitoring wells were installed and the first quarterly background sampling event was conducted in September-October 2001 (dry season).
- Second Quarterly Background Report (IT, 2002b). Second quarterly background groundwater sampling event was conducted in January 2002 (wet season).
- Third Quarterly Background Report (IT, 2002c). Third quarterly background groundwater sampling event was conducted in April 2002 (wet season).
- 2002 Groundwater Data Summary and Evaluation Report (Shaw, 2003a). Fourth quarterly background groundwater sampling event was conducted in July 2002 (dry season).
- Fifth Quarterly Background Groundwater Report (IT, 2003a). Fifth quarterly background groundwater sampling event was conducted in September 2002 (dry season).
- Sixth Quarterly Background Groundwater Report (Shaw, 2003b). Sixth quarterly background groundwater sampling event was conducted in April 2003 (wet season).
- Seventh Quarterly (September 2003) Background Groundwater Report (Shaw, 2003c). Seventh quarterly background groundwater sampling event was conducted in September 2003 (dry season).

- Eighth Quarterly (December 2003) Background Groundwater Report (Shaw, 2004a). Eighth quarterly background groundwater sampling event was conducted in December 2003 (dry season).

- Ninth Quarterly (March 2004) Background Groundwater Report (Shaw, 2004b). Ninth quarterly background groundwater sampling event was conducted in March 2004 (wet season).

In addition, quarterly groundwater elevation measurements were also conducted by International Consultants, Inc. (ICI) to support ongoing investigation and remediation activities at PBOW. This information, critical to the evaluation of groundwater flow and contaminant transport, is incorporated into this report.

The field activities completed by Shaw were conducted pursuant to the following documents: Site-Specific Sampling and Analysis Plan, Site-Specific Safety and Health Plan (Shaw, 2003d), Site-Wide Sampling and Analysis Plan (SAP) (IT, 1996a), Quality Assurance Project Plan (QAPP) (IT, 1996b), and the Site-Wide Safety and Health Plan (IT, 1996c).

1.1 Scope of Work and Project Objectives

The scope of the RI included the preparation of a quality control plan and site-specific addenda to the site-wide SAP and safety and health plan, monitoring well installation, monitoring well development, in-situ permeability determination, groundwater sampling, soil sampling, analytical work, investigation-derived waste (IDW) management and disposal, and preparation and submittal of quarterly background groundwater reports. Based on the findings of previous investigations, this report presents both historical groundwater data (pre-2004) and new groundwater data obtained as part of this groundwater RI. Groundwater information that was collected during these investigations will also be used to support groundwater modeling activities; the groundwater flow and fate and transport model is scheduled to be submitted in 2005 (USACE, 2001). Figure 1-2 identifies the five investigated areas of concern (AOC); TNTA, TNTB, TNTC, WARWP, and PRRWP in relation to other AOCs and site features.

The objectives of this investigation included the following:

- Define site physical features and characteristics (background conditions).

- Evaluate fate and transport pathways through sitewide groundwater modeling (anticipated to be completed in 2005).

- Define current and future routes of exposure.

- Determine if hazardous substances are present at the site at concentrations that may exceed risk-based screening values.
- Determine the nature and extent of source areas.
- Determine whether contaminant distribution is consistent with former DOD activities.
- Establish naturally occurring levels of inorganics in PBOW groundwater to use in screening site data in risk assessments.

1.2 Report Organization

Chapter 2.0 of this report describes the PBOW site, its physical setting, geology, and hydrogeology features. Previous investigations of TNTA, TNTB, TNTC, WARWP and the PRRWP are found in Chapter 3.0. Sampling strategy and field procedures are described in Chapter 4.0. The analytical program and background comparison data are presented in Chapters 5.0 and 6.0, respectively. Chapter 7.0 describes analytical results for each area. Chapter 8.0 presents bedrock groundwater conclusions. Recommendations are provided in Chapter 9.0. References that were used in preparing the report are listed in Chapter 10.0.

All appendices are contained in Volume 1, Part 2. Groundwater sample collection logs generated during the investigation are included in Appendix A. Soil boring and monitoring well drill logs and well construction diagrams, site photographs, and well development logs are provided in Appendices B, C, and D, respectively. Appendix E contains hydraulic conductivity data while Appendix F contains land survey data. Appendix G presents copies of waste manifests used for disposal of the IDW. Appendices H through K contain analytical data pertinent to the downgradient (May and August 2004) and background (June 2004) sampling events. Appendix L presents the Chains-of-Custody for laboratory analysis. Background groundwater summary statistics are tabulated and described in Appendix M. Appendix N presents a teleconference note on local benzene, toluene, ethyl benzene, and total xylenes (BTEX) and an e-mail message on active oil/gas fields. Appendix O presents recharge calculations for PBOW. Appendix P provides comments and responses from Shaw's internal review.

1.3 Facility Location and Description

The former PBOW site is currently owned by NASA and is operated as the PBS of the NASA John Glenn Research Center, which is located at Lewis Field in Cleveland, Ohio. Most of the aerospace testing facilities built at the site in the 1960s are in standby or inactive status. The site

is located approximately 4 miles south of Sandusky, Ohio, and 59 miles west of Cleveland. Although primarily in Perkins and Oxford Townships, the eastern edge of the site extends into Huron and Milan Townships. PBOW is bounded on the north by Bogart Road, on the south by Mason Road, on the west by Patten Tract Road, and on the east by U.S. Highway 250. The areas surrounding PBOW are mostly agricultural and residential. Public access is restricted at PBOW except during the annual deer hunting season.

1.4 Site History and Potential for Contamination

The PBOW site was built in early 1941 as a manufacturing plant for 2,4,6-TNT, dinitrotoluene (DNT), and pentolite (PETN). Production of explosives began on December 16, 1941 and continued until 1945. It is estimated that more than one billion pounds of explosives were manufactured during the 4-year operating period.

The United States Army began decontamination and decommissioning of all TNT, DNT, and PETN lines in September 1945. Three areas manufactured TNT and DNT (TNTA, TNTB, and TNTC) and one area manufactured PETN (Figure 1-2). TNTA consisted of manufacturing lines 1 through 4, TNTB lines 5 through 7, and TNTC lines 8 through 12. TNTA is located on the northeast side of PBOW, TNTB at the southern central part, and TNTC at the southwestern side of PBOW. The PETN manufacturing area is located in the north-central portion of PBOW and lies within the boundaries of Ransom Road on the west, Pentolite Road on the south, and Patrol Road on the north and east. The central portion of the former PETN manufacturing area is occupied by NASA's in-active nuclear reactor. The PETN Area contained three PETN lines with a designated capacity of 7,000 pounds per 24 hours (Morrison-Knudsen Corporation [MK], 1994; Science Applications International Corporation [SAIC], 1995). The nuclear reactor is presently being decommissioned with a completion date estimated in July 2007.

Typical decontamination and decommissioning methods of all the manufacturing lines involved removing and relocating any explosive waste from the buildings or structures to a burning ground for open burning. Above-ground portions of buildings and structures were demolished and burned where possible. Based on soil investigations completed at the TNT areas, at least portions of the concrete foundations remain in place. Steam lines used for facility heating and associated building drain lines were flushed and dismantled, but no record was found indicating the wash-out location. By December 1945, it was estimated that 65 percent of the necessary decontamination was complete (MK, 1994).

From January 1 to June 30, 1946, the USACE assumed responsibility for maintenance and custodial activities. Further decontamination activities were conducted, and the extent of contamination was certified (MK, 1994).

In the summer of 1955, a significant effort was made by the USACE through Ravenna Arsenal to decontaminate the surface and subsurface soil at the TNT Areas (Dames and Moore, Inc. [D&M], 1997a). Decontamination was performed first at TNTA. The decontamination process at TNTA included the removal of contaminated surface and subsurface soil around the wash houses, bi-tri houses, fortifier buildings, DNT sweating and graining building, DNT nitrating building and nail houses. They also removed wooden and ceramic waste disposal lines containing from 1.0 to 2.5 inches of TNT. In addition, concrete catch basins containing thousands of pounds of TNT were discovered overlain by wood and scrap lumber. This lumber and TNT was removed and transported to the Burning Grounds where it was burned. Decontamination of TNTB and TNTC was supposed to be modified to address only surface contamination detected by visual inspection leaving underground flumes in place. It is unknown whether this modification in the procedure took place as part of the 1955 decontamination of TNTB and TNTC (D&M, 1997a).

NASA acquired PBOW on March 15, 1963 and currently utilizes the site. The General Services Administration decontaminated the TNT Manufacturing Areas to facilitate transfer. The decontamination is believed to have occurred in 1963 (D&M, 1997a) and work was accomplished in five steps:

1. Inspecting then removing contaminated surface soil above the drain tiles, flumes, etc.

2. Spot checking of subsurface soil in the vicinity of drain tiles, flumes, etc., to determine where the contaminated tiles and flumes were located. Where contamination was found, the flumes, tiles, etc., were removed in sections.

3. Removal of some items previously decontaminated to three X (XXX) condition to a storage facility and additional decontamination of the remainder of the items to a five X (XXXXX) condition in order to be sold ("X" indicates the Army's specific decontamination level).

4. Destruction of all buildings by fire then removal of all debris and concrete foundations. All the materials were flashed in those areas, including the earth, and the area was then rough-graded. As previously noted, recent soil investigations at the TNT areas suggest that at least portions of the concrete building foundations remain in place.

5. Decontamination of all sump basins and removal of the concrete.

The decontamination process also included the burning of nitroaromatic-filled flumes that were excavated. As shown in the records review (D&M, 1997b) this was performed on July 10, 1963, near the intersection of Fox Road and Snake Road.

On April 18, 1978, NASA declared approximately 2,152 acres of land as excess. The Perkins Township Board of Education acquired 46 acres of the excess for use as a bus transportation center. The General Services Administration retains the remaining acreage and currently has a use agreement with the Ohio National Guard for 604 acres of the land. NASA presently controls about 6,400 acres and is using the site to conduct space research as a satellite operation of the John Glenn Research Center based in Cleveland, Ohio. The details of these land transactions are listed in the site management plan and can be found at NASA PBS.

Based on review of historical use of the site and soil and groundwater findings from previous investigations, contaminants related to the manufacture of nitroaromatic explosives are present at PBOW. These potential contaminants include: nitroaromatic compounds, volatile organic compounds (VOC), semivolatile organic compounds (SVOC), cyanide, and inorganics.

2.0 Physical Setting

2.1 Geography, Topography, and Surface Drainage

PBOW is located within the Eastern Lake Region of the Central Lowland Province (Soil Conservation Service [SCS], 1971). Erie County is overlain by lacustrine sediment, glacial outwash, and glacial till. The surface is a plain with a slight slope to the north-northeast toward Lake Erie at approximately 25 feet (ft) per mile. Elevations at the site range from 680 ft above mean sea level at the intersection of Taylor Road and Patrol Road on the southwestern side of the site to 625 ft above mean sea level at the northern portion of the installation (Figure 2-1). In general, the topography of PBOW is characterized by a flat ground surface with occasional low hummocks caused primarily by glacial scouring and deposition. A low escarpment trends from the western to the northeastern portion of the site.

PBOW lies in the eastern region of the Pickeral Creek-Pipe Creek Basin, which is part of the St. Lawrence River drainage basin (D&M, 1997a). Eleven streams exist within PBOW and flow north-northeast toward Lake Erie, which is located approximately 3.5 miles north of the site. The site is part of four drainage areas: (1) Sawmill Creek (southern PBOW); (2) Plum Brook (central PBOW); (3) Pipe Creek (western PBOW); and (4) Storrs-Hemminger Ditch (north central PBOW), all of which flow into Sandusky Bay (D&M, 1997b). Surface water for TNTA specifically drains into ditches that are tributaries to Lindsley Ditch, which eventually drains (off site) into Plum Brook. Surface water on the northern side of TNTB drains to ditches that are tributaries to Ransom Brook while surface water on the southern side of TNTB drains to tributaries flowing into Plum Brook. Surface water at TNTC flows into tributaries which flow into Pipe Creek. Surface water drainage at the WARWP flows into tributaries for Pipe Creek while surface water at the PRRWP is drained by tributaries for Plum Brook. The drainage pattern is dendritic where streams are incised into bedrock and is poorly developed where they have not yet eroded to the bedrock. Two drainages at the site, Kuebler Ditch and Plum Brook are being monitored by NASA PBS for National Pollutant Discharge Elimination System outfall permits. In addition to the streams, 17 isolated ponds and reservoirs and former red water ponds are located at PBOW (U.S. Geological Survey [USGS], 1992; D&M, 1997b).

2.2 Geology and Soils

2.2.1 Regional Geology

The bedrock in northern Ohio consists of Devonian and Silurian carbonates (limestone and dolomite) and clastics (shale, siltstone, and sandstone). These units unconformably overlie older

sedimentary sequences of Ordovician and Cambrian Age rocks, which in turn unconformably overlie pre-Cambrian basement rocks (D&M, 1997a). The local bedrock is situated on the eastern flank of the Findlay Arch. In the Devonian and Silurian of northern and western Erie County, weathering of the carbonates has produced cavernous porosity and karst topography.

2.2.2 Local Geology

Three formations, all of Devonian Age, outcrop across the PBOW site (Figure 2-1). Each of the units discussed below were encountered in the upper 100 ft of bedrock along the lines of section presented in Figure 2-2. Two-dimensional cross sections presenting data in three dimensions were prepared from the monitoring well and soil boring lithologic data and are shown on Figures 2-3 through 2-8.

The Delaware limestone is the lowermost formation screened by site wells. It is characterized as a hard, dense, finely crystalline limestone and dolomite. The unit is typically buff colored, massive and usually is described as fossiliferous. In the vicinity of PBOW, quarries (Hanson Aggregates to the north, Hanson-Sandusky Crushed Stone to the southwest, and abandoned Castalia quarry to the west) mine limestone from the Delaware. Traces of natural petroleum-derived hydrocarbons and hydrogen sulfide (also known as H_2S) are common in all 3 quarries. Overlying the Delaware Limestone is the Olentangy Shale. Geographic Information System (GIS) data calculations indicate that the Olentangy shale of PBOW dips to the southeast at a slope of approximately 21.1 ft per mile. Two members of the Olentangy Shale have been characterized at the site, the Plum Brook Shale and the overlying Prout Limestone. The Plum Brook Shale is interpreted to consist of approximately 35 ft of bluish-gray, soft, fossiliferous shale containing thin layers of dark, hard, fossiliferous limestone. The Prout Limestone has been described as an approximate 15 to 50- foot thick unit which occasionally outcrops in a 1,000-to-2,000-foot-wide, northeast-striking band across the middle portion of PBOW. It is described as a dark-gray to blue, very hard, siliceous, fossiliferous limestone or dolomitic mudstone. The uppermost formation at the site is the Ohio Shale. GIS data show that the Ohio Shale dips to the southeast at a slope of approximately 26.4 ft per mile. Only one member of the Ohio Shale is present in the PBOW area, the Huron Shale. This unit has been described as black, thinly bedded, with abundant carbonaceous matter. Some large pyrite/carbonate concretions are also present in the Huron Shale, some as large as 6 ft in diameter (D&M, 1997a).

To aid in the geologic and hydrogeologic interpretation of the site, lithologic data from 109 off-site drinking water wells were obtained from the Ohio Department of Natural Resources (ODNR) office in Columbus, Ohio, to better determine thickness of the overburden, which

overlies the shale and Delaware limestone. Also, review of this lithologic data assisted in gaining a better understanding of off-site groundwater flow. Table 2-1 presents a summary of the data obtained from the wells. The location of most of the drinking water wells has not been surveyed. An ODNR figure showing the location of each well was transferred to a Shaw map permitting approximate survey coordinates to be measured. Figure 2-1 shows the location of the drinking water wells and environmental monitoring wells. Lithologic information for the drinking water wells shown on Table 2-1 was obtained from bore logs that were created during well installation by non-Shaw personnel, normally the lead driller. An area-wide top-of-shale elevation contour map is presented in Figure 2-9. The top-of-shale elevation used in construction of the map is the elevation of the first shale encountered in the borehole and may be either the Plum Brook shale or the Ohio shale, depending on the location of the borehole. An area-wide top-of-Delaware limestone elevation contour map is presented on Figure 2-10 and an area-wide overburden thickness contour map is presented in Figure 2-11. Contouring of elevations of the top-of-shale and top-of-Delaware from private drinking water wells was not included on the elevation contour maps where the data appeared questionable when plotted on the figure.

2.2.3 Local Soils

The bedrock overburden in Erie County is predominantly glacial till, glacial outwash, or glacial lacustrine (lake) deposits. In the vicinity of PBOW, the soil has been interpreted as lacustrine. In many areas, the overburden also consists of highly weathered shale bedrock. The thickness of the overburden ranges from 1 foot to greater than 25 ft. As shown on Figure 2-11, overburden soil is thickest on the northern portion of the site in the vicinity of the Reactor Facility, where it has filled in a bedrock low.

The 1971 SCS *Soil Survey for Erie County* mapped four soil associations on PBOW (in order of areal percentage) as the Prout, Arkport-Galen, Del Rey-Lenawee, and Lewisburg (SCS, 1971). More recently, the ODNR revised the soil associations in the county, which also changed the soil associations at PBOW. As shown in the 1994 report (ODNR, 1994), the soil in the northwest portion of the PBOW site is now placed within the Kibbie-Elnora-Tuscola-Colwood Association that is described as nearly level to gently sloping. The soil is described as somewhat poorly drained, moderately well drained, and very poorly drained soils formed in outwash, lacustrine, and deltaic sediments. Along a strip from west to northeast across the site is the Castalia-Millsdale-Milton-Ritchey Association. This association is described as shallow to moderately deep, nearly level to moderately steep, well-drained and very poorly drained soils formed in glacial till, lacustrine sediments, and limestone residuum. Across much of the central portion of

the site is the Hornell-Fries-Colwood Association, described as moderately deep to deep, nearly level to gently sloping, somewhat poorly drained to very poorly drained soils formed in glacial till and lacustrine sediments over shale bedrock. At the extreme southeast portion of PBOW is the Pewamo-Bennington Association, described as nearly level to gently sloping, very poorly drained and somewhat poorly drained soils formed from glacial till and lacustrine sediments.

2.2.4 Hydrogeology

2.2.4.1 Current Groundwater Usage

The majority of residents in Erie County receive water from public utilities whose sources are surface water. Residences to the north and east of PBOW are connected to city, county, or rural services. Erie County's primary groundwater source is from the limestone and dolomite aquifer found in the western end of the county. Groundwater wells in the central and eastern portions of the county tap lower yielding shale and sandy zones in the overburden (D&M, 1997a). Some wells surrounding PBOW are used for agricultural purposes, including irrigation, which could have an effect on drawdown near the site (ICI, 1995). A few wells in the vicinity of PBOW were determined to be used for private and public consumption (SAIC, 1991); however, none within the facility boundary are used. The nearest private well to PBOW is approximately 840 ft to the northeast and the use of the well is unknown (Figure 2-1).

2.2.4.2 Regional Hydrogeology

Regional groundwater flow is to the north-northeast towards Lake Erie, although local flow may vary due to local topography. Water in the limestone typically occurs in joints and along bedding planes or in solutionally enlarged openings. Although some limestones in the middle of the county provide well yields of up to 500 gallons per minute (gpm), the overburden and the majority of the other formations can sustain groundwater pumping of only 10 gpm or less (D&M, 1997b). A hydrogeological study by the USGS conducted on the glacial deposits in Sandusky in 1990 reported a horizontal hydraulic conductivity of 0.046 ft/day and a vertical hydraulic conductivity of 1.2 ft/day (USGS, 1992).

2.2.4.3 General Site Hydrogeology

At PBOW, the bedrock groundwater has been divided into three zones based on location and yield. Zone 1 occurs in the north and northwestern portion of PBOW. It has been characterized as yielding from 100 to 500 gpm from karstic limestone approximately 100 ft below grade. Zone 2 is in the northern portion of PBOW and has yields of 15 gpm or less from limestone approximately 300 ft below grade. Zone 3 is located in the eastern and southern portion of the

site in predominantly shale bedrock. In addition to being found in the shale, groundwater is located in thin sand and gravel horizons interbedded with silt and clay deposits. Most Zone 3 wells are poor yielding, many of them providing less than 3 gpm (D&M, 1997a).

Two main water-bearing zones at PBOW are present; one in the overburden/shale and one in the Delaware Limestone bedrock. Data from recent investigations (2002 Groundwater Data Summary and Evaluation [Shaw, 2003a]; TNT Areas A and C Remedial Investigation [IT, 2000a,b]; Summary Report, Site-Wide Groundwater Monitoring [IT, 1999]; and the Site-Wide Groundwater Investigation Report [IT, 1997]) have found that groundwater in the overburden is in discontinuous pockets during dry time periods exemplified by a monitoring wells that are typically dry or areas in which wells could not be installed due to a lack of water in the overburden soil at the time of drilling. Figure 2-12 is an isopach map of the overburden groundwater in August 2001(dry season) during the TNTA, TNTB, TNTC temporary piezometer installation. Only limited lateral migration of contaminants would typically occur in the overburden due to the lack of water. During a wet period, the general flow direction in the overburden/shale water-bearing zone (where present) is to the north-northeast largely mirroring surface topography. The flow also corresponds somewhat to the topography of the top of the bedrock. In contrast, the limestone bedrock water-bearing zone is saturated year-round. The conceptual model of the site is that groundwater flow in the Delaware Limestone water-bearing zone migrates and is influenced by the frequency, orientation, density, and connectivity of fractures in the Delaware. Groundwater flow in the Delaware Limestone bedrock is only indicated by wells screened in the Delaware Limestone. Similar to the overburden/shale flow direction, groundwater in the Delaware Limestone flows to the north-northeast. A more detailed discussion of hydrogeological information is presented in Section 6.0.

2.3 Climatological Setting

The climate of Erie County is continental but strongly influenced by Lake Erie, with cold and cloudy winters and warm, humid summers. Wind is from the southwest 55 percent of the time (MK, 1994; D&M, 1997c).

Based on 30-year metrological data from the Midwestern Regional Climate Center (http://mcc.sws.uiuc.edu/Precip/OH/337447_psum.html), the U.S. Weather Bureau station in Sandusky, OH reported the average annual precipitation from 1971 to 2000 was 34.46 inches. Within that 30-year time, February had the lowest monthly precipitation average with 1.72 inches, whereas June had the highest of 4.19 inches. The maximum daily high temperature in Sandusky recorded from 1896 to 2001 was 105 degrees Fahrenheit (ºF) measured on August 6,

1918, and July 14, 1936. The lowest recorded daily temperature in this time period was -20º F on January 19, 1994. On the average, July is typically the warmest month (averaging 81.8º F) while January is the coldest (averaging 18.9º F). The county's first freezing temperature is usually in October, and its last freezing temperature is typically in April. A discussion of the precipitation data and charts generated from 1998 to June 2004 data is presented in Section 6.2.4.

2.4 Site Conceptual Model

Figure 2-13 presents a generalized block diagram or conceptual model of PBOW showing the possible contaminant migration transport routes, the overburden/shale and bedrock water-bearing units, the geologic units, and the interrelationship between the water-bearing zones. Groundwater sampling investigations and groundwater monitoring well measurement events have found that groundwater in the overburden may be limited to discrete areas during dry time periods of little rainfall. During these periods of low precipitation, only limited migration of contaminants would occur due to less infiltration of rainwater. The site conceptual model illustrates this seasonal, discontinuous nature of the overburden/shale groundwater.

The site conceptual model also illustrates groundwater flow in the Delaware bedrock water-bearing zone through fractures. Groundwater flow paths and velocity are dictated by the frequency, orientation, density, fracture size, and connectivity of these bedrock fractures. In addition to fractures, some solutional cavities may be present in the limestone bedrock. Generally, groundwater in the bedrock flows to the north-northeast. A more detailed discussion of hydrogeological information is presented in Section 6.0.

Based on historical data, groundwater geochemistry varies between the overburden/shale, shale, and limestone. Geochemistry results show that monitoring wells screened in the overburden/shale, typically have higher concentrations of dissolved oxygen with sulfate as the dominant anion. The higher concentrations of sulfate are likely due to the oxidation of residual sulfide minerals in the unconsolidated materials and weathered shale. Monitoring wells that are screened in more competent shale and limestone tend to be depleted of dissolved oxygen, and chloride is the dominant anion present. Chloride is dominant partially due to the fact these sediments were originally deposited in a marine environment and also due to the lower dissolved oxygen that limits the oxidation of sulfide minerals. The significance of the varying groundwater geochemistry is that waste products from the manufacture of TNT include nitrate from nitric acid and sulfate from sulfuric acid as well as sellite. The presence of these compounds in groundwater may be indicative of potential impact by waste disposal activities (ponds, tanks, etc) even if nitroaromatics are not detected.

3.0 Summary of Previous Environmental Studies

Eight previous investigations documenting site hydrogeology and groundwater contamination have been conducted at PBOW. Documents include the *Engineering Report of the Contamination Evaluation* (IT, 1991), *Site Inspection Report* (MK, 1994), *Site Management Plan* (ICI, 1995), *Sitewide Groundwater Investigation Draft Report* (D&M, 1997b), *Site-Wide Groundwater Investigation Report* (IT, 1997), *Site-Wide Groundwater Monitoring Report (1997-1998)* (IT, 1999), 2001 Groundwater Remedial Investigation (IT, 2002a), and 2002 Groundwater Data Summary and Evaluation Report (Shaw, 2003a).

The discussion of existing site data focuses on the primary areas investigated under this RI, which include the three TNT Manufacturing Areas (TNTA, TNTB, and TNTC), the WARWP, and the PRRWP. This chapter discusses analytical results of: 1) groundwater analytical data collected prior to 1997, and 2) soil, surface water and sediment analytical data. The results of these other environmental media are discussed because they may represent potential groundwater contaminant sources or (in the case of surface water and sediment) media that may potentially be impacted by groundwater.

3.1 TNT Areas

TNT was manufactured in three areas, designated TNTA, TNTB, and TNTC (Figure 1-2). Each area had production lines consisting of a mono house, a bi-tri house, a fortifier house, and a wash house used in the manufacture of TNT. In addition, other buildings (e.g., nailing houses, wastewater settling tanks, and DNT sweating and graining houses) were present at each site. Each TNT area is discussed in the following paragraphs.

3.1.1 TNT Area A

TNTA occupies approximately 114 acres in the northeastern part of PBOW. Columbus Avenue bisects the site, as shown in Figures 1-2 and 3-1. NASA constructed its administration building on the east side of Columbus Avenue in the central portion of former TNT process buildings at TNTA (Buildings 121 and 122). TNTA was used during World War II as a manufacturing facility for TNT and DNT. During PBOW operations, TNTA had four TNT lines consisting of five buildings each, and two DNT lines, each consisting of one building (Figure 3-1). Wastewater from TNTA was routed through the wastewater settling tanks and pump house to the PRRWP through underground flumes and sewer lines. Aboveground evidence of the former TNTA structures and features include abandoned railroad tracks, portions of foundations, soil

mounds (indicative of former building foundations), roadways, ditches, manholes, drains, and water valves.

Significant previous remediation activities have been performed in TNTA. According to the records review report (D&M, 1995), TNTA was decontaminated along with the two other TNT areas (TNTB and TNTC) in 1955 and again in 1966. The decontamination at TNTA was reportedly very thorough. Significant subsurface contamination was removed, including underground flumes and sewer lines. Approximately 16,000 pounds of TNT were removed from TNTA.

Previous environmental investigations in this area include a 1993 site inspection by MK (1994); a 1994 TNT Areas site investigation by D&M (1997a); groundwater investigations by Shaw in 1996 (IT, 1996a), 1997 (IT, 1997), 1998 (IT, 1998), 2001 (IT, 2002a), and 2002 (Shaw, 2003a); and a soil, surface water/sediment investigation by Shaw in 2000 (Shaw, 2003e). Historical surface water, sediment, soil, and groundwater (1993, 1994, and 1996) analytical results are shown on Tables 3-1, 3-2, 3-3, and 3-4, respectively. Historical groundwater analytical results are compared to risk-based screening concentrations (RBSC). Groundwater analytical results from 1997 to 2004 are compared to RBSCs (Section 5.2.1) and BSCs (Section 5.2.2). The results of these comparisons are discussed in Section 7.0.

The 1993 MK inspection of the TNTA site included one soil sample, one collocated sample each of surface water and sediment, and three overburden groundwater samples. No nitroaromatic residues were detected in any of these samples (MK, 1994).

During a 1994 site investigation by D&M, a total of 36 soil samples were collected from 28 borings in TNTA. Borings were placed in and around former buildings that were associated with the TNT production lines. In addition, one soil boring was installed in a ditch north of Maintenance Road. A wide range of nitroaromatic compounds were detected, including concentrations of TNT up to 580 milligrams per kilogram (mg/kg) near the Wastewater Settling Tanks and 53 mg/kg near the Fortifier House, Building 143. One boring located near the Mono House, Building 141, exhibited 2,4-DNT and 2,6-DNT concentrations of 45 mg/kg and 47 mg/kg, respectively (D&M, 1997a).

D&M also collected groundwater samples. There were seven existing monitoring wells in TNTA. Five are overburden wells (MK-MW22, -MW23, -MW24, and TNTA-MW10, and

-MW11) and two are Delaware Limestone bedrock wells (BED-MW17 and -MW18). Ten nitroaromatics were detected, nine above RBSCs in the overburden wells. Five nitroaromatics were detected above RBSCs in the bedrock wells (D&M, 1997a).

Shaw conducted a site-wide groundwater investigation at PBOW during September 1996 (IT, 1997), November 1997 (IT, 1998), and again in May 1998 (IT, 1999). Investigations included the collection of groundwater samples from the overburden/shale and Delaware Limestone wells in TNTA. Samples were analyzed for nitroaromatics, VOCs, SVOCs, metals, pesticides, polychlorinated biphenyls (PCB), and cyanide. Groundwater analytical results are compared to RBSCs and BSCs. The results of these comparisons are discussed in Chapter 7.0.

During June through October 2000, Shaw conducted an RI of TNTA to determine the nature and extent of contamination in surface soil, subsurface soil, surface water, sediment and shallow groundwater. A total of 427 soil samples were collected for field screening analysis of nitroaromatics, including 39 confirmation soil samples. Additionally, 10 (9 on-site, 1 off-site) surface water samples, 15 (10 on-site, 5 off-site) sediment samples, and 9 shallow groundwater samples were collected. It was determined that most of the nitroaromatic-impacted soil was encountered within 1 to 5 ft of the former building foundations. The largest nitroaromatic concentration of 2,4,6-TNT was located at Wash House, Building 146 (530 mg/kg) in a sample collected at 4 to 6 ft below ground surface (bgs) (IT, 2001a).

Of the 9 on-site surface water samples, 8 were collected from drainage areas, and 1 from a suspected “red water” puddle at Wash House, Building 146. Three nitroaromatic compounds were detected in 2 samples from the drainage ditches with the highest concentration being 2.34 micrograms per liter (µg/L) of 4A-2,6-DNT. Three VOC compounds (acetone [2.95 µg/L], carbon disulfide [11.5 µg/L], and methylene chloride [3.75 µg/L]) and one SVOC (di-n-butyl phthalate [1.3 µg/L]) were detected. Analytical results shown in parentheses are the maximum detected concentration (MDC) of each analyte. Twenty metals were also detected. The surface water sample from Wash House, Building 146 was analyzed only for nitroaromatics; TNT was detected at a concentration of 11,000 µg/L (IT, 2001a).

As part of the June through October 2000 RI, Shaw collected 9 overburden/shale groundwater samples from confirmation soil sample locations which displayed the highest detections for PBOW-related contaminants. Groundwater samples were collected from temporary piezometers

and analyzed for VOCs, SVOCs, nitroaromatics, and metals with three samples for metals (GW-02, GW-06, and GW-10) were filtered (IT, 2001a).

A baseline ecological risk assessment (BERA) was performed by Shaw for TNTA (IT, 2001b). The BERA estimated that ecological hazards associated with TNTA surface and total soils were elevated. These estimates are regarded as conservative and are associated with a considerable degree of uncertainty; additional investigation and evaluation would be necessary to provide more accurate estimates of ecological hazards. However, it was agreed that TNTA soils be remediated to human health-based remedial goal options (RGO) (described below). The resulting residual soil concentrations evaluated for ecological risk in the focused feasibility study (FFS) were found to be protective of the environment (Shaw, 2003e). Because of uncertainties of estimating chemical concentrations in aquatic insects, the limited amount and low quantity of aquatic habitat, and the low hazard estimates, neither remedial action nor further study was recommended for surface water and sediment.

A BHHRA was also performed for exposure to TNTA soil, surface water, and sediment (IT, 2001c). Results of the BHHRA indicate that cumulative human health risks associated with TNTA total soil for the potential future resident and construction worker exceed the respective risk management criteria for cancer risk (i.e., incremental lifetime cancer risk [ILCR]>1E-5) and noncancer hazard (i.e., hazard quotient [HQ] >1). Exposure to surface water and sediment were found to contribute insignificantly to human health risks. Exposure to surface soil (as evaluated for the groundskeeper, indoor worker, and hunter/venison eater) resulted in noncancer and cancer risk estimates equal to or less than the risk management criteria. The chemicals of concern (COC) for TNTA total soil are lead, Aroclor 1260, and several nitroaromatics. Human health risk-based RGOs for TNTA soil (presented later in this section)were developed as cleanup criteria in the TNTA and TNTC FFS (Shaw, 2003e).

In July 2001 as a continued part of the RI, Shaw conducted direct-push groundwater screening to characterize the overburden groundwater at TNTA. The plan was to place direct-push groundwater screening sample locations at historical “hot spot” soil sample locations and use the overburden groundwater analytical results to place permanent overburden monitoring wells. A total of 13 direct-push boreholes were drilled but only 2 encountered sufficient overburden groundwater for sample collection. Due to the lack of overburden groundwater at TNTA, in agreement with the USACE and Ohio Environmental Protection Agency (OEPA), the direct-push groundwater screening and permanent overburden well installation was discontinued. To determine the quality of groundwater in bedrock, 1 deep monitoring well (TNTA-BEDGW-001)

screened within the Delaware Limestone, was installed at a location selected based on historical soil and groundwater data (Shaw, 2003a).

Groundwater sampling for this RI was then conducted during two seasonal time periods: October 2001 "dry season" and April 2002 "wet season" to monitor any seasonal fluctuations in groundwater quality. Groundwater samples were collected only in October from the 2 temporary overburden piezometers that encountered groundwater (TNTA-DP14 and TNTA-DP21). Groundwater samples were collected from 2 overburden/shale wells (TNTA-MW10 and TNTA-MW11), and from 3 bedrock wells (BED-MW17, BED-MW18, and TNTA-BEDGW-001) in both October 2001 and April 2002. Groundwater samples from the temporary piezometers were analyzed for nitroaromatics and VOCs by a screening method, and groundwater samples collected from the monitoring wells were analyzed for nitroaromatics, VOCs, SVOCs, filtered and unfiltered metals, cyanide, and water quality parameters (Shaw, 2003a). Groundwater analytical results, compared to background screening results, are discussed in Chapter 7.0.

In 2003, Shaw prepared an FFS for soil at TNTA (Shaw, 2003e). Site-specific RGOs for the TNTA soil COCs, derived in the FFS, are presented in the table below.

Chemical of Concern	TNTA RGO (mg/kg)
Nitroaromatics	
2-A-4,6-DNT	1.3
4-A-2,6-DNT	1.7
2,4-DNT	6.0
2,6-DNT	1.5
2-Nitrotoluene	31
4-Nitrotoluene	9
2,4,6-TNT	8.0
Polychlorinated Biphenyls	
Aroclor 1260	1.0
Inorganics	
Lead	400

The FFS recommended excavation (16,328 cubic yards [yd^3]), windrow composting, on-site disposal of treated material, and off-site disposal of soil with lead contamination greater than 200 mg/kg (approximately 708 yd^3) and PCB contamination greater than 50 mg/kg (approximately 119 yd^3) at a Subtitle C hazardous waste treatment, storage, and disposal facility. Note that 200 mg/kg was used as a criterion for lead in soil that was contaminated with other COCs, so that the

material would meet land use restrictions; otherwise, 400 mg/kg served as the lead RGO at or below which soil could be left in place. The total cost of the alternative for TNTA was estimated to be $7,688,000. The estimated cost for simultaneous remediation of TNTA and TNTC would be $10,987,000, which includes the cost savings realized for a single mobilization (Shaw, 2003e).

3.1.2 TNT Area B

TNTB comprises an area of approximately 55 acres in the south-central portion of PBOW, immediately north of West Sheid Road, as shown on Figures 1-2 and 3-2. TNTB was used during World War II as a manufacturing facility for TNT and DNT. During PBOW operations, TNTB had three TNT lines consisting of 5 buildings each, and one DNT line consisting of one building. All of the buildings that were present during the TNT manufacturing period have been demolished but most foundations have been located during environmental investigations. Figure 3-2 presents a site map showing the locations of all former buildings. Aboveground evidence of former PBOW facilities exists at TNTB in the form of roads, hydrants, and ditches. In addition, aboveground water valves indicate the presence of underground utilities.

Two NASA facilities present at the site are currently active, the Hypersonic Testing Facility and the Nitrogen Dewar Tanks (Figure 3-2). The Hypersonic Testing Facility is located on the site of the former Wash House, Building 476 in the northwest portion of TNTB. The facility consists of a single building, aboveground and underground piping and utilities, and paved parking areas. The Nitrogen Dewar Tanks are located in the center of TNTB, with aboveground piping and underground utilities leading to the northwest and to the northeast off site (D&M, 1997a).

Previous environmental investigations in this area include a 1993 site inspection by MK (1994); a 1994 TNT Areas site investigation by D&M (1997a); groundwater investigations by Shaw in 1996, 1997, 1998, 2001, and 2002; and a soil, surface water/sediment investigation by Shaw in 2000. Historical surface water, sediment, soil, and groundwater (1993, 1994, and 1998) analytical results are shown on Tables 3-5, 3-6, 3-7, and 3-8, respectively. Soil analytical results for COCs are compared to TNTB RGOs developed in the feasibility study (FS) (IT, 2001d). Historical groundwater analytical results are compared to RBSCs. Groundwater analytical results from 1997 to 2004 are compared to RBSCs and BSC values and are discussed in Section 7.0.

In 1993, MK collected two surface water, two sediment, and two surface soil samples in the vicinity of TNTB. The samples were analyzed for VOCs, SVOCs, nitroaromatics, and dissolved

metals. The surface water and sediment locations were SW07/SD07 and SW08/SD08. SW07 and SD07 were collected near the beginning of Ransom Brook, approximately 250 ft north of Magazine Road near the former red water settling tanks. SW08 and SD08 were collected north of TNTB, approximately 200 ft south of Fox Road and approximately 3,000 ft downgradient of SW07 and SD07 (ICI, 1995).

The surface water samples exhibited no detections of VOCs or SVOCs. No metals were detected in the surface water at concentrations above their maximum contaminant level (MCL) or secondary MCL. The sediment sample collected at SD07 had detections of 5 VOCs and 14 SVOCs. The BHHRA (IT, 2000d) assumes that due to reduced exposure, sediment screening levels are adjusted to 10 times the soils screening levels. If this same assumption is applied to TNTB soil RGOs, all sediment concentrations of soil COCs are below 10 times the soil RGO levels. The only nitroaromatic detection in SD07 was TNT at a concentration of 25 mg/kg (less than 10 times the TNTB soil RGO of 3.36 mg/kg). Eleven organic compounds were detected in sediment sample SD08, all at concentrations of 0.1 mg/kg. Detected organic compounds included two VOCs and nine SVOCs, eight of which were polynuclear aromatic hydrocarbons (PAH). All were less than 10 times the TNTB soil RGO (IT, 2001d).

The two surface soil sample locations were designated SB09 and SS13. SB09 was collected from the borehole for monitoring well MK-MW17. Sample SS13 was collected in the vicinity of the railroad tracks southwest of the Fortifier House, Building 463 (ICI, 1995). VOCs (toluene and xylenes), SVOC (bis[2-ethylhexyl]phthalate), and nitroaromatics (TNT and 2,6-DNT) were detected in the surface soil. Nitroaromatics were present at SB09, with TNT detected at a concentration of 12 mg/kg (MK, 1994).

Two overburden/shale monitoring wells were installed at TNTB in July 1993 by MK. Well MK-MW16 is located upgradient and well MK-MW17 is located downgradient of TNTB (Figure 3-2). Groundwater samples collected from both wells were analyzed for VOCs, SVOCs, nitroaromatics, and dissolved metals. No VOCs or nitroaromatics were detected in either of the wells. Twelve unfiltered metals were detected at levels that exceeded RBSCs. One SVOC, bis(2-ethylhexyl)phthalate, was detected at a concentration of 12 µg/L in MK-MW17 (MK, 1994).

In October 1994, as part of the TNT Areas site investigation, D&M sampled soil at 26 locations at TNTB. All samples were collected between 0.5 and 3.5 ft bgs. Eighteen of the 26 locations were sampled at one depth, and 8 locations were sampled at two depths. The samples were

analyzed for nitroaromatics and metals. Nitroaromatics were detected in 18 of the 26 locations, and most locations had at least one sample with a concentration greater than 1.0 mg/kg. Concentrations of nitroaromatics detected in excess of 10,000 mg/kg were present in soils at the Bi-Tri House for Line 5 (Building 452) and the DNT Sweating and Graining House (Building 412) (D&M, 1997a).

In December 1994, D&M sampled both MK-MW16 and MK-MW17 as part of the TNT Areas site investigation. Samples from the wells were analyzed for nitroaromatics, nitrates, and unfiltered and filtered concentrations of 14 metals, the 13 priority pollutant list metals plus manganese. MK-MW16 did not exhibit any detection of nitroaromatics. The downgradient well MK-MW17 contained 6 nitroaromatics (4A-2,6-DNT, 2A-4,6-DNT, 2,4-DNT, 2,6-DNT, 3,4-DNT, and 2,4,6-TNT) that exceeded RBSCs. Nitrates were detected, but at concentrations below RBSCs. Five metals were detected above RBSCs in unfiltered overburden groundwater: arsenic, cadmium, manganese, nickel, and thallium. Three of the metals (manganese, nickel, and thallium) were detected in both wells. Four metals (antimony, manganese, nickel, and thallium) were detected above RBSCs in filtered groundwater samples. Manganese and nickel were common to both wells (D&M, 1997a).

In September and October 1996, Shaw collected groundwater samples from MK-MW16 and MK-MW17 as part of the site-wide groundwater investigation. Both groundwater samples were analyzed for nitroaromatics VOCs, SVOCs, metals, pesticides, PCBs, and cyanide (IT, 1997). Groundwater analytical results are compared to RBSCs and presented in historical data Table 3-7.

In 1997, Shaw installed two bedrock wells near TNTB. TNTB-BEDGW-001 was installed northwest of the site to monitor bedrock groundwater downgradient of TNTB, and TNTB-BEDGW-002 was installed southeast of TNTB to monitor bedrock groundwater upgradient of the site (IT, 1998).

In November 1997 and May 1998, as part of the semiannual monitoring portion of the groundwater investigation, overburden wells MK-MW16 and MK-MW17 were sampled by Shaw. Overburden groundwater samples were analyzed for VOCs, SVOCs, nitroaromatics, metals (unfiltered and filtered), cyanide, and water quality parameters (alkalinity, chloride, hardness, sulfate, nitrate, total dissolved solids, total organic carbon, and total suspended solids) (IT, 1999). Groundwater analytical results, compared to background screening results, are discussed in Section 7.0.

In October and November 1998, Shaw conducted an RI of TNTB to determine the nature and extent of contamination in surface soil, subsurface soil, surface water, and sediment. A total of 391 soil samples were collected for field-screening analysis of nitroaromatics, and 40 confirmation soil samples, two surface water samples, and five sediment samples were collected. It was determined that most of the nitroaromatic-impacted soil above TNTB RGOs was encountered within 1 to 5 ft of the former building foundations. A total of 23 soil samples with nitroaromatic compounds above TNTB RGOs were recorded, with the highest detected 2,4,6-TNT concentration (6,900 mg/kg) being located at the Bi-Tri House, Building 452, in a 0 to 1 foot bgs sample. Wash House, Building 456, exhibited 6 soil sample concentrations of 2,4,6-TNT, 4A-2,6-DNT and 2A-4,6-DNT nitroaromatics above RGOs. Surface water results indicated that only VOCs and metals were present, while sediment analytical results showed VOCs, SVOCs, and metals (IT, 2000c).

A BHHRA and BERA were performed for TNTB (IT, 2000d). Total soil was found to exceed the cancer (1E-5) and noncancer cumulative risk management criteria for both receptors evaluated (potential future resident and construction worker). Likewise, surface soil was found to exceed the respective risk management criteria for both receptors evaluated (groundskeeper and indoor worker). Thirteen human health risk COCs were identified in TNTB surface and total soils. Site-related human health risks associated with surface water and sediment were found to be within or less than the risk management criteria (i.e., ILCR$\leq$1E-5 and hazard index [HI]$\leq$1).

The TNTB BERA estimated that ecological hazards associated with TNTB surface and total soils were elevated. These estimates are regarded as conservative and are associated with a considerable degree of uncertainty; additional investigation and evaluation would be necessary to provide more accurate estimates of ecological hazards. However, it was agreed that TNTB soils be remediated to human health-based cleanup levels. The resulting residual ecological risks to terrestrial receptors were re-evaluated in the FFS based on cleanup of areas previously exceeding the cleanup levels. The resulting ecological risks were estimated to be reduced an average of approximately 750-fold. The BERA concluded that remediating the site to human health cleanup levels would result in residual concentrations that are protective of terrestrial receptors. Additionally, the BERA found that due to the limited aquatic habitat and the lack of rare, threatened, or endangered species, that the development of remedial action objectives based on aquatic receptors was unwarranted (IT, 2000d).

Shaw generated an FS for TNTB in July 2001. Site-specific RGOs for TNTB surface and subsurface soil for each of the COCs, which serve as cleanup levels, are as follows (IT, 2001d):

Chemical of Concern	TNTB RGO (mg/kg)
Nitroaromatics	
2-A-4,6-DNT	0.40
4-A-2,6-DNT	0.40
2,4-DNT	7.50
2,6-DNT	2.75
2-Nitrotoluene	74
2,4,6-TNT	3.36
Polychlorinated Biphenyls	
Total for Aroclor 1254 and Aroclor 1260	1
Polynuclear Aromatic Hydrocarbons	
Total carcinogenic PAHs	1

Also in July, as part of the 2001 RI, Shaw conducted a direct-push groundwater screening event to characterize the overburden groundwater at TNTB. The plan was to place direct-push groundwater screening sample locations at historical "hot spot" soil sample locations and use the overburden groundwater analytical results to place permanent overburden monitoring wells. A total of 5 direct-push boreholes were drilled but only 2 encountered sufficient overburden groundwater for sample collection. Due to the lack of overburden groundwater at TNTB, in agreement with the USACE and OEPA, the direct-push groundwater screening and permanent overburden well installation was discontinued. To determine the quality of groundwater in bedrock, 1 deep monitoring well (TNTB-BEDGW-003) screened within the Delaware Limestone, was installed at a location selected based on historical soil and groundwater data. A second deep well (TNTB-BEDGW-004) was installed to monitor the groundwater leaving TNTB (Shaw, 2003a).

Groundwater sampling for this RI was conducted during two seasonal time periods; October 2001 "dry season" and April 2002 "wet season" to monitor any seasonal fluctuations in groundwater quality. Groundwater samples in the dry season were collected from the 2 temporary piezometers that encountered groundwater (TNTB-DP02 and TNTB-DP03), from 1 overburden/shale well (MK-MW17) (overburden/shale well MK-MW16 was dry), and from 4 existing bedrock wells screened in the shale bedrock: TNTB-BEDGW-001, -002, -003, and -004. Groundwater sampling in April was conducted from both overburden/shale wells and all bedrock wells (Figure 3-2). Groundwater samples from the temporary piezometers were analyzed for nitroaromatics and VOCs by a screening method and groundwater samples collected from the

monitoring wells were analyzed for nitroaromatics, VOCs, SVOCs, filtered and unfiltered metals, cyanide, and water quality parameters (Shaw, 2003a). Groundwater analytical results, compared to background screening results, are discussed in Section 7.0.

The FS recommended excavation (estimated at 3,300 yd^3), ex situ stabilization, and off-site disposal at a nonhazardous waste landfill. The total cost of the alternative for TNTB was estimated to be $358,000 (IT, 2001d). In September 2002, removal of contaminated soil began at TNTB. Soil above the site-specific clean-up levels was excavated, stabilized, and transported off-site for disposal.

3.1.3 TNT Area C

The former TNTC occupies approximately 119 acres of land in the southwestern portion of PBOW, as shown in Figures 1-2 and 3-3. TNTC was used during World War II as a manufacturing facility for TNT and DNT. During PBOW operations, TNTC contained five TNT lines consisting of five buildings each (Figure 3-3). Wastewater from TNTC was routed to the WARWP through underground flumes and sewer lines.

Presently, the area is largely overgrown with trees and brush; however, some of the roads, building foundations, manholes, drains, and remnants of utilities from former TNT operations are still recognizable. According to the records review report, TNTC was decontaminated along with the two other TNT areas in 1955 and again in 1966 (D&M, 1995). However, the decontamination at TNTC was reportedly not as thorough as that at TNTA, and significant subsurface contamination associated with underground flumes and sewer lines is probably still present (Shaw, 2003a).

Previous environmental investigations in this area include a 1993 site inspection by MK (1994); a 1994 TNT Areas site investigation by D&M (1997a); groundwater investigations by Shaw in 1996 (IT, 1996a), 1997 (IT, 1997), 1998 (IT, 1998), 2001 (IT, 2002a), and 2002 (Shaw 2003a); and a soil, surface water/sediment investigation by Shaw in 2000 (Shaw 2003e). Historical surface water, sediment, soil, and groundwater (1993, 1994, and 1996) analytical results are shown on Tables 3-9, 3-10, 3-11, and 3-12, respectively. Historical groundwater analytical results are compared to RBSCs. Groundwater analytical results from 1997 to 2004 are compared to RBSCs and BSC values and are discussed in Section 7.0.

The MK inspection of the TNTC site included two surface soil samples and one collocated pair of surface water and sediment samples. Organic compounds were not detected in the surface

water sample nor in the collocated sediment sample. Toluene was detected in both surface soil samples at concentrations below the quantitation limit (MK, 1994).

A total of 30 soil samples were collected from 26 borings within the TNTC site during the 1994 D&M investigation. Boring locations were placed in and around former buildings that were associated with the TNT production lines (Line 12 - Buildings 626, 612, and 604). A wide range of nitroaromatic compounds were detected, including TNT at concentrations up to 2.7 mg/kg (near Building 626) and 2,4-DNT up to 8.7 mg/kg (near Building 626) (D&M, 1997a).

D&M also collected groundwater samples from wells in TNTC. There were 4 overburden wells present (TNTC-MW03, TNTC-MW04, TNTC-MW05, and TNTC-MW06) and one Delaware Limestone bedrock well (PB-BED-MW13). Overburden wells TNTC-MW03 and TNTC-MW04 were not sampled due to insufficient water present during sampling activities (D&M, 1997a). One nitroaromatic (2,4-DNT) was detected slightly (0.1 µg/L) above its RBSC in overburden well TNTC-MW05. No VOCs, SVOCs, nitrates, or water quality parameters were detected above RBSCs. Inorganics above RBSCs included aluminum (filtered) and manganese (filtered and unfiltered) in well TNTC-MW05 and chromium (filtered and unfiltered), iron (unfiltered), and manganese (filtered and unfiltered) (Shaw, 2003a).

Four nitroaromatic compounds (4A-2,6-DNT, 2,4-DNT, 2,6-DNT, and 3-nitrotoluene) were detected above RBSCs in the bedrock well PB-BED-MW13. VOCs and SVOCs above RBSCs included benzene, toluene, total xylenes, 2-methylnaphthalene, and naphthalene. Antimony (filtered) was the only inorganic detected above its RBSC (Shaw, 2003a).

Shaw conducted a site-wide groundwater investigation at PBOW in 1996 (IT, 1997), in 1997 (IT, 1998), and again in 1998 (IT, 1999). The 1996 investigation included collection of groundwater samples from four overburden/shale monitoring wells (TNTC-MW03, TNTC-MW04, TNTC-MW05, and TNTC-MW06) and in 1997 and 1998, from five overburden/shale wells (the previously sampled four wells and IT-MW09). One Delaware Limestone bedrock monitoring well, PB-BED-MW13, was also sampled during all three events. Samples were analyzed for nitroaromatics, VOCs, SVOCs, metals, pesticides, PCBs, and cyanide. Groundwater analytical results, compared to background screening results, are discussed in Section 7.0.

During June through October 2000, Shaw conducted an RI of TNTC to determine the nature and extent of contamination in surface soil, subsurface soil, surface water, sediment, and shallow groundwater. A total of 383 soil samples were collected for field-screening analysis of

nitroaromatics, and 40 confirmation soil samples, 10 surface water samples, and 15 sediment samples were collected for a confirmatory analysis. During excavation for soil sample placement, most of the former building foundations were located. As at TNTB, it was determined that most of the nitroaromatic-impacted soil was encountered within 1 to 5 ft of the former building foundations. The highest detection was 54,969 mg/kg of 2,4,6-TNT in a sample collected from 0.25 to 1.25 ft bgs at the former Bi-Tri House (Building 692). It should be noted that this sample was of a suspected waste product from a clay line that was encountered during excavation at the former building. Surface water results indicated that only VOCs and metals were present, while sediment analytical results showed VOCs, SVOCs, and metals. Based on the low concentrations of the contaminants in the soil, surface water, and sediment, concentrations were believed not to be attributable to former site activities (IT, 2001e).

As part of the June through October 2000 RI, Shaw collected 9 shallow groundwater samples from confirmation soil sample locations that displayed the highest detections of PBOW-related contaminants. Groundwater samples were collected from temporary piezometers and analyzed for VOCs, SVOCs, nitroaromatics, and metals. Only 3 of the 9 groundwater wells (GW-04, GW-06, and GW-10) yielded adequate water volume so that a filtered fraction could be collected for metals analysis (IT, 2001e).

A BERA was performed for TNTC (IT, 2001c), which estimated that ecological hazards associated with exposure to TNTC surface and total soils were elevated for terrestrial receptors. These estimates are regarded as conservative and are associated with a considerable degree of uncertainty; additional investigation and evaluation would be necessary to provide more accurate estimates of ecological hazards. However, it was agreed that TNTC soils be remediated to human health-based RGOs. The resulting residual soil concentrations evaluated for ecological risk in the FFS were found to be protective of the environment (Shaw, 2003e). Also, neither remedial action nor further study are recommended for aquatic receptors exposed to TNTC surface water based on the following: uncertainties associated with estimating chemical concentrations in aquatic insects, limited area and low quality of aquatic habitat, and relatively low hazard estimates especially when using the lowest-observable-adverse-effects-level approach.

A BHHRA was also performed for exposure to TNTC soil, surface water and sediment (IT, 2001c). Results of the BHHRA indicate that cumulative human health risks associated with total soil for the potential future resident and construction worker exceed the respective risk management criteria for cancer risk (i.e., ILCR >1E-5) and noncancer hazard (i.e., HQ >1).

Similarly exposure associated with surface soil for the groundskeeper, indoor worker, and adult hunter exceeded the respective risk management criteria. Noncancer risks associated with exposure to sediment for the potential future resident and construction worker also exceeded the risk management range (i.e., ILCR>1E-5), and cancer risks associated with exposure to sediment contributed significantly to the overall ILCR of the construction worker and potential future resident. Human health risk-based RGOs for TNTC soil and sediment were developed as cleanup criteria in the TNTA and TNTC FFS. The TNTC RGOs for soil and sediment RGOs are presented below.

Chemical of Concern	TNTC RGO (mg/kg)
Nitroaromatics in Soil	
2-A-4,6-DNT	1.7
4-A-2,6-DNT	1.3
2,4-DNT	6.5
2,6-DNT	1.0
2,4,6-TNT	8.0
Polychlorinated Biphenyls in Soil	
Total for Aroclor 1254 and Aroclor 1260	1
Polynuclear Aromatic Hydrocarbons in Soil	
Total carcinogenic PAHs	1
Inorganics in Soil	
Lead	400
Nitroaromatics in Sediment	
2-A-4,6-DNT	12.1
4-A-2,6-DNT	12.1
2,4,6-TNT	101

In July 2001 as a continued part of the RI, Shaw conducted direct-push groundwater screening to characterize the overburden groundwater at TNTC. The plan was to place direct-push groundwater screening sample locations at historical "hot spot" soil sample locations and use the overburden groundwater analytical results to place permanent overburden monitoring wells. A total of 13 direct-push boreholes were drilled but only 2 encountered sufficient overburden groundwater for sample collection. Due to the lack of overburden groundwater at TNTC, in agreement with the USACE and OEPA, the direct-push groundwater screening and permanent overburden/shale well installation was discontinued. To determine the quality of groundwater in bedrock, 1 deep monitoring well (TNTC-BEDGW-001) screened within the Delaware Limestone, was located based on historical soil and groundwater data (Shaw, 2003a).

Groundwater sampling for this RI was conducted during two seasonal time periods; October 2001 "dry season" and April 2002 "wet season" to monitor any seasonal fluctuations in groundwater quality. Groundwater samples in the dry season were collected from the 2 temporary piezometers that encountered groundwater (TNTC-DP13 and TNTA-DP19); from 2 overburden/shale wells (TNTC-MW04 and TNTC-MW05) (overburden/shale well TNTC-MW03 was dry); and from both existing Delaware Limestone screened bedrock wells (BED-MW13 and TNTC-BEDGW-001). Groundwater sampling in April was conducted from all three overburden/shale wells and both Delaware Limestone bedrock wells (Figure 3-3). Groundwater samples from the temporary piezometers were analyzed for nitroaromatics and VOCs by a screening method and groundwater samples collected from the monitoring wells were analyzed for nitroaromatics, VOCs, SVOCs, filtered and unfiltered metals, cyanide, and water quality parameters (Shaw, 2003a). Groundwater analytical results, compared to background screening results, are discussed in Section 7.0.

In 2003, Shaw prepared an FFS for TNTC. The study recommended excavation, windrow composting, on-site disposal of treated material, and off-site disposal of soil with lead contamination greater than 200 mg/kg (approximately 400 yd^3) at a Subtitle C hazardous waste treatment, storage, and disposal facility. Note that 200 mg/kg was used as a criterion for lead in soil that was contaminated with other COCs, so that the material would meet land use restrictions; otherwise, 400 mg/kg served as the lead RGO at or below which soil could be left in place. The total cost of the alternative is estimated to be $5,504,000 (IT, 2003b). The estimated cost for simultaneous remediation of TNTC and TNTA would be $11,099,000, which includes the cost savings realized for a single mobilization.

3.2 Red Water Pond Areas

3.2.1 West Area Red Water Ponds

The WARWP is located on the western edge of PBOW, near the intersection of Campbell Street and Fox Road and to the north and west of Pipe Creek, as shown in Figures 1-2 and 3-4. Two former red water ponds in the WARWP have been identified through the use of aerial photographs, site reconnaissance, and the presence of nitroaromatic compounds in soil and groundwater. Historical surface water, sediment, soil, and groundwater (1993, 1994, and 1996) analytical results are shown on Tables 3-13, 3-14, 3-15, and 3-16, respectively. Historical groundwater analytical results are compared to RBSCs. Groundwater analytical results from 1997 to 2004 are compared to RBSCs and BSC values and are discussed in Section 7.0.

In 1984, Battelle Laboratories collected a surface soil sample from the spoils area at WARWP. Concentrations of nitroaromatics were detected in the low-parts per million (ppm) range (IT, 2000c)

Prior to 1985, numerous studies were conducted of the surface water and sediment from the red water pond areas. The Ohio National Guard conducted surface sediment screening for TNT and DNT. The highest values found in the screened sediments were less than 1 mg/kg (IT, 2000c).

Shaw was contracted in 1989 to conduct surface water, soil, and groundwater sampling to determine the presence or absence of residual chemical contamination from PBOW operations. Six surface soil samples were collected from borings IT-MW02, IT-SB07, IT-SB10, IT-SB11, and IT-SB12. Overburden/shale monitoring well IT-MW02 was installed in a downgradient location of the WARWP. Soil sample analysis showed that dinitrobenzene (DNB), trinitrobenzene (TNB), DNT, and TNT were present in the soils at the WARWP. Low-level nitroaromatics were also detected in the overburden groundwater from IT-MW02. In 1991, SAIC further confirmed that hazardous substances had been released into the environment at the WARWP (USACE, 1997).

A site inspection by MK from June through July 1993 indicated low levels of VOCs and SVOCs in the sediments around Pipe Creek near the WARWP area but found no contaminant concentrations of VOCs, SVOCs, or nitroaromatics in the surface water. MK installed four overburden/shale groundwater monitoring wells (MK-MW09, MK-MW10, MK-MW11, MK-MW12) near WARWP. Groundwater samples were collected from the four newly installed wells and IT-MW02 and analyzed for the above contaminants. Laboratory analysis did not indicate the presence of VOCs, SVOCs, or nitroaromatics in the groundwater samples near Pipe Creek (MK, 1994).

In 1994, D&M conducted a Focused Remedial Investigation to evaluate groundwater occurrence and flow conditions in the overburden and bedrock water-bearing zones; assess groundwater quality in the overburden water-bearing zone; and investigate the baseline groundwater quality of the bedrock water-bearing zone to evaluate the necessity of additional work at PBOW. Two Delaware Limestone bedrock wells (BED-MW14 and BED-MW19) and two overburden/shale wells (WA-MW01 and WA-MW02) were installed in the vicinity of the WARWP area. Hydrogeologic data indicated that groundwater flow in the overburden exhibited a strong downward vertical component and the presence of groundwater was strongly seasonally dependent. The general groundwater flow in the bedrock water-bearing zone was determined to

be to the north toward Lake Erie. Groundwater samples were analyzed for VOCs, SVOCs, nitroaromatics, and metals. Significant concentrations of nitroaromatics were determined to be present adjacent to the ponds in both the residuum and the bedrock water-bearing zones. VOCs and BNAs were also present in the Delaware Limestone bedrock wells. Some metals (antimony, manganese, and nickel) were also detected at concentrations exceeding their MCLs (D&M, 1997a).

As part of the 1994 Focused RI, to identify and evaluate the source, nature, and extent of contamination of former DOD activities, surface and subsurface soil at the Red Water Ponds was investigated by D&M. Soil samples were collected from the WARWP and analyzed for nitroaromatics and metals. Nitroaromatics 1,3,5-TNB and 2,4-DNT were most commonly detected (D&M, 1997a).

Shaw conducted groundwater investigations in 1996 and 1997. Both investigations indicated that the overburden/shale had been impacted by nitroaromatic compounds in the central portion of the WARWP and that inorganic compounds were present at concentrations exceeding screening values throughout the area. Shaw determined that the bedrock water-bearing zone was impacted by nitroaromatics and other organic and inorganic compounds north of the WARWP, but not in the central portion of the area. Shaw recommended additional subsurface investigations to determine the nature and extent of contamination in these areas. Groundwater sampling of the WARWP groundwater wells in November 1997 and May 1998 indicated continued elevated levels of nitroaromatics (IT, 1999).

Shaw conducted a soil and groundwater risk assessment and direct-push investigation in June and November 1998 at the WARWP. A total of 19 surface soil, 37 subsurface soil, 14 groundwater, and 6 sediment/surface water samples were collected. Four nitroaromatic compounds were detected in soil samples in direct-push borings DP09, DP10, DP11, and DP18 (IT, 2000c).

A screening level ecological risk assessment (SLERA) was initially performed for the WARWP (IT, 2000c). Based on the SLERA results which suggested the potential for ecological impact, a full BERA (IT, 2001f) was performed to more accurately determine whether ecological receptors may be adversely impacted by PBOW-related chemicals in WARWP soil, surface water or sediment. The BERA included revised food-web models based on site-specific bioconcentration factors (BCF) derived from tissue sample and site-specific aquatic and terrestrial toxicity testing. It was concluded from the BERA that PAH concentrations in one surface soil indicated some

earthworm toxicity; however, survival was decreased by less than 30 percent. These PAHs may be generated by controlled burning which is practiced at PBOW. Food-chain modeling indicated some potential for ecological risk to the shrew associated with PAHs, but only under the most conservative assumptions. Given the weight of evidence, it is unlikely that WARWP Area soils represent an unacceptable ecological concern. Iron concentrations in one sediment sample indicated the potential for ecological risk to the raccoon and heron through food chain modeling under the most conservative assumptions; more typical central tendency. Toxicity study results suggested some toxicity to benthic invertebrates. However, the maximum iron concentration detected in the sediment samples (24,200 mg/kg) likely results from the native background soil which comprises the substrate of the pond. Iron concentrations in PBOW background soil range up to 234,000 mg/kg (mean of 40,100 mg/kg). Thus, there appear to be no site-related impacts to sediment with regard to ecological receptors in the WARWP Area.

A BHHRA was also performed for exposure to WARWP soil, surface water and sediment (IT, 2000c). Results of the BHHRA indicate that site-related cumulative human health risks do not exceed the respective risk management levels for cancer risk (i.e., ILCR >1E-5) and noncancer hazard (i.e., HQ >1) when summed across all media for any of the receptors evaluated.

In December 2002, an FFS was submitted by Shaw for the two Red Water Pond Areas (IT, 2002d). It concluded that the cancer risk and the noncancer hazard associated with exposure to contaminants in surface soil, total soil, sediment, and surface water are within the risk management range or are *de minimus* for all receptors at the WARWP. Because no WARWP COCs were identified in the BHHRA, the FFS did not identify or evaluate any remedial alternatives for the WARWP.

As part of the expanded groundwater RI, Shaw sampled groundwater from two existing Delaware Limestone bedrock wells (BED-MW14 and BED-MW19) associated with the WARWP. No pre-existing overburden/shale monitoring wells were sampled. Groundwater sampling was conducted during two seasonal time periods; September-October 2001 “dry season” and April 2002 “wet season” to monitor any seasonal fluctuations in groundwater quality (Figure 3-4). Groundwater samples were analyzed for nitroaromatics, VOCs, SVOCs, filtered and unfiltered metals, cyanide, and water quality parameters (Shaw, 2003a). Groundwater analytical results, compared to background screening results, are discussed in Section 7.0.

3.2.2 Pentolite Road Red Water Ponds

The PRRWP are located in the north-central portion of the PBOW facility, north of Maintenance Road and south-southeast of the Reactor Facility Area across Pentolite Road, as shown in Figures 1-2 and 3-5. Historical surface water, sediment, soil, and groundwater (1993, 1994, and 1996) analytical results are shown on Tables 3-17, 3-18, 3-19, and 3-20, respectively. Historical groundwater analytical results are compared to RBSCs. Groundwater analytical results from 1997 to 2004 are compared to RBSCs and BSC values and are discussed in Section 7.0.

In April 1977, PBS personnel reported pockets of reddish brown water in the small surface ditch east of and adjacent to the PRRWP. The source of the reddish brown water was discovered to be a broken drain tile that was formerly used to drain the ponds. As a corrective action, retention dikes and sump pits were excavated to prevent further leakage of the material to the stream. Approximately 60,000 gallons of the red water were removed from the PRRWP by a private contractor and grading and drainage improvements were made to the area. The action also included backfilling of the former ponds and excavation of a new drainage ditch approximately 300 ft east of the ponds to reduce standing surface water (D&M, 1997c).

In 1989, Shaw conducted an evaluation to determine whether residual chemical contamination was present from former DOD activities at the red water pond areas. Soil samples from borings IT-SB13 through IT-SB18 were collected at the PRRWP area. Overburden/shale monitoring well IT-MW05 was installed on the northern edge of the PRRWP, in a suspected downgradient location. Nitroaromatic compounds 2,4-DNT and 2,6-DNT were detected in soils at concentrations of at least 0.740 part per million (IT, 2000c).

In 1993, MK conducted a site inspection to assess the threat posed to human health and the environment and to determine the need for additional investigations. Surface soil and sediment samples were collected and analyzed from a drainage ditch along Pentolite Road, north of the PRRWP area. No samples from the Pentolite Road ditch showed detectable levels of VOCs, SVOCs, or nitroaromatics (MK, 1994).

As part of the 1994 Focused RI, to identify and evaluate the source, nature, and extent of contamination of former DOD activities, surface and subsurface soil at the Red Water Ponds was investigated by D&M. Soil samples were collected and analyzed for nitroaromatics and metals. Nitroaromatics 1,3,5-TNB and 2,4-DNT were most commonly detected (D&M, 1997c).

From May to June of 1994, D&M conducted a groundwater investigation to evaluate groundwater conditions in several areas at PBOW. One scope of work (SOW) included the assessment of groundwater quality in the overburden/shale and bedrock water-bearing zones at the PRRWP area. Overburden monitoring wells PR-MW7, PR-MW8, and PR-MW9 and bedrock monitoring well BED-MW15 were installed. The investigation found that the groundwater flow in the overburden exhibited a strong downward vertical component and the presence of groundwater in the residuum was seasonally dependent. Groundwater sample results indicated that nitroaromatics were present in the overburden water-bearing zone, while lower levels of nitroaromatics were present in the bedrock water-bearing zone (D&M, 1997b).

A site-wide groundwater investigation performed by Shaw in 1996 determined that the overburden/shale water-bearing zone had been impacted by nitroaromatic compounds and that the bedrock water-bearing zone had been impacted by BTEX compounds, SVOCs, and nitroaromatics (IT, 1997). Groundwater sampling events in November 1997 and May 1998 indicated continued elevated concentrations of nitroaromatic compounds (IT, 1999).

Shaw conducted a soil and groundwater risk assessment and direct-push investigation in June and November 1998 at the PRRWP. A total of 20 surface soil, 39 subsurface soil, and 20 groundwater samples were collected. Nitroaromatic compounds were detected in soil samples in direct-push borings DP01, DP02, DP03, DP06, DP09, DP10, DP11, and DP16. Maximum concentrations included 9.3 mg/kg 1,3-DNB and 25 mg/kg 2,4-DNT in DP03 (4 to 5 ft), 1.7 mg/kg 2,6-DNT in DP10 (9 to 10 ft), and 2.7 mg/kg 4A-2,6-DNT in boring DP11 (0 to 2 ft). Groundwater samples with detected nitroaromatics exceeding RBSCs included DP01, DP03, DP04, DP06, DP07, DP08, DP10, DP11, DP12, DP13, DP17 and DP18. A maximum nitroaromatic concentration of 600 µg/L 1,3,5-TNB was detected in DP11, 4,800 µg/L 1,3-DNB, 6,800 µg/L 2,4-DNT in DP03, and 400 µg/L 2,6-DNT was detected in DP10 (IT, 2000c).

A SLERA was initially performed for the PRRWP (IT, 2000c). Based on the SLERA results which suggested the potential for ecological impact, a full BERA (IT, 2001f) was performed to more accurately determine whether ecological receptors may be adversely impacted by PBOW-related chemicals in WARWP soil, surface water, or sediment. The BERA included revised food-web models based on site-specific BCFs. It was concluded from the BERA, using the most conservative exposure assumptions, only a low potential for adverse ecological effects exists upon exposure to PRRWP soil by terrestrial receptors. No site-related chemicals were identified as potentially impacting PRRWP surface water or sediment.

A BHHRA was also prepared by Shaw for exposure of PRRWP surface soil and total soil (IT, 2000c). Results of the BHHRA indicate that cumulative human health risks associated with total soil exceed the respective risk management criteria for cancer risk (i.e., ILCR >1E-5) and noncancer hazard (i.e., HQ >1) in the potential future resident. Also, the noncancer hazards for the construction worker also exceed the risk management range for exposure to total soil. Six nitroaromatics and benzo(a)pyrene COCs were identified in the BHHRA.

An FFS was conducted for the two Red Water Pond areas (IT, 2002d). The FFS evaluation of the PRRWP was initially based on the BHHRA and the COCs identified therein. During the FFS, a single location with elevated nitroaromatics concentrations, particularly TNT, was identified. It was determined that if this small "hot spot" was remediated, then the remaining soil would not pose a cancer risk nor noncancer hazard for any PRRWP receptor at levels exceeding the respective risk management criteria.

In September 2001, as a continued part of the expanded groundwater RI, Shaw installed Delaware Limestone bedrock monitoring well BED-MW23 (Figure 3-5). It was positioned to monitor groundwater leaving the PRRWP and entering the Reactor Facility Area. Shaw also sampled groundwater from one pre-existing Delaware Limestone bedrock well (BED-MW15) and groundwater from the newly installed well (BED-MW23). No pre-existing overburden/shale monitoring wells were sampled. Groundwater sampling was conducted during two seasonal time periods; September-October 2001 "dry season" and April 2002 "wet season" to monitor any seasonal fluctuations in groundwater quality. Groundwater samples were analyzed for nitroaromatics, VOCs, SVOCs, filtered and unfiltered metals, cyanide, and water quality parameters (Shaw, 2003a). Groundwater analytical results, compared to background screening results, are discussed in Section 7.0.

3.3 Background Area

3.3.1 Soil

As part of the SOW for the TNT Areas Site Investigation by D&M, background soil conditions were investigated in late October-early November 1994. Based on historical use of property by former DOD and NASA operations, background borings were drilled by hand auger in areas where soil contamination was least likely to be present. Figure 3-6 shows an approximate location of each boring. Soil samples were collected from composite samples from depths of 0.5-3.0 and 3.0 -5.0 ft bgs except where bedrock was encountered before 5.0 ft. A total of 9 borings were drilled and 14 soil samples collected. Soil samples were analyzed for

nitroaromatics, metals, VOCs, and SVOCs. No nitroaromatics were detected in any of the background samples. Four VOC compounds (toluene, trichloroethene, xylenes, and cis-1,2-dichloroethene) and 1 SVOC (bis[2-ethylhexyl]phthalate) were detected (D&M, 1997a). Historical soil (1994) analytical results are shown on Figure 3-6.

3.3.2 Groundwater

No background groundwater investigations had been conducted at PBOW prior to September-October 2001. As part of the groundwater RI conducted by Shaw in 2001, 3 bedrock monitoring wells (BED-MW24, BED-MW25, and BED-MW26) were installed in assumed upgradient, background locations (Figure 2-2). Sampling of the bedrock groundwater was performed on a quarterly basis to monitor the seasonal changes in the groundwater quality.

In August 2003, 2 additional background monitoring wells (BED-MW28 and BED-MW29) were installed on off-site property to assess background locations and further define the background groundwater analytical data. Monitoring well installation, development, survey, conductivity testing, and sampling is discussed in Section 4.0.

In summary, seven wells were installed as potential upgradient bedrock background wells for PBOW. Based on a review of all available site data, the following wells were used for inclusion in the PBOW background data set (Shaw, 2004d):

- BG8-BEDGW-001 (10 samples)
- BED-MW25 (10 samples)
- BED-MW28 (4 samples)
- BED-MW29 (4 samples).

Only samples from the above wells collected using low-flow (minimal drawdown) sampling were used in the derivation of BSCs, and only these samples will be used in statistical population testing or other evaluations (Appendix M), as needed, in the groundwater BHHRA (Shaw 2004c).

The following wells were excluded from the PBOW background well data set, with the reasons for exclusion provided in parentheses (see Attachment M1 in Appendix M for detailed explanations):

- BED-MW20 (excluded due to the presence of methane)
- BED-MW24 (excluded because location is now interpreted as being downgradient from a contamination source; also, presence of multiple nitroaromatics)
- BED-MW26 (insufficient well yield).

A total of 10 quarterly groundwater sampling events have been performed at the monitoring wells in the background locations. Monitoring well installation, development, conductivity, and surveying activities along with analytical results for the first 4 quarters were presented in the Shaw *2002 Groundwater Data Summary and Evaluation Report* (Shaw, 2003a). Groundwater analytical results of the next 5 quarterly sampling events were presented in quarterly background reports as documented in Section 1.0.

4.0 Field Activities

4.1 Introduction

In February 2003, a continued RI/FS SOW was issued by the Nashville USACE which expanded the present TNT and Red Water Pond Areas groundwater investigation to locations both upgradient and downgradient of NASA's PBS boundaries. Analytical results of the upgradient groundwater was intended to be part of a background data set for metals in various groundwater risk assessments and to help describe regional PAH levels. Downgradient nitroaromatic groundwater data was used to show the extent of chemicals beyond the boundary of PBOW (USACE, 2003).

Based on the USACE 2003 SOW, 2 background and 5 downgradient bedrock monitoring wells were to be installed during 2 separate mobilizations. The boreholes were located on property outside of PBS boundaries on private or government owned property (Figure 2-2). All drilling locations required legal right-of-entry forms, which were obtained by the USACE Huntington District. Background monitoring well BED-MW28 was located on NASA property near the intersection of Taft and Mason Roads and well BED-MW29 was located on private property south of West Scheid Road and west of Ransom Road. Drilling of background monitoring wells began in August 2003.

Drilling of boreholes at the off-site, downgradient locations began in March 2004. As noted in the 2003 USACE SOW, 5 downgradient monitoring wells were to be installed but because groundwater was not encountered in the Delaware Limestone during drilling at 3 of the 5 boreholes, only 2 (BED-MW30 and BED-MW33) were able to be completed as monitoring wells (Figure 2-2). Monitoring well BED-MW30 is located on the west side of PBOW, near the intersection of Bouy and Patten Tract Road and BED-MW33 is located north-northeast of PBOW, in Columbus Park. Downgradient borehole BED-MW31 is located on off-site property on the northwest side of PBOW, west of Schenk Road. Borehole BED-MW32 is located north of PBOW on the east side of Columbus Avenue beneath the State Route 2 overpass and borehole BED-MW34 is located on NASA owned property, at the abandoned former sewage treatment plant area, north of Taylor Road near Botay Road.

Mobilization for both the background and downgradient field events included drilling, well installation, development, permeability testing, land surveying, groundwater sampling, and IDW management.

Four consecutive quarterly groundwater sampling events of the new background monitoring wells were conducted in correlation with the existing background wells. Table 4-1 provides a complete summary of the background groundwater sampling investigations. Background groundwater sampling conducted in 2003 included a seventh round (September 16 to 18, 2003 during the PBOW dry season) and an eighth round (December 9 to 11, 2003 during the dry season). Background groundwater sampling continued in 2004 with the ninth round (March 9 to 11, 2004 during the wet season) and was completed by the tenth round (June 15 to 17, 2004 during the wet season). To make a determination if groundwater quality of the downgradient wells fluctuated on a seasonal basis, sampling of the new and existing downgradient wells was conducted May 5 to 7, 2004 (wet season) and August 24 to 27, 2004 (dry season).

4.2 Monitoring Well Installation

Four 2-inch diameter bedrock monitoring wells were installed as part of the continued groundwater RI. Two wells are located in upgradient (background) positions, 1 well (BED-MW30) is located downgradient of WARWP, and 1 well (BED-MW33) is located downgradient of the PBOW facility. Figure 2-2 (site map with wells and lines of cross-section) shows the site-wide locations of the newly installed wells along with the pre-existing monitoring wells. Two bedrock background wells, BED-MW28 and BED-MW29, monitor groundwater entering PBOW from the south and southwest perimeter areas, respectively. After well installation and monitoring of static groundwater levels, it was interpreted that monitoring well BED-MW30 monitors groundwater downgradient of the WARWP. Monitoring well BED-MW33 monitors groundwater that has left PBS in the north-northeasterly direction. As noted in Section 4.1, five downgradient bedrock wells were planned to be installed, but because groundwater was not encountered in the Delaware Limestone, only 2 of the 5 boreholes were able to be completed as monitoring wells.

Monitoring wells were installed in accordance with guidelines specified in the USACE Engineering Manual EM-1110-1-4000 (USACE, 1998) and following the procedures in the site-wide SAP (IT, 1996a). All monitoring wells were completed as described below.

Background bedrock monitoring well installation began in August 2003 and downgradient bedrock well installation began in March 2004. Prior to drilling, Ohio's Utility Protection Service was notified to locate any underground utility lines at boreholes located on private property. NASA was notified to locate underground utilities at boreholes located on NASA property. The borehole was relocated, if necessary, to avoid buried utilities after the state utility protection service and NASA personnel surveyed the locations.

All 4 bedrock wells were installed as double-cased monitoring wells. Although groundwater was not encountered during drilling of boreholes BED-MW31, BED-MW32, and BED-MW34, drilling procedures and equipment were identical to the drilling procedures for downgradient wells BED-MW30 and BED-MW33. A Schramm 450 air rotary drilling rig was used to drill a pilot borehole in the overburden soil of background boreholes while an Ingersoll-Rand T-3 air rotary rig drilled the overburden soil of the downgradient boreholes. As a precautionary measure, at each background and downgradient borehole location (even after underground utilities were located) the first 4 ft of the borehole was attempted to be manually dug using a 4-inch outside diameter (OD), decontaminated, stainless-steel posthole digger. During posthole digging of the background wells, weathered shale bedrock was encountered at a depth of 2.3 ft bgs at BED-MW28 and 3.8 ft at borehole BED-MW29. Hazardous, toxic, and radiological waste (HTRW) drilling logs for each borehole are included in Appendix B.

At background borehole BED-MW28, since weathered shale was encountered at a depth of less than 4 ft, no split-spoon sampling was performed. Because a severely weathered shale in background borehole BED-MW29 was encountered, a split-spoon sample was attempted beginning at 4 ft bgs. Consistency of the shale increased with depth and only 0.7 ft was able to be collected. A pilot hole of each background borehole was drilled with a 6-inch OD roller bit for the purpose of identifying the depth to competent shale bedrock and then advancing at least 3 ft into the competent rock. The pilot hole was advance to 14 ft in borehole BED-MW28 and 18 ft in BED-MW29. The pilot hole was then reamed with a 10-inch OD roller cone enlarging the hole for placement of isolation casing and to confirm the competent shale bedrock depth. The 10-inch background borehole for BED-MW28 was advanced to 14 ft bgs and to a total depth of 24 ft in BED-MW29. Black steel isolation casing (6-inch inside diameter [ID] by 6 5/8-inch OD) was installed into the 10-inch borehole, pressure grouted in place, and allowed to cure for a minimum of 48 hours.

In downgradient boreholes, bedrock was not encountered during initial post-hole digging activities. Soil core samples were continuously collected from the ground surface to the terminating depth using a 2.5-inch ID/3-inch OD stainless steel split-spoon. After each soil sample was collected, a 6 5/8-inch OD roller cone bit cut the soil to the next sample depth. Hollow stem augers were not used during drilling. Soil cores were visually examined by a Shaw field geologist and documented on HTRW drilling logs (Appendix B). No soil overburden samples were collected for laboratory analysis because bedrock monitoring wells were installed

in suspected "clean" soil areas; thus, overburden soil was not analyzed for chemical parameters, except for disposal characterization as described in Section 6.0.

After determining depth to bedrock, the soil borehole was reamed using a 10-inch OD air hammer at least 4 ft into competent bedrock to provide a stable base for the isolation casing. Black steel casing (6-inch ID by 6 5/8-inch OD) was installed, pressure grouted into the bedrock, and allowed to cure for a minimum of 48 hours.

Bedrock was then cored with water using a Schramm or Ingersoll-Rand air rotary drill rig. Coring was conducted through the center of the black steel casing using a 4 5/8-inch OD PQ bit attached to a 20-foot long core barrel. The PQ bit was not custom built to cut a 6-inch OD borehole so after the desired depth had been reached, the bedrock was reamed using a 6-inch OD roller cone. Rock cores of both the background and downgradient borings were visually examined and a lithology description prepared (Appendix B). Photographs of the rock cores were taken and are presented in Appendix C.

If groundwater was encountered during drilling, well completion was accomplished using a 2-inch diameter Schedule 40 polyvinyl chloride (PVC) riser pipe and 10 to 20 foot sections of 0.010-inch factory-slotted screen. Filter packs in screened wells were constructed with sand (tremied) beginning at a depth approximately 1-foot below the screen to approximately 2 ft above the screen. Three to six ft of pellet bentonite was then placed above the sand. The remaining annular space between the PVC/borehole and PVC/black steel casing, from the top of the bentonite to approximately 2 ft bgs, was filled (tremied) with bentonite-cement grout. Because the wells were constructed on private property or property outside of NASA's security fencing and to remove the visual presence associated with the stick-up protective casing, all wells were constructed as flush mount wells.

A 2-foot-square, 4-inch-thick, concrete pad with sides sloping away was constructed around all 4 wells. No protective steel posts surrounding the wells were necessary. An identification plate that verified the well name, total depth, depth to screen, and survey information was secured inside the flush mount access hole.

The construction details for the new monitoring wells at the site are summarized in Table 4-2. Drilling logs and well construction diagrams are included in Appendix B.

4.3 Monitoring Well Development

Prior to true well development activities, a "predevelopment" of the well was conducted. Predevelopment of the well was performed following the addition of the filter pack but before the addition of the bentonite seal. This was performed to allow compaction of the filter pack, prevent any bridging of the sand that may have occurred during installation, and allow placement of any additional sand after predevelopment (Shaw 2003d). Predevelopment activities of each monitoring well included surging with a 2-inch OD surge block or Grundfos pump within the entire well screen for 20 minutes, followed by removal of 2 casing volumes of groundwater. Groundwater was removed using a Grundfos pump which was operated at variable speeds to also produce a surging effect on the filter pack. Following groundwater removal, additional sand was added to the filter pack, if necessary, followed by the bentonite. No water quality readings were recorded or logs created during predevelopment.

All newly constructed monitoring wells were developed no sooner than 48 hours and no later than 7 days after completion of well construction. Well development was performed by surging and bailing with a polyethylene disposable bailer or surging and pumping using a Grundfos™ submersible pump. The method of development chosen depended upon groundwater yield in the well. A well development log was completed for each well to document well development progress, field parameters, and other pertinent information. Photographs of development water and well development logs are included in Appendices D and E, respectively. One monitoring well, PB-BED-MW33, could not be properly developed due to a limited water column and poor recharge. A total of 20 gallons was removed from this well during predevelopment activities but groundwater did not recharge during development. The impact of the limited development may present groundwater samples with higher turbidity, not representative of bedrock aquifer conditions.

It is noted that following well completion activities, remeasurement of BED-MW30 and BED-MW33 well depths, and discussion with the drilling firm, it was determined that an incorrect sand size had been used for filter pack construction in these two wells. As a result of using Driller Service, Inc. size #1 sand rather than the appropriate size #2 sand, quantities of filter pack sand passed through screen slots and into the monitoring well during well development. This influx of sand decreased the total accessible depth of BED-MW30 by approximately 3 ft and BED-MW33 by approximately 4.5 ft. The change in total depth of BED-MW30 was recorded following predevelopment but the change was thought to have been caused by raising the well during surging actions. The change in total depth of BED-MW33 was also noted prior to its development. Approximately 2 weeks later, confirmation with the drilling firm was made that an

incorrect sand size had been used for filter pack construction. The needed water column for complete sample collection is available in monitoring well BED-MW30 but only a partial sample suite can be collected from the groundwater in well BED-MW33. The Nashville USACE were notified and repair was determined unnecessary.

4.4 Monitoring Well Abandonment

In January 2003, overburden/shale monitoring well PR-MW08 (PRRWP well) and Delaware Limestone well BED-MW27 (downgradient well) were abandoned. Overburden/shale well PR-MW08 was abandoned for an interim soil remediation action (IT, 2002d) and well BED-MW27 was abandoned at the publics request due to "nuisance" hydrogen sulfide odors. Well abandonment activities were conducted by Waste Tron, Inc. under contract by the USACE-Huntington District. Prior to BED-MW27 abandonment, a groundwater sample was collected by Shaw in October 2002. Groundwater sampling activities are discussed in Section 4.5.

4.5 Groundwater Sampling

A total of 12 groundwater sampling events have taken place at PBOW since the data presented in the 2002 Groundwater Data Summary and Evaluation Report (Shaw, 2003a). Sampling events have included a total of 10 background and 2 downgradient episodes. As noted in Section 1.0, analytical results and field sampling activities from the first background groundwater sampling event through the ninth groundwater sampling event are not presented in this report as individual reports have already been prepared and submitted for each sampling event.

Information in this report includes groundwater sampling activities during the October 2002 downgradient monitoring well BED-MW27 sampling, 2004 10th background groundwater sampling, and both 2004 downgradient monitoring well sampling events. Sampling events are presented in the order of occurrence. Groundwater samples from each event were analyzed for nitroaromatics, metals (filtered and unfiltered), VOCs, SVOCs, and water quality parameters (alkalinity, chloride, cyanide, hardness, nitrate, sulfate, total dissolved solids, total organic carbon, total suspended solids, and turbidity).

To obtain additional off-site, downgradient, analytical data for groundwater delineation purposes, a privately owned water well (PT-5912) was sampled during the second downgradient well sampling event (August 2004). Well PT-5912 is located at 5912 Patten Tract Road (hence the selected well identification name for this report) on private property, northwest of Acid Area No. 2 (AA2), and north of well BED-MW30 (Figure 2-1). It was installed in 1982 for the purpose of lawn watering. Well PT-5912 is constructed of 6-inch OD steel casing set to a depth

of 25 ft. A 5-inch OD open borehole is present from the bottom of the casing to a total depth of 89 ft into the Delaware Limestone. The well was never used for any purpose because of the hydrogen sulfide odor (i.e., "rotten egg" odor) received when extracting the groundwater (typical with groundwater from the Delaware Limestone). A completed right-of-entry form was obtained from the property owner prior to any field work being conducted. Top-of-casing survey measurements were recorded for this well for potentiometric map construction. Survey data is discussed in Section 4.8.

Upon arrival at all monitoring wells and following removal of the security lock, the lid to the well was removed and the vapors within the casing were immediately measured using a photoionization detector and a 4-gas lower explosive limit meter that measured the lower explosive limit, carbon monoxide, oxygen, and hydrogen sulfide content. Measurement was performed as an early indication of the breathing air vapors that may be encountered when purging activities began. Once well purging activities commenced, breathing air concentrations were continuously measured and compared with the health and safety requirements (Shaw, 2003d). Hydrogen sulfide was one of the hazardous chemicals commonly encountered when purging groundwater from the bedrock wells screened within the Delaware Limestone. If hydrogen sulfide within the working area remained above the site action limit of 5 ppm (meaning 4 instantaneous peaks in any 15-minute period or a sustained reading for 5 minutes), relocation of sampling equipment upwind of the vapors was conducted. If no wind was present or relocation did not permit the instrument readings to drop below 5 ppm, then sampling activities were discontinued. During sampling activities at BED-MW17, hydrogen sulfide vapors were greater than 500 ppm; therefore, a continuously operating mechanical fan was positioned at the top of the well head to evacuate vapors away from the work zone and allow sampling to continue.

Two procedures were used for purging and sampling monitoring wells. Low-flow (minimal drawdown) was the preferred purging and sampling method in wells where adequate recharge was present. If a well did not recharge adequately to use the low-flow sampling method (i.e., water level dropped 6 inches or more), removal of 3 to 5 volumes of groundwater was performed either by continued pumping or bailing followed by sampling.

Filtered and unfiltered samples were collected for metals analysis. Filtered groundwater samples were filtered in the field through a 0.45-micrometer high-capacity filter attached to the discharge line of the bladder pump. If the well was not sampled using the bladder pump (i.e., sampled with a disposable bailer), a hand-operated 0.45-micrometer filter was used. Sample filtration,

preservation, packing, and shipment were performed in accordance with Section 5.4 of the site-wide QAPP (IT, 1996b).

All groundwater that was removed from the wells during purging activities was containerized and properly disposed of following the IDW management procedures as identified in the Shaw SOW (Shaw, 2003d). Details of disposal activities are presented in Section 4.9.

Table 4-3 shows a list of the primary groundwater samples collected. Final field measurements recorded immediately prior to groundwater sample collection are shown in Table 4-4. A final water quality reading was not recorded if adequate water volume was not present (BED-MW33) or if sample water would have possibly contaminated the recording instrument beyond decontamination efforts (BED-MW27). Monitoring well locations are shown on Figure 2-1.

October 2002 Downgradient Well BED-MW27 Sampling (Prior to Abandonment)

Monitoring well BED-MW27 was sampled October 18, 2002, prior to scheduled abandonment, as part of the fifth quarterly background groundwater sampling activities. Groundwater samples could not be collected by the low-flow (minimal drawdown) sampling method because of approximately 0.5 foot of natural petroleum hydrocarbon on the surface of the water. Water within the groundwater column was black in color, continued to exhibit a small amount of petroleum hydrocarbon during purging, and contained black, oxidized "flakes" of some material; possibly, the flakes resulted from the metal of the inner steel casing that had been oxidized by the hydrogen sulfide gas and fallen into the groundwater). Due to the visually affected groundwater and concern of potential damage to water quality equipment, no water quality readings were attempted.

Groundwater was purged from the well using a 3-inch OD, decontaminated, PVC bailer. The well was bailed dry after removing approximately 60-gallons of water. A groundwater sample was collected with a new, disposable, Teflon® bailer. Dissolved metals were filtered using a 0.45-micrometer filter hand pump.

May 2004 Downgradient Well Sampling

The first downgradient monitoring well sampling event was conducted during the wet season, May 4 through 7, 2004. Groundwater samples were collected from existing, on-site, downgradient monitoring wells BED-MW17, BED-MW19, and BED-MW22 and from newly installed, off-site, downgradient wells BED-MW30 and BED-MW33. Groundwater was not

encountered during drilling activities in 3 of the 5 planned downgradient boreholes which prevented installation of a monitoring well.

Groundwater recharge rates permitted 4 of the 5 wells to be sampled with the low-flow sampling methodology. A bladder pump was used to complete the sampling. The pump was inserted into the screened portion of the monitoring well and the well was pumped at a rate that minimized drawdown. Purging rates ranged from 100 milliliters/minute (ml/min) in well BED-MW19 to a maximum purge rate of 200 ml/min in well BED-MW22. The purge rate was set such that drawdown in the well was never greater than 0.5 foot in all wells except BED-MW17. The purge rate in well BED-MW17 was approximately 160 ml/min but the water level in this well dropped 1.68 ft from the static measurement. At a drawdown of 1.68 ft, the water level stabilized along with the water chemistry parameters. Water chemistry parameters (pH, oxidation-reduction potential, conductivity, temperature, dissolved oxygen, and turbidity) were monitored for stability. Sufficient groundwater recharge was not present in monitoring well BED-MW33 to permit low-flow sampling so the well was purged using a 2-inch disposable, polyethylene bailer and sampled using a disposable Teflon bailer. Due to a limited volume of groundwater, only nitroaromatics, metals (filtered and unfiltered), and VOCs were collected. Dissolved metals were filtered using a 0.45-micrometer filter as described above.

June 2004 Background Well Sampling (10th Quarterly)

The tenth background groundwater sampling event was conducted during the wet season, June 15 through 17, 2004. Groundwater samples were collected from existing on-site and off-site potential background bedrock monitoring wells BG8-BEDGW-001, BED-MW20, BED-MW24, BED-MW25, BED-MW28, and BED-MW29. Groundwater samples were collected following the same sampling procedures as identified above and were analyzed for the same parameters.

Groundwater recharge rates permitted 6 of the 7 possible background wells to be sampled with the low-flow sampling methodology. A sufficient water column was not present in background well BED-MW26 so a sample was not collected. A bladder pump was used to complete the sampling. The pump was inserted into the screened portion of the monitoring well and the well was pumped at a rate that minimized drawdown. Purging rates ranged from 50 ml/min in well BED-MW20 to a maximum purge rate of 400 ml/min in well BED-MW25. The purge rate was set such that drawdown in the well was never greater than 0.5 foot in all wells except BED-MW20. At a purge rate of 50 ml/min, the water level dropped 1.23 ft from the static measurement. At a drawdown of 1.23 ft, the water level stabilized along with the water chemistry parameters. Water chemistry parameters as noted above were monitored for stability.

August 2004 Downgradient Well Sampling

The second downgradient monitoring well sampling event was conducted during the dry season, August 25 through 27, 2004. Groundwater samples were collected from existing, on-site, downgradient monitoring wells BED-MW17, BED-MW19, and BED-MW22 and from off-site, downgradient wells BED-MW30, BED-MW33, and PT-5912.

Groundwater recharge rates permitted 5 of the 6 wells to be sampled with the low-flow sampling methodology. A bladder pump was used to complete the sampling. The pump was inserted into the screened portion of the monitoring well and the well was pumped at a rate that minimized drawdown. Purging rates ranged from 90 ml/min in well BED-MW19 to a maximum purge rate of 180 ml/min in well BED-MW17. The purge rate was set such that drawdown in the well was never greater than 0.5 foot in all wells except BED-MW19. The purge rate in well BED-MW19 was approximately 90 ml/min but the water level in this well dropped 0.71 ft from the static measurement. At a drawdown of 0.71 ft, the water level stabilized along with the water chemistry parameters. Water chemistry parameters were monitored for stability. Sufficient groundwater recharge was not present in monitoring well BED-MW33 to permit low-flow sampling so the well was purged using a 2-inch disposable polyethylene bailer and sampled using a disposable Teflon bailer. Due to a limited volume of groundwater, only nitroaromatics, metals (filtered and unfiltered), and VOCs were collected. Dissolved metals were filtered using a 0.45-micrometer filter as described above.

4.6 Hydraulic Conductivity Testing

A rising and/or falling head slug test was performed at background wells BED-MW28 and BED-MW29 and newly installed wells BED-MW30 and BED-MW33 on May 4 to 6, 2004 to acquire information on the hydraulic conductivity of each water-bearing zone. Equipment used in the test included:

- Ten-pounds-per-square-inch pressure transducer equipped with an atmospheric pressure compensation tube
- HERMIT 1000C Environmental Data Logger
- New, disposable five-foot-long or two five-foot-long, 1.5-inch-diameter PVC slugs.

Rising and/or falling head tests were completed by performing the following steps:

- Measure the static water level from the top of casing.
- Place a pressure transducer at least ½ foot above the bottom of the well and initiate the reference information on the data logger.
- Allow the water level to re-equilibrate, then initiate the data logging sequence on the recording device and insert the slug to start the falling head test.

After the falling head test was complete and the water level returned to the pre-testing condition, the data logger was reset. The rising head test was begun by removing the slug from the well.

The slug test results were analyzed using AQTESOLV for Windows Pro 3.0 (Geraghty and Miller Environmental Services, 1989), which assumes that the aquifer being tested is homogenous and isotropic. Since the aquifer is rarely a homogenous and isotropic media, the hydraulic conductivity calculation based on commonly accepted assumption and the Bouwer and Rice method will have uncertainties associated with it. The degree of uncertainty is directly proportional to the deviation of the homogenous and isotropic model from the reality. Such uncertainty can only be reduced but not eliminated through specifically designed pumping tests with sufficient monitoring coverage and duration. Pumping tests are not practical for this phase of the investigation. Furthermore, an accurate estimation of hydraulic conductivity in a fractured bedrock medium poses more challenge than in porous medium. Therefore, the calculated hydraulic conductivity value using the best available data at the site represents an approximation of the aquifer's "true" hydraulic conductivity. It is recommended that the slug test data be used with caution, knowing the limitations and uncertainties associated with these results. The hydraulic conductivity testing data are included in Appendix E, along with a description of the method used in the data analysis.

Based upon the current hydrology understanding, where fractured bedrock is encountered, slug test results would most likely be biased low. Results would probably be low since vertical anisotropy is not considered but results are associated with a higher degree of uncertainty with using the Bouwer and Rice method. However, the extent of the uncertainty or the bias is highly dependent on the well development, skin effect, and fracture distribution. Opposite results or tendency (biased high) may occur if the fractures are very well developed just in the immediate proximity of the well and no skin effect is present, which is a very unlikely situation. This is because any slug test only affects the immediate proximity of the well and not the formation farther away. Unlike the slug test, a pumping test covers a much larger area around the well and, therefore, the hydraulic conductivity result is more representative of the site than slug test.

4.7 Decontamination Procedures

Decontamination of drill rigs, downhole tools, and sampling equipment was performed in accordance with Section 4.4.3 of the SAP (IT, 1996a). Specifically, drill rigs, rods, drill bits, and augers were cleaned at the decontamination pad using high pressure hot water from a steam-cleaner before entering the drilling site, between sites, and after completion of the last borehole. Other equipment, including water level indicators, slugs, and transducers, was decontaminated by rinsing in sequence with phosphate-free soapy water, deionized water, isopropyl alcohol, and a final rinse with deionized water. Equipment was then air dried before use. The bladder pump was decontaminated by running the decontamination fluids through the pump head. Disposable tubing and bailers were used in the sampling. New tubing and new bailers were used for each well.

4.8 Land Survey

An Ohio-registered professional land surveyor surveyed soil borings and existing bedrock and new bedrock monitoring well locations during 3 different mobilizations. Background bedrock monitoring well locations BED-MW28 and BED-MW29 were surveyed in August 2003 along with 7 background soil borings (background soil boring data previously submitted under a separate cover) and existing well MK-MW17 (top of riser cut to permit lid closure). Downgradient monitoring wells (BED-MW30 and BED-MW33) and soil boring locations (BED-MW31, BED-MW32, and BED-MW34) were surveyed in April 2004. Vertical coordinates of existing, off-site, privately owned well PT-5912 located on Patten Tract Road, were surveyed in August 2004. Horizontal coordinates were surveyed to the closest 0.1 foot and referenced to the Ohio State Plane Coordinate System. Vertical coordinates (land surface elevation and top-of-casing elevation) were surveyed to the nearest 0.01 foot and referenced to the 1929 National Geodetic Vertical Datum. Complete land survey data are included in Appendix F.

4.9 IDW Management

IDW generated during the background and groundwater investigations included soil, groundwater, rock cores, decontamination water, and personnel protective equipment. All IDW was managed and handled in accordance with procedures described in the SAP (IT, 1996a). IDW (soil, groundwater, and rock cores) generated from locations outside of NASA PBS property was never transported back onto NASA property. This IDW was stored in a secured truck on Perkins county school property, located adjacent to the entrance of NASA.

Soiled personal protective equipment generated during the project was double-bagged and placed in the on-site industrial dumpster. Decontamination, development, and purge water generated

during field activities was labeled and stored in 55-gallon drums. Soil generated during soil boring sampling and monitoring well installation was collected in 55-gallon drums, labeled with contained material, content volume, date of generation, and source of origin as applicable.

Following soil and/or groundwater sample collection from on-site or off-site well and boring locations and determination of the media being non-hazardous from analytical results, the IDW was transported to a registered disposal facility. Soil, purge and development water, and some rock cores from wells BED-MW28 and BED-MW29 were transported to US Liquids of Detroit for disposal. The OEPA was given several rock cores from the nonhazardous, background well borings for use in scientific study. Purge water, development water, and soil generated during background sampling (June 2004), drilling of downgradient soil borings (BED-MW30 through BED-MW34), and sampling of the downgradient wells (May and August 2004) was transported to Evergreen landfill in Toledo, Ohio for disposal. After rock core lithologic data had been recorded and photographs made, a determination was made based on groundwater (if present) analytical results if the cores were non-hazardous. Upon approval from Hanson Quarries (formerly Wagner Quarries), rock cores generated during downgradient rock core drilling (BED-MW30 through BED-MW34) were transported to the quarry to be crushed and used for limestone gravel. Waste manifests and Bills-Of-Lading generated for the IDW disposal during the sampling and drilling events are shown in Appendix G.

5.0 Analytical Program and Data Review Methodologies

The following sections present the analytical program used in this investigation. This review includes the laboratories used for all samples, the analytical methods used, data quality evaluation, and blank analysis. In addition, a description and derivation of RBSCs, referenced in Chapter 3.0 and included in the analytical results tables (Section 7.0) as points of reference, are presented in Section 5.2.1. The derivation and use of BSCs, also referenced in Chapter 3.0 and included in the analytical results tables, are presented in Section 5.2.2.

5.1 Analytical Program Methodologies

5.1.1 Sample Analysis and Data Validation

Primary and field duplicate project samples were analyzed by Severn Trent Laboratories, Inc. of Knoxville, Tennessee. Analyses for water quality parameters were provided by Severn Trent's North Canton, Ohio, laboratory. Quality assurance samples (field splits) were analyzed by Accutest Laboratory of Orlando, Florida. Complete analytical data for the May 2004, June 2004, and August 2004 sampling events are presented. Shaw performed the data validation. The validation summaries for the May 2004 and August 2004 downgradient samples and July 2004 background groundwater samples are provided in Appendix H. The analytical results for the samples are summarized in Appendix I. Tables of detected hits that exclude "B" qualified (Section 5.1.3) data are included in Appendix J. A data quality evaluation is located in Appendix K.

All data analyzed were reviewed for accuracy and completeness. One hundred percent of the data analyzed were subjected to data validation following guidelines in the U.S. Environmental Protection Agency (EPA) Contract Laboratory Program National Functional Guidelines for organic and inorganic data review (EPA, 1999, 2002). These documents, since they specify procedures for CLP protocol, are used as guidelines only. Method and laboratory quality assurance and quality control requirements supersede these guidelines where applicable. Data were evaluated to verify the achievement of precision, accuracy, representativeness, completeness, and comparability goals established to meet the project data quality objectives (DQO). The criteria for blank evaluation mimic those detailed in the EPA's *Region III Modifications to National Functional Guidelines for Organic Data Review* (EPA, 1994) and *Region III Modifications to the Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses* (EPA, 1993). The procedure is outlined in Section 5.1.4.

5.1.2 Analytical Methods

Chemical analyses for the investigation were performed in accordance with guidelines detailed in the EPA's *Test Methods for Evaluating Solid Waste (SW-846), Physical/Chemical Methods,* Third Edition, September 1986 (EPA, 1986) and subsequent revisions. The groundwater samples and associated quality assurance/quality control samples were analyzed for VOCs, SVOCs, filtered and unfiltered metals, nitroaromatics, total cyanide, and water quality parameters alkalinity, chloride, nitrate, sulfate, total dissolved solids, turbidity, and hardness. Methods used for analysis for all four events are summarized in Table 5-1.

5.1.3 Data Quality Evaluation

The reliability of the sampling and analytical procedures used during the investigation was demonstrated by implementing the project-specific quality assurance procedures specified in the site-wide SAP (IT, 1996c) and QAPP (IT, 1996a) and its site-specific attachments. Successful execution of these procedures provides strong supporting evidence that the data are representative of the areas under investigation.

The DQOs for this project were to produce scientifically valid data of known accuracy and precision that were complete with respect to identified critical samples, comparable with similar data types, and representative of the media sampled so as to be useful for the cited purposes. Evaluation of the data using the DQOs and the data validation process resulted in the determination that most of the data set is valid and of sufficient quality to meet the objectives of the investigation. A complete evaluation of the analytical results is given in the data quality evaluations found in Appendix K.

5.1.4 Blank Evaluation

The purpose of blank analysis is to detect contamination resulting from laboratory and field activities. Blank evaluation involves qualification of data based on the results of associated field blanks, trip blanks, equipment rinsates, and laboratory method blanks. The criteria for blank evaluation are as follows:

- If a parameter is found in a blank but not detected in the sample, no action is taken.
- For organics, if the sample result is greater than the practical quantitation limit, but is less than 5 times (most analytes) or 10 times (common laboratory contaminants) that of the blank result, the sample result is qualified "B."
- For organics, if the sample result is less than the practical quantitation limit and less than 5 times (most analytes) or 10 times(common laboratory contaminants) the blank result, the sample result is qualified "B." The "J" qualifier is not used.

- For inorganics, if the sample result is greater than the method detection limit but less than 5 times the blank result, the sample result is qualified "B."

- If the sample result is greater than 5 times (most analytes) or 10 times (common laboratory contaminants) the blank result, the sample result is not qualified.

In instances where more than one blank is associated with a given sample, qualification is based upon a comparison with the associated blank having the highest concentration of a contaminant. Blank results are not subtracted from sample concentrations. Note that data with "B" validation qualifiers are included in the Section 7.0 tables, but the associated concentrations are not included in the tables' "MDC" column because "B" qualified data are not used in PBOW risk assessments (Shaw, 2004c).

5.2 Comparison to Screening Criteria

The analytical results tables presented in Section 7.0 include RBSCs and BSCs as points of reference. Concentrations of analytes that exceed the RBSCs are highlighted in the tables. RBSCs do not infer a regulatory limit or mandated cleanup level, nor does an exceedance necessarily represent an unacceptable human health risk.

Concentrations in individual samples that exceed the respective BSCs are identified in the Section 7.0 results tables.

The derivation of RBSCs and BSCs, as well as their intended use in the BHHRA, are provided in subsections 5.2.1 and 5.2.2, respectively. Figure 5-1 depicts a simplified protocol of how RBSCs and BSCs will be used for screening in the BHHRA. This figure is provided for additional information and does not directly apply to this report because, as mentioned, RBSCs and BSCs are provided herein as points of reference only.

5.2.1 Derivation and Use of RBSCs in the BHHRA

The groundwater RBSCs are derived from EPA (2004) tap water criteria. The RBSCs are based on a generalized residential drinking water scenario, assumed to be the most restrictive use of groundwater, and correspond to a one-in-a-million (1E-6) ILCR or a noncancer HQ of 0.1, whichever results in a lower concentration (Shaw, 2004c). In the BHHRA, the groundwater MDC of each chemical (for each study area) will be compared to the corresponding RBSC for each chemical. Essentially, those chemicals with MDCs exceeding the corresponding RBSCs (unless characterized as infrequently detected and nonsite-related [Shaw, 2004c]) will be further

evaluated in the BHHRA (see Figure 5-1); those with MDCs less than the RBSC will not. It is again emphasized that RBSCs do not infer a regulatory limit or mandated cleanup level, nor does an exceedance necessarily represent an unacceptable human health risk or indicate the need for remedial action.

5.2.2 Background Screening

BSCs were derived from PBOW background groundwater concentrations of inorganics and BTEX compounds. The derivation of BSCs is detailed in Appendix M. In summary, the BSC represents either the calculated upper tolerance limit of the background data set or the MDC, whichever is less, for each relevant analyte.

In the BHHRA, the groundwater MDC of each inorganic (for each study area) will be compared to the corresponding BSC (Shaw, 2004c). Those chemicals with MDCs exceeding the corresponding BSCs will be further evaluated in the BHHRA, unless already screened out on the basis of RBSC comparison or frequency of detection. This further evaluation may include statistical population testing or other statistical analysis (Appendix M) as deemed appropriate. Based on the results of the statistical analysis, the chemical is either carried forward into the risk assessment process (refer to Figure 5-1) or is excluded from further evaluation. Inorganic chemicals with MDCs less than the BSCs will be screened out.

Although BSCs were derived for BTEX compounds, organic compounds will not be screened out of the groundwater BHHRA based solely on a comparison to BSCs. Instead, these BSCs will be used in the BHHRA only as a qualitative comparison. It is noted that BSCs would also have been derived for PAHs, had these rather ubiquitous compounds been detected in PBOW background groundwater.

6.0 Investigation Results

6.1 Quarterly Groundwater Level Measurements

A total of 10 site-wide quarterly groundwater level measurement events have taken place since the last groundwater summary report was presented in June 2003 (Shaw, 2003a). Nine of these site-wide measuring events were conducted by ICI for the USACE and 1 (September 2003) was conducted by Shaw. The additional groundwater level measurement events were conducted in August and November 2002, March, May, August, September and November 2003, and March, May and August 2004. Shaw received the water-level data and used it to assist in better defining the groundwater hydrology. Table 6-1 lists a summary of the groundwater elevation measurements. Note that elevations were corrected for those wells with free-phase hydrocarbon product.

6.2 Geologic and Hydrogeologic Investigation Results

This section presents updated information and revisions of interpretations made of geologic and hydrogeologic data presented since the last site-wide groundwater summary investigation report (Shaw, 2003a). As during the 2001 monitoring well installation and sampling events, petroleum hydrocarbons were again encountered during the borehole drilling and groundwater sampling events conducted in 2004. Petroleum hydrocarbons, believed to be natural, were encountered in the rock cores and measured in the breathing-zone air during drilling of all the Delaware limestone bedrock boreholes (BED-MW30, BED-MW31, BED-MW32, BED-MW33, and BED-MW34). Also, prior to abandonment of borehole BED-MW34, approximately 0.03 to 0.08 ft of free-phase hydrocarbon was measured on the less than 1 foot of groundwater in the bedrock borehole.

As noted on the teleconference log generated November 18, 1998 regarding BTEX (Appendix N) and in Section 2.2.2, traces of natural petroleum are common in the local quarries mining the Delaware Limestone. An e-mail message was received in August 2002 from the OEPA stating that an actively producing oil and gas field was present in the Delaware Limestone in Florence and Berlin Townships in Erie County (Appendix N). Review of documents (Herdendorf, 1966; Stout, 1941) and discussions with OEPA and ODNR personnel (Appendix N) indicated that the Delaware and Columbus (Columbus bedrock unit located stratigraphically below the Delaware bedrock limestone) bedrock units contain active and abandoned natural gas and petroleum hydrocarbon wells. During review of off-site drinking water well bore logs, hydrogen sulfide gas was noted to have been encountered during the drilling process of 11 wells, natural gas encountered in 2 boreholes, and natural petroleum encountered in 1 boring. No records between

the association of the hydrogen sulfide odor and natural petroleum have been found. However, based on drilling experience at PBOW and correlation of the hydrogen sulfide odor with groundwater analytical results and visual detections, petroleum hydrocarbon is usually present in the Delaware Limestone bedrock unit. Table 2-1 identifies off-site wells that have encountered hydrogen sulfide gas, natural gas, and petroleum hydrocarbon while Figure 2-1 shows well locations. Figure 6-1 shows the active/inactive natural oil and gas wells near the PBOW facility. A total of 29 monitoring wells on PBOW property are screened within the petroleum hydrocarbon containing Delaware geologic bedrock unit. Therefore, it is important to note that some VOCs (primarily BTEX) and SVOCs may be naturally occurring in site groundwater. Table 6-2 shows the hydrocarbons detected during the former 2001 and present 2004 drilling activities.

Hydraulic conductivity tests were conducted on background (BED-MW28 and BED-MW29) and downgradient (BED-MW30 and BED-MW33) bedrock wells on May 2004. Hydraulic conductivity results from the new bedrock monitoring wells are shown on Table 6-3 along with results from the other bedrock wells. Vertical gradients calculated on existing paired monitoring wells are provided on Table 6-4.

Contour maps of water level elevations in the overburden and bedrock water-bearing zones have been generated from May 2004 (wet season) and August 2004 (dry season) data to show seasonal variations in the groundwater flow. Contours of water level elevations in the shallow overburden/shale (where present) and Delaware Limestone bedrock water-bearing zones are presented in Figures 6-2 through 6-5. Figures 6-2 and 6-3 show data from overburden/shale wells for May 2004 and August 2004, respectively. Figures 6-4 and 6-5 show data from bedrock wells screened in the Delaware Limestone for May 2004 and August 2004, respectively. The generalized block diagram of PBOW depicting the relationship of the overburden/shale groundwater-bearing zone with the bedrock water-bearing zone has not changed since the 2002 Groundwater Data Summary and Evaluation Report but is shown again to illustrate the hydrogeology and contaminant relationship (Figure 2-13).

6.2.1 Hydrogeology of Overburden/Shale Water-Bearing Zone

The shallow water-bearing zone at the former PBOW is encountered within the unconsolidated glacial, lacustrine, alluvial deposits, and severely to moderately weathered shale. An area-wide top-of-shale elevation contour map is presented in Figure 2-9. The water table extends into the upper severely to moderately weathered shale from the central portion of the facility to the south-central and southwestern areas. Based on all monitoring wells installed at PBOW, a total of 87

wells monitor the overburden/shale. The total includes 76 overburden wells and 11 wells screened in the shale bedrock (5 wells screened in the Olentangy Shale, and 6 wells in the Ohio Shale). Table 4-2 shows the geologic unit of each overburden/shale well. This total includes overburden wells at NASA's Reactor Area, near upgradient and downgradient perimeter locations, and at the NASA hazardous storage and space research facilities. Groundwater levels from 11 of the 76 wells were not measured for this event due to well access. Groundwater elevations in the shallow water table fluctuated an average of 6.48 ft since initial measurements began in overburden/shale wells in December 1994. The greatest change in groundwater levels was recorded in well TNTC-MW05 with a fluctuation of 20.53 ft. The least measured change in water levels recorded during the measurement events was found in shale screened monitoring well BED-MW29 (1.21 ft).

Groundwater flow in the shallow water-bearing zone presents a downward gradient and trends toward the north. However, there is a strong seasonal component to the overburden, and the water-bearing zone is highly discontinuous. The northern flow direction of the overburden largely mirrors the surface topography and corresponds to the topography of the top of the bedrock. This is demonstrated by comparing the top-of-Delaware Limestone bedrock map (Figure 2-10) with the water table elevation contour maps (Figures 6-2 and 6-3). In the southeastern portion of the site, groundwater flow appears to have a relatively uniform horizontal hydraulic gradient to the east-northeast. Groundwater in the central portion of the facility generally flows to the north and discharges to both Ransom Brook and Plum Brook. On the north side of the site, the flow is toward Ransom Brook and a wetland area located southwest of the Reactor Facility Area. Groundwater in the western portion of the site flows to the north-northwest and discharges to Pipe Creek. In the western corner, northwest of the WARWP, groundwater flows east-southeast toward Pipe Creek. Connectivity between groundwater in the shallow water-bearing zone and surface water is particularly evident during the spring wet season.

Figures 6-6 and 6-7 show groundwater flow in both the overburden and bedrock (Delaware Limestone) water-bearing zones in the vicinity of the Reactor Facility Area for November 2001 and August 2004, respectively. Figure 6-6 of the November 2001 groundwater level measurements (submitted in the 2002 RI report), interprets the overburden and Delaware Limestone groundwater to be flowing in opposing directions. After installation of additional overburden and Delaware screened limestone bedrock monitoring wells in the Reactor Area, groundwater flow of the overburden zone has been reinterpreted to be basically toward the northeast, the same as the groundwater in the bedrock zone (Figure 6-7). A convex groundwater

flow pattern is evident however in the bedrock groundwater believed to be caused by the pumping of the bedrock Reactor wells and the bedrock pumping treatment system at Buildings 1111, 1131, and 1134.

Based on information obtained from the installation of bedrock wells in 2001, 2003, and 2004, the interpretation of the overburden water-bearing zone including the upper portions of the Ohio and Olentangy Shale remains basically the same. This interpretation was based on 1) the similarity of shale and overburden groundwater elevations at well pairs, 2) depth similarity of groundwater encountered in soil (overburden) and shale wells site-wide, and 3) the merging of overburden and bedrock groundwater contours along the shale outcrops and the shale/limestone contact. However, more recently, the overburden has been demonstrated to be more strongly seasonal and less continuous than previously believed.

Overburden/shale horizontal hydraulic gradients were calculated for three transects across the site from the May 2004 (wet season) and August 2004 (dry season) groundwater level surveys. Flow along the western side of the site is toward the north to Pipe Creek at a gradient of approximately 0.0087 ft/ft. Flow in the center of the site is to the north at a gradient of approximately 0.0043 ft/ft and groundwater from the east-central portion of the site moves to the northeast at a gradient of approximately 0.0051 ft/ft. For comparison, previous hydraulic gradient calculations (August and November 1997, February and May 1998, and November 2001 and May 2002) for the groundwater flow on the west side of the facility were to the north-northwest at 0.012 ft/ft. In the central portion of the site, north at 0.0053 ft/ft and in the eastern side, flowed northeast at a gradient ranging from 0.0054 to 0.0059 ft/ft. These measurements were taken at locations and during time periods when overburden groundwater was present. However, it should be understood that because the overburden unit is highly discontinuous and seasonal, the representativeness of these measurements should not be overstated.

Hydraulic conductivity of wells completed within the surficial deposits measured by slug tests ranged from 0.74 ft/day (AA1-GW-002) to 212 ft/day (ABG-GW-002), as shown in Table 6-3. The calculated geometric mean for the five wells tested was 8.75 ft/day. The hydraulic conductivity of wells completed in the shale units ranged from 0.002 (TNTB-BEDGW-003) to 22.2 ft/day (ABG-BEDGW-001). The geometric mean for the shale portion of the water table was calculated to be 0.963 ft/day. The occurrence of water within the deeper zones of the shale is limited with variable conductivity. Well BED-MW26 has been essentially dry since installation, purge rates of well BED-MW25 have been as great as 450 ml/min, while BED-MW20 has shown slow to moderate recharge with purge rates of 0 to 200 ml/min during

groundwater sampling. Slug test data for new, background monitoring wells BED-MW28 and BED-MW29 that are screened in the shale bedrock are included in the totals above and are presented in Appendix E.

Groundwater elevations in the overburden/shale fluctuate seasonally, irrespective of the area of the site. Hydrographs have been prepared to show the similarity between groundwater fluctuations in the overburden and in the shale bedrock. Figure 6-8 shows fluctuations in site-wide wells in the overburden. Figure 6-9 shows groundwater fluctuations in the overburden wells and wells specifically screened in the Ohio Shale and Figure 6-10 shows fluctuations in overburden wells and wells specifically screened in the Olentangy Shale. As the graphs show, groundwater fluctuations in overburden wells correspond to groundwater fluctuations in wells screened in shale, and indicate a significant vertical connectivity between the overburden and shale wells. Groundwater levels in the shallow water-bearing zone are believed to be controlled by regional fluctuations in the shale groundwater elevations.

6.2.2 Geology and Hydrogeology of Delaware Limestone Water-Bearing Zone

A deep water-bearing zone is located within the Delaware Limestone. Potentiometric maps of this unit are presented as Figures 6-4 and 6-5. Based on boring logs from the PBOW bedrock wells installed for environmental monitoring purposes, there are currently 29 wells completed in the Delaware Limestone. This includes bedrock wells both in the Reactor Area and at off-site downgradient locations, installed by Shaw and other contractors (Table 4-2).

Delaware Limestone bedrock groundwater level interpretations for those wells measured in May 2004 (Figure 6-4) are very similar to those measured in August 2004 (Figure 6-5); contour lines on both figures are dashed to indicate the uncertainty. The May 2004 potentiometric groundwater flow map is slightly different than the August 2004 because it was partially constructed using a computer program. Although the majority of the figure is computer generated the interpretation of the groundwater flow is nearly the same as the hand drawn August 2004 interpretation; groundwater flow is toward Lake Erie in the north-northeast direction. The potentiometric surface of the Delaware Limestone water-bearing unit shows a fairly large linear depression that extends from the Reactor facility southwest through the western portion of PBOW. This depression may be a result of groundwater pumping from the Reactor wells (Reactor wells 1 through 4) at the Reactor facility and also structurally or fracture controlled based on the geologic map (Figure 2-1). Groundwater from the depression exits PBOW to the northeast of the reactor facility and flows off-site. Groundwater from the eastern portion of the site flows in a north-northeast direction.

Horizontal hydraulic gradients in the Delaware Limestone bedrock were calculated for four transects across the site from the May 2004 (wet season) and August 2004 (dry season) groundwater level surveys. Flow in the northwestern corner of the site toward the groundwater trough is to the southeast at a gradient of approximately 0.0077 ft/ft. Flow in the trough is to the northeast at a gradient of approximately 0.0010 ft/ft. Flow from the central portion of the site, from a bedrock high into the trough, is toward the northwest at a gradient of 0.0097 ft/ft and groundwater from the eastern portion of the site moves to the north-northeast at a gradient of approximately 0.0096 ft/ft. Comparison to previous hydraulic gradient calculations (August and November 1997, February and May 1998, and November 2001 and May 2002) could not be made because groundwater levels from wells screened in the shale were used during previous reports.

Groundwater elevations in the Delaware Limestone water-bearing zone typically showed significant elevation fluctuations over time (Figure 6-11). The variations do not correspond with each other or with monthly precipitation events (Figure 6-13). Wells constructed in the Delaware Limestone in the Reactor Facility Area (wells REACTOR 1, 2, and 3) showed the greatest variation over time, with water levels fluctuating as much as 25 ft (Figure 6-12). Well BED-MW16 showed a one-time rise of more than 60 ft between December 1994 and March 1995. Water levels in BED-MW16 remained relatively steady over the course of several years until it displayed a 25-foot drop in water level between August and November 2002. Recent water level measurements of the monitoring wells in NASA's Reactor facility area have not been actively measured due to access issues during Reactor demobilization activities.

Hydraulic conductivity in the Delaware Limestone measured by slug tests performed in the site wells range from 0.002 (former well BED-MW27) to 1.84 ft/day (BED-MW24) (Table 6-3). Slug test results from new wells BED-MW30 and BED-MW33 are also included on Table 6-3. This range also demonstrates the variability in hydraulic conductivity of the bedrock across the site. The geometric mean conductivity for Delaware Limestone bedrock wells is 0.18 ft/day.

Weathered petroleum and H_2S, a byproduct of anaerobic petroleum degradation, are frequently present in monitoring wells screened within the Delaware Limestone at the site (Table 6-2). To the east-southeast of the site, an active oil and gas field is present in the Delaware Limestone in Florence and Berlin Townships in Erie County (see Appendix N, e-mail received from the OEPA in August 2002). It is probable that the Delaware Limestone is the natural source for the hydrocarbons found. This is further supported by boring logs that noted petroleum seeping from

Delaware Limestone cores during drilling, the wells in which monitoring equipment had detected H_2S, and the widespread, sporadic location of those monitoring wells.

6.2.3 Hydraulic Connection Between Zones

As presented in the 2002 Groundwater Data Summary and Evaluation Report and updated with recent water levels, vertical hydraulic gradients were calculated for the five paired wells at the PBOW site (Table 6-4). Two of the three well pairs (wells with well identifications beginning with AA1 [Acid Area 1] and AA3 [Acid Area 3]) on the northern central and western portions of the site (bedrock wells screened in the Delaware Limestone) showed higher groundwater elevations in the overburden zone than in the bedrock aquifer. This difference suggests that there may be relatively limited connectivity between the overburden and bedrock water bearing zones in these areas. In addition, any vertical groundwater migration that occurs will be downward from the overburden into the bedrock. The greatest difference in water levels occurred in the overburden/Delaware Limestone well pair AA1-GW002/AA1-BEDGW-001, with approximately 27.5 ft of difference in the water levels (November 2001) and an average vertical hydraulic gradient over time of 0.9 ft/ft downward from the overburden to the bedrock (Table 6-4). In contrast, the central and southern portions of the site showed very similar groundwater elevations in the paired wells (wells with well identifications beginning with ABG [Additional Burning Ground] and well pair MK-MW16/TNTB-BEDGW-002). As noted in Section 6.2.1, this is due to the well monitoring the same geologic unit. The difference in water level elevations ranged from a minimum of 0.0 ft in paired ABG wells (November 15, 2001) to a one time maximum of 3.5 ft in paired wells MK-16 and TNTB-BEDGW-001 (May 5, 1998). This is indicative of the high degree of connectivity in the groundwater between the overburden and the Ohio Shale. There are no paired wells in the overburden and Olentangy Shale to show this same relationship.

6.2.4 Influence of Precipitation on Water Levels

Although previous investigations have indicated that there is a strong connection between precipitation and groundwater elevations, no clear correlation exists between monthly precipitation rates and water level elevations in site wells. The lack of observed correlation is probably influenced by the amount of precipitation and the runoff rate. For example, summer thunderstorms that produce short periods of heavy precipitation may result in more surface runoff and less infiltration. Conversely, constant periods of precipitation at a lower rate over a period of days may result in more infiltration. Freezing rain or snow will also not result in an immediate recharge to groundwater. These factors are not discernable from total monthly precipitation data shown on Figure 6-13. When comparing the number of seasonal groundwater elevation measurements collected from the site, shown in Table 6-1 with aquifer recharge rates

(Figure 6-14), a seasonal correlation appears to be present. January through June is determined to be a "wet" time period at PBOW and is therefore an optimal time for sampling the overburden wells while July through December is determined to be a "dry" time period. Recharge at PBOW was obtained by subtracting potential evapotranspiration rates (from Cleveland, Ohio data) and calculated runoff rates from rainfall. Appendix O shows previous calculations and reference information along with newly acquired rainfall data required for this calculation.

Figure 6-14 demonstrates that there is a strong correlation between seasons of the year and calculated monthly aquifer recharge rates at PBOW. Recharge to the overburden is calculated to be highest in the winter months (December, January, or February) for 9 of the 10 years shown. A lag time should, however, occur from the time the rain infiltrates the soil to the time it reaches the water table. At PBOW, this lag time should be weeks from the time of precipitation. The lag time depends largely upon the infiltration capacity of the soil, the thickness of the overburden in the areas of recharge, and the presence of frozen ground. Thus, the groundwater elevations should typically be highest in February or March. Although Figure 6-13 shows that the greatest rainfall occurs in summer months, Figure 6-14 shows that recharge rates are actually lower during that season. This is because evapotranspiration is highest in the mid to late summer in north-central Ohio. Similar to the lag time for the groundwater high, a lag time in the groundwater low should also occur. Thus, groundwater elevations should be lowest in early fall. Correspondingly, groundwater sample collection events were scheduled to take place during two "dry" and two "wet" season time periods.

Figures 6-13 and 6-14 show that both precipitation and recharge rates were similar for most of the years measured. However, in 1994 the annual precipitation was approximately 25 percent lower than the average annual rate in Sandusky. Correspondingly, the lowest water levels measured in site wells occurred in December 1994. This reveals that significant fluctuation in groundwater elevation can occur during drought conditions such as in 1994.

7.0 Groundwater Sampling Events

7.1 Areas and Water Bearing Units Sampled

Three types of areas were sampled as part of the groundwater investigations beginning in November 1997 through August 2004 at PBOW:

- AOCs
- Downgradient perimeter areas
- Background areas.

Bedrock monitoring wells were sampled in each of the AOCs, downgradient perimeter areas, and background areas. Overburden/shale monitoring wells were sampled at AOC locations. Additionally, overburden temporary piezometers (or where water volume was adequate in open boreholes) installed using direct-push technology were sampled in the three TNT AOCs and the two red water pond AOCs. The types of wells/piezometers sampled at each of the AOCs, downgradient perimeter areas, and background areas are summarized as follows:

- TNTA, TNTB, TNTC – overburden temporary piezometers, overburden/shale monitoring wells, and bedrock monitoring wells
- PRRWP and WARWP – overburden temporary piezometers and bedrock wells
- Acid Areas (Nos. 1,2 and 3) and Maintenance Shop Area – bedrock monitoring wells only
- Additional Burning ground Area – bedrock monitoring well only
- Upper Toluene Tanks (UTT) Area – one bedrock and one overburden/shale monitoring well
- Downgradient perimeter –bedrock monitoring wells only
- Background areas – bedrock monitoring wells only.

Areas-of-Concern. Overburden temporary piezometer groundwater samples were collected from TNT Areas A and C during September-October 2000, from all three TNT areas during August 2001 field investigations, and from both red water pond areas during a June 1998 investigation. Temporary piezometer groundwater samples collected during the September-October 2000 and the red water ponds field efforts were analyzed for nitroaromatics, VOCs, SVOCs, PCBs, and metals (filtered and unfiltered), while the groundwater samples collected

during August 2001 were screening samples analyzed only for nitroaromatics and VOCs. Piezometer data is considered to be of lesser quality due to the fact that piezometers were not developed as is done with standard monitoring wells. The data is useable, but certain parameters (specifically metals) are biased due to elevated turbidity in the samples.

Four site-wide groundwater sampling events were conducted in November 1997, May 1998, September-October 2001 and April 2002 Groundwater samples were collected from overburden/shale and bedrock monitoring wells associated with the AOCs as listed above. Samples were analyzed for the nitroaromatics, VOCs, SVOCs, metals (filtered and unfiltered), and water quality parameters. Field activities associated with installation and sampling of the overburden/shale and bedrock groundwater sampling have been presented in previous reports and will not be presented or discussed. Analytical results of the groundwater from each AOC will be represented based upon the "wet" or "dry" season during which the sampling was conducted and compared to RBSC and/or BSC values (Tables 7-1 through 7-16). Note that only inorganics and BTEX compounds are compared to BSC values. Also, "B" qualified data are discussed in the text of each sampling event for each AOC, but these data are not regarded as detections. Thus, discussion in the summary sections of each AOC does not include B qualified among the detections.

Downgradient. In the May "wet season" and August 2004 "dry season" groundwater sampling events, samples were collected from 3 existing (BED-MW17, BED-MW19, and BED-MW22) and 2 new (BED-MW30 and BED-MW33) downgradient monitoring wells. Groundwater samples were analyzed for nitroaromatics, VOCs, SVOCs, metals (filtered and unfiltered), and water quality parameters. Downgradient monitoring well BED-MW27 was sampled in October 2001 and April 2002 (prior to abandonment) and analytical detections are shown with other downgradient monitoring wells. Analytical data from these downgradient monitoring wells are compared to RBSC and/or BSC concentrations to determine the extent of off-site contamination migration, if any. Note that only inorganics and BTEX compounds are compared to BSC values. Also, "B" qualified data are discussed in the text of each sampling event, but these data are not regarded as detections. Therefore, discussion in the summary section of the downgradient wells does not include B qualified data among the detections. Table 7-17 shows detected results from all sampling events. Figure 7-13 presents analytical detections and downgradient well locations.

Background. A total of 10 background groundwater sampling events have been conducted from background wells beginning in September-October 2001 through March 2004. During the

remaining background sampling event conducted in June 2004 ("wet season") groundwater samples were collected from monitoring wells BG8-BEDGW-001, BED-MW20, BED-MW24, BED-MW25, BED-MW28, and BED-MW29. These samples were analyzed for nitroaromatics, VOCs, SVOCs, metals (filtered and unfiltered), and water quality parameters. After installation of monitoring well BED-MW30 and calculation of water level elevations, it was determined that well BED-MW24 was not in a background location, but is actually downgradient of known contaminant source WARWP (Section 3.3.2). Therefore, the results of this well are included in the discussion of downgradient perimeter wells. Also, "B" qualified data are discussed in the text of each sampling event, but these data are not regarded as detections. Thus, discussion in the summary section for background does not include B qualified data among the detections.

Analytical data from June 2004 event are combined with groundwater analytical data from the previous events and used to calculate a background bedrock groundwater screening value for inorganics and BTEX. Only samples collected using low-flow (minimal drawdown) were used in the calculation of BSCs. Groundwater data from the background bedrock quarterly sampling also permitted determination of any trending patterns of inorganic chemical constituents throughout the wet and dry time periods (Appendix M). As noted in Section 1.0, details of the sampling activities for each of the previous 9 background sampling events were presented in former quarterly reports and will not be discussed. Table 7-18 shows detected results from all quarterly sampling events. Figure 7-13 presents the background wells and analytical detections.

7.2 Areas of Concern Analytical Results

The following sections present the validated analytical results of the AOCs (listed above) during the wet and dry season sampling events monitored by the water-bearing zones (overburden/shale and bedrock) since the site-wide sampling episode in November 1997. All data is compared to RBSC values. In addition, for inorganics and BTEX compounds, the data is also compared against the calculated BSC values (Appendix M). In the text, only the greater value of the RBSC and BSC for inorganics is discussed. The ubiquitous, nutritionally essential inorganic elements calcium, magnesium, potassium, and sodium will not be presented or included in the totals referenced for a sampling event. As discussed in Section 5.4, BSCs are provided only for comparison purposes for the detected constituents in the bedrock groundwater. Analytes detected below RBSCs or BSCs are not discussed in detail but are presented in the referenced data tables (Table 7-1 through 7-16). Detected concentrations from the November 1997, May 1998, September-October 2001, and April 2002 analytical results are shown on Figures 7-1 through 7-13. Analytical data for the June 2004 background and the May and August 2004 groundwater sampling are presented in Appendices H and K.

7.2.1 TNT Area A

7.2.1.1 Overburden Temporary Piezometers

Nine overburden groundwater samples (GW01 through GW08 and GW10) were collected from temporary piezometers or boreholes during the September-October 2000 dry season, TNT investigation. Two overburden groundwater samples (DP14 and DP21) were collected from temporary piezometers during the August 2001, dry season field groundwater sampling efforts. Groundwater samples collected during the 2000 dry season sampling event were analyzed for nitroaromatics, VOCs, SVOCs, PCBs, and metals (unfiltered and filtered). Groundwater during 2001 sampling was analyzed by the laboratory using a screening method for only nitroaromatics and VOCs. Table 7-1 presents detected constituents above RBSC and/or BSC values in the overburden/shale groundwater. Figure 7-1 shows analytical results along with sampling locations.

2000 Dry Season Sampling Event (September-October). A total of 10 nitroaromatic compounds, 9 above the RBSC values, were detected at TNTA in the groundwater from the temporary piezometers. All 9 groundwater samples exhibited at least 1 compound above the RBSC values. Compounds above the RBSC included 4A-2,6-DNT, 2A-4,6-DNT, 1,3-DNB, total DNT, nitrobenzene, 2-, 3-, 4-nitrotoluenes, and 2,4,6- TNT. Ten VOC compounds were detected in the groundwater from all of the samples while only 2 direct-push points (GW01 and GW03) contained VOC compounds above BSC values. Note that BSC values apply only to inorganics and BTEX compounds. Toluene was detected above the BSC value at a concentration of 5.24 µg/L in point GW-03 and benzene (4.81 µg/L), ethyl benzene (2.33 µg/L), and toluene (1,350 µg/L) were above either BSC or RBSC screening values in GW01 boring. Two nitroaromatics detected as SVOC parameters were detected above RBSC values in 7 of the 9 groundwater samples: 2,4-DNT, and 2,6-DNT. Fifteen unfiltered inorganics were detected at TNTA above the RBSC and/or BSC value. All 9 groundwater samples exhibited unfiltered compounds above both the RBSC and BSC values. The most common unfiltered inorganic above both the RBSC and BSC was manganese. It was detected in all 9 samples with detections ranging between 1,430 µg/L in GW04 and 7,050 µg/L in GW01. Other inorganics above both the RBSC and BSC in one or more samples included aluminum, arsenic, chromium, copper, iron, lead, nickel, and zinc. Sample GW05 exhibited 12 unfiltered compounds above the RBSC value and a total of 8 compounds above BSC values. Cobalt was the only metal detected in the groundwater exceeding BSC values that was not detected above the RBSC value. Due to lack of groundwater, only 3 filtered groundwater samples from borings GW02, GW06, and GW10 were able to be collected. Many of the metals above RBSC and BSC values were removed during

filtration but all 3 samples still exhibited filtered manganese above the RBSC. Manganese concentrations from borings GW06 and GW10 were also above the BSC value. Manganese was detected at concentrations ranging from 187 µg/L in GW01 to 2,060 µg/L in GW10. Besides manganese, sample GW10 also exhibited nickel above the BSC at a concentration of 8.84 µg/L. PCBs were detected in only 1 groundwater sample from TNTA. Aroclor 1260 was detected in direct-push point GW03 at a concentration of 0.239 µg/L, above the RBSC of 0.034 µg/L.

2001 Dry Season Sampling Event (August). No nitroaromatics or VOCs were detected in the screening groundwater sample from DP14. A total of 8 nitroaromatic compounds were detected in the screening groundwater sample from DP21, 7 of which exceeded RBSC levels. Detected nitroaromatics above RBSC levels included 4A-2,6-DNT, 2A-4,6-DNT, 2,4-DNT, 2,6-DNT, 2-nitrotoluene, 4-nitrotoluene, and 2,4,6-TNT. Chloroform was also detected above the RBSC value at a concentration of 1 µg/L in groundwater from temporary piezometer DP21.

Wet Season Sampling Event. No temporary piezometers were installed at TNTA during the wet season therefore no groundwater samples were collected.

7.2.1.2 Overburden/Shale

Five overburden/shale wells (MK-MW22, MK-MW23, MK-MW24, TNTA-MW10 and TNTA-MW11) were sampled at TNTA. Overburden monitoring well MK-MW22 is located at the north central portion of TNTA, upgradient of the wastewater settling tanks (Building 187), on the corner of Columbus Avenue and an unnamed road. MK-MW23 is located downgradient of the Wash House (Building 116), and well MK-MW24 is located on southern side of TNTA, upgradient of the DNT Sweating and Graining House (Building 192). TNTA-MW10 is located north of Maintenance Road, downgradient of the Wash House (Building 136). Well TNTA-MW11 is located south of Maintenance Road, downgradient of the Wash House (Building 146). Groundwater samples were collected from all 5 monitoring wells during the November 1997 and May 1998 site investigations and analyzed for nitroaromatics, VOCs, SVOCs, metals (unfiltered and filtered), cyanide, and water quality parameters. Monitoring wells MK-MW22, MK-MW23, and MK-MW24 were not scheduled to be sampled during the October 2001 and April 2002 investigations. During the October 2001 sampling event, no groundwater sample was collected from overburden monitoring well TNTA-MW10 due to lack of groundwater, and only a limited sample volume could be collected from TNTA-MW11. During the October 2001 field event, groundwater from TNTA-MW11 was analyzed for nitroaromatics, VOCs, SVOCs, metals (unfiltered), and total organic carbon only. Table 7-2 presents detected constituents above RBSC and/or BSC values in the overburden/shale groundwater. Figure 7-1 shows analytical results along with sampling locations.

1997 Dry Season Sampling Event (November). Five nitroaromatic compounds (4A-2,6-DNT, 2,4-DNT, 2,6-DNT, 1,3,5-TNB, and 2,4,6-TNT) were detected in the groundwater during the 1997 sampling, all from well MK-MW22. The nitroaromatics 2,4-DNT (0.53 µg/L) and 2,6-DNT (0.20 µg/L) were detected in the groundwater at concentrations above RBSCs. VOCs detected included acetone, carbon disulfide, and methylene chloride from well MK-MW23 and acetone from well TNTA-MW10, but none were above the RBSC or (for BTEX compounds) BSC. No SVOC compounds were detected above the RBSC. Sixteen unfiltered inorganics were detected in the overburden/shale monitoring wells. All 5 groundwater samples exhibited unfiltered compounds above both the RBSC and BSC values. The most common unfiltered inorganic above both the RBSC and BSC was iron. It was detected in all 5 samples with detections ranging between 13,300 µg/L in TNTA-MW11 to 68,200 µg/L in MK-MW23. Other inorganics above both the RBSC and BSC in one or more samples included aluminum, arsenic, manganese, and nickel. Groundwater from well MK-MW23 exhibited 8 unfiltered compounds above the RBSC value and a total of 7 compounds above BSC values. All 5 wells exhibited filtered manganese above the RBSC while concentrations from samples in wells TNTA-MW10 and TNTA-MW11 were also above the BSC value. Manganese was detected at concentrations ranging from 149 µg/L in MK-MW22 to 1,440 µg/L in TNTA-MW10. Besides manganese, other filtered inorganics above both the RBSC and BSC included only arsenic in well MK-MW23.

In general, the overburden/shale is characterized by sulfate as the dominant anion. This was the case for wells TNTA-MW10, MK-MW23, and MK-24. In these wells, sulfate was detected at up to 1,200,000 µg/L, while chloride was detected at up to 47,000 µg/L. The exception to this was TNTA-MW11, in which nearly equal concentrations of chloride (140,000 µg/L) and sulfate (150,000 µg/L) were reported.

1998 Wet Season Sampling Event (May). Three nitroaromatic compounds (4A-2,6-DNT, 2,4-DNT, and 2,6-DNT) were detected in the groundwater at TNTA above RBSC levels during the 1998 sampling, all from well MK-MW22. Nitroaromatic 4A-2,6-DNT was detected in the groundwater at a concentration of 0.86 µg/L, 2,4-DNT was detected at 0.35 µg/L, and 2,6-DNT was detected at a concentration of 1.2 µg/L. The VOC toluene was the only compound that exceeded screening levels. It was detected at concentrations of 7.8 µg/L in monitoring well MK-MW22 and 10 µg/L in well MK-MW24, both above the BSC value. Bis(2-ethylhexyl)phthalate (890 µg/L), a common laboratory contaminant, was the only SVOC detected above the RBSC; it was found in the groundwater sample from well MK-MW23. Fifteen unfiltered inorganics were detected in the overburden/shale monitoring wells, 12 above the RBSC and/or BSC. All 5

groundwater samples exhibited unfiltered compounds above both the RBSC and BSC values. The most common unfiltered inorganics above both the RBSC and BSC were iron and manganese. Iron was detected in all 5 samples with detections ranging between 1,960 µg/L in MK-MW24 to 304,000 µg/L in MK-MW23. Manganese exhibited detections ranging from 142 µg/L in well MK-MW22 to 7,550 µg/L in well MK-MW23. Other inorganics above both the RBSC and BSC in one or more samples included aluminum, antimony, arsenic, chromium, cobalt, copper, lead, manganese, nickel, vanadium, and zinc. Groundwater from well MK-MW23 had the most RBSC and BSC exceedances. In this well, 11 unfiltered compounds were above the RBSC value and 8 compounds were above BSC values. All 5 wells exhibited filtered manganese above the RBSC and the concentration from the groundwater sample in well TNTA-MW10 (1,370 µg/L) was detected above the BSC value. Manganese was detected at concentrations ranging from 114 µg/L in MK-MW22 to 1,370 µg/L in TNTA-MW10. Iron was found above both RBSC and BSC values in 2 samples. Groundwater from MK-MW24 exhibited iron above the RBSC at a concentration of 1,440 µg/L and groundwater in well TNTA-MW10 exhibited iron at a concentration of 9,330 µg/L, above both RBSC and BSC. In addition, vanadium exceeded the RBSC in well MK-MW24 (57.3 µg/L) but this concentration was B qualified (B qualified meaning detection not significantly above levels found in the associated field blank).

During the wet season sampling, sulfate was the dominant anion in wells MK-MW22 and MK-MW24. In well MK-MW22, chloride and sulfate were detected at 3,000 µg/L and 30,000 µg/L, respectively. Similarly, chloride and sulfate were detected at 7,000 µg/L and 1,100,000 µg/L in well MK-MW24. Chloride and sulfate were both detected at 100,000 µg/L in well TNTA-MW10. In well TNTA, MW11, chloride (180,000 µg/L) was the dominant anion, with sulfate detected at 93,000 µg/L.

2001 Dry Season Sampling Event (October). Three nitroaromatic compounds (4A-2,6-DNT, 2A-4,6-DNT, and 2,4,6-TNT) were detected in well TNTA-MW11 and 4A-2,6-DNT and 2A-4,6-DNT were above RBSC screening levels. Thirteen metals were detected and 5 (aluminum, arsenic, chromium, iron, and manganese were above RBSC levels in the unfiltered metals. Three compounds (aluminum [8,950 µg/L], iron [16,400 µg/L], and nickel [22.4 µg/L]) were above BSC values.

2002 Wet Season Sampling Event (April). Three nitroaromatic compounds (4A-2,6-DNT, 2A-4,6-DNT, and 2,4,6-TNT) were detected in well TNTA-MW11 above the RBSC levels. No nitroaromatics were detected in TNTA-MW10. No VOCs or SVOCs were detected in either well above the RBSC. A total of 9 unfiltered inorganic compounds were detected in wells

TNTA-MW10 and TNTA-MW11. In well TNTA-MW10, iron exceeded the RBSC and BSC value with a concentration of 4,710 µg/L while manganese exceeded the RBSC value with a concentration of 607 µg/L. Aluminum and iron were above the BSC value in the groundwater from well TNTA-MW11 while only iron exceeded the RBSC value. In the filtered groundwater samples, iron and manganese were both above the RBSC and iron also exceeded the BSC at a concentration of 3,270 µg/L in well TNTA-MW10.

During this sampling even, sulfate was the dominant anion, detected at 261,000 µg/L (TNTA-MW10) and 309,000 µg/L (TNTA-MW11). The concentrations of chloride in the wells were 40,100 µg/L and 10,500 µg/L, respectively.

7.2.1.3 Delaware Limestone Bedrock

Two bedrock monitoring wells (BED-MW18 and TNTA-BEDGW-001), both screened in the Delaware Limestone, were sampled at TNTA. Bedrock well BED-MW18 is positioned upgradient (east) of TNTA and well TNTA-BEDGW-001 is located at the northwest corner (downgradient) of the former Wash House (Building 146). Monitoring well TNTA-BEDGW-001 was installed at the beginning of October 2001 at the location that exhibited the greatest nitroaromatic soil contamination found during the 2000 TNTA and C RI. The first groundwater sampling event at TNTA-BEDGW-001 was conducted October 9, 2001. Groundwater was analyzed for VOCs, SVOCs, nitroaromatics, metals (unfiltered and filtered), cyanide, and water quality parameters. Table 7-3 presents detected constituents above RBSC and/or BSC values in the bedrock groundwater. Figure 7-1 shows analytical results along with sampling locations.

1997 Dry Season Sampling Event (November). Three nitroaromatics (1,3-DNB, nitrobenzene, and 1,3,5-TNB) were detected in the groundwater sample from well BED-MW18 and 1,3-DNB (1 µg/L) and nitrobenzene (2 µg/L) were greater than the RBSC. The VOCs benzene (11 µg/L) and total xylenes (170 µg/L) both exceeded RBSC and BSC levels, while ethyl benzene (32 µg/L) and toluene (21 µg/L) exceeded only BSC values. Naphthalene (3.8 µg/L) was the only SVOC to exceed its RBSC value. Excluding the nutritionally essential elements, barium was the only unfiltered compound to exceed either the respective RBSC or BSC values. Barium was found at a concentration of 893 µg/L in the unfiltered metals and at a concentration of 1,010 µg/L in the filtered metals, both above the RBSC of 255 µg/L.

Chloride was consistently detected at much higher concentrations than sulfate during this sampling event. During November 1997, chloride was detected at 6,900,000 µg/L and sulfate was detected at 16,000 µg/L in BED-MW18.

1998 Wet Season Sampling Event (May). Two nitroaromatics (2,4-DNT and 2,6-DNT) were detected in the groundwater samples collected during May 1998. 2,4-DNT (0.49 µg/L) and 2,6-DNT (3.6 µg/L) were both above RBSC levels. The VOCs benzene (5.7 µg/L) and total xylenes (420 µg/L) both exceeded RBSC and BSC levels while ethyl benzene (88 µg/L) and toluene (53 µg/L) exceeded only BSC values. Bis(2-ethylhexyl)phthalate was the only SVOC compound to exceed the RBSC, but it was B qualified. Like the 1997 sampling results, barium was the only unfiltered compound to exceed the RBSC value. Barium was found at a concentration of 942 µg/L in the unfiltered metals and at a concentration of 994 µg/L in the filtered metals, both above the RBSC of 255 µg/L. During this sampling event, chloride (1,200,000 µg/L) was again the dominant anion in BED-MW18. Sulfate was detected at 18,000 µg/L.

2001 Dry Season Sampling Event (October). 4A-2,6-DNT was detected at a concentration (1.3 µg/L) above the RBSC level in the groundwater sample from well TNTA-BEDGW-001. VOC compounds chloromethane (35 µg/L), methylene chloride (47 µg/L), and total xylenes (150 µg/L) exceeded RBSC levels in well BED-MW18. Ethyl benzene (32 µg/L) also exceeded the BSC in this well. BTEX parameters exceeded both the RBSC and BSC levels in well TNTA-BEDGW-001 and methylene chloride (330 µg/L) exceeded only the RBSC value. Six SVOCs including bis[2-ethylhexyl]phthalate (8.6 µg/L), chrysene (15 µg/L), dibenzofuran (12 µg/L), 2- methylnaphthalene (470 µg/L), naphthalene (170 µg/L), and phenanthrene (74 µg/L) were detected above RBSC values in the groundwater sample from well TNTA-BEDGW-001. Well BED-MW18 exhibited naphthalene (3.1 µg/L) above the RBSC. Barium was the only inorganic above the RBSC in unfiltered and filtered samples from well BED-MW18. In well TNTA-BEDGW-001, arsenic (10.8 µg/L), barium (1,000 µg/L), manganese (11,700), and nickel (75.7 µg/L) were above RBSCs in the unfiltered sample and arsenic, manganese, and nickel also exceeded BSC values. In the filtered sample, barium (382 µg/L) and vanadium (12.5 µg/L) were the only compounds above the RBSC values.

In the water quality measurements, chloride (9,450,000 µg/L) and sulfate (56,000 µg/L) were detected in BED-MW18 at similar ratios, as was reported in previous sampling events.

2002 Wet Season Sampling Event (April). 4A-2,6-DNT was detected at a concentration (1.3 µg/L) above the RBSC in the groundwater sample from well TNTA-BEDGW-001. BTEX compounds exceeded BSC values in well BED-MW18 and all but ethyl benzene exceeded the RBSCs. BTEX parameters exceeded both the RBSC and BSC values in well TNTA-BEDGW-

001 and methylene chloride (170 µg/L) exceeded the RBSC. Naphthalene was the only SVOC compound to exhibit concentrations greater than the RBSC. It was found in well BED-MW18 at a concentration of 9.9 µg/L and in well TNTA-BEDGW-001 at 39 µg/L. In the unfiltered groundwater sample from well BED-MW18, barium (1,290 µg/L) and manganese (109 µg/L) exceeded RBSC values. In well TNTA-BEDGW-001, 8 compounds (aluminum, arsenic, barium, chromium, iron, lead, manganese, and vanadium) exceeded RBSCs. Unfiltered aluminum, arsenic, cobalt, copper, iron, manganese, and nickel exceeded BSC values. In the filtered samples from well BED-MW18, only barium and manganese exceeded the RBSCs. Groundwater from well TNTA-BEDGW-001 only exhibited barium above the RBSC. Chloride was the dominant anion in bedrock wells BED-MW18 and TNTA-BEDGW-001 during this sampling event. Chloride (12,900,000 in well BED-MW18 and 4,810,000 µg/L in well TNTA-BEDGW-001) was detected at concentrations at least an order of magnitude greater than sulfate (440 and 388,000 µg/).

7.2.1.4 Summary of Sampling Events, TNT Manufacturing Area A

Overburden/shale. Ten nitroaromatics were detected at concentrations above RBSC levels in the overburden/shale groundwater at TNTA during both the wet and the dry season. Two nitroaromatics were detected above RBSC levels in November 1997, 3 in 1998, 9 in 2000, 7 in 2001, and 3 in 2002. Benzene, toluene, and chloroform were the only VOC compounds detected in the groundwater above RBSC and/or BSC values. Benzene was detected in the groundwater during October 2000 direct-push operations at one boring (GW01), toluene was detected in May 1998 (2 wells) and October 2000 (2 direct-push points), and chloroform was detected in the groundwater during August 2001 direct-push operations from boring DP01. Three SVOC compounds were detected above RBSC levels. Bis(2-ethylhexyl)phthalate was detected during May 1998 sampling from well MK-MW23 and one or both nitroaromatics 2,4-DNT and 2,6-DNT, were detected in 7 direct-push samples in October 2000. Unfiltered metals aluminum, arsenic, iron, manganese, and vanadium have been most commonly detected in the overburden/shale groundwater above both RBSC and BSC values during both the wet and dry seasons. Aluminum, arsenic, chromium, iron, lead, manganese, and vanadium were commonly detected above RBSC values in direct-push groundwater samples collected during the dry season of October 2000. Filtration removed most of the metals above RBSC and BSC values but manganese was still detected above the RBSC and/or BSC value in 14 of the 15 groundwater samples. Iron was also found in the groundwater of MK-MW24 and TNTA-MW10 and arsenic in the groundwater from MK-MW23, above both the RBSC and BSC. Sulfate was the dominant

anion in most of the overburden/shale wells, with the exception of TNTA-MW11. The dominant anion in well TNTA-MW11 varied over the sampling period from sulfate to chloride.

Delaware Limestone Bedrock. Nine nitroaromatic compounds were detected at concentrations above RBSC levels in the bedrock groundwater at TNTA during both the wet and the dry seasons. Concentrations of nitroaromatic compounds 1,3-DNB, 2,4-DNT, 2,6-DNT, and nitrobenzene exceeded RBSC values in BED-MW18 during the dry and wet seasons of 1997 and 1998. 4A-2,6-DNT concentrations exceeded the RBSC in well TNTA-BEDGW-001 during the October 2001 (dry season) and April 2002 (wet season). VOC compounds have consistently been detected in all site wells since 1997 with BTEX parameters and methylene chloride commonly above RBSC and (for BTEX) BSC values. Bis(2-ethylhexyl)phthalate exceeded the RBSC value in TNTAGWBED-001, though was reported as B qualified in the other well. Naphthalene exceeded the RBSC value during each sampling event from both wells. PAH compounds chrysene, dibenzofuran, and phenanthrene were detected in well TNTA-BEDGW-001 above the RBSC value during October 2001 dry season.

Barium was the only metal to be detected in both the unfiltered and filtered samples from both wells during all sampling events. Manganese was detected above the RBSC in both the unfiltered and filtered sample from BED-MW18 during the April 2002 event and from well TNTA-BEDGW-001 during the October 2001 sampling event. Including barium and manganese, 11 inorganics were detected in the unfiltered groundwater sample from TNTA-BEDGW-001 at concentrations above RBSC and BSC values during the last sampling episode in the wet season of April 2002, but in the filtered sample only barium was detected. BTEX constituents in monitoring well TNTA-BEDGW-001 remained above RBSC and BSC levels during both sampling events, likely due to the free-phase hydrocarbon on the groundwater. Anions were dominated by chloride in both the bedrock wells in all sampling events. The concentration of chloride was as much as two orders of magnitude greater than the concentration of sulfate.

7.2.2 TNT Manufacturing Area B

7.2.2.1 Temporary Piezometers

No groundwater samples were collected from temporary piezometers at TNTB during 2000 TNTA and C RI activities. Two groundwater samples (DP02 and DP03) were collected during the direct-push investigation in 2001. One sample, DP02, was collected downgradient of the Fortifier House (Building 453), and the other sample, DP03, was collected downgradient of the

Bi-Tri House (Building 452). Groundwater collected from the temporary piezometers was analyzed for VOCs and nitroaromatics by the screening method. Table 7-1 presents detected constituents above RBSC and/or BSC values in the overburden/shale groundwater. Figure 7-2 shows analytical results along with sampling locations.

2000 Dry Season Sampling Event (October). No temporary piezometers were installed at TNTB during 2000, therefore no overburden/shale groundwater samples were collected.

2001 Dry Season Sampling Event (August). No nitroaromatics or VOCs were detected in the screening groundwater samples from DP02 and DP03 above RBSC or BSC values.

7.2.2.2 Overburden/Shale

Two overburden/shale wells (MK-MW16 and MK-MW17) were sampled at TNTB. Overburden monitoring well MK-MW16 is paired with bedrock monitoring well TNTB-BEDGW-002, and is located upgradient of TNTB, south of West Scheid Road. Well MK-MW17 is located downgradient of TNTB. Overburden well MK-MW16 was dry during the October 2001 sampling event, so no groundwater sample was collected. Groundwater was analyzed for VOCs, SVOCs, nitroaromatics, metals (unfiltered and filtered), cyanide, and water quality parameters during the other sampling events. Table 7-4 presents detected constituents above RBSC and/or BSC values in the overburden/shale groundwater. Figure 7-1 shows analytical results along with sampling locations.

1997 Dry Season Sampling Event (November). One nitroaromatic compound, 4A-2,6-DNT, was detected in the groundwater during the 1997 sampling, and its concentration (3.6 µg/L at monitoring well MK-MW17) exceeded the RBSC. No VOCs or SVOCs were detected from either well above the RBSC or BSC values. Six unfiltered inorganics were detected in the overburden/shale monitoring wells above RBSC or BSC values. Iron and manganese were detected in each well above both the RBSC and BSC. Aluminum was detected in the groundwater from well MK-MW16 and arsenic, cobalt and nickel were detected in the groundwater from well MK-MW17, at concentrations above RBSCs and BSCs. Five filtered metals were detected in the groundwater above RBSCs and BSC values. Iron and manganese concentrations exceeded the RBSC and BSC while aluminum and nickel exceeded the BSC value only in well MK-MW16. In groundwater from well MK-MW17, iron, manganese and nickel exceeded the RBSCs and BSCs while cobalt exceeded only the BSC value. Sulfate was the dominant anion in both overburden wells. Sulfate was detected at 470,000 and 330,000 µg/L, while chloride was detected at 4,000 and 3,000 µg/L.

1998 Wet Season Sampling Event (May). Two nitroaromatic compounds, 4A-2,6-DNT (5.7 µg/L) and 2,4-DNT (1.7 µg/L) were detected in the groundwater during sample collection in 1998, both above the RBSC. No VOC compounds from either well were detected above the RBSC or (for BTEX) BSC. The only SVOC detected above RBSC values was nitroaromatic 2,4-DNT (1.8 µg/L) from well MK-MW17. Eight unfiltered inorganics were detected in the overburden/shale monitoring wells above RBSCs or BSCs. Iron, manganese, and nickel were detected in each well above both sets of screening values. Aluminum and cobalt were detected in the groundwater from well MK-MW16 above respective BSC values. Groundwater from well MK-MW17 exhibited arsenic above the RBSC and BSC, lead (16.4 µg/L) above the RBSC, and cobalt and copper above BSC values. Nine filtered metals were detected in the groundwater above RBSCs and BSC values from both wells during May 1998. Iron, manganese, and nickel concentrations exceeded the RBSC and BSC values from both wells. Aluminum, cobalt, and copper concentrations exceeded BSC values in monitoring well MK-MW16. Groundwater in well MK-MW17 displayed arsenic above both the RBSC and BSC at a concentration of 22 µg/L. Cobalt and copper exceeded BSC values and lead (17 µg/L) and thallium (10.1 µg/L) exceeded RBSC values. Filtered thallium was B qualified. Sulfate was the dominant anion in both overburden wells. In MK-MW16, sulfate was detected at 550,000 µg/L and chloride was detected at 3,000 µg/L. In well MK-MW17, sulfate and chloride were detected at 330,000 and 6,000 µg/L, respectively.

2001 Dry Season Sampling Event (October). Four nitroaromatic compounds (2A-4,6-DNT, 4A-2,6-DNT 2,4-DNT, and 2,4,6-TNT) were detected in the groundwater from well MK-MW17, above the allowable RBSC value. Two SVOCs, indeno[1,2,3-cd]pyrene (1 µg/L) and nitroaromatic 2,4-DNT (2 µg/L) were detected at concentrations exceeding RBSC values. Six unfiltered metals were detected at concentrations exceeding RBSC and BSC values from well MK-MW17. Cobalt, iron, manganese, and nickel concentrations exceeded both the RBSC and BSC values in the unfiltered groundwater sample. Arsenic (6.6 µg/L) concentrations were greater than the respective RBSC and the aluminum (3,310 µg/L) concentration exceeded the BSC value. In the filtered groundwater sample from MK-MW17, cobalt (105 µg/L), iron (14,800 µg/L), manganese (1,830 µg/L), and nickel (248 µg/L) concentrations exceeded both the RBSC and BSC values. Concentrations of aluminum (3,390 µg/L) exceeded the BSC value and arsenic (6.5 µg/L) exceeded the RBSC value.

2002 Wet Season Sampling Event (April). Five nitroaromatics (2A-4,6-DNT, 4A-2,6-DNT, 2,4-DNT, 2,6-DNT and, 2,4,6-TNT were detected at concentrations in the groundwater

from well MK-MW17 above the RBSCs. No nitroaromatic compounds were detected in well MK-MW16. Two nitroaromatics, were detected as SVOCs, 2,4-DNT (4 µg/L) and 2,6-DNT (1.4 µg/L), at concentrations exceeding RBSC values. In the unfiltered metals, iron, manganese, and nickel exceeded both the RBSC and BSC values in both monitoring wells. Aluminum (2,380 µg/L) and cobalt (47.3 µg/L) both exceeded BSC values in well MK-MW16 and well MK-MW17 exhibited both compounds (aluminum 4,600 µg/L and cobalt 95.7 µg/L) above RBSC and BSC values. Thallium (8.6 µg/L) was detected in well MK-MW17 above the RBSC and it was validated by a B qualifier. In filtered metals, manganese and nickel were detected at concentrations above RBSCs and BSCs in both wells MK-MW16 and MK-MW17. From well MK-MW16, aluminum (1,480 µg/L) and cobalt (45.3 µg/L) were detected at concentrations greater than the BSC value. In well MK-MW17, other metals besides manganese and nickel above both the RBSC and BSC were aluminum (4,680 µg/L), cobalt (95.5 µg/L), and iron (11,500 µg/L). Sulfate was the dominant anion in both overburden wells. In MK-MW16, sulfate was detected at 300,000 µg/L and chloride was detected at 4,000 µg/L. In well MK-MW17, sulfate and chloride were detected at 286,000 and 2,100 µg/L, respectively.

7.2.2.3 Shale Bedrock

Four bedrock monitoring wells (TNTB-BEDGW-001, -002, -003, and -004), all screened in the shale bedrock, are present in TNTB. Bedrock well TNTB-BEDGW-001 is located downgradient of the TNTB area, TNTB-BEDGW-002 is positioned upgradient of the site (paired with overburden/shale well MK-MW16), TNTB-BEDGW-003 is located downgradient of Bi-Tri House (Building 452), and TNTB-BEDGW-004 is located downgradient of the Wash House (Building 458). Bedrock monitoring wells TNTB-BEDGW-003 and TNTB-BEDGW-004 were installed in October 2001 so groundwater sampling began with the October 2001 event. Groundwater was analyzed for nitroaromatics, VOCs, SVOCs, metals (unfiltered and filtered), cyanide, and water quality parameters. Table 7-5 presents detected constituents above RBSC and/or BSC values in the bedrock groundwater. Figure 7-2 shows analytical results along with sampling locations.

1997 Dry Season Sampling Event (November). No nitroaromatics were detected in wells TNTB-BEDGW-001 or -002. Benzene (0.91 µg/L) and methylene chloride (4.8 µg/L) concentrations in monitoring well TNTB-BEDGW-002 were greater than the RBSC, and the total xylenes concentration (12 µg/L) was greater than the BSC. No SVOC parameters were detected in either well greater than the RBSC or BSC values. Three unfiltered metals (aluminum, copper, and nickel) were detected in well TNTB-BEDGW-001 at levels only above the BSC and iron and manganese exceeded both the RBSCs and BSCs. Unfiltered inorganic

aluminum exceeded the BSC value in groundwater from well TNTB-BEDGW-002 while barium exceeded only the RBSC value. From the filtered groundwater samples, iron (16,300 µg/L) and manganese (694 µg/L) were the only compounds in well TNTB-BEDGW-001 to exceed both the RBSC and BSC values and barium (384 µg/L) exceeded the RBSC value in well TNTB-BEDGW-002. Similar concentrations of chloride and sulfate were detected in bedrock wells TNTB-BEDGW-001 and TNTB-BEDGW-002. Chloride was detected at 90,000 and 91,000 µg/L, compared to 140,000 and 90,000 µg/L for sulfate.

1998 Wet Season Sampling Event (May). No nitroaromatics or VOCs were detected in wells TNTB-BEDGW-001 or -002 during the May 1998 groundwater sampling event. The SVOC bis(2-ethylhexyl)phthalate exceeded the RBSC TNTB-BEDGW-001 but was B qualified. Arsenic (12.9 µg/L) and iron (13,000 µg/L) from well TNTB-BEDGW-001 exceeded both the RBSC and BSC in the unfiltered metals. Aluminum and copper concentrations exceeded only the BSC values, while barium and manganese exceeded only the RBSC. Barium (406 µg/L) was the only parameter detected at a concentration above either screening level in well TNTB-BEDGW-002; its concentration exceeded only the RBSC. Barium and manganese both exceeded RBSC values in the filtered sample from well TNTB-BEDGW-001 and barium also was above the RBSC value in well TNTB-BEDGW-002. Anions in bedrock well TNTB-BEDGW-001 were dominated by chloride (600,000 µg/L). Sulfate was detected at 120,000 µg/L. In well TNTB-BEDGW-002, sulfate (140,000 µg/L) was detected at a higher concentration than chloride (74,000 µg/L).

2001 Dry Season Sampling Event (September-October). No nitroaromatics were detected in the bedrock wells at TNTB during the 2001 groundwater sampling. The VOC benzene (17 µg/L) was detected above the RBSC and BSC in well TNTB-BEDGW-003 and toluene (5.2 µg/L) was detected above the BSC. Benzene (1.4 µg/L) was also detected above the RBSC in well TNTB-BEDGW-004. Barium was the most common unfiltered parameter detected in the wells at TNTB. It was found at concentrations above only the RBSC in wells TNTB-BEDGW-001, -002, and -003. Well TNTB-BEDGW-003 exhibited the greatest number of unfiltered metal detections above screening values. Unfiltered groundwater parameters above RBSC and BSC values in well TNTB-BEDGW-003 included aluminum, arsenic, iron, and manganese. Compounds that exceeded only the BSC value included cobalt, copper, and nickel. Chromium, lead and vanadium were detected in well TNTB-BEDGW-003 at concentrations that exceeded only the RBSC. In well TNTB-BEDGW-004, unfiltered iron and manganese concentrations exceeded both the RBSC and BSC values and aluminum exceeded only the BSC value. Barium was the parameter most commonly detected at concentrations above RBSC

values in the filtered samples, including wells TNTB-BEDGW-001, -002, and -003. Arsenic (4.9 µg/L), selenium (20.4 µg/L), and vanadium (8.5 µg/L) exceeded RBSC values in well TNTB-BEDGW-003. Iron (5,670 µg/L) and manganese (812 µg/L) were found at concentrations above RBSC and BSC values in well TNTB-BEDGW-004. Bedrock wells TNTB-BEDGW-001 and TNTB-BEDGW-003 were both chloride-dominant. In TNTB-BEDGW-001, chloride was detected at 704,000 µg/L as compared to 72,500 µg/L for sulfate. Similar results were seen in well TNTB-BEDGW-003 for chloride (1,460,000 µg/L) and sulfate (86,200 µg/L). The remaining two bedrock wells at the site (TNTB-BEDGW-002 and TNTB-BEDGW-004) had much higher sulfate concentrations (152,000 and 129,000 µg/L) than chloride (77,900 and 7,400 µg/L).

2002 Wet Season Sampling Event (April). No nitroaromatics were detected in the bedrock wells at TNTB. As with the October 2001 sampling, the VOC benzene (14 µg/L) was detected at a concentration above the RBSC and BSC in well TNTB-BEDGW-003 and toluene (4.7 µg/L) was detected above the BSC. Benzene (0.5 µg/L) was also detected above the RBSC in well TNTB-BEDGW-004. The SVOC naphthalene (2.8 µg/L) was detected for the first time at TNTB, above the RBSC, and it was found in well TNTB-BEDGW-003. Once again, barium was the most common unfiltered groundwater parameter detected in the wells at TNTB. It was found at a concentration above the RBSC in wells TNTB-BEDGW-001, -002, and -003. Well TNTB-BEDGW-003 exhibited the greatest number of unfiltered metal detections. Unfiltered groundwater parameters above both RBSC and BSC values included aluminum, arsenic, and iron. Besides barium, analytes detected at concentrations above only the RBSCs in well TNTB-BEDGW-003 included chromium, manganese, thallium, and vanadium. Analytes from this well that exceeded only the BSC were copper and nickel. Iron was found at a concentration above both the RBSC and BSC in the unfiltered metal groundwater sample from TNTB-BEDGW-004. Manganese exceeded only the RBSC value in this well. Barium in the metals groundwater sample was again the most common parameter above RBSC values in the filtered data. It was found at concentrations above the RBSC in wells TNTB-BEDGW-001, -002, and -003. Vanadium was also detected above only the RBSC in well TNTB-BEDGW-003. Filtered metals iron and manganese were also found at concentrations above both the RBSC and BSC value in well TNTB-BEDGW-004. Consistent with previous sampling results, well TNTB-BEDGW-001 and TNTB-BEDGW-003 were chloride-dominant, while the remaining two wells (TNTB-BEDGW-002 and TNTB-BEDGW-004) were sulfate dominant. The difference in these two anions was up to two orders of magnitude. In wells TNTB-BEDGW-001 and TNTB-BEDGW-003, chloride was detected at 761,000 and 3,720,000 µg/L while sulfate was detected at 32,100 and 31,000 µg/L, respectively. Sulfate (165,000 and 160 µg/L) was detected at higher

concentrations than chloride (117,000 and 2,800 µg/L) in wells TNTB-BEDGW-002 and TNTB-BEDGW-004, respectively.

7.2.2.4 Summary of Sampling Events, TNT Manufacturing Area B

Overburden/shale. Nitroaromatic compounds have consistently been present in the overburden/shale groundwater in monitoring well MK-MW17 during all sampling events at concentrations exceeding the RBSCs. VOCs have not been detected at concentrations above RBSC or BSC values in the groundwater from either well. Three SVOC parameters have been detected above RBSC levels during 3 of the 4 sampling events. The SVOC parameter indeno(1,2,3-cd)pyrene was detected at a concentration (1 µg/L) in well MK-MW17 above the RBSC value; the nitroaromatics 2,4-DNT and 2,6-DNT likewise were detected as SVOCs in well MK-MW17. Since sampling in November 1997, unfiltered metals continually present in both overburden wells at concentrations above RBSC and BSC levels have included iron, manganese, and nickel whereas aluminum has consistently been above the BSC. Arsenic and cobalt were detected in well MK-MW17 above RBSC and/or BSC levels during at least 3 of the 4 sampling events. In the filtered groundwater samples from both wells, iron, manganese, and nickel concentrations have fairly consistently been above the RBSC and BSC and aluminum and cobalt concentrations have frequently been detected above the BSC values. Lead was detected during 1 sampling event at well MK-MW17(17 µg/L). Sulfate was the dominant anion present in overburden groundwater. The sulfate concentrations are approximately two orders of magnitude greater than the chloride.

Shale Bedrock. Nitroaromatic compounds have not been detected in the groundwater from the shale bedrock monitoring wells at TNTB. Benzene concentrations above the RBSC and BSC values were frequently detected in the groundwater from wells TNTB-BEDGW-003 and TNTB-BEDGW-004. It was also above the BSC value in groundwater from well TNTB-BEDGW-003, but only during the November 1997 sampling event. Toluene concentrations were consistently above the BSC in well TNTB-BEDGW-003. The SVOC naphthalene was detected once in the groundwater sample from TNTB-BEDGW-003 at a concentration above the RBSC. Barium has fairly routinely been detected at concentrations in both the unfiltered and filtered samples above the RBSC in all wells except TNTB-BEDGW-004. Well TNTB-BEDGW-003 showed the largest number of unfiltered metals above RBSC and/or BSC levels. Detections during both sampling events included aluminum, arsenic, chromium, copper, iron, manganese, nickel, and vanadium. The unfiltered groundwater sample from well TNTB-BEDGW-004 displayed iron and manganese concentrations above both RBSC and BSC values. Filtration of the groundwater

removed many of the metals from all of the wells. Remaining metals above both the RBSC and BSC included iron and manganese in well TNTB-BEDGW-001 (November 1997) and well TNTB-BEDGW-004 (October 2001 and April 2002). Other compounds detected in the unfiltered sample and also found in the filtered sample included arsenic (October 2001) and vanadium (October 2001 and April 2002) in the groundwater sample from well TNTB-BEDGW-003. The four bedrock wells showed greater variability in terms of anion concentrations. Wells TNTB-BEDGW-001 and TNTB-BEDGW-003 were chloride-dominant for all but one sampling event. The remaining two wells (TNTB-BEDGW-002 and TNTB-BEDGW-004) were sulfate-dominant. A difference of up to two orders of magnitude was observed in the chloride and sulfate concentrations.

7.2.3 TNT Manufacturing Area C

7.2.3.1 Temporary Piezometers

Nine overburden groundwater samples were collected from temporary piezometers or boreholes during the October 2000 TNT Area C site investigation, and 2 groundwater samples were collected from temporary piezometers during the 2001 field groundwater sampling efforts. Groundwater during the 2000 dry season sampling event was analyzed for nitroaromatics, VOCs, SVOCs, PCBs, and metals (unfiltered and filtered). Groundwater collected during 2001 sampling was analyzed by the laboratory using the screening method for nitroaromatics and VOCs. Table 7-1 presents detected constituents above RBSC and/or BSC values in the overburden/shale groundwater. Figure 7-3 shows analytical results along with sampling locations.

2000 Dry Season Sampling Event (September-October). A total of 10 nitroaromatic compounds, 9 at concentrations above the RBSC values, were detected at TNTC. All 9 groundwater samples exhibited concentrations of at least 1 compound above the RBSCs. Compounds detected above the RBSCs include 4A-2,6-DNT, 2A-4,6-DNT, 1,3-DNB, total DNT, nitrobenzene, 2-, 3-, 4-nitrotoluenes, and 2,4,6- TNT. Five VOC compounds were detected in the groundwater from all of the samples, but toluene (7.88 µg/L) in sample TNTC-GW09 was the only VOC that exceeded the BSC value. However, benzene at concentrations of 0.51 J (estimated) µg/L (TNTC-GW03) and 0.59 µg/L (TNTC-GW09) exceeded the RBSC. Two SVOC parameters were detected in the groundwater samples, the nitroaromatics 2,4-DNT and 2,6-DNT; the concentrations of both DNTs were above the RBSC in groundwater samples TNTC-GW02, TNTC-GW04, TNTC-GW05, TNTC-GW07, TNTC-GW08, TNTC-GW09, and TNTC-GW10.

A total of 22 unfiltered inorganics were detected at TNTC. All 9 groundwater samples exhibited unfiltered compounds above both the RBSC and BSC limits. The most common unfiltered inorganics above both the RBSC and BSC were aluminum and iron. Aluminum was detected in all 9 samples with detections ranging from 426 µg/L in TNTC-GW10 to 221,000 µg/L in TNTC-GW09. In all of the samples, the concentrations of iron ranged from 810 µg/L in TNTC-GW10 to 979,000 µg/L in TNTC-GW09. Other inorganics detected at concentrations above both the RBSC and BSC in one or more samples included arsenic, cobalt, copper, manganese, nickel, and zinc. Sample TNTC-GW09 exhibited 14 unfiltered compounds at concentrations above the RBSCs and a total of 8 compounds above BSC values. Due to lack of groundwater, only 3 filtered groundwater samples were collected. All 3 samples exhibited filtered manganese above the RBSC at concentrations ranging from 115 µg/L in TNTC-GW10 to 236 µg/L in TNTC-GW04, but the BSC was not exceeded. Aluminum (334 µg/L) in TNTC-GW06 was the only metal present in the filtered samples at a concentration that exceeded the BSC. No PCBs were detected in the groundwater samples from TNTC.

2001 Dry Season Sampling Event (August). Only one nitroaromatic compound was detected in this sampling event. This was 2,4,6 TNT at a concentration of 4 µg/L in the sample from TNTC-DP19. The detected concentration exceeded the RBSC. Acetone (8.8 µg/L)was detected in the groundwater sample from TNTC-DP13 and carbon disulfide (0.75 µg/L) was detected in TNTC-DP19. Neither of these concentrations exceeded the RBSC values, and both are recognized as common laboratory contaminants. The samples from TNTC-DP13 and TNTC-DP19 were not analyzed for VOCs and inorganics.

Wet Season Sampling Event. No temporary piezometers were installed at the TNT Area C during the wet season; therefore, no groundwater samples were collected.

7.2.3.2 Overburden/Shale

Three overburden/shale wells (TNTC-MW03, TNTC-MW04, and TNTC-MW05) were sampled at TNTC. Overburden monitoring well TNTC-MW03 is located north (downgradient) of TNTC and west (side-gradient) of the Waste Water Settling Basins (Building 657), TNTC-MW04 is located downgradient of Wash House (Building 626), and TNTC-MW05 is located downgradient of the Wash House (Building 606). Overburden well TNTC-MW03 was dry during the October 2001 sampling event, so no sample was collected. Groundwater was analyzed for VOCs, SVOCs, nitroaromatics, metals (unfiltered and filtered), cyanide, and water quality parameters during the sampling events. Table 7-7 presents constituents detected at concentrations above

RBSC and/or BSC values in the overburden/shale groundwater. Figure 7-3 shows analytical results along with sampling locations.

1997 Dry Season Sampling Event (November). No nitroaromatic compounds were detected in the groundwater during the 1997 sampling. Only two VOCs (carbon disulfide and methylene chloride) were detected, and both were in samples from well TNTC-MW05. Both carbon disulfide and methylene chloride are recognized as common laboratory contaminants and were B qualified. The concentrations were not above the RBSC or BSC. No SVOC compounds were detected in any of the samples. Fourteen unfiltered inorganics were detected in the overburden/shale monitoring wells. All 3 groundwater samples exhibited unfiltered compounds at concentrations above both the RBSC and BSC values. The most common unfiltered inorganic above both the RBSC and BSC was manganese. It was detected in all 3 samples with detections ranging from 713 µg/L in TNTC-MW05 to 2,950 µg/L in TNTC-MW03. Other inorganics detected at concentrations above both the RBSC and BSC in one or more samples included aluminum, arsenic, iron, and nickel. Groundwater from well TNTC-MW04 exhibited 5 unfiltered inorganics at concentrations above the RBSCs and a total of 5 above BSC values. All 3 wells exhibited filtered manganese above the RBSC while concentrations from samples in wells TNTC-MW03 and TNTC-MW04 were also above the BSC value. Manganese was detected at concentrations ranging from 522 µg/L in TNTC-MW05 to 2,900 µg/L in TNTC-MW03. Besides manganese, other filtered inorganics detected at concentrations above both the RBSC and BSC included only nickel in well TNTC-MW03. In the overburden wells, the concentrations of sulfate ranged from 430,000 µg/L in TNTC-MW05 to 2,000,000 µg/L in TNTC-MW03, and the corresponding chloride concentrations ranged from 17,000 (TNTC-MW03) to 50,000 µg/L (TNTC-MW05).

1998 Wet Season Sampling Event (May). No nitroaromatic compounds were detected in the groundwater during the 1998 sampling. Two VOCs (acetone and methylene chloride) were reported, but both were B qualified and neither exceeded the RBSCs. No SVOCs were detected in the groundwater samples. Twelve unfiltered inorganics were detected in the overburden/shale monitoring wells, 7 at concentrations above the RBSC and/or BSC. All 3 groundwater samples exhibited unfiltered compounds above both the RBSCs and BSCs. The inorganics detected most commonly at concentrations above both the RBSCs and BSCs were aluminum and iron. Aluminum was detected in all 3 samples with detections ranging from 4,570 µg/L in TNTC-MW04 to 6,030 µg/L in TNTC-MW03. In the same samples, the concentrations of iron ranged between 8,230 µg/L in TNTC-MW04 and 23,500 µg/L in TNTC-MW03. Other unfiltered inorganics detected at concentrations above both the RBSCs and BSCs in one or more samples

included arsenic and manganese. Groundwater from well TNTC-MW03 exhibited 5 unfiltered inorganics above the RBSC and 4 above BSC values.

All 3 wells exhibited filtered manganese above the RBSC. Manganese was detected at concentrations ranging from 452 µg/L in TNTC-MW05 to 617 µg/L in TNTC-MW03. None of these concentrations exceeded the BSC values. In all samples, the detected concentrations of the other inorganics were below the RBSC and BSC values. In the overburden wells, the concentrations of sulfate ranged for 240,000 (TNTC-MW05) to 1,300,000 µg/L (TNTC-MW03), and the corresponding chloride concentrations ranged from 14,000 to 27,000 µg/L.

2001 Dry Season Sampling Event (October). No nitroaromatics, VOCs, or SVOCs were detected at concentrations above RBSC or BSC levels in overburden wells TNTC-MW04 and TNTC-MW05. Seventeen metals were detected, and 7 (aluminum, arsenic, chromium, iron, manganese, thallium, and vanadium) at concentrations above RBSC levels in the unfiltered metals. Six compounds (aluminum [6,160 J µg/L], arsenic [8.8 J µg/L], cobalt [16.7 J µg/L], iron [13,300 J µg/L], manganese [1,520 J µg/L], and nickel [17.2 J µg/L]) were above BSC values. Among the filtered samples, manganese concentrations exceeded both the RBSC and BSC in TNTC-MW04 (686 µg/L) and TNTC-MW05 (1,180 µg/L). Nickel (15.6 µg/L) exceeded the BSC in TNTC-MW04, and aluminum (6,160 µg/L) was above the BSC in TNTC-MW05. Thallium (5.9 µg/L) exceeded the RBSC in TNTC-MW05, but the result was B qualified. In wells TNTC-MW04 and TNTC-MW05, sulfate (839,000 and 423,000 µg/L) was detected at much higher concentrations than chloride (19,800 and 46,900 µg/L).

2002 Wet Season Sampling Event (April). No nitroaromatic compounds were detected at concentrations above the RBSC levels in this sampling event. A total of 15 unfiltered inorganic compounds were detected in wells TNTC-MW03, TNTC-MW04, and TNTC-MW05. In well TNTC-MW04, iron and manganese exceeded the RBSC and BSC values with concentrations of 3,060 J µg/L and 684 µg/L, respectively. Thallium exceeded the RBSC value with a concentration of 5.9 µg/L in TNTC-MW03, but the result was B qualified. Aluminum (1,190 µg/L) and nickel (9.2 µg/L) were above the BSC values in the groundwater from well TNTC-MW04. In the filtered groundwater samples, only manganese (448 µg/L) in TNTC-MW04 exceeded the RBSC value. None of the inorganic concentrations in the filtered samples exceeded the BSC levels. In the three wells sampled, sulfate was detected at concentrations ranging from 163,000 (TNTC-MW05)to 749,000 µg/L (TNTC-MW04), while chloride was detected from 4,500 µg/L (TNTC-MW03) to 20,000 µg/L (TNTC-MW04).

7.2.3.3 Delaware Limestone Bedrock

Two bedrock monitoring wells (BED-MW13 and TNTC-BEDGW-001), both screened in the Delaware Limestone, are present in TNTC. Bedrock well BED-MW13 is located downgradient of the TNTC area and bedrock well TNTC-BEDGW-001 is located at the former Fortifier House (Building 683). Groundwater was analyzed for nitroaromatics, VOCs, SVOCs, metals (unfiltered and filtered), cyanide, and water quality parameters. Table 7-8 presents detected constituents above RBSC and/or BSC values in the bedrock groundwater. Figure 7-3 shows analytical results along with sampling locations.

1997 Dry Season Sampling Event (November). No nitroaromatics were detected in the groundwater sample from well BED-MW13. The VOCs benzene (130 µg/L), toluene (170 µg/L), and total xylenes (520 µg/L) exceeded both the RBSCs and BSCs in the sample from this well. Ethyl benzene (73 µg/L) was detected at a concentration above the BSC value. The SVOCs bis(2-ethylhexyl)phthalate (39 µg/L), 2-methylnaphthalene (20 µg/L), and naphthalene (15 µg/L) exceeded the RBSC value in the sample from this well. Excluding the nutritionally essential elements, barium was the only unfiltered metal to exceed RBSC values. Barium was found at a concentration of 1,550 µg/L in the unfiltered sample from BED-MW13. In the filtered sample, barium was detected above the RBSC at the concentration of 1,680 µg/L. Apart from the nutrient elements, none of the inorganic concentrations exceeded the BSC values. Chloride was detected in well BED-MW13 at 2,500,000 µg/L and sulfate was detected at 13,000 µg/L.

1998 Wet Season Sampling Event (May). No nitroaromatics were detected in the groundwater sample collected from well BED-MW13 during the May 1998 sampling event. The VOC compounds benzene (47 µg/L), toluene (120 µg/L), and total xylenes (540 µg/L) exceeded both the RBSC and BSC values. Ethyl benzene (57 µg/L) was above the BSC. Methylene chloride (51 µg/L) was above the RBSC, but the result was B qualified. The SVOCs bis(2-ethylhexyl)phthalate (55 µg/L), 2-methylnaphthalene (14 µg/L), and naphthalene (10 µg/L) exceeded the RBSCs. In the filtered and unfiltered samples, none of the detected metals exceeded BSC or RBSC values. Sulfate was detected at 5,000 µg/L in well BED-MW13; chloride was not detected.

2001 Dry Season Sampling Event (October). No nitroaromatics were detected in the groundwater samples from wells BED-MW13 and TNTC-BEDGW-001. The VOC compounds benzene (270 µg/L) and toluene (270 µg/L) exceeded both the BSCs and RBSCs in the sample from BED-MW13. Total xylenes were above the RBSC and BSC in BED-MW13 (1,200 µg/L)

and TNTC-BEDGW-001 (190 µg/L). Ethyl benzene was above the BSC in the samples from both wells, and methylene chloride exceeded the RBSC in both wells. The SVOCs bis[2-ethyl-hexyl]phthalate, 2-methylnaphthalene, and naphthalene exceeded the RBSCs in the sample from BED-MW13, and naphthalene was above the RBSC in the sample from the other well. In the unfiltered samples from TNTC-BEDGW-001, arsenic and manganese exceeded the RBSC values. Barium and thallium concentrations were above the RBSC values in the unfiltered samples from BED-MW13. None of the inorganic detections in the unfiltered samples exceeded the BSC values. In the filtered samples from TNTC-BEDGW-001, arsenic and manganese concentrations exceeded the RBSC. Barium exceeded the RBSC in the sample from the other well. None of the detections in the unfiltered samples exceeded the BSC values. Well BED-MW13 is chloride-dominant; chloride was detected at 4,290,000 µg/L compared to sulfate at 78,400 µg/L. In well TNTC-BEDGW-001, chloride was detected at 274,000 µg/L and sulfate was detected at 1,340,000 µg/L.

2002 Wet Season Sampling Event (April). No nitroaromatic compounds were detected in the samples from wells BED-MW13 and TNTC-BEDGW-001. The VOC benzene was detected above both the RBSC and BSC in BED-MW13 (410 µg/L) and TNTC-BEDGW-001 (8.4 µg/L). Toluene (300 µg/L) exceeded both criteria in BED-MW13. Total xylenes exceeded the RBSC and BSC in both wells. The toluene concentration (8.8 µg/L) was above the BSC only in TNTC-BEDGW-001, and ethyl benzene exceeded the BSC in both wells. Methylene chloride concentrations were above the RBSC values in both wells. The SVOCs bis(2-ethylhexyl)phthalate, 2-methylnaphthalene, and naphthalene were detected above the RBSC screening values in BED-MW13. Naphthalene was above the RBSC in the sample from TNTC-BEDGW-001. Barium was above the RBSC in the unfiltered sample from BED-MW13. In the unfiltered groundwater samples from both wells, thallium exceeded the RBSC value, but the detected quantities were B qualified. The concentrations of arsenic and barium were above the RBSC values in the filtered sample from BED-MW13. With the exception of several nutrient metals, none of the detected metals exceeded the BSC in either the unfiltered or filtered samples from the two wells. Anion results seen in April 2002 were similar to those observed in the previous (October 2002) sampling. Chloride was detected in well BED-MW13 at 4,220,00 µg/L, and sulfate was detected at 66,600 µg/L. Well TNTC-BEDGW-001 was dominated by sulfate. In this well, sulfate was detected at 1,030,000 µg/L, as compared to chloride at 242,000 µg/L.

7.2.3.4 Summary of Sampling Events, TNT Manufacturing Area C

Overburden/Shale. Nitroaromatics were detected in the overburden/shale groundwater at TNTC only during the dry season of 2000 and 2001. Benzene and toluene were the only VOC compounds detected in the groundwater above RBSC and/or BSC values, and this occurred in the dry season of 2000. In the same event, the nitroaromatics 2,4-DNT and 2,6-DNT were detected as SVOCs. The unfiltered metals aluminum, arsenic, iron, and manganese have been the analytes most commonly detected in the overburden/shale groundwater at concentrations above both RBSC and BSC values during both the wet and dry seasons. Chromium, cobalt, copper, nickel, thallium, vanadium, and zinc were detected above the RBSC and/or BSC values in dry season samples. Thallium and nickel exceeded the RBSC or BSC in the 2000 wet season samples. Manganese was the filtered metal most commonly detected at concentrations at above the RBSC and/or BSC values in both the wet and dry seasons. In the 1997 dry season sample from TNTC-MW03, nickel was detected above both the RBSC and BSC. In the 2001 dry season, nickel was detected above the BSC in the filtered sample from TNTC-MW04. The filtered aluminum concentration also exceeded the BSC in the dry season. Likewise, the reported concentrations of thallium in the dry season exceeded the RBSC and BSC; however, thallium was B qualified. In addition, chloride was detected at concentrations at least one order of magnitude greater than the corresponding sulfate concentrations in the groundwater from overburden/shale monitoring wells.

Delaware Limestone Bedrock. No nitroaromatic compounds were detected in the dry season or wet season bedrock groundwater samples from TNTC. VOC compounds have been detected consistently in both site wells since 1997. BTEX parameters are commonly above RBSC and/or BSC values in the Delaware Limestone screened monitoring wells. Reported concentrations of methylene chloride (a common laboratory contaminant) consistently exceeded the RBSC in both wells, though some were B qualified. The SVOCs bis(2-ethylhexyl)phthalate, 2-methylnaphthalene, and naphthalene were detected at concentrations above RBSCs in every sampling event. The first two compounds were detected above this criterion exclusively in BED-MW13. However, naphthalene exceeded the RBSC in all sampling events in all wells. Four unfiltered and filtered metals (arsenic, barium, manganese, and thallium) were detected at concentrations above the RBSC values in groundwater samples from the two TNTC bedrock wells. Barium was the metal most commonly detected at concentrations above its RBSC in both the unfiltered and filtered samples from most sampling events. In all sampling events, none of the detected metals exceeded BSC values. The detected anions varied in the bedrock wells at the

site. In well BED-MW13, chloride is the dominant anion, while sulfate is the dominant anion in well TNTC-BEDGW-001.

7.2.4 West Area Red Water Ponds Area

7.2.4.1 Temporary Piezometers

Fourteen overburden groundwater samples were collected from temporary piezometers or boreholes during the June 1998 wet season site investigation at the WARWP area. Groundwater during the 1998 wet season sampling event was analyzed for nitroaromatics, VOCs, SVOCs, metals (unfiltered and filtered), PCBs, cyanide, and water quality parameters. Due to an insufficient groundwater volume, samples from direct-push locations WARP-DP01, DP06, DP08, DP12, DP15, and DP19 were analyzed only for nitroaromatics and VOCs. Table 7-8 presents detected constituents and identifies those detected at concentrations above RBSC and/or BSC values in the overburden/shale groundwater. Figure 7-4 shows analytical results along with sampling locations.

1998 Wet Season Sampling Event (June). Up to 5 nitroaromatic compounds (1,3-DNB, 2,4-DNT, 2,6-DNT, 1,3,5-TNB, and 2,4,6-TNT) were detected at 1 or more locations in the overburden groundwater above RBSC values in 6 of the 14 temporary piezometer locations (DP08, -09, -11, -12, -13, -15, and -17). 1,3-DNB was detected at 4 sampling locations with concentrations ranging from 0.69 µg/L in DP12 to 270 µg/L in direct-push location DP13. 2,4-DNT was detected at 6 locations and concentrations above the RBSC ranged from 1.1 µg/L in DP15 to 950 µg/L in DP13. 2,6-DNT was encountered at 3 locations at a concentration of 0.25 µg/L in DP-12 to a maximum of 2.7 µg/L in boring DP09. 1,3,5-TNB was detected at a concentration of 680 µg/L and found only in direct-push point DP13, and 2,4,6-TNT was detected at 7.1 µg/L only in boring DP11. Three VOC compounds were detected in the groundwater above RBSC values at the WARWP. Tetrachloroethene was reported in direct-push borings DP08 (0.2 µg/L) and DP09 (0.15 µg/L) and trichloroethene was reported at borings DP02 (0.3 µg/L) and DP11 (0.16 µg/L) but both of the trichloroethene detections were B qualified. Bis(2-ethylhexyl)phthalate (5.1 µg/L), a common laboratory contaminant, was reported in boring DP04 and the result was also B qualified. Nitroaromatics 4,6-dinitro-2-methylphenol, 2,4-DNT , 2,6-DNT, and 3-nitroaniline, detected as SVOCs, were found above RBSC values in the WARWP direct-push borings. Direct-push boring DP09 exhibited 4,6-dinitro-2-methylphenol (24 µg/L), 2,4-DNT (60 µg/L), 2,6-DNT (6.3 µg/L), and 3-nitroaniline (5.1 µg/L) above RBSC levels. Borings DP11 detected only 2,4-DNT (1.8 µg/L) while boring DP13 detected 2,4-DNT (660 µg/L), 2,6-DNT (56 µg/L), and 3-nitroaniline (15 µg/L). Borings DP16 and DP17 both encountered concentrations of SVOC detected nitroaromatics 2,4-DNT (60

and 15 µg/L), 2,6-DNT (52 and 18 µg/L), and 3-nitroaniline (43 and 49 µg/L), respectively, in the groundwater. Adequate groundwater volume permitted 8 of the 14 direct-push points to be analyzed for unfiltered and filtered inorganic analysis. From these borings, a total of 16 unfiltered metals were detected above RBSC and/or BSC values in the overburden groundwater. Aluminum (range 1,240 µg/L [DP04] to 206,000 µg/L [DP16]), iron (range 2,650 µg/L [DP04] to 339,000 µg/L [DP16]), and manganese (range 750 µg/L [DP02] to 12,600 µg/L [DP13]) were detected above both the RBSC and BSC in all 8 of the direct-push points. A total of 14 analytes whose concentrations exceeded the RBSC and/or BSC value were found at direct-push point DP16. A total of 8 filtered metals were detected above RBSC or BSC values in the overburden groundwater. Filtered manganese (range 480 µg/L [DP07] to 8,480 µg/L [DP09]) was detected above both the RBSC and/or BSC value in each of the 8 direct-push borings. Direct-push point DP17 detected 6 inorganics at concentrations that exceeded the RBSC and/or BSC value. Sulfate was the dominant anion detected. In two samples analyzed (DP13 and DP09), sulfate was detected at 278,000 and 305,000 µg/L, respectively. Nitrate was also detected at 1,600 µg/L (DP13). Chloride was not detected in any samples.

Dry Season Sampling Event. No temporary piezometers were installed at the WARWP Area during the dry season; therefore, no groundwater samples were collected.

7.2.4.2 Overburden/Shale

No pre-existing overburden monitoring wells were sampled at the WARWP area during the 1997 dry season, 1998 wet season, 2001 dry season, or 2002 wet season events.

7.2.4.3 Delaware Limestone Bedrock

One bedrock monitoring well (BED-MW14), screened in the Delaware Limestone, is located at the WARWP area, downgradient (northeast) of the red water ponds. Groundwater was analyzed for nitroaromatics, VOCs, SVOCs, metals (unfiltered and filtered), cyanide, and water quality parameters. Table 7-9 presents detected constituents above RBSC and/or BSC values in the bedrock groundwater. Figure 7-5 shows analytical results along with sampling locations.

1997 Dry Season Sampling Event (November). Benzene was detected in the groundwater at a concentration of 1.1 µg/L, above the RBSC. Toluene was reported at a concentration of 1.7 µg/L, above the BSC value, but this value was B qualified. Aluminum (374 µg/L) and nickel (42.3 µg/L) were both detected above BSC values in the unfiltered groundwater sample. Nickel was the only filtered metal compound detected above the BSC value at a concentration of 40.7 µg/L. Water quality parameter nitrate-nitrite was detected at the RBSC

value (300 µg/L). Sulfate was detected at 610,000 µg/L and chloride was detected at 79,000 µg/L.

1998 Wet Season Sampling Event (May). Four nitroaromatics, detected as SVOC compounds, were encountered above RBSC values in the groundwater during the May 1998 sampling event. SVOCs included 4,6-dinitro-2-methylphenol (28 µg/L), 2,4-dinitrophenol (14 µg/L), 2,4-DNT (16 µg/L), and nitrobenzene (5.8 µg/L). The inorganic compound nickel was the only unfiltered metal detected above either screening value; it was detected at a concentration of 45.5 µg/L, exceeding only the BSC value. Filtered inorganic compounds cobalt (65.4 µg/L) and nickel (71.3 µg/L) were both detected in the groundwater at concentrations exceeding only BSC values. Water quality compound nitrate was detected above the RBSC, at a concentration of 24,000 µg/L. Sulfate was detected at 630,000 µg/L and chloride was detected at 3,000 µg/L.

2001 Dry Season Sampling Event (September). No nitroaromatics were detected in the groundwater from the bedrock monitoring well. Unfiltered metals cobalt (102 µg/L) and nickel (111 µg/L) were detected in the groundwater sample both exceeding RBSC and BSC levels. Arsenic (6.1 µg/L) and thallium (5 µg/L) were found at concentrations above only RBSC values and copper (30.7 µg/L) exceeded only the BSC value. The filtered groundwater sample detected cobalt (105 µg/L) and nickel (117 µg/L) above both RBSC and BSC values while arsenic (5.5 µg/L) and thallium (7.2 µg/L) exceeded only RBSC values. Copper (27 µg/L) exceeded only the BSC value. Like the May 1998 groundwater sampling result, water quality parameter nitrate (22,000 µg/L) exceeded the RBSC level. Chloride was detected at 72,200 µg/L. No analytical results were available for sulfate.

2002 Wet Season Sampling Event (April). Two nitroaromatics, detected as SVOC compounds, were encountered above RBSCs in the groundwater during the April 2002 sampling event. These are 2,4-DNT (19 µg/L) and 3-nitroaniline (150 µg/L). Unfiltered metals arsenic (9.5 µg/L), cobalt (267 µg/L), and nickel (278 µg/L) were detected in the groundwater sample, at concentrations exceeding both RBSC and BSC levels. Manganese (136 µg/L) and vanadium (5.5 µg/L) were found above only RBSC values and the copper concentration (94.8 µg/L) exceeded only the BSC value. The filtered groundwater sample detected arsenic (9 µg/L), cobalt (265 µg/L), and nickel (276 µg/L) at concentrations above both RBSC and BSC values. Manganese (136 µg/L) and vanadium (5.8 µg/L) concentrations exceeded only RBSC values, and Copper (92 µg/L) concentrations exceeded only the BSC value. Like previous groundwater sampling events, the concentration of the water quality parameter nitrate (79,300 µg/L) exceeded

the RBSC level. Sulfate was detected at 2,660,000 µg/L and chloride was detected at 75,600 µg/L.

7.2.4.4 Summary of Sampling Events, West Area Red Water Ponds

Overburden/Shale. Seven nitroaromatic compounds were detected at concentrations above RBSC levels in the 14 groundwater samples from temporary piezometers during the wet season of June 1998. Two of the nitroaromatics (2,4-DNT and 2,6-DNT) were also detected as SVOC compounds and 2 (4,6-dinitro-2-methylphenol and 3-nitroaniline) were detected only as an SVOC. VOC compounds tetrachloroethene and trichloroethene (trichloroethene detections B qualified) were detected above RBSC values at the WARWP and may not be related to former DOD operations. Nitroaromatic detections are indicative of former DOD site activities. The unfiltered metals most frequently detected at concentrations above both RBSC and BSC values included aluminum, iron, and manganese. Most of the inorganic compounds were removed or concentrations reduced from filtration processes, but manganese remained above RBSC and/or BSC values in 7 of the 8 groundwater samples. Sulfate was the dominant anion present. In addition, nitrate was detected in this area above the RBSC. No temporary piezometers were drilled and no overburden/shale wells were sampled during the dry season.

Delaware Limestone Bedrock. Benzene was detected only once (November 1997 dry season) and at a concentration above the RBSC value. Five nitroaromatic compounds, all detected as SVOCs, were found to be above RBSC levels during the wet season of May 1998. Nitroaromatics 3-nitroaniline and 2,4-DNT, detected as SVOCs, were also present above RBSC levels during the April 2002 wet season. Nickel was the inorganic most commonly detected at a concentration that exceeded screening levels. Nickel concentrations exceeded the BSC during all four sampling events in both the unfiltered and filtered groundwater samples, and nickel concentrations exceeded the RBSC (73 µg/L) during the September 2001 dry season and the April 2002 wet season in both the unfiltered and filtered samples. Concentrations of cobalt and copper were above BSC values during the September 2001 and April 2002 sampling events in both the unfiltered and filtered samples, and arsenic was also found above RBSCs and BSCs during the last 2 sampling events. Anions in the bedrock groundwater are dominated by sulfate, which was detected at concentrations up to two orders of magnitude greater than the concentrations of chloride in all sampling events except September 2001. In this latter event, no sulfate data were available.

7.2.5 Pentolite Road Red Water Ponds Area

7.2.5.1 Temporary Piezometers

Twenty overburden groundwater samples were collected from temporary piezometers or boreholes during a June 1998 wet season site investigation at the PRRWP area. Groundwater during the 1998 wet season sampling event was analyzed for nitroaromatics, VOCs, SVOCs, PCBs, metals (unfiltered and filtered), and water quality parameters. Table 7-10 presents detected constituents above RBSC and/or BSC values in the overburden/shale groundwater. Figure 7-6 shows analytical results along with sampling locations.

1998 Wet Season Sampling Event (June). As many as 4 nitroaromatic compounds (1,3-DNB, 2,4-DNT, 2,6-DNT, and 1,3,5-TNB) were detected at 1 or more locations in the overburden/shale groundwater above RBSC values at 12 of the 20 temporary piezometer locations (DP01, -03, -04, -06, -07, -08, -10, -11, -12, -13, -17, and -18). 1,3-DNB was detected at 10 sampling locations with concentrations ranging from 0.42 µg/L in DP07 to 4,800 µg/L in direct-push location DP03. 2,4-DNT was detected at 12 locations at concentrations above the RBSC ranged from 0.47 µg/L in DP04 to 6,800 µg/L in DP03. 2,6-DNT was detected at 7 locations with concentrations in the groundwater ranging from 0.28 µg/L (DP08) to 400 µg/L (DP10) and 1,3,5-TNB was detected at 600 µg/L only in DP11. Two VOC compounds were detected above the RBSC and 1 above the BSC. Tetrachloroethene was detected in direct-push borings DP02 (0.14 µg/L), DP03 (0.22 µg/L), DP05 (0.26 µg/L), DP07 (0.17 µg/L), and DP19 (0.13 µg/L), above the RBSC. Trichloroethene was detected above the RBSC in the groundwater at borings DP07 (0.43 µg/L) and DP08 (0.16 µg/L). Toluene was detected above the BSC value at a concentration of 1.9 µg/L in direct-push piezometer DP12. Six nitroaromatics detected as SVOC compounds were encountered above RBSC concentrations at the PRRWP. 4,6-dinitro-2-methylphenol was detected at DP03 (2,300 µg/L), DP10 (1,700 µg/L), and DP15 (830 µg/L). 2,4-dinitrophenol was detected above the RBSC value in groundwater from DP01 (8.3 µg/L), DP03 (5,800 µg/L), DP10 (5,900 µg/L), and DP16 (22 µg/L). 2,4-DNT was above the RBSC at 10 direct push locations at concentrations ranging from 2.8 µg/L in DP08 to 9,200 µg/L in DP03. 2,6-DNT (detected as a SVOC) was found at 4 locations with concentrations ranging from 3.3 µg/L in DP01 to 550 µg/L in DP03. SVOC 3-nitroaniline was above the RBSC value in DP01 at a concentration of 88 µg/L and 4-nitrophenol was found at a concentration above the RBSC in DP03 (290 µg/L), DP10 (210 µg/L), and DP16 (5 µg/L). Naphthalene was detected above the RBSC in boring DP05 at a concentration of 1.9 µg/L. A total of 15 unfiltered metals were detected above RBSC or BSC values in the overburden groundwater. Aluminum (4,820 µg/L-DP11 to 178,000 µg/L-DP08), chromium (16 µg/L-DP13 to 56 µg/L-DP04), iron (15,500 µg/L-DP11 to 679,000 µg/L-DP04), and manganese

(496 µg/L-DP13 to 55,100 µg/L-DP11) were the four most frequently detected at concentrations above both the RBSCs and BSCs. Direct-push points DP08, DP12, and DP19 each detected 14 compounds that exceeded the RBSC and/or BSC values. A total of 9 filtered metals were detected at concentrations above RBSC or BSC values in the overburden groundwater samples. Manganese (108 µg/L-DP13 to 62,400 µg/L-DP10) was the inorganic most frequently detected at concentrations above both the RBSC and BSC. Direct-push point DP11 detected 7 analytes that exceeded the RBSC and/or BSC value. Total cyanide was also detected in the groundwater at concentrations above the RBSC in direct-push locations DP03 and DP11, while nitrate was detected above the RBSC at points DP03, DP09, and DP11. In addition to nitrate, sulfate was detected at concentrations up to 10,000,000 µg/L and chloride at concentrations up to 9,800 µg/L.

7.2.5.2 Overburden/Shale

No pre-existing overburden monitoring wells were sampled at the PRRWP area during the 1997 dry season, 1998 wet season, 2001 dry season, or 2002 wet season events.

7.2.5.3 Delaware Limestone Bedrock

Two monitoring wells (BED-MW15 and BED-MW23), both screened in the Delaware Limestone, are located at the PRRWP area. Both bedrock wells are located downgradient (north) of the area. Bedrock well BED-MW23 was installed September 2001 which was, therefore, the beginning of the groundwater sampling program for this well. Groundwater was analyzed for nitroaromatics, VOCs, SVOCs, metals (unfiltered and filtered), cyanide, and water quality parameters. Table 7-10 presents constituents detected at concentrations above RBSC and/or BSC values in the bedrock groundwater. Figure 7-7 shows analytical results along with sampling locations.

1997 Dry Season Sampling Event (November). In groundwater from bedrock monitoring well BED-MW15, VOC compounds benzene (570 µg/L), ethyl benzene (130 µg/L), toluene (490 µg/L), and total xylenes (920 µg/L) were detected above both the RBSC and the BSC values. Chloroform (8.4 µg/L) and methylene chloride (31 µg/L) were reported at concentrations above the RBSC, but the analytical results were B qualified. SVOCs bis(2-ethylhexyl)phthalate (37 µg/L), 2-methylnaphthalene (31 µg/L), and naphthalene (22 µg/L) were detected above RBSC values in well BED-MW15. Chloroform and methylene chloride were both B qualified. Barium was the only inorganic detected above the RBSC value and it was found in both the unfiltered (605 µg/L) and filtered (555 µg/L) samples. Chloride was detected in BED-MW15 at 1,400,000 µg/L; sulfate was not detected in this well.

1998 Wet Season Sampling Event (May). Nitroaromatic compounds 2,4-DNT (0.89 µg/L) and 2,6-DNT (0.89 µg/L) were detected above the RBSC in the groundwater from monitoring well BED-MW15 in May 1998. Similar to the November 1997 sampling event, VOC compounds benzene (780 µg/L), ethyl benzene (130 µg/L), toluene (550 µg/L), and total xylenes (880 µg/L) were detected at concentrations above both the RBSC and the BSC values in the groundwater from well BED-MW15. The VOCs 1,1,2-trichloroethane (4.9 µg/L) were detected above RBSCs. The SVOCs 2-methylnaphthalene (37 µg/L) and naphthalene (31 µg/L) were detected at concentrations above the RBSC in well BED-MW15. Reported concentrations of the VOC methylene chloride and the SVOC bis(2-ethylhexyl)phthalate exceeded RBSCs but were both B qualified. During the 1998 groundwater sampling, barium (1,710 µg/L), chromium (20.6 µg/L), manganese (139 µg/L), and thallium (50.8 µg/L) were detected at concentrations above the RBSCs. Iron (4,810 µg/L) was found at concentrations above the RBSC and BSC, and aluminum (513 µg/L) and copper (39.5 µg/L) were detected at concentrations above the BSC value only. Barium (1,390 µg/L) and thallium (62.2 µg/L) were detected in the filtered groundwater samples and were above the respective RBSCs. Chloride was detected at 2,200,000 µg/L and sulfate was detected at 82,000 µg/L.

2001 Dry Season Sampling Event (October). In 2001, groundwater from monitoring well BED-MW15 and BED-MW23 was sampled. BTEX compounds exceeded RBSCs and BSC values in both monitoring wells. The concentration of the VOC methylene chloride was above the RBSC value in well BED-MW15. Monitoring well BED-MW23 groundwater displayed detections of acetone and methylene chloride above the RBSC; both are common laboratory contaminants. Four SVOCs; 2-methylnaphthalene (25 µg/L) and naphthalene (24 µg/L) from well BED-MW15 and bis[2-ethylhexyl]phthalate (7.1 µg/L), 4-methylphenol (21 µg/L), 2-methylnaphthalene (22 µg/L) and naphthalene (21 µg/L) from well BED-MW23 were detected at concentrations above RBSC values. Barium was the only inorganic detected at concentrations above the RBSC in unfiltered and filtered samples from well BED-MW15. In well BED-MW23, the concentration of arsenic was above the RBSC value in both the unfiltered and filtered groundwater samples while iron and manganese exceeded both the RBSC and BSC in both samples. Concentrations of aluminum and nickel exceeded BSC values in the unfiltered groundwater samples from well BED-MW23. In the two wells sampled, chloride was detected at 1,910,000 µg/L (BED-MW15) and 2,480,000 µg/L (BED-MW23). Sulfate was detected at concentrations of 89,200 µg/L and 85,800 µg/L, respectively, from the wells.

2002 Wet Season Sampling Event (April). Two nitroaromatics (4A-2,6-DNT and nitrobenzene) were detected in the groundwater at concentrations above RBSC values in well BED-MW15. VOCs benzene, ethyl benzene, toluene, and total xylenes were detected above RBSC and BSC screening levels in both wells. Methylene chloride exceeded the RBSC value in well BED-MW15 while acetone and methylene chloride exceeded RBSC values in well BED-MW23; both are common laboratory contaminants. The SVOCs 2-methylnaphthalene and naphthalene exceeded the RBSCs in both wells and 4-methylphenol also exceeded the RBSC in well BED-MW23. Barium was detected in both the unfiltered and filtered groundwater samples from BED-MW15 at concentrations above the RBSC value. In well BED-MW23, iron exceeded the RBSC and BSC values while the concentration of manganese exceeded only the RBSC value in both the unfiltered and filtered groundwater samples. In well BED-MW15, chloride and sulfate were detected at concentrations of 2,100,000 µg/L and 103,000 µg/L, respectively. Similar results were seen for chloride (6,400,000 µg/L) and sulfate (218,000 µg/L) in well BED-MW23.

7.2.5.4 Summary of Sampling Events, Pentolite Road Red Water Ponds Area

Overburden/Shale. As many as 8 nitroaromatic compounds were detected above RBSC levels in the 20 groundwater samples collected from temporary piezometers during the wet season of June 1998. Two of the nitroaromatics (2,4-DNT and 2,6-DNT) were also detected as SVOCs and 5 (4,6-dinitro-2-methylphenol, 2,4-dinitrophenol, 3-nitroaniline, and 4-nitrophenol) were detected only as SVOCs. VOC compounds above RBSC values at the PRRWP included tetrachloroethene from 5 locations at concentrations ranging from 0.13 µg/L (DP19) to 0.26 µg/L (DP05). Trichloroethene was detected at direct-push locations DP07 (0.43 µg/L) and DP08 (0.16 µg/L), and naphthalene was detected at location DP05 (1.9 µg/L). Toluene was detected above the BSC value at a concentration of 1.9 µg/L in direct-push piezometer DP12. The metals most frequently detected at concentrations above both RBSC and BSC values included aluminum, chromium, iron, and manganese. Manganese was the most frequently detected filtered metal at concentrations above both the RBSC and BSC. It was detected at concentrations ranging from 108 µg/L (DP13) to a maximum concentration of 62,500 µg/L (DP10). Total cyanide was also detected in the groundwater above the RBSC at 2 locations and nitrate was detected above the RBSC at 3 locations. In addition to nitrate, sulfate is the dominant anion in this area. No temporary piezometers were drilled and no overburden/shale wells were sampled during the dry season.

Delaware Limestone Bedrock. Four nitroaromatic compounds (4A-2,6-DNT, 2,4-DNT, 2,6-DNT, and nitrobenzene) were found to be above RBSC levels during the wet seasons of May 1998 and April 2002 from well BED-MW15. BTEX parameters were consistently found in both wells exceeding the screening values during both the wet and dry seasons. Acetone, a common laboratory contaminant, exceeded the RBSC value during both sampling events in well BED-MW23. The SVOC bis(2-ethylhexyl)phthalate, a common laboratory contaminant, was detected above the RBSC value in well BED-MW15 during 1 (dry season) sampling event and was reported in another of the 4 sampling events at well BED-MW23 as B qualified. The concentrations of SVOCs 2-methylnaphthalene and naphthalene exceeded the RBSCs in both wells during all sampling events. SVOC 4-methylphenol was detected above the RBSC on both sampling occasions from well BED-MW23. Unfiltered and filtered groundwater samples exhibited barium concentrations consistently above the RBSC value in well BED-MW15 during all 4 sampling events. Iron and manganese concentrations were usually above the RBSC and BSC values in the unfiltered and filtered samples from well BED-MW23. Arsenic was found to be above the RBSC in BED-MW23 in the dry season in both the unfiltered and filtered samples. Chloride is the dominant anion in the bedrock, detected at concentrations one to two orders of magnitude greater than the concentrations of sulfate.

7.2.6 Acid Areas and Maintenance Shop Area

7.2.6.1 Acid Area No. 1

7.2.6.1.1 Overburden/Shale

No overburden/shale monitoring wells were scheduled to be sampled at AA1 during the 1997 dry season, 1998 wet season, 2001 dry season, or 2002 wet season events.

7.2.6.1.2 Delaware Limestone Bedrock

Only one bedrock monitoring well (AA1-BEDGW-001), screened in the Delaware Limestone, is located upgradient (south) of AA1 and is paired with overburden/shale well AA1-GW002. Groundwater was analyzed for nitroaromatics, VOCs, SVOCs, metals (unfiltered and filtered), cyanide, and water quality parameters. No groundwater sample was collected from this well during the October 2001 or April 2002 episodes due to very high hydrogen sulfide vapors. Table 7-11 presents detected constituents above RBSC and/or BSC values in the bedrock groundwater during the 1997 and 1998 sampling events. Figure 7-8 shows analytical results along with sampling locations.

1997 Dry Season Sampling Event (November). The VOC compounds benzene (11 µg/L) and total xylenes (150 µg/L) were detected above both the RBSC and BSC values. VOCs ethyl benzene (7.7 µg/L) and toluene (18 µg/L) were reported above the BSC values while methylene chloride (8.8 µg/L) was reported above the RBSC. Methylene chloride and toluene were both B qualified. SVOCs bis(2-ethylhexyl)phthalate (28 µg/L), 2-methylnaphthalene (28 µg/L), and naphthalene (16 µg/L) were detected above the RBSCs. Unfiltered metals concentrations above the RBSC values included arsenic (16.5 µg/L), barium (1,060 µg/L), chromium (12.7 µg/L), iron (1,920 µg/L), and manganese (575 µg/L). Unfiltered metals above BSC values included aluminum (637 µg/L), arsenic (16.5 µg/L), copper (26.2 µg/L), and iron (1,920 µg/L). Unfiltered arsenic and iron concentrations exceed both the RBSCs and BSCs. Two filtered inorganics exceeded RBSCs: barium (1,260 µg/L) and manganese (516 µg/L). Chloride (1,900,000 µg/L and sulfate (7,000 µg/L) were also reported in the sample.

1998 Wet Season Sampling Event (May). Three nitroaromatics were detected at concentrations above RBSCs in the groundwater during the 1998 sampling. They were cyclotrimethylenetrinitramine (RDX), 2,4-DNT, and 2-nitrotoluene. RDX was reported at a concentration of 2.8 µg/L, which exceeded the RBSC value of 0.61 µg/L. However, RDX is not known to have ever been used or manufactured at PBOW, and is not a degradation product of nitroaromatics formerly produced. Based on information and analyses at a similar site, the reported concentrations of RDX at PBOW are likely a laboratory artifact (Shaw, 2004d). The concentrations of 2,4-DNT (0.23 µg/L) and 2-nitrotoluene (1.1 µg/L) exceeded the RBSCs of 0.090 µg/L and 0.05 µg/L, respectively.

Similar to the groundwater sampling results of November 1997, VOC compounds benzene (31 µg/L) and total xylenes (500 µg/L) were detected above both the RBSC and BSC values. The VOCs ethyl benzene (39 µg/L) and toluene (50 µg/L) were detected above the BSC values while methylene chloride (4.4 µg/L) was reported above the RBSC, but was B qualified.

SVOCs 2-methylnaphthalene (31 µg/L) and naphthalene (18 µg/L) were detected at concentrations above the RBSCs. The SVOC bis(2-ethylhexyl)phthalate was reported at a concentration (23 µg/L) exceeding the RBSC, but the data were B qualified. Unfiltered metals concentrations exceeding the RBSC values included arsenic (21.2 µg/L), barium (1,330 µg/L), iron (2,540 µg/L), and manganese (732 µg/L). Unfiltered metals above BSC values included aluminum (468 µg/L), arsenic (21.2 µg/L), iron (2,540 µg/L), and manganese (732 µg/L). Arsenic, iron, and manganese were exceeded both screening values. The concentrations of three filtered inorganics exceeded RBSCs and they were arsenic (19.6 µg/L), barium (1,490 µg/L), and

manganese (696 µg/L). Arsenic and manganese concentrations also exceeded the BSC screening values. Chloride (3,000,000 µg/L) and sulfate (40,000 µg/L) were also reported in the sample.

2001 Dry Season Sampling Event (October). No groundwater samples were collected from AA1-BEDGW-001 due to extremely high hydrogen sulfide vapors and potential health and safety concerns.

2002 Wet Season Sampling Event (April). No groundwater samples were collected from AA1-BEDGW-001 due to extremely high hydrogen sulfide vapors and potential health and safety concerns.

7.2.6.1.3 Summary of Sampling Events, Acid Area No. 1

Overburden/Shale. No overburden/shale monitoring wells were scheduled to be sampled at AA1 during the 1997 dry season, 1998 wet season, 2001 dry season, or 2002 wet season events.

Delaware Limestone Bedrock. Three nitroaromatic compounds have been detected above RBSC values in the bedrock groundwater at AA1. They were RDX (2.8 µg/L), 2,4-DNT (0.23 µg/L), and 2-nitrotoluene (1.1 µg/L). As discussed, RDX is likely a laboratory artifact BTEX parameters were detected above RBSC values and/or BSC values were common in both dry and wet season sampling events. The SVOC bis(2-ethylhexyl)phthalate was detected during one sampling events above the RBSC and was B qualified during the other. The SVOCs 2-methylnapthalene and naphthalene were detected at concentrations above the RBSCs in both sampling events. Unfiltered and filtered inorganic analytical results were very similar during both sampling events. Arsenic and iron were detected above RBSC and BSC values in unfiltered metals during both wet and dry sampling events. Aluminum was detected at concentrations above BSC value in the unfiltered metals during both sampling events, and barium and manganese concentrations were above RBSC values during the same events. Barium and manganese were also detected at concentrations above RBSC values during both the wet and dry season sampling events in the filtered metals. Arsenic was detected at concentrations above the RBSC and BSC value in the filtered metals during May 1998. The bedrock groundwater at AA1 is characterized as chloride-dominant, with chloride detected at more than an order of magnitude greater than sulfate.

7.2.6.2 Acid Area No. 2

7.2.6.2.1 Overburden/shale

No overburden/shale monitoring wells were scheduled to be sampled at AA2 during the 1997 dry season, 1998 wet season, 2001 dry season, or 2002 wet season events.

7.2.6.2.2 Delaware Limestone Bedrock

Two bedrock monitoring wells (AA2-BEDGW-001 and BED-MW19), both screened in the Delaware Limestone, are located at AA2. Monitoring well AA2-BEDGW-001 is located downgradient (south) of the area and is paired with overburden/shale well AA2-GW002 (not sampled as part of this investigation). Well BED-MW19 is further downgradient of AA2, in a northeast direction. Monitoring well BED-MW19 is located in a position that it is also considered a downgradient (perimeter) well and is therefore also included in the Downgradient/Perimeter Wells section (Section 7.1.9). In addition to the sampling that was performed in 1997, 1998, 2001, and 2002, groundwater samples from well BED-MW19 were also collected in May and August 2004. Groundwater was analyzed for nitroaromatics, VOCs, SVOCs, metals (unfiltered and filtered), cyanide, and water quality parameters. Table 7-12 presents detected constituents above RBSC and/or BSC values in the bedrock groundwater. Figure 7-9 shows analytical results along with sampling locations.

1997 Dry Season Sampling Event (November). BTEX VOC compounds were detected in both bedrock wells and the concentrations exceeded RBSCs and/or BSC values. Benzene was detected in well AA2-BEDGW-002 at 33 µg/L and in well BED-MW19 at 11 µg/L, both exceeding the RBSC and BSC. Ethyl benzene and toluene were also reported in both wells and exceeded only the BSC value. Total xylenes concentrations exceeded the RBSC and BSC values in both wells. Chlorobenzene (21 µg/L) and methylene chloride (7.4 µg/L) were both reported in well AA2-BEDGW-002 at concentrations above BSC values. Analytical results of methylene chloride and toluene were both B qualified meaning that the analytical result was not detected significantly above levels found in the associated field blank. Two SVOCs (bis[2-ethylhexyl]phthalate and naphthalene) were detected in the groundwater from well BED-MW19, and their concentrations exceeded only the RBSC. Iron (5,240 µg/L) was the only unfiltered metal detected in the groundwater that exceeded both the RBSC and BSC value and the highest concentrations were found in well AA2-BEDGW-002. Other unfiltered metals from well AA2-BEDGW-002 that were detected at concentrations above screening values included aluminum (1,060 µg/L) that exceeded the BSC and manganese (522 µg/L) that exceeded the RBSC. Copper concentrations (61.7 µg/L) were above the BSC in groundwater from well BED-MW19,

and barium (1,520 µg/L) exceeded the RBSC. Barium was the only filtered metal to be detected at a concentration above the RBSC value; its filtered concentration in well BED-MW19 was also 1,520 µg/L. Chloride (47,000 µg/L) and sulfate (48,000 µg/L) were also reported in the sample at nearly equal concentrations in well AA2-BEDGW-001. In well BED-MW19, chloride (330,000 µg/L) was detected at a much higher concentration than sulfate (14,000 µg/L).

1998 Wet Season Sampling Event (May). Three nitroaromatics were detected at concentrations above RBSC values in well AA2-BEDGW-001. 1,3-DNB was detected at a concentration of 0.81 µg/L, which is above the RBSC of 0.37 µg/L. In the same well, 2,4-DNT (2.5 µg/L) and 2,6-DNT exceeded their RBSC of 0.099 µg/L. The VOC benzene was detected in well AA2-BEDGW-001 at a concentration of 130 µg/L, exceeding the RBSC and BSC, and in well BED-MW19 at 1.9 µg/L, exceeding only the RBSC. The concentration of toluene, detected only in well AA2-BEDGW-001, exceeded the BSC. Ethyl benzene exceeded only the BSC value in both wells. The total xylenes concentration exceeded both the RBSC and BSC in AA2-BEDGW-002, but it exceeded only the BSC in BED-MW19. The SVOC bis[2-ethylhexyl]phthalate was reported in the groundwater from both wells exceeding the RBSC, but in both cases, the result was B qualified. Naphthalene was detected at a concentration (8.1 J µg/L) above the RBSC in AA2-BEDGW-001. Nine unfiltered metals were detected at concentrations above the RBSC (aluminum, arsenic, barium, copper, chromium, iron, lead, manganese, nickel, vanadium), and 7 were detected above the BSC (aluminum, arsenic, cobalt, copper, iron, manganese, and nickel) in well AA2-BEDGW-001. Barium (1,800 µg/L) was the only unfiltered metal detected in well BED-MW19 that exceeded the RBSC value. Barium was the only filtered metal detected at a concentration that exceeded the RBSC, and it was found in both wells (AA2-BEDGW-001 and BED-MW19) at concentrations of 279 µg/L and 1,740 µg/L, respectively. Chloride (53,000 µg/L) and sulfate (70,000 µg/L) were also reported in the sample from well AA2-BEDGW-001. In well BED-MW19, chloride (280,000 µg/L) was detected at a much higher concentration than sulfate (49,000 µg/L).

2001 Dry Season Sampling Event (September-October). VOC BTEX parameters were again detected above screening values in both wells. Benzene was detected in well AA2-BEDGW-001 at a concentration of 45 µg/L and in well BED-MW19 at a concentration of 46 µg/L, both exceeding RBSC and BSC values. The concentration of toluene, detected only in well BED-MW19, exceed the BSC. Ethyl benzene and total xylenes were also detected in both wells. The ethyl benzene concentrations exceeded only the BSC value, but the concentrations of total xylenes exceeded both the RBSC and BSC. Chloromethane (30 µg/L) and methylene chloride (100 µg/L) were detected in well AA2-BEDGW-002 at concentrations above the

RBSCs. Bromomethane (7.9 µg/L) and methylene chloride (30 µg/L) were detected above the RBSC in well BED-MW19. The SVOC naphthalene was detected above the RBSC at 12 µg/L in AA2-BEDGW-001 and 8.6 J µg/L in BED-MW19. Five unfiltered metals were detected above the RBSC (arsenic, barium, iron, manganese, and thallium) and 4 were detected at concentrations above the BSC (aluminum, arsenic, iron, and manganese) in well AA2-BEDGW-001. Barium (1,060 µg/L) was the only unfiltered metal detected in well BED-MW19 that exceeded the RBSC value while copper (99 µg/L), and the concentration of nickel (13.8 µg/L) exceeded the BSC value. The concentrations of three inorganics (barium, arsenic, and iron) exceeded RBSC levels in the filtered groundwater sample from well AA2-BEDGW-001, and only barium exceeded the RBSC in filtered water from well BED-MW19. Chloride was reported at higher concentrations than sulfate in both wells. In well AA2-BEDGW-001, chloride was detected at 68,100 µg/L and sulfate was reported at 31,700 µg/L. In well BED-MW19, chloride (248,000 µg/L) was detected at a much higher concentration than sulfate (27,700 µg/L).

2002 Wet Season Sampling Event (April). VOC BTEX parameters were again detected above screening values in both wells. Benzene was detected in well AA2-BEDGW-001 at a concentration of 4.8 µg/L and in well BED-MW19 at a concentration of 42 µg/L, both exceeding RBSC and BSC values. Toluene and ethyl benzene were also detected in both wells, and at concentrations exceeding the BSC value. Total xylenes were detected in both wells, and the detected concentrations exceeded both the RBSC and BSC. Methylene chloride (9.7 µg/L) was detected in well AA2-BEDGW-002 above the RBSC. The SVOC bis[2-ethylhexyl]phthalate was detected at a concentration in the groundwater sample from well BED-MW19 exceeding the RBSC. The concentrations of naphthalene were above the RBSC in both wells. Five unfiltered metals were detected above the RBSC (arsenic, barium, iron, manganese, and thallium) and 1 (iron) was detected above the BSC in well AA2-BEDGW-001. Barium (892 µg/L) was the only unfiltered metal detected in well BED-MW19 that exceeded the RBSC value. Two inorganics (barium and arsenic) exceeded RBSC levels in the filtered groundwater sample from well AA2-BEDGW-001, and arsenic in this well exceeded the BSC value. Barium was the only constituent to exceed the RBSC in well BED-MW19. Chloride was reported at high concentrations than sulfate in both wells. In well AA2-BEDGW-001, chloride was detected at 56,000 µg/L and sulfate was reported at 32,700 µg/L. In well BED-MW19, chloride (373,000 µg/L) was detected at a much higher concentration than sulfate (32,200 µg/L).

2004 Wet Season Sampling Event (May). VOC BTEX parameters were again detected above screenings values in the only well sampled, BED-MW19. Benzene was detected at a concentration of 18 µg/L, above both the RBSC and BSC. Ethyl benzene (6.8 µg/L) and toluene

(8 µg/L) were detected only above BSC values. The concentration of total xylenes (66 µg/L) exceeded both the RBSC and BSC values. Methylene chloride (7.3 µg/L) was detected at a concentration above the RBSC. The SVOC naphthalene (3.7 J µg/L) was detected above its RBSC. Two unfiltered metals, barium at a concentration of 1,120 µg/L and thallium at 5.1 µg/L, were detected above the RBSC value. Copper (52.2 µg/L) and nickel (9.2 µg/L) was detected above the RBSC value only. Among the filtered metals, barium (1,050 µg/L) and thallium (4.4 µg/L) were the only 2 analytes were detected at concentrations above the RBSC values. Chloride (229,000 µg/L) was again detected at a much higher concentration than sulfate (21,100 µg/L).

2004 Dry Season Sampling Event (August). BTEX parameters were again detected above screenings values in the only well sampled, BED-MW19. Benzene was detected at a concentration of 28 µg/L, exceeding both the RBSC and BSC. Ethyl benzene (8.8 µg/L) and toluene (11 µg/L) were detected at concentrations only above BSC values. Total xylenes (95 µg/L) exceeded both screening criteria. The SVOC naphthalene was detected at a concentration above the RBSC. One unfiltered metal, barium, was detected above the RBSC value at a concentration of 1,190 µg/L, and unfiltered metal thallium was detected at a concentration of 5.1 µg/L, above the BSC value. Among the filtered metals, barium (1,140 µg/L) and thallium (2.6 µg/L) were the only 2 analytes detected above the RBSC values. Chloride (396,000 µg/L) was again detected at a much higher concentration than sulfate (29,500 µg/L).

7.2.6.2.3 Summary of Sampling Events, Acid Area No. 2

Overburden/Shale. No overburden/shale monitoring wells were scheduled to be sampled at AA2 during the 1997 dry season, 1998 wet season, 2001 dry season, 2002 wet season, or 2004 wet and dry season sampling events.

Delaware Limestone Bedrock. During the 6 sampling events at AA2, three nitroaromatic compounds (1,3-DNB; 2,4-DNT; and 2,6-DNT) were detected in the bedrock wells at concentrations above the RBSC; these were present during the wet season of May 1998. BTEX compounds during both the wet and dry seasons have consistently been detected in both bedrock wells and exceeded the RBSC and/or BSC values. The VOC methylene chloride was commonly detected in both wells above the RBSC value of 4.1 µg/L. The SVOC bis(2-ethylhexyl)phthalate was detected 2 times above the RBSC value of 4.8 µg/L (during 2 other sampling events it was also reported at concentrations exceeding the RBSC, the results were B qualified). Both methylene chloride and bis(2-ethylhexyl)phthalate are common laboratory contaminants.

Naphthalene was detected at concentrations above the RBSC in every sampling event, but the detected quantities were all estimated. Barium was the most commonly detected inorganic in both wells. It was found in both the unfiltered and filtered groundwater samples during all 6 sampling events above RBSC levels (except from well AA2-BEDGW-001 during November 1997). Iron was the metal most commonly detected at concentrations above both the RBSC and BSC values in the unfiltered samples from well AA2-BEDGW-001, whereas manganese was the most commonly detected filtered inorganic detected in this well at concentrations above either the RBSC or BSC values. Copper was detected above the BSC value in the unfiltered samples from BED-MW19 in 4 of the 6 sampling events. In general, the bedrock groundwater is characterized by higher concentrations of chloride than sulfate.

7.2.6.3 Acid Area No. 3

7.2.6.3.1 Overburden

No overburden/shale monitoring wells were scheduled to be sampled at AA3 during the 1997 dry season, 1998 wet season, 2001 dry season, or 2002 wet season events.

7.2.6.3.2 Delaware Limestone Bedrock

Only one bedrock monitoring well (AA3-BEDGW-001), screened in the Delaware Limestone, is located at AA3 and is paired with overburden/shale well AA3-GW002 (not sampled as part of this investigation). This well is located within AA3, in the southeast corner, in a downgradient groundwater flow direction. Groundwater was analyzed for nitroaromatics, VOCs, SVOCs, metals (unfiltered and filtered), cyanide, and water quality parameters. Table 7-13 presents detected constituents above RBSC and/or BSC values in the bedrock groundwater. Figure 7-10 shows analytical results along with sampling locations.

1997 Dry Season Sampling Event (November). Bis(2-ethylhexyl)phthalate (5.8 µg/L) was the only SVOC above an RBSC or BSC value in bedrock well AA3-BEDGW-001. No inorganics exceeded the RBSC or BSC values. Consistent with most wells screened in the Delaware Limestone, chloride (790,000 µg/L) was the dominant anion. Sulfate was not detected in this sampling event.

1998 Wet Season Sampling Event (May). The reported results of the VOC compounds methylene chloride and toluene exceeded screening values in well AA3-BEDGW-001. Methylene chloride was detected at a concentration of 160 µg/L exceeding the RBSC and toluene was detected at a concentration of 29 µg/L, exceeding only the BSC. Both analytical

results were B qualified. Only 2 inorganics were detected at AA3 above screening values; aluminum and thallium. One unfiltered metal, thallium (10.1 µg/L), and was reported at a concentration above the RBSC value but was B qualified. Unfiltered metal aluminum was detected at a concentration of 397 µg/L, exceeding the BSC value of 309 µg/L. Chloride (860,000 µg/L) was detected at a concentration two orders of magnitude greater than the concentration of sulfate (8,000 µg/L).

2001 Dry Season Sampling Event (September). In well AA3-BEDGW-001, VOC compounds benzene (11 µg/L) and total xylenes (28 µg/L) were both detected at concentrations exceeding the RBSC and BSC values, while ethyl benzene (4 µg/L) and toluene (11 µg/L) were detected above BSC values only. The only unfiltered or filtered inorganic reported at a concentration above RBSC and/or BSC values was thallium in the filtered metals sample. It was reported at a concentration of 6.4 µg/L but it was validated with a B qualifier. Chloride was again the dominant anion, detected at 451,000 µg/L, as compared to sulfate, detected at 31,100 µg/L.

2002 Wet Season Sampling Event (April). Once again VOC compounds ethyl benzene (4.6 µg/L), toluene (12 µg/L), and total xylenes (31 µg/L) exceeded BSC values in well AA3-BEDGW-001. Benzene was detected at a concentration of 8 µg/L, exceeding both the RBSC and BSC. Methylene chloride, a common laboratory contaminant, was detected at a concentration of 9.2 µg/L exceeding the RBSC. The only inorganic detected above RBSC and/or BSC values was thallium in the unfiltered metals sample (6.9 µg/L), but was validated with a B qualifier. Chloride was again the dominant anion detected (369,000 µg/L). Sulfate was not detected in this well.

7.2.6.3.3 Summary of Sampling Events, Acid Area No. 3

Overburden/Shale. No overburden/shale monitoring wells were scheduled to be sampled at AA3 during the 1997 dry season, 1998 wet season, 2001 dry season, or 2002 wet season sampling events.

Delaware Limestone Bedrock. No nitroaromatic compounds were detected at AA3. VOC compounds BTEX were present in the groundwater at AA3-BEDGW-001 only during the September 2001 (dry season) and April 2002 (wet season) sampling events, above the BSC levels. Benzene was also detected during these 2 events above the RBSC value. Bis(2-ethylhexyl)phthalate was detected once (November 1997 dry season) and it was above the RBSC

value. Unfiltered inorganic manganese was detected twice during the 4 sampling rounds above the RBSC values. Unfiltered aluminum was detected only 1 time above BSC values. No filtered inorganics were detected at a concentration exceeding the RBSC or BSC values.

7.2.6.4 Maintenance Area

7.2.6.4.1 Overburden/Shale

No overburden/shale monitoring wells were scheduled to be sampled at the Maintenance Shop Area (MNTA) during the 1997 dry season, 1998 wet season, 2001 dry season, or 2002 wet season sampling events.

7.2.6.4.2 Delaware Limestone Bedrock

Only one bedrock monitoring well (MNTA-BEDGW-001), screened in the Delaware Limestone, is located in the MNTA north of AA1. Monitoring well MNTA-BEDGW-001 is located on the eastern side of the area. Groundwater was analyzed for nitroaromatics, VOCs, SVOCs, metals (unfiltered and filtered), cyanide, and water quality parameters. Table 7-14 presents detected constituents above RBSC and/or BSC values in the bedrock groundwater. Figure 7-8 shows analytical results along with sampling locations.

1997 Dry Season Sampling Event (November). Two VOC compounds were detected in groundwater from bedrock well MNTA-BEDGW-001. Methylene chloride was reported at a concentration of 5.1 µg/L, above the RBSC value and total xylenes were reported at 8.2 µg/L, above the BSC value. Both compounds were validated by a B qualifier, and methylene chloride was recognized as a common laboratory contaminant. SVOC naphthalene was detected above the RBSC at 2.3 µg/L. Unfiltered metals detected at concentrations above RBSC and BSC values included iron (6,400 µg/L) and manganese (849 µg/L). Unfiltered barium (424 µg/L) was detected above the RBSC. Manganese (899 µg/L) was the only filtered metal detected at a concentration greater than the RBSC and BSC. The concentration of barium (449 µg/L) in the filtered sample was detected at a concentration above the RBSC only. Chloride (55,000 µg/L) and sulfate (62,000 µg/L) were detected at nearly equal concentrations.

1998 Wet Season Sampling Event (May). Three nitroaromatics above RBSC values were detected in well MNTA-BEDGW-001. Nitroaromatic 1,3-DNB was detected at a concentration of 0.86 µg/L, 2,4-DNT 2 µg/L, and 2,6-DNT at 0.34 µg/L (nitroaromatic 2,4-DNT [1.3 µg/L] was also detected as a SVOC). The VOC benzene was detected in well MNTA -BEDGW-001 at a concentration of 19 µg/L, exceeding the RBSC and BSC. Ethyl benzene (7.7 µg/L), toluene

(18 µg/L), and total xylenes (150 µg/L) were also detected but exceeded only the BSC value. The SVOC bis[2-ethylhexyl]phthalate (6.5 µg/L), a common laboratory contaminant, was at a concentration exceeding the RBSC, but the result was B qualified. 2,4-DNT, also detected as a SVOC, was found above the RBSC at a concentration of 1.3 µg/L. Unfiltered metals detected in the groundwater above RBSC values included barium (457 µg/L) and manganese (181 µg/L). Likewise, filtered metals detected at concentrations exceeding the RBSC were barium (596 µg/L) and manganese (183 µg/L). During this sampling event, chloride (380,000 µg/L) was detected at a much higher concentration than sulfate (64,000 µg/L).

2001 Dry Season Sampling Event (October). No nitroaromatic compounds were detected in the bedrock monitoring well MNTA-BEDGW-001. VOCs detected above RBSC and BSC levels included benzene (110 µg/L), toluene (140 µg/L), and total xylenes (490 µg/L) while ethyl benzene (61 µg/L) was above the BSC levels. Methylene chloride (61 µg/L) was above the RBSC only. Bis(2-ethylhexyl)phthalate (5 µg/L), 2-methylnaphthalene (21 µg/L), and naphthalene (11 µg/L) were SVOCs that were above RBSC values. Unfiltered metals that were detected above RBSC levels included arsenic (2.9 µg/L), barium (381 µg/L), and thallium (5.4 µg/L). Unfiltered metals above both the RBSC and BSC included only manganese (641 µg/L). Filtered metals reported at concentrations above RBSC levels included barium (387 µg/L), manganese (621 µg/L), but thallium (4.8 µg/L) was validated with a B qualifier. The major anion detected in this sampling event was chloride (4,130,000 µg/L). Sulfate was not detected.

2002 Wet Season Sampling Event (April). No nitroaromatic compounds were detected in the bedrock monitoring well MNTA-BEDGW-001. VOCs detected at concentrations above RBSC and BSC levels included benzene (36 µg/L) and total xylenes (310 µg/L). Ethyl benzene (25 µg/L) and toluene (40 µg/L) were above the BSC levels. Methylene chloride (110 µg/L) was above the RBSC only. 2-Methylnaphthalene (23 µg/L) and naphthalene (16 µg/L) are SVOCs that were detected at concentrations above RBSC values. Unfiltered metals that were detected at concentrations above RBSC levels included barium (388 µg/L) and manganese (388 µg/L); thallium was also reported above the RBSC, but was validated with a B qualifier. Filtered metals found at concentrations above RBSC levels included only barium (398 µg/L) and manganese (380 µg/L). Again, this sampling even indicates the major anion in bedrock groundwater is chloride, detected at 3,480,000 µg/L. Sulfate was detected at 1,400 µg/L.

7.2.6.4.3 Summary of Sampling Events, Maintenance Area

Overburden/Shale. No overburden/shale monitoring wells were scheduled to be sampled at MNTA during the 1997 dry season, 1998 wet season, 2001 dry season, or 2002 wet season sampling events.

Delaware Limestone Bedrock. Three nitroaromatic compounds 1,3-DNB (0.86 µg/L), 2,4-DNT (2 µg/L), and 2,6-DNT (0.34 µg/L) were detected at bedrock well MNTA-BEDGW-001 in the wet season of May 1998. Nitroaromatic 2,4-DNT (1.3 µg/L) was also detected as a SVOC during the wet season. BTEX parameters were commonly present during nearly all sampling events with concentrations above either the RBSC and/or BSC values. Methylene chloride (a common laboratory contaminant) was detected at a concentration above the RBSC in 1 of the 4 events, and reported as B qualified in 2 other. BTEX compounds were present at concentrations exceeding RBSCs in the last 3 of the 4 sampling events. Bis(2-ethylhexyl)phthalate, 2-methylnaphthalene, and naphthalene were SVOCs detected above RBSC values. Bis(2-ethylhexyl)phthalate, a common laboratory contaminant, was detected above the RBSC in 1 of the 4 sampling events and was B qualified in 1 of the other 3. Naphthalene was encountered during 3 sampling events and 2-methylnaphthalene during the last 2 (October 2001 and April 2002). Barium and manganese were detected above RBSC and/or BSC values on a regular basis in the unfiltered and filtered groundwater samples. The major anion in bedrock groundwater is chloride, which exceeded sulfate by at least an order of magnitude in all but the 1997 sampling event.

7.2.7 Additional Burning Ground Area

7.2.7.1 Overburden/Shale

No overburden/shale monitoring wells were scheduled to be sampled at the ABG during the 1997 dry season, 1998 wet season, 2001 dry season, or 2002 wet season events.

7.2.7.2 Shale Bedrock

Only one bedrock monitoring well (ABG-BEDGW-001), screened in the shale bedrock, is at the ABG Area. Monitoring well ABG-BEDGW-001 is located in the northeastern corner of ABG, is paired with overburden/shale well ABG-GW002 (not sampled during this investigation), and is located in an upgradient groundwater flow direction. Groundwater was analyzed for nitroaromatics, VOCs, SVOCs, metals (unfiltered and filtered), cyanide, and water quality

parameters. Table 7-15 presents detected constituents above RBSC and/or BSC values in the bedrock groundwater. Figure 7-11 shows analytical results along with sampling locations.

1997 Dry Season Sampling Event (November). No nitroaromatics or SVOCs were detected in bedrock well ABG-BEDGW-001, which is the only well at the ABG. The only VOC detected in November 1007 sampling was trichloroethene (0.25 µg/L), and the concentration exceeded the RBSC level. In the unfiltered sample, arsenic (11.7 µg/L), iron (8,890 µg/L), and manganese (912 µg/L) concentrations exceeded both the RBSC and BSC values. Aluminum was above the BSC, and the mercury concentration exceeded the RBSC. Iron and manganese concentrations exceeded both the RBSC and BSC levels in the filtered sample. Groundwater in the shale bedrock is sulfate-dominant. Sulfate was detected at 140,000 µg/L, as compared to chloride, detected at only 2,000 µg/L.

1998 Wet Season Sampling Event (May). No nitroaromatics or SVOCs were detected in the bedrock well at the ABG. Two VOCs (carbon disulfide and methylene chloride) were detected, but the concentrations did not exceed the RBSC levels. In the unfiltered sample, iron (5,770 µg/L) and manganese (745 µg/L) concentrations exceeded both the RBSC and BSC values. Lead exceeded the RBSC. In the filtered sample, iron and manganese exceeded both the RBSC and BSC levels. The concentration of aluminum was above the BSC value. Concentrations of chloride (3,000 µg/L) and sulfate (190,000 µg/L) reported during this sampling event were similar to 1997 results.

2001 Dry Season Sampling Event (September-October). No nitroaromatics were detected in the sample from the bedrock well. One VOC (acetone) was detected, but the concentration did not exceed the RBSC level. Three SVOCs (benzo[a]pyrene, dibenz[a,h]anthracene, and indeno[1,2,3-cd]pyrene) were detected at concentrations above the RBSC. In the unfiltered and filtered samples, iron (7,900 µg/L) and manganese (846 µg/L) were above both the RBSC and BSC values. Chloride (4,400 µg/L) was detected at a much lower concentration than sulfate (163,000 µg/L).

2002 Wet Season Sampling Event (April). No nitroaromatics or SVOCs were detected in the sample from the bedrock well. One VOC (methylene chloride) was detected, but the concentration was B qualified and did not exceed the RBSC level. In the unfiltered sample, iron (9,130 µg/L) and manganese (872 µg/L) were above both the RBSC and BSC values. This was also true of iron and manganese in the filtered sample. Sulfate was detected at 292,000 µg/L, and chloride was detected at 10,000 µg/L.

7.2.7.3 Summary of Sampling Events, Additional Burning Ground Area

Overburden/Shale. No overburden/shale monitoring wells were scheduled to be sampled at ABG during the 1997 dry season, 1998 wet season, 2001 dry season, or 2002 wet season sampling events.

Shale Bedrock. No nitroaromatics have been detected at the ABG during the four sampling episodes. At least one VOC (trichloroethene, carbon disulfide, methylene chloride, or acetone) was detected in each sampling event, but only trichloroethene exceeded RBSC values. Three SVOCs were detected one time (September 2001), and each concentration was above the RBSCs. Arsenic was detected above the RBSC and BSC in the dry season of November 1997. In the same sampling event, aluminum exceeded the BSC, and mercury was above the RBSC. Total lead was detected at a concentration above the RBSC level in the wet season of May 1998, and aluminum exceeded the BSC in the filtered sample. Unfiltered and filtered iron and manganese were above both the RBSCs and BSCs in all sampling events. The concentrations of anions in the shale bedrock in this area are dominated by sulfate, detected at more than an order of magnitude greater than chloride.

7.2.8 Upper Toluene Tanks Area

7.2.8.1 Overburden/Shale

No overburden/shale monitoring wells were scheduled to be sampled at the UTT Area during the 1997 dry season, 1998 wet season, or 2001 dry season sampling events. During February 2002 (wet season) quarterly groundwater level measurements of monitoring wells were conducted by ICI. ICI records indicated that no groundwater level measurement was made in monitoring well MK-MW20 due to the presence of a "petroleum like product". Because monitoring well MK-MW20 is an overburden well located immediately downgradient of the UTT area and all free-phase hydrocarbons previously discovered had been in bedrock wells, groundwater from this well warranted further investigation. In July 2002, during the fourth quarter background monitoring well sampling event, Shaw collected a groundwater sample from MK-MW20 (CC3002). The samples were analyzed for BTEX, gasoline-range organics (GRO), and diesel-range organics (DRO). Analytical results can be found in the 2002 Groundwater Data Summary and Evaluation Report (Shaw 2003a) but are summarized on Table 7-16.

2002 Wet Season Sampling Event (July). No free-phase petroleum was encountered in overburden/shale monitoring well MK-MW20. Benzene, ethylene benzene, and total xylenes were not detected. Toluene was detected at a concentration of 37,000 µg/L, above both the RBSC and BSC; GRO was detected at 65,000 µg/L and DRO at a concentration of 140 µg/L.

7.2.8.2 Delaware Limestone Bedrock

One bedrock monitoring well (BED-MW16), screened in the Delaware Limestone, is present and is located in a downgradient groundwater flow direction of the former toluene tanks. Groundwater was analyzed for nitroaromatics, VOCs, SVOCs, metals (unfiltered and filtered), cyanide, and water quality parameters. Table 7-16 presents detected constituents above RBSC and/or BSC values in the bedrock groundwater. Figure 7-12 shows analytical results along with sampling locations.

1997 Dry Season Sampling Event (November). In the groundwater sample from BED-MW16, VOCs benzene (490 µg/L), toluene (390 µg/L), and total xylenes (1,100 µg/L) were detected at concentrations that exceeded both the RBSC and BSC values. Ethyl benzene (130 µg/L) exceeded only the BSC value. Methylene chloride (8.8 µg/L), a common laboratory contaminant, was reported at a concentration that exceeded the RBSC, but was B qualified. Only one SVOC, bis[2-ethylhexyl]phthalate, (920 µg/L) was detected at a concentration above the RBSC. In the unfiltered inorganics groundwater sample, aluminum (502 µg/L) exceeded only the BSC value. Barium (463 µg/L), chromium (24.4 µg/L), iron (1,140 µg/L), manganese (133 µg/L), and vanadium (64.7 µg/L) were detected at concentrations exceeding the RBSC values. In the filtered groundwater samples, barium (389 µg/L), chromium (13.6 µg/L), and vanadium (58.3 µg/L) concentrations were above the RBSC levels. Chloride and sulfate were detected at concentrations of 88,000 and 150,000 µg/L, respectively.

1998 Wet Season Sampling Event (June). The VOCs benzene (450 µg/L), ethyl benzene (140 µg/L), toluene (350 µg/L), and total xylenes (1,000 µg/L) exceeded both the RBSC and BSC levels in the sample from bedrock well BED-MW16. Methylene chloride was reported as a concentration above the RBSC, but was B qualified. Two SVOCs, bis[2-ethylhexyl]phthalate (4.9 µg/L) (a common laboratory contaminant) and nitroaromatic 1,2,4-trichlorobenzene (1.6 µg/L) were reported at concentrations above the RBSC, but the former was B qualified. In the unfiltered groundwater sample, aluminum (11,000 µg/L), iron (45,900 µg/L), and manganese (2,200 µg/L) concentrations exceeded both the RBSCs and the BSCs. Copper (84.9 µg/L) and nickel (54.7 µg/L) concentrations were above only the BSC values; barium (612 µg/L), chromium (105 µg/L), lead (40.4 µg/L), thallium (101 µg/L), and vanadium (126 µg/L) exceeded

only the RBSC among the unfiltered samples. In filtered groundwater samples, barium (523 µg/L), chromium (14.8 µg/L), thallium (53.1 µg/L), and vanadium (50.6 µg/L) concentrations were above only the RBSC levels. Chloride (140,000 µg/L) was the dominant anion during this sampling event. Sulfate was detected at 37,000 µg/L.

2001 Dry Season Sampling Event (October). The VOCs benzene (800 µg/L), ethyl benzene (200 µg/L), toluene (590 µg/L), and total xylenes (1,500 µg/L) exceeded both the RBSC and BSC levels. Acetone (930 µg/L) and methylene chloride (52 µg/L) were detected at concentrations only above the RBSCs. SVOCs 2-methylnaphthalene (64 µg/L) and naphthalene (52 µg/L) were detected above RBSC levels. In the unfiltered groundwater sample, the concentration of nickel (10.8 µg/L) exceeded only the BSC. In the filtered sample, nickel (10.2 µg/L) was again detected above only the BSC value. Thallium (6.4 µg/L) was reported in the filtered sample at a concentration above the RBSC but it was B qualified. Chloride was again the dominant anion (370,000 µg/L) as compared to sulfate (212,000 µg/L).

2002 Wet Season Sampling Event (April). In the groundwater sample from BED-MW16, nitroaromatic 2,6-DNT (11 µg/L) was detected at a concentration above the RBSC. The VOCs benzene (150 µg/L), toluene (150 µg/L), and total xylenes (610 µg/L) were detected at concentrations that exceeded both the RBSCs and BSCs. Ethyl benzene (40 µg/L) was above BSC values and methylene chloride (11 µg/L) was detected above RBSC values. As during the October 2001 sampling event, SVOCs 2-methylnaphthalene (24 µg/L) and naphthalene (5 µg/L) were again detected above RBSC levels. In the unfiltered and filtered samples, reported concentrations of thallium exceeded the RBSC, but both concentrations were B qualified. Much higher concentrations of sulfate (734,000 µg/L) were reported in this well than during previous sampling events. In addition, chloride was detected at the lowest concentration (75,900 µg/L) in the four sampling events.

7.2.8.3 Summary of Sampling Events, Upper Toluene Tanks Area

Overburden/Shale. No overburden/shale monitoring wells were scheduled to be sampled at UTT during the 1997 dry season, 1998 wet season, or 2001 dry season sampling events. During the July 2002 wet season sampling event, groundwater from overburden/shale monitoring well MK-MW20 (located downgradient from the UTT) was sampled. Nitroaromatics were not detected in the groundwater sample. Groundwater concentrations did exhibit a detection of toluene above the RBSC value, and detections of both GRO and DRO. Chromatograms (not included in this document) showed detections of hydrocarbons in the gasoline and diesel ranges

not resembling gasoline and diesel range standards. The GRO chromatogram revealed the predominant peak was from toluene. The sample did not contain concentrations of several components of the gasoline standard such as methylpentane, heptane, ethyl benzene, xylene, or trimethylbenzene. Although weathering of the hydrocarbon would lower the concentrations of the alkanes, the aromatic compounds should be present. The lack of benzene, ethyl benzene, and xylenes in the 8260B analysis confirms that it is probably not gasoline and only two single components of the diesel standard were present in the sample. Therefore, the potential source of the contaminants in the groundwater appears to be from the toluene stored in the tanks that was used for production of nitroaromatics.

Delaware Limestone Bedrock. Of the sampling events since November 1997, only one nitroaromatic (2,6-DNT) has been detected in the bedrock groundwater above the RBSC level. This was in the April 2002 wet season. BTEX compounds have been routinely encountered in the analytical results above RBSCs and/or BSCs. Methylene chloride concentrations exceeded the RBSCs in 2 samples and the result was B qualified in the other. The SVOC bis(2-ethylhexyl)phthalate was detected in one of the sampling events above the RBSC level (November 1997) and had a reported B qualified concentration in another. SVOCs 2-methylnaphthalene and naphthalene were detected above RBSC levels during the last 2 sampling events but are believed to be associated with the natural petroleum hydrocarbon found in the well. In the unfiltered sample for the 1998 wet season, aluminum, iron, and manganese concentrations were above both the RBSC and BSC values. Copper and nickel concentrations were above the BSCs in the sample from this event. Aluminum and nickel concentrations were above the BSC in the samples from the 1997 and 2001dry season events. Among most sampling events, one or more of the following metals were detected at a concentrations above RBSCs in unfiltered samples: barium, chromium, lead, iron, manganese, thallium, and vanadium. In the filtered samples, nickel was the only metal detected at a concentration above the BSC (2001 dry season). The filtered metals detected above the RBSCs were barium, thallium, and vanadium. The concentrations of sulfate were dominant in the Delaware Limestone bedrock groundwater during two occasions, the November 1997 wet season and April 2002 wet season, while chloride was dominant during the June 1998 wet season and October 2001 dry season.

The low level concentration of nitroaromatic 1,2,4-trichlorobenzene (1.6 µg/L), detected as an SVOC, was found during one sampling episode only (June 1998). The presence of this nitroaromatic and 2,6-DNT indicates that the groundwater at the UTT Area may be impacted by former site activities.

The detection of the BTEX compounds exceeding RBSC and BSC levels is not surprising due to the occasional measurement of free-phase hydrocarbons in the Delaware bedrock screened monitoring well. However, due to the location of BED-MW16 downgradient of the UTT Area, known toluene contamination in the overburden/shale well MK-MW20, and the consistent detections of toluene above RBSC and BSC values, toluene contamination may be present in the Delaware Limestone bedrock.

7.3 Downgradient Perimeter Wells Analytical Results

7.3.1 Overburden/Shale

No downgradient, perimeter overburden/shale monitoring wells were scheduled to be sampled during the 1997 dry season, 1998 wet season, 2001 dry season, or 2002 wet season sampling events.

7.3.2 Delaware Limestone Bedrock

Four existing bedrock monitoring wells (BED-MW17, BED-MW19, BED-MW22, and BED-MW24) monitor the groundwater exiting the PBOW site, and 2 newly installed bedrock wells (BED-MW30 and BED-MW33) monitor groundwater that has left the PBOW site (Figure 7-13). A private well, identified as PT-5912 for this investigation, is located at 5912 Patten Tract Road, downgradient of the WARWP and AA2. A right-of entry was obtained from the property owner prior to sampling of this well. Monitoring well BED-MW27 was an on-site, downgradient perimeter well on the northeastern side but was abandoned in January 2003 at the public's request due to obnoxious hydrogen sulfide odors. Analytical results from 14 sampling events (November 1997, May 1998, October 2001, January 2002, April 2002, July 2002, October 2002, April 2003, September 2003, December 2003, March 2004, May 2004, June 2004, August 2004).

Monitoring well BED-MW17 was formerly associated with TNTA. It is located in the northern part of PBOW on the eastern side. Due to its location downgradient of TNTA, the distance away from former TNT manufacturing buildings, and its location near the property boundary, it is considered a downgradient, perimeter well. Monitoring well BED-MW19 is located downgradient of AA2, but it is also considered a perimeter well because it monitors groundwater just prior to exiting the PBOW site. Well BED-MW22 is located in the extreme north part of PBOW, near the property boundary. Monitoring well BED-MW24 was installed as a background well but was determined to be monitoring groundwater exiting the northwestern corner of the site, downgradient of the WARWP. Wells BED-MW30 and BED-MW33 are located just outside of PBOW. Well BED-MW30 is located west of PBOW near the intersection

of Bouy and Patten Tract Roads and monitors groundwater that has left PBOW. Private well PT-5912 is located off-site at a public residence, and like BED-MW30, monitors groundwater leaving the WARWP and AA2. Well BED-MW33 is located northeast of PBOW in Columbus Park and monitors groundwater that has left the northeastern side of the facility. Groundwater during the sampling episodes was analyzed for nitroaromatics, VOCs, SVOCs, metals (unfiltered and filtered), cyanide, and water quality parameters. Table 7-17 presents detected constituents above RBSC and/or BSC values in the bedrock groundwater. Figure 7-13 shows analytical results along with sampling locations.

Analytical results from bedrock monitoring wells located immediately downgradient of source areas are repeated in this section to provide a better overall evaluation of any natural attenuation processes.

1997 Dry Season Sampling Event (November). Two wells were sampled in this event. Nitrobenzene (0.34 µg/L) was detected above the RBSC in BED-MW17. The VOC benzene exceeded the RBSC and BSC in samples from both wells, and toluene exceeded both screening criteria in the sample from BED-MW17. Ethyl benzene exceeded the BSCs in both wells, as did toluene in BED-MW19. The total xylenes concentrations exceeded the RBSC and BSC values in the samples from both wells. Methylene chloride was reported at a concentration above the RBSC in BED-MW17, but it was B qualified. The only SVOCs detected at concentrations above the screening values were bis(2-ethylhexyl)phthalate and naphthalene, which exceeded the RBSCs in the sample from BED-MW19. In the unfiltered samples, iron exceeded both the RBSC and BSC in BED-MW17. The reported aluminum concentration exceeded the BSC in this well, but was B qualified. The copper concentration exceeded the BSC in BED-MW19. Barium was detected at a concentration above the RBSC in the unfiltered samples from both wells. The manganese concentrations were above the RBSC in the sample from BED-MW17. In the filtered samples, the barium concentrations exceeded the RBSC in both wells. The concentration of total cyanide (320 µg/L) exceeded the RBSC in the sample from BED-MW17. Chloride was the dominant anion in both wells, detected at concentrations of 1,800,000 and 330,000 µg/L. Sulfate was reported at 59,000 µg/L and 14,000 µg/L in corresponding samples.

1998 Wet Season Sampling Event (May). Total xylenes exceeded both the RBSC and BSC in BED-MW17 and the BSC alone in BED-MW19. In the samples from BED-MW17 and BED-MW19, ethyl benzene was detected at concentrations above the BSC. The benzene concentration exceeded the RBSC in BED-MW19. The methylene chloride concentration was reported above the RBSC in BED-MW17, and the reported toluene concentration exceeded the

BSC in well BED-MW17; however, these concentrations of methylene chloride and toluene were B qualified. The concentration of SVOC bis(2-ethylhexyl)phthalate, a common laboratory contaminant, exceeded the RBSC in the samples from both wells. In addition, 2-methylnaphthalene and naphthalene concentrations were above the RBSCs in BED-MW17. Barium was above the RBSC in the unfiltered samples from both wells. In the filtered sample from BED-MW17, arsenic was detected at a concentration above both the RBSC and BSC. Barium was detected at concentrations above the RBSC in the filtered samples from both monitoring wells. Similar concentrations of chloride (1,600,000 and 280,000 µg/L) and sulfate (80,000 and 49,000 µg/L) were reported.

2001 Dry Season Sampling Event (October). Five wells (BED-MW17, BED-MW19, BED-MW22, BED-MW24, and BED-MW27) were sampled in this event. Two nitroaromatics were detected. 2,4-DNT (1.5 µg/L) and 2,6-DNT (1.1 µg/L) were detected above the RBSC (0.099 µg/L) in BED-MW27. In BED-MW17, 2,6-DNT 9 (0.3 µg/L) exceeded the RBSC.

In the samples from every well, BTEX compounds were detected in various combinations. Benzene exceeded both the RBSC and BSC levels in BED-MW19, BED-MW24, and BED-MW27. It was above the RBSC in BED-MW22. The ethyl benzene concentrations were above the BSC in all wells. Toluene was above both the RBSC and BSC in BED-MW17 and BED-MW27. Total xylenes exceeded both the RBSC and BSC in all wells except BED-MW22 where it exceeded only the BSC. It was above the BSC in the samples from BED-MW19 and BED-MW24. Another VOC (bromomethane) exceeded the RBSC in BED-MW19. With the exception of the sample from BED-MW22, methylene chloride was detected at concentrations above the RBSC in all samples. In all wells except BED-MW22, the SVOC naphthalene was detected above the RBSC, and 2-methylnaphthalene exceeded the RBSC in BED-MW27. In the unfiltered samples, iron and manganese were above both the RBSC and BSC in well BED-MW27. Cobalt and nickel exceeded the BSC in BED-MW19. Aluminum and copper concentrations exceeded the BSC in BED-MW22 and BED-MW27, respectively. Barium was detected above the RBSC in all wells except BED-MW27. Arsenic was reported at concentrations above the RBSC in BED-MW17 and BED-MW27, but was B qualified for the latter well. In the filtered samples, barium was above the RBSC in all wells except BED-MW27. Arsenic and manganese exceeded the RBSCs in the samples from BED-MW17 and BED-MW27, respectively. With the exception of well BED-MW27, chloride was the dominant anion in these wells, detected at concentrations up to 2,420,000 µg/L. The maximum concentration of sulfate observed in these same wells was 53,000 µg/L. In well BED-MW27, sulfate was detected at 1,280,000 µg/L and chloride at only 260,000 µg/L.

2002 Wet Season Sampling Event (January). Monitoring well BED-MW24 was sampled in this event. The VOCs benzene and toluene were detected at concentrations above both the RBSC and BSC values in the sample from this well. The ethyl benzene concentration was above the BSC level, and total xylenes exceeded both the RBSC and BSC levels. The SVOC naphthalene was detected at a concentration above the RBSC. In the unfiltered and filtered samples, barium and thallium were reported at concentrations above the RBSCs. In both cases, the detections of thallium were B qualified. Nearly equal concentrations of chloride (140,000 µg/L and sulfate (150,000 µg/L) were detected.

2002 Wet Season Sampling Event (April). Monitoring wells BED-MW17, BED-MW19, BED-MW22, BED-MW24, and BED-MW27 were sampled in this event. Three nitroaromatic compounds were detected at concentrations above RBSCs. In BED-MW17, 2-nitrotoluene (0.55 µg/L) was detected above its RBSC (0.05 µg/L). The nitroaromatic 2,6-DNT (0.43 µg/L) exceeded the RBSC (0.099 µg/L) in BED-MW24, and the same chemical (0.59 µg/L) was above the RBSC in the sample from BED-MW27. In the sample from BED-MW27, the concentration of 2,4-DNT (0.58 µg/L) exceeded the RBSC of 0.099 µg/L. With the exception of monitoring well BED-MW22, BTEX compounds were detected in various combinations in every well. Benzene exceeded both the RBSC and BSC levels in BED-MW17, BED-MW19, BED-MW24, and BED-MW27. Toluene concentrations exceeded both levels in BED-MW17 and BED-MW24, and toluene concentrations exceeded the BSCs in BED-MW19 and BED-MW27. Ethyl benzene exceeded the BSCs in the wells where benzene was detected. Total xylenes exceeded both the BSCs and RBSCs in the same four wells. With the exception of the sample from BED-MW24, the VOC methylene chloride was detected above the RBSC in the samples from all wells. The SVOC bis(2-ethylhexyl)phthalate) was detected at a concentration that exceeded the RBSC in the sample from BED-MW19. Naphthalene concentrations were above the RBSC in BED-MW17, BED-MW19, BED-MW24, and BED-MW27, and 2-methylnaphthalene exceeded the RBSC in BED-MW27. In the unfiltered samples, iron and manganese concentrations were above both the RBSCs and BSCs in well BED-MW27. Nickel exceeded the BSC in the same well. Chromium and vanadium were above the RBSCs in this well. Barium was detected above the RBSC in the samples from all wells except BED-MW27. Arsenic and thallium concentrations were reported above the RBSCs in BED-MW17, but thallium was B qualified. In the filtered samples, manganese exceeded both the RBSC and BSC in BED-MW27. The barium concentrations exceeded the RBSC in all wells except BED-MW27. Arsenic concentrations exceeded the RBSC in the samples from BED-MW17 and BED-MW27, respectively. Similar to the October 2001 sampling event, all wells were chloride-dominant except BED-MW27. The

concentrations of chloride and sulfate in BED-MW27 were 194,000 and 868,000 µg/L, respectively. In the remaining wells, the maximum concentrations of chloride were approximately an order of magnitude greater than the concentrations of sulfate. The maximum concentrations of these two anions were 2,210,000 and 53,600 µg/L.

2002 Dry Season Sampling Event (July). Monitoring well BED-MW24 was sampled in this event. The VOC benzene was detected above both the RBSC and BSC values in the sample from this well, as were total xylenes. Toluene and ethyl benzene concentrations exceeded the BSC levels in this sample. The SVOC naphthalene was detected at a concentration greater than the RBSC. In the unfiltered sample, iron was detected at a concentration above both the RBSC and BSC. Aluminum exceeded the BSC. Arsenic, barium, manganese, and vanadium were detected at concentrations above the RBSCs. In the filtered sample, barium was the only metal that exceeded screening criteria; the detected concentration was above the RBSC. Chloride was detected in this well at 155,000 µg/L; sulfate was detected at 32,300 µg/L.

2002 Dry Season Sampling Event (October). Two wells (BED-MW24 and BED-MW27) were sampled in this event. Two nitroaromatic compounds, 2,4-DNT (0.98 µg/L) and 2,6-DNT (1.4 µg/L) were detected at concentrations above RBSCs in BED-MW27. The VOC benzene exceeded the RBSC and BSC in the samples from both wells. Toluene exceeded both levels in the sample from BED-MW27, and it exceeded the BSC in BED-MW24. The concentrations of ethyl benzene exceeded the BSCs in both wells, and total xylenes exceeded both the RBSC and BSC in the same two wells. Two SVOCs (2-methylnaphthalene and naphthalene) were above the RBSCs in the sample from BED-MW27. In the unfiltered sample from BED-MW27, iron and manganese concentrations exceeded both the RBSCs and BSCs. Barium was detected at a concentration above the RBSC in BED-MW24. The barium concentration was above both the RBSC and BSC in the filtered sample from BED-MW27. In the filtered sample from BED-MW24, only barium was detected at a concentrations that exceeded the RBSC. In well BED-MW24, chloride was detected at 126,000 µg/L; sulfate was not detected in this well. In well BED-MW27, sulfate (1,110,000 µg/L) was again detected at a much higher concentration than chloride (206,000 µg/L).

2003 Wet Season Sampling Event (April). Monitoring well BED-MW24 was sampled in this event. The VOC benzene was detected at a concentration above both the RBSC and BSC values. Toluene and ethyl benzene exceeded the BSC levels in the same sample. Total xylenes exceeded the RBSC and BSC. Methylene chloride was detected at a concentration above the RBSC. The SVOC naphthalene was above the RBSC in the sample from this well. In the

unfiltered and filtered samples, barium was detected at concentrations above the RBSC. Consistent with previous sampling results, chloride (105,000 µg/L) was detected at higher concentrations than sulfate (20,300 µg/L).

2003 Dry Season Sampling Event (September). One monitoring well (BED-MW24) was sampled in this event. The VOC benzene was detected at a concentration above both the RBSC and BSC values. Toluene and ethyl benzene concentrations exceeded the BSC levels, and total xylenes exceeded both the RBSC and BSC. The SVOC naphthalene was above the RBSC. In the unfiltered sample, barium and thallium were reported at concentrations above the RBSC, but the thallium was B qualified. In the filtered sample, the barium concentration was the only metal that exceeded a screening criterion, and it was above the RBSC. Chloride was detected at 98,000 µg/L, and sulfate was detected at 24,600 µg/L.

2003 Dry Season Sampling Event (December). Monitoring well BED-MW24 was the only well sampled in this event. The VOC benzene was detected above both the RBSC and BSC values. Toluene and ethyl benzene concentrations exceeded the BSC levels. Total xylenes exceeded both the RBSC and BSC. The SVOC naphthalene was above the RBSC. In the unfiltered sample, barium and thallium were reported at concentrations above the RBSC, but thallium was B qualified. In the filtered sample, barium was the only inorganic detected at a concentration that exceeded the RBSC. Chloride was detected at 48,700 µg/L, and sulfate was detected at 32,600 µg/L.

2004 Wet Season Sampling Event (March). One monitoring well (BED-MW24) was sampled in this event. The VOC benzene was detected above both the RBSC and BSC values in the sample. Toluene and ethyl benzene concentrations exceeded the BSC. Total xylenes were detected at concentrations greater than both the RBSC and BSC. In the unfiltered sample, aluminum was reported at a concentrations above the BSC, but the value was B qualified. Barium was the only inorganic detected at a concentration greater than the RBSC. In the filtered sample, barium was the only metal that exceeded a screening criterion; its concentration exceeded the RBSC. Chloride was detected at 79,700 µg/L, and sulfate was detected at 25,500 µg/L.

2004 Wet Season Sampling Event (May). Monitoring wells BED-MW17, BED-MW19, BED-MW22, BED-MW30, and BED-MW33 were sampled in this event. With the exception of monitoring well BED-MW22, BTEX compounds were detected in various combinations in every well. Benzene exceeded both the RBSC and BSC levels in BED-MW17, BED-MW19, BED-

MW30, and BED-MW33. Toluene exceeded both levels in BED-MW17, and its concentration was above the BSC in BED-MW19, BED-MW30, and BED-MW33. Ethyl benzene concentrations exceeded the BSCs in these four wells, and concentrations of total xylenes exceeded both the RBSC and BSC. With the exception of the sample from BED-MW30, the VOC methylene chloride was detected above the RBSC in the samples from all wells. Acetone and chlorobenzene were detected at concentrations above the RBSCs in BED-MW17. The SVOC naphthalene exceeded the RBSC in samples from BED-MW17 and BED-MW19.

In the unfiltered samples, arsenic concentrations exceeded both the RBSC and BSC in wells BED-MW30 and BED-MW33. In addition, iron concentrations exceeded both criteria in BED-MW22 and BED-MW33. Aluminum was above the BSC in BED-MW22, BED-MW30, and BED-MW33. Chromium exceeded the RBSC in BED-MW33. Copper and cobalt concentrations exceeded the BSCs in monitoring well BED-MW19. Arsenic exceeded the RBSC in BED-MW17, and barium concentrations exceeded the RBSCs in all wells except BED-MW30. Manganese was above the RBSC in the samples from BED-MW22 and BED-MW33. The reported concentrations of thallium exceeded the RBSC in the samples from all wells except BED-MW17, but the detected quantities were B qualified for every sample. Vanadium was detected at a concentration greater than the RBSC in the groundwater sample from BED-MW33. In the filtered samples, arsenic was reported at concentrations above both the RBSC and BSC in BED-MW30 (where the value was B qualified) and BED-MW33. It was also above the RBSC in BED-MW17, but this value was also B qualified. Barium was detected above the RBSC in all wells except BED-MW30 and BED-MW33. Manganese was detected at a concentration above the RBSC in BED-MW33. Thallium was reported at concentrations above the RBSC in all five wells, but the quantity was B qualified for each sample. Chloride was the dominant anion detected in all wells. The maximum detected concentrations of chloride and sulfate were 2,460,000 µg/L (BED-MW17) and 32,600 µg/L (BED-MW30).

2004 Wet Season Sampling Event (June). One monitoring well (BED-MW24) was sampled in this event. The VOC benzene was detected at a concentration above both the RBSC and BSC values in the sample from this well. Toluene and ethyl benzene exceeded the BSC levels in the same sample, and total xylenes exceeded both the RBSC and BSC. The SVOC naphthalene was detected at a concentration greater than the RBSC. In the unfiltered and filtered samples, barium was detected at concentrations above the RBSC. Similar to other sampling events, chloride (79,000 µg/L) was detected at a higher concentration than sulfate (25,500 µg/L).

2004 Dry Season Sampling Event (August). Monitoring wells BED-MW17, BED-MW19, BED-MW22, BED-MW30, BED-MW33, and private well PT-5912 were sampled in this event. One Nitroaromatic compound (2-nitrotoluene, 0.16 µg/L)) was detected above the RBSC (0.05 µg/L). BTEX compounds were detected in various combinations in every well. Benzene concentrations exceeded both the RBSC and BSC levels in all wells except BED-MW22. Toluene and ethyl benzene exceeded the BSCs in all wells except BED-MW22. The toluene concentration exceeded the RBSC in well BED-MW17. Total xylenes were detected at concentrations above the RBSC and BSC in all but two wells (BED-MW22 and PT-5912). The SVOC naphthalene was detected at concentrations greater than the RBSC in BED-MW17, BED-MW19, and BED-MW30.

In the unfiltered samples, arsenic and iron concentrations were above both the RBSCs and BSCs in well BED-MW33, and arsenic was above the RBSC in BED-MW30. In addition, iron exceeded both criteria in PT-5912. Aluminum was detected at concentrations above the BSC in all wells except BED-MW17 and BED-MW19, and copper exceeded the BSC only in BED-MW19. Barium concentrations exceeded the RBSC in three wells (BED-MW17, BED-MW19, and BED-MW22). The manganese exceeded the RBSC in the sample from the private well. Thallium exceeded the RBSC in BED-MW22 and BED-MW33. Vanadium was above the RBSC in the unfiltered sample from BED-MW33. Among the filtered samples, arsenic was the only metal above both the RBSC and BSC (BED-MW33), and this metal was above the RBSC in the sample from BED-MW30. Filtered aluminum exceeded the BSC in BED-MW30. Barium was above the RBSC in the filtered results from three wells (BED-MW17, BED-MW19, and BED-MW22). Manganese exceeded the RBSC in PT-5912. The thallium concentrations were above the RBSC in the samples from BED-MW17, BED-MW19, and BED-MW30. Vanadium was detected at a concentration greater than the RBSC in BED-MW33. Chloride was the dominant anion detected in all wells except the private well PT-5912. The maximum concentrations of chloride and sulfate detected were 2,790,000 µg/L (BED-MW17) and 52,500 µg/L (BED-MW30). In private well PT-5912, sulfate was detected at 70,500 µg/L and chloride was detected at 14,900 µg/L.

7.3.3 Summary of Sampling Events, Downgradient Perimeter Wells.

Overburden/Shale. No downgradient, perimeter overburden/shale monitoring wells were scheduled to be sampled during the 1997 dry season, 1998 wet season, 2001 dry season, or 2002 wet season sampling events.

Delaware Limestone Bedrock. In samples from the downgradient perimeter wells, four nitroaromatic compounds were detected at concentrations that exceeded screening criteria. In the 1997 dry season sampling event (November), nitrobenzene was detected above the RBSC in BED-MW17 at a concentration of 0.34 µg/L. 2,4-DNT (1.5 µg/L) was detected in BED-MW27 in the 2001 dry season event (October). In this same event, 2,6-DNT at concentrations of 0.3 µg/L and 1.1 µg/L were detected above the RBSC in BED-MW17 and BED-MW27, respectively. In the 2002 wet season sampling event (April), 2-nitrotoluene (0.55 µg/L) was detect above the RBSC in BED-MW17. In the same event, the concentration of 2,4-DNT (0.58 µg/L) was above the RBSC in BED-MW27. The compound 2,6-DNT was also detected at 0.43 µg/L and 0.59 µg/L in BED-MW24 and BED-MW27, respectively. In the 2002 dry season sampling event (October), 2,4-DNT (0.98 µg/L) and 2,6-DNT (1.4 µg/L) were above the RBSCs. The compound 2-nitrotoluene (0.16 µg/L) was detected at a concentration above the RBSC in BED-MW30).

A number of VOC compounds (acetone, benzene, chlorobenzene, ethyl benzene, methylene chloride, toluene, and total xylenes) were detected at concentrations above RBSCs and/or BSCs. In particular, the BTEX compounds (individually or in various combinations) exceeded the RBSCs and/or BSCs consistently throughout all sampling events in all of the monitoring wells. Three SVOCs were detected above the RBSCs. The SVOC (bis[2-ethylhexyl]phthalate) was detected in the samples from BED-MW19 in the 1997 dry season sampling event (November), BED-MW17 and BED-MW19 in the 1998 wet season event (May), and BED-MW19 in the 2002 wet season sampling event (April). With the exception of the 2004 wet season sampling event (March), naphthalene was detected at concentrations above the RBSC in all sampling events, particularly in BED-MW17, BED-MW-19, BED-MW24, BED-MW27, and BED-MW30. Another SVOC (2-methylnaphthalene) was detected at concentrations above the RBSC in the 1998 wet season event (May), 2001 dry season event (October), 2002 wet season event (April), and 2002 dry season event (October). These detections above the RBSC were always in BED-MW17 and BED-MW27. Various metals were detected above screening criteria in every well throughout all sampling events. The metals detected above RBSCs and/or BSCs in the unfiltered samples were aluminum, arsenic, barium, chromium, copper, iron, manganese, nickel, thallium, and vanadium. The most prevalent above the screening criteria were barium, aluminum, arsenic, and thallium. The metals detected above RBSCs and/or BSCs in the filtered groundwater samples were aluminum, arsenic, barium, manganese, thallium, and vanadium. The most prevalent above screening criteria were barium and arsenic. Total cyanide (320 µg/L) was detected above the RBSC only one time in a groundwater sample from BED-MW17, collected

in the 1997 dry season sampling event. In general, chloride was detected at higher concentrations than sulfate in all wells except BED-MW17 and private well PT-5912.

7.4 Background Monitoring Wells Analytical Results

7.4.1 Overburden/Shale

One background overburden/shale monitoring well (IT-MW01) was sampled. Overburden monitoring well IT-MW01 is located near the western property boundary of PBOW near the intersection of West Scheid and Patrol Road. During the October 2001 sampling event, the stick-up riser within the protective casing was found to be indented and therefore prevented insertion of a sampling pump or bailer. After the groundwater sampling of November 1997 and May 1998, sampling was not conducted until July 2002. The riser of the well could not be repaired but groundwater samples were collected using a peristaltic pump. IT-MW01 was not scheduled to be sampled after September 2003. Groundwater was analyzed for VOCs, SVOCs, nitroaromatics, metals (unfiltered and filtered), cyanide, and water quality parameters during the sampling events. Cyanide was not scheduled for analysis during the 1997 and 1998 sampling. Table 7-18 presents detected constituents above RBSC and/or BSC values in the overburden/shale groundwater. Figure 7-13 shows analytical results along with sampling locations. Background groundwater analytical results are not compared with RBSCs or BSC values.

November 1997, Dry Season Sampling Event. No nitroaromatics or SVOCs were detected in the groundwater from well IT-MW01. VOCs methylene chloride (0.33 µg/L) and total xylenes (0.31 µg/L) were reported, but results were both B qualified. Unfiltered metals iron (1,320 µg/L), manganese (1,320 µg/L), mercury (0.45 µg/L), and zinc (51.6 µg/L) were detected. Filtered metal groundwater detections included iron (1,090 µg/L), manganese (331 µg/L), and zinc (46.9 µg/L). Sulfate was detected at 79,000 µg/L, and chloride was detected at 4,000 µg/L.

May 1998, Wet Season Sampling Event. No nitroaromatics or SVOCs were detected in the groundwater from well IT-MW01. VOCs methylene chloride (0.58 µg/L) and toluene (22 µg/L) were reported, but the toluene results were B qualified. Unfiltered metals iron (2,200 µg/L), manganese (348 µg/L), and zinc (149 µg/L) were detected. Filtered metal groundwater detections included aluminum (276 µg/L), iron (1,970 µg/L), and manganese (395 µg/L). The filtered zinc result, reported at 47.5 µg/L, was B qualified. Sulfate was detected at 140,000 µg/L, and chloride was detected at 3,000 µg/L.

2001 Dry Season Sampling Event (September/October - First Quarter). Due to an indentation of the PVC riser, monitoring well IT-MW01 was not sampled.

January 2002, Wet Season Sampling Event (Second Quarter). On January 16, 2002, an attempt was made to repair IT-MW01. Like the September-October 2001 sampling, an indentation of the PVC riser (2 ft below the top of the casing) prevented sampling equipment (pump and bailer) from reaching groundwater in the well. Review of IT-MW01 well construction diagram showed that the bottom of the only riser joint (3.2 ft stickup to 4 ft bgs) is located within the filter pack. This, therefore, precluded removal of the riser for replacement. Sampling personnel attempted to remove or push back the indentation in the riser, but did not succeed.

April 2002, Wet Season Sampling Event (Third Quarter). Due to an indentation of the PVC riser, monitoring well IT-MW01 was not sampled.

July 2002, Dry Season Sampling Event (Fourth Quarter). No nitroaromatics or SVOCs were detected in the overburden background well. Two VOC compounds, acetone (3.5 µg/L) and methylene chloride (0.19 µg/L) were reported, though both values were B qualified. Several unfiltered and filtered metals samples were detected. Unfiltered-filtered analytical results respectively were: aluminum (117 and 62.2 B µg/L), barium (75.9 and 82.5 µg/L), cobalt (7.5 and 10.3 µg/L), copper (9.1 and 2.8 µg/L), iron (563 and 745 µg/L), manganese (292 and 326 µg/L), nickel (15 and 26.2 µg/L), and zinc (34.3 and 124 µg/L). Similar to previous analytical results, sulfate (118,000 µg/L) was detected at a much higher concentration than chloride (3,400 µg/L).

October 2002, Dry Season Sampling Event (Fifth Quarter). No nitroaromatics or SVOCs were detected in the overburden background well. One VOC compound, 2-butanone (0.7 µg/L), a common laboratory contaminant, was reported though the result was B qualified. Seventeen unfiltered and 8 filtered metals were detected. Filtered analytical results are included following the unfiltered metals results, if the compound was detected. Unfiltered and filtered metals included: aluminum (10,000 and 71.6 B µg/L), antimony (8 µg/L), arsenic (52.6 µg/L), barium (139 and 89.1 µg/L), beryllium (4.6 µg/L), cadmium (1.5 µg/L), chromium (14.1 µg/L), cobalt (14 and 4.9 µg/L), copper (72.2 and 3.7 µg/L), iron (52,100 and 1,840 µg/L), lead (101 µg/L), manganese (490 and 424 µg/L), nickel (35 and 10.5 µg/L), selenium (5 µg/L), thallium (5.7 µg/L), vanadium (35.9 µg/L), and zinc (124 and 13.1 µg/L). Sulfate was detected at 67,300 µg/L, and chloride was detected at 9,900 µg/L.

April 2003, Wet Season Sampling Event (Sixth Quarter). No nitroaromatics were detected in the overburden background well. Two VOC compounds, acetone (1.5 µg/L) and carbon disulfide (0.1 µg/L) (both common laboratory contaminants) were reported, though acetone was B qualified. One SVOC, diethyl phthalate (1.5 µg/L) was also reported, but was B qualified. Twelve identical unfiltered and filtered metals were detected. Filtered analytical results are included following the unfiltered metals results and included: aluminum (14,000 and 1,470 µg/L), barium (60.7 and 52.6 µg/L), beryllium (0.84 B and 1.2 B µg/L), cadmium (0.38 and 0.48 µg/L), cobalt (35.8 and 34.8 µg/L), copper (48.8 and 49.2 µg/L), iron (3,530 and 2,480 µg/L), lead (8.8 and 8.7 µg/L), manganese (396 and 360 µg/L), nickel (74.9 and 82.9 µg/L), thallium (4 B and 4.9 B µg/L), and zinc (74.8 and 73.8 µg/L). Sulfate was detected at 211,000 µg/L, and chloride was detected at 3,000 µg/L.

7.4.2 Shale Bedrock

Three existing bedrock monitoring wells (BG8-BEDGW-001, BED-MW20, and BED-MW25) and 2 new bedrock wells (BED-MW28 and BED-MW29) have been selected from upgradient on-site and off-site locations to determine background distributions for inorganics and BTEX in the bedrock groundwater. Groundwater was analyzed for VOCs, SVOCs, nitroaromatics, metals (unfiltered and filtered), cyanide, and water quality parameters during the sampling events.

As noted in Section 1.0, analytical results and discussion of sampling activities of the first through the ninth background groundwater sampling events are not included in the text, though analytical results are included in Table 7-19. Sampling information from those quarterly sampling events can be fond in the quarterly reports referenced in Chapter 1.0. Table 7-18 presents detected constituents in the bedrock groundwater from all sampling events and Figure 7-14 shows analytical results along with sampling locations.

Note that the analytical results for well BED-MW26 are provided in Table 7-18. This well is not part of the background wells used for derivation of BSCs and should not be used for other comparisons to the background analytical database. Therefore, the concentrations in this well are not included under the "MDC column" on this table.

June 2004, Wet Season Sampling Event (Tenth Quarter). No nitroaromatic compounds were detected in the groundwater samples of the background monitoring wells (BG8-BEDGW-001, BED-MW20, BED-MW25, BED-MW28, and BED-MW29). Five VOC compounds were detected from the monitoring wells during sampling. Constituents of BTEX were common to

most wells. Benzene was found in well BED-MW20 (0.34 µg/L), BED-MW28 (1.1 µg/L), and BED-MW29 (0.23 µg/L), ethyl benzene in well BED-MW29 (0.55 µg/L), toluene in well BED-MW28 (0.13 µg/L), and total xylenes in well BED-MW29 (3.7 µg/L). Carbon disulfide (a common laboratory contaminant) was also common to wells BG8-BEDGW-001 (0.16 µg/L), BED-MW25 (1.9 µg/L), and BED-MW28 (0.1 µg/L). Acetone was also reported in each well but results were validated with a B qualifier. No SVOCs were detected in the background bedrock groundwater samples.

Eleven unfiltered and filtered metals were detected from the groundwater samples. The most metals most commonly unfiltered metals detected are (MDC in parentheses): aluminum (129 µg/L [MW28]), barium (22,500 µg/L [MW20]), iron (1,000 µg/L [MW29]), manganese (170 µg/L [MW20]), and zinc (85.5 µg/L [MW20]). The most common filtered metals detected with concentration ranges included: aluminum (128 µg/L [MW20]), barium (23,100 µg/L [MW20]), manganese (178 µg/L [MW20]), and zinc (102 µg/L [MW20]). Sulfate (26,000 and 514,000 µg/L) was detected at higher concentrations than chloride (9,600 and 95,400 µg/L) in wells BG8-BEDGW-001 and BED-MW25. In well BED-MW20, chloride was detected at 24,200,000 µg/L, the highest concentration observed in any PBOW well as compared to in this report. Sulfate was not detected in this well.

7.4.3 Summary of Sampling Events, Background Monitoring Wells

Overburden/Shale. No nitroaromatics were detected in monitoring well IT-MW01 during the 5 sampling events. Six VOC compounds were reported in the groundwater but all except carbon disulfide (0.1 µg/L) and toluene (22 µg/L) were B qualified data. One SVOC compound, diethyl phthalate, was reported, but the low concentration (1.5 µg/L) of this common laboratory contaminant was also B qualified. Iron, manganese, and zinc were the most common detected unfiltered and filtered metals found during all 5 sampling events. Concentrations of iron in the unfiltered samples ranged from 563 µg/L detected in the July 2002 dry season to 52,100 µg/L also detected in the dry season of October 2002. Unfiltered manganese concentrations ranged from 292 µg/L detected in the 2002 dry season to 490 µg/L detected also during the dry season of October 2002. Concentrations of zinc were relatively low and ranged from 34.4 µg/L (July 2002 dry season) to 149 µg/L (May 1998 wet season). Filtered concentrations of iron were found at 745 µg/L in the dry season to 2,480 µg/L in the wet season of April 2003. Manganese ranged from 331 µg/L in the 1997 dry season to 424 µg/L, also in the dry season of 2002. Zinc concentrations varied from 13.1 µg/L in the dry season to 73.8 µg/L in the wet season. Sulfate is

the dominant anion present, detected at concentrations at least one order of magnitude greater than chloride.

Shale Bedrock. Three nitroaromatic compounds were detected in the background bedrock groundwater during the 12 sampling events since November 1997 (note that 12 sampling events were not conducted from all background wells, sampling activities began when the well was installed). Nitroaromatic 4A-2,6-DNT was detected once in well BED-MW20 at a concentration of 0.19 µg/L (September 2003 dry season), nitrobenzene was detected twice in well BED-MW25 at 0.076 µg/L (April 2002 wet season) and 0.12 µg/L (October 2002 dry season), and once in well BED-MW20 at 0.088 µg/L (April 2002 wet season), and RDX was detected once in well BED-MW20 at 0.17 µg/L (September 2003 dry season). As discussed in Section 7.6.1.2, RDX is regarded as a likely lab artifact. No nitroaromatics have been detected in groundwater samples from background wells BG8-BEDGW-001, BED-MW28, and BED-MW29. The most common VOC compounds detected in the groundwater from the background wells were carbon disulfide, benzene, acetone, and toluene. Carbon disulfide was detected 24 times from 42 samples with a maximum concentration of 13 µg/L in well BED-MW29 (December 2003 dry season). Benzene was detected in 19 samples, predominantly from wells BED-MW20, BED-MW25, BED-MW28, and BED-MW29, with a maximum concentration of 3.2 µg/L in well BED-MW20 (July 2002 dry season). Acetone was reported in 18 samples with a maximum concentration of 17 µg/L in well BED-MW29 (September 2003 dry season). Although acetone was reported in 18 samples, results of 9 were B qualified. Toluene was reported in 16 samples with a maximum concentration of 1.7 µg/L in well BED-MW20 (January 2002 wet season) and 6 of the results were B qualified, all from BED-MW20. Only 2 SVOC compounds were detected from the 42 background groundwater samples. Bis[2-ethylhexyl]phthalate was reported in 7 of the 42 samples, but 4 of the results were B qualified. The maximum concentration of bis(2-ethylhexyl)phthalate was 2.9 µg/L in well BED-MW20. The SVOC 2-methylnaphthalene was detected once and it was found in well BED-MW20 in the November 1997 dry season.

Manganese was the most common unfiltered metal and was detected in all 42 samples. The maximum unfiltered manganese concentration detected was 2,240 µg/L in well BG8-BEDGW-001 during the dry season of November 1997. Barium was detected in 40 unfiltered samples at a maximum value of 26,900 µg/L in well BED-MW20 during the wet season of April 2003. Aluminum and iron were each encountered 39 times in the 42 unfiltered samples, but was B qualified in 20 of the samples. Aluminum was detected at a maximum concentration of 9,020 µg/L in well BG8-BEDGW-001 (November 1997 dry season). Unfiltered iron was reported at a maximum concentration of 22,600 µg/L from the same well during the same time, and was B

qualified in one sample. In the filtered groundwater samples, like the unfiltered samples, manganese was the most common metal to be detected. It was detected in all 42 samples at a maximum value of 1,300 µg/L in well BG8-BEDGW-001 during the November 1997 dry season. Barium was detected in 41 samples at a maximum concentration of 26,200 µg/L in BED-MW20 during April 2003 wet season. Filtered iron and zinc were each detected in 33 samples. Iron was found at a maximum concentration of 6,180 µg/L from well BED-MW20 in January 2002 and zinc was found at 673 µg/L in well BED-MW20 in December 2003 dry season.

There is great variability in anion concentrations in background shale bedrock wells. Groundwater well BG8-BEDGW-001 was chloride-dominant in samples collected from July through September. During the January through June sampling events, data indicate that differences in concentrations between chloride and sulfate were less, with sulfate being nearly equal to or greater than chloride in four of the six events. In background well BED-MW20, extremely high concentrations of chloride were observed, presumably related to the natural gas present in this well and probable brackish formation water. Chloride was the dominant anion in well BED-MW25 in all but three sampling events. In July 2002 and June 2004, sulfate was detected at higher concentrations than chloride, and nearly equal concentrations of the anions were detected in September 2003. In background wells BED-MW28 and BED-MW29, chloride was the dominant anion present, detected at a concentration up to 3,540,000 µg/L, compared to sulfate with a maximum detection of 35,200 µg/L.

8.0 Conclusions

Since November 1997, Shaw has completed 12 sampling events at monitoring wells located in background positions, upgradient of former ordnance manufacturing activities. From groundwater analytical result interpretations and water level elevation measurements, monitoring wells BG8-BEDGW-001, BED-MW20, BED-MW25, BED-MW28, and BED-MW29 are determined to be located in "true" background localities. Resulting analytical values from wells BG8-BEDGW-001, BED-MW25, BED-MW28, and BED-MW29 were used to generate BSCs of inorganics and BTEX in bedrock groundwater for comparison to site and downgradient data. Although monitoring well BED-MW20 is in a background location, analytical data from the well were not used as part of the background data set to generate BSC values due to irregular analytical results believed to be caused by methane gas encountered in the borehole.

As part of the present SOW, BSC values generated from sampling of background wells are compared to groundwater sampling results collected from selected wells and direct-push sampling points at specific AOCs and downgradient perimeter locations. In addition to comparison of analytical results to BSC values, if present, analytical results are also compared to October 2004 RBSC derived values. Groundwater analytical results from selected monitoring wells at the AOCs were sampled in November 1997, May 1998, October 2001, and April 2002. Groundwater samples from downgradient perimeter wells were collected in May and August 2004. Chapter 6.0 in this report presented results from these sampling events as well as the associated hydrogeologic interpretations. This chapter presents conclusions of the semi-annual, downgradient, and background monitoring well sampling results previously presented.

8.1 Overburden/Shale Water-Bearing Zone

A total of 7 overburden monitoring wells (2 in TNTA, 2 in TNTB, and 3 in TNTC) and 5 monitoring wells screened in the shale bedrock (1 at ABG and 4 at TNTB) were selected to be sampled on a semi-annual basis in September/October 2001 (dry season) and April 2002 (wet season), along with groundwater samples obtained from direct-push operations at TNTA, TNTB, and TNTC in September-October 2000 and August 2001. Analytical results from previous sampling events in November 1997 (dry season) and May 1998 (wet season) were used as additional data for comparison to RBSC and BSC values. Groundwater analytical results of samples from direct-push operations at the PRRWP and WARWP were collected in June 1998 and show overburden/shale water quality in those areas, respectively. Interpretations from the analytical data indicate that site-related contaminants have impacted the overburden/shale water-bearing zone to varying degrees across each AOC.

8.1.1 Nitroaromatic Compounds

A total of 11 nitroaromatic compounds above RBSCs were detected in the overburden/shale water-bearing zone from direct-push or monitoring well samples at TNTA, TNTB, TNTC, PRRWP and WARWP. Monitoring wells screened in the shale bedrock detected no nitroaromatics. TNTA exhibited 6 nitroaromatics in groundwater from direct-push sample DP21 (downgradient of the Bi-Tri House [Building 132]) and 3 nitroaromatics in groundwater from overburden/shale monitoring well TNTA-MW11 (downgradient of Wash House Building 146) above screening levels. TNTB showed 4 nitroaromatics above RBSCs, all from downgradient monitoring well MK-MW17. TNTC detected 6 nitroaromatics above RBSCs from direct-push samples GW02 (downgradient of the Bi-Tri House [Building 682]) and GW09 (downgradient of Mono House [Building 681]). The PRRWP encountered a total of 8 nitroaromatics (4 were detected as SVOCs) above RBSCs with one or more found at 11 of the 22 direct-push sampling points. Seven nitroaromatics (2 also detected as SVOCs and 2 detected only as SVOCs) were detected at the WARWP with one or more found in 8 of the 14 direct-push locations. Explosive compounds above screening levels were detected during the dry and wet time periods.

Based on the nitroaromatic detections of 2A-4,6-DNT, 4A-2,6-DNT, 2-nitrotoluene, 3-nitrotoluene, 4-nitrotoluene, nitrobenzene, and nitroanilines, site conditions indicate that a natural biodegradation of 2,4,6-TNT, 2,4-DNT, and 2,6-DNT may be taking place.

8.1.2 Organic Compounds

Eight VOC compounds above RBSC and/or BSC values are present in the overburden/shale water-bearing zone. Four compounds were detected by direct-push groundwater samples above the RBSC and BSC levels at the TNT manufacturing areas. Benzene, ethyl benzene, toluene, and chloroform were found at TNTA above the RBSC and/or the BSC values in direct-push points GW01, GW03, and DP21 while benzene was detected only above the RBSC at TNTC in points GW03 and GW09. Methylene chloride (B qualified) was found at TNTA in overburden/shale well MK-MW23 above the RBSC, and toluene was detected in well MK-MW24 above the BSC. VOCs tetrachloroethene and trichloroethene were detected above RBSC levels at both red water pond areas while only toluene from 1 location (DP12 at PRRWP) was detected above the BSC level. Shale screened bedrock well TNTB-BEDGW-002 detected benzene above the RBSC and methylene chloride (B qualified) in the November 1997 dry season. Trichloroethene was detected in the overburden/shale groundwater above the RBSC from well ABG-BEDGW-001 at the ABG. Trichloroethene contamination may be related to previous site activities.

Twelve different SVOC compounds above RBSC values are present in the overburden/shale water-bearing zone. Eight SVOCs were encountered during direct-push operations at PRRWP during the June 1998 (wet season) activities, 5 compounds were detected at WARWP during the same time period, 4 were detected at TNTC during the 2000 dry season, and 3 were detected at the ABG during September-October 2001 (dry season). TNTB overburden/shale monitoring well MK-MW17 detected (indeno(1,2,3-cd)pyrene) during October 2001 (dry season). Shale screened bedrock well ABG-BEDGW-001 detected the 3 PAH compounds (benzo(a)pyrene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene) above RBSC levels during the same time period and may be attributable to site contamination.

8.1.3 Inorganic Compounds

Many filtered and unfiltered metals were detected in the overburden/shale water-bearing zone during direct-push and monitoring well sampling activities. Most of the metals were removed during the field filtration process, but several metals (arsenic, beryllium, iron, lead, manganese, and thallium) remained above the RBSC and/or BSC values. Lead was detected during 2 sampling events. It was encountered above the RBSC at the PRRWP in push point DP09 during June 1998 (wet season) activities at a concentration of 31.5 µg/L and in well sampling activities at MK-MW17 in May 1998 (wet season) at a concentration of 16.4 µg/L. Both lead detections during the wet season may be indicative of site contamination.

In general, the overburden is characterized by higher levels of sulfate than chloride. More than 90 percent of the groundwater samples collected from overburden piezometers and monitoring wells had higher levels of sulfate. The highest levels of sulfate were observed in piezometers at the PRRWP, suggesting that this may be a useful parameter in determining potential impacts to overburden groundwater. However, given the fact that the concentration of sulfate detected in background overburden well IT-MW01 was up to 211,000 µg/L, distinguishing overburden background from potential site impacts may be difficult for areas outside of major sources (i.e., the red water ponds). Nitrate was infrequently detected; however, nitrate was detected at concentrations up to 465,000 µg/L. Nitrate was also detected in one sample from the WARP at a concentration of 1,600 µg/L. While nitrate may be an indication of potential impacts from PBOW activities, caution should be used in interpreting the results, given that nitrates are also commonly associated with septic tank leach fields and the application of fertilizers.

Unlike the overburden, chloride is the dominant anion in the shale bedrock groundwater. In the background wells, chloride was detected at concentrations greater than sulfate in approximately

85 percent of the samples. In the site wells, two areas deviated from this trend. In TNTB, chloride was the dominant anion in wells TNTB-BEDGW-001 and TNTB-BEDGW-003. Well TNTB-BEDGW-001 is located on the northeast corner of TNTB, while TNTB-BEDGW-003 is located at one of the process buildings. However, in wells TNTB-BEDGW-002 and TNTB-BEDGW-004, sulfate was the dominant anion. In both of these wells, the source of sulfate could be infiltration through the residuum, as they are screened in the upper shale. Well TNTB-BEDGW-002 is located upgradient from the site, and has no known source of contamination nearby. Well TNTB-BEDGW-004 is located near a former process building that used sulfate compounds in the TNT manufacturing process. The other area is the Additional Burning Ground Area. Well ABG-BEDGW-001 is shallow, and the sulfate could reflect infiltration through the residuum. The burning of waste TNT products is not suspected as a source for sulfate.

8.1.4 Geologic and Hydrogeological Conclusions

Groundwater flow in the overburden/shale water-bearing zone is predominantly to the north (Figures 6-2 and 6-3). Based on historical and present data, groundwater within the unconsolidated material above the bedrock (overburden groundwater) is isolated in pockets, is seasonally dependent for existence, and is discontinuous throughout PBOW (Figure 2-12). Based on information from groundwater level data, hydraulic conductivity data, and contaminant migration, the groundwater within the overburden and shale bedrock is considered to be a single hydrogeologic unit and includes groundwater in the Ohio and Olentangy Shale. This interpretation is based on:

- Similarity of shale and overburden groundwater elevations at well pairs
- Depth similarity of groundwater encountered in residuum and bedrock shale wells site-wide
- Bedrock groundwater contours (along the shale outcrops and the shale/limestone contact) merging with contours of the overburden
- Visual interpretations of cross-sections (Figures 2-3 through 2-8).

The shallow water table extends into the upper severely to moderately weathered shale from the central portion of the facility to the south-central and southwestern areas. In the southeastern portion of the site, overburden/shale groundwater flow appears to have a relatively uniform horizontal hydraulic gradient to the east-northeast. Overburden/shale groundwater in the central portion of the facility generally flows to the north and discharges to both Ransom and Plum Brook. On the north side of the site, the flow is toward Ransom Brook and a wetland area

located southwest of the Reactor Facility Area. Groundwater in the western panhandle of the site flows to the north-northwest and discharges to Pipe Creek. In the far northwest corner of PBOW, a groundwater divide is present (marked by Pipe Creek) where overburden/shale groundwater is interpreted to flow in a southwest direction toward Pipe Creek. Since the initial water level measurements in December 1994 (applicable only to wells installed at that time), groundwater elevations in the overburden/shale wells have had variable water level elevations. The minimum change was seen in background well BED-MW29 with a change of 1.21 ft (well is screened in shale bedrock) while the maximum change was 25.03 ft in well TNTC-MW04 (well at TNTC) (Table 6-1). The average fluctuation of water levels in the overburden/shale monitoring wells was 6.65 ft. Groundwater elevations in the overburden fluctuate seasonally, irrespective of the area of the site. Consistent fluctuations in other overburden wells may imply a significant horizontal connectivity across the overburden water-bearing zone and that water levels are controlled by regional fluctuations in the bedrock groundwater elevations.

8.2 Delaware Limestone Bedrock Water-Bearing Zone

Bedrock monitoring wells from 3 distinct areas with different groundwater collection purposes were sampled at PBOW. Locations of monitoring wells were at site AOCs, in downgradient perimeter areas, and in background locations.

8.2.1 AOC Well Samples

A total of 13 bedrock monitoring wells from 9 AOCs (AOC total excluding TNTB and ABG because no monitoring wells are screened in the Delaware Limestone bedrock) were sampled on a semi-annual basis beginning in September/October 2001 (dry season), followed six months later by sampling in April 2002 (wet season). Only 12 wells were able to be sampled during both events due to high hydrogen sulfide vapors in well AA1-BEDGW-001 at AA1, which prevented sample collection. If available, analytical data from November 1997 and May 1998 were also used for RBSC and BSC comparison purposes for the associated monitoring well. Shown by the following sections, contaminants have also impacted the bedrock water-bearing zone, but to a lesser degree than the overburden/shale water-bearing zone.

8.2.1.1 Nitroaromatic Compounds

From bedrock monitoring wells located at the AOCs visited for sampling, bedrock groundwater in 2 areas failed to exhibit any nitroaromatic detections above RBSCs. Those areas included TNTC and AA3. A total of 9 nitroaromatic compounds above RBSCs (4 of the 9 detected as SVOCs) were detected at the remaining 7 AOCs. TNTA exhibited 5 compounds (4A-2,6-DNT, 1,3-DNT, 2,4-DNT, 2,6-DNT, and nitrobenzene), WARWP groundwater revealed 5 compounds

detected only as SVOCs (4,6-dinitro-2-methylphenol, 2,4-dinitrophenol, 2,4-DNT, 3-nitroaniline, and nitrobenzene), PRRWP had 4 compounds (4A-2,6-DNT, 2,4-DNT, 2,6-DNT, and nitrobenzene), AA1 had three compounds (RDX, 2-4-DNT, and 2-nitrotoluene), AA2 detected 3 (1,3-DNB; 2,4-DNT; and 2,6-DNT), MNTA exhibited 3 (1,3-DNB, 2, 4-DNT, and 2,6-DNT), and the UTT Area detected 2,6-DNT. From the four sampling events (2 wet season and 2 dry season) in which groundwater was collected, the nitroaromatics above RBSC levels were detected during the wet season of May 1998 or April 2002 in all of the AOCs.

8.2.1.2 Organic Compounds

Benzene was the most frequently detected VOC above RBSC and BSC values during sampling of bedrock groundwater during the 4 sampling periods. It was detected in each of the 13 monitoring wells sampled and in a total of 38 samples of the 46 samples collected since November 1997. Benzene concentrations above the RBSC and BSC ranged from 5.7 µg/L (well BED-MW18, November 1997 dry season) to 2,500 µg/L (well BED-MW23, April 2002 wet season). Other VOC compounds that were above screening levels usually associated with the natural hydrocarbon that is typical of the Delaware Limestone include toluene, ethyl benzene, and total xylenes. These compounds were also found above the RBSC and/or BSC values in all samples except those from monitoring well BED-MW14 in the WARWP. Another frequent VOC detected above RBSCs was methylene chloride. It was found in 30 of the 46 groundwater samples since November 1997. Concentrations above the RBSC value ranged from 4.4 µg/L (well AA1-BEDGW-001, May 1998 wet season) to 330 µg/L (well TNTA-BEDGW-001, October 2001 dry season). Other contaminants exceeding screening levels that may be considered related to former DOD site activities are chloromethane (AA2), bromomethane (AA2 and AA3), trichloroethene (MNTA), 1,1,2-trichloroethane (PRRWP), and toluene (UTT).

Several SVOCs were also detected at levels exceeding RBSCs in the bedrock wells. The most frequent SVOC was bis(2-ethylhexyl)phthalate. It was detected above RBSCs in 11 of the 13 monitoring wells. Concentrations above the screening level ranged from 4.9 µg/L in well BED-MW16 (UTT-June 1998 wet season) to 920 µg/L at the same well during the dry season of November 1997. SVOCs 2-methylnaphthalene (range 28 to 31 µg/L) and naphthalene (range 16 to 18 µg/L) were detected above the RBSCs in AA1 in November 1997 and May 1998. In AA2, naphthalene exceeded the RBSC in all sampling events with a range of 2.1 µg/L to 12 µg/L. The groundwater sample from BED-MW14 at the WARWP exhibited SVOCs that may be site related. Five nitroaromatics recorded as SVOCs (2,4-DNT [May 1998], 4,6-dinitro-2-methylphenol [May 1998], 2,4-dinitrophenol [May 1998 and April 2002], nitrobenzene [May

1998], and 3-nitroaniline [April 2002]) have impacted the bedrock groundwater as a result of past site activities.

8.2.1.3 Inorganic Compounds

Many filtered and unfiltered metals were detected in the bedrock water-bearing zone during monitoring well sampling activities. Most of the metals were removed during the field filtration process but several metals (arsenic, iron, manganese, and thallium) remained above the RBSC and/or BSC values.

In addition, review of anion analytical data suggests that chloride is the dominant anion (versus sulfate) in the Delaware Limestone bedrock at most of the sites. The most notable areas where sulfate is dominant are TNTC and the WARP. At TNTC, well TNTC-BEDGW-001 was installed at a process building known to have elevated concentrations of nitroaromatics in the soil. The presence of sulfate may be indicative of leaching from acidic waste; however, nitroaromatics were not reported from this well. It is possible that the absence of nitroaromatics reflects the tendency of these compounds to sorb to soil, where sulfate tends to more readily leach to groundwater. In the WARP, elevated sulfate was seen in bedrock well BED-MW14. Nitroaromatics were also detected in this well at concentrations up to 28 µg/L This suggests that elevated sulfate may be associated with site impacts, but further evaluation may be warranted.

8.2.2 Downgradient Perimeter Well Samples

Following the conclusion of the 2002 Groundwater Data Summary and Evaluation Report, it was determined that low-level nitroaromatics 2,4-DNT and 2,6-DNT above RBSCs were migrating to off-site areas. Two new wells (BED-MW30 and BED-MW33) were installed on off-site property to ascertain the impact, if any, and the extent of nitroaromatic contamination from the PBOW facility.

Groundwater analytical results from 8 downgradient wells were presented in Section 7.0. Sample results from 4 monitoring wells (BED-MW17, BED-MW19, BED-MW22, and BED-MW24) exist on-site, and the analytical data from on-site well BED-MW27 was obtained prior to abandonment in January 2003. Monitoring well BED-MW17 was previously associated with TNTA, and BED-MW19 was associated with AA2. However, due to their downgradient location close to the property line, analytical data from the wells may also be used to measure any contamination possibly moving off-site. Monitoring well BED-MW24 was previously associated and sampled during the 10 events with the background monitoring. After review of analytical and groundwater level data, it was determined that the well is actually downgradient of

the WARWP. Private well PT-5912 is northwest of PBOW, downgradient of the WARWP and AA2. The owner of well PT-5912 signed a right-of-entry form to allow sampling for this investigation.

8.2.2.1 Nitroaromatic Compounds

In the samples from the downgradient perimeter wells, four nitroaromatic compounds were detected at concentrations that exceeded screening criteria. In the 1997 dry season sampling event (November), nitrobenzene was detected above the RBSC in BED-MW17 at a concentration of 0.34 µg/L. 2,4-DNT (1.5 µg/L) was detected in BED-MW27 in the 2001 dry season event (October). In this same event, 2,6-DNT at concentrations of 0.3 µg/L and 1.1 µg/L were detected above the RBSC in BED-MW17 and BED-MW27, respectively. In the 2002 wet season sampling event (April), 2-nitrotoluene (0.55 µg/L) was detect above the RBSC in BED-MW17. In the same event, 2,4-DNT (0.58 µg/L) was above the RBSC in BED-MW27. The compound 2,6-DNT was also detected at 0.43 µg/L and 0.59 µg/L in BED-MW24 and BED-MW27, respectively. In the 2002 dry season sampling event (October), 2,4-DNT (0.98 µg/L) and 2,6-DNT (1.4 µg/L) were above the RBSCs. The compound 2-nitrotoluene (0.16 µg/L) was detected at a concentration above the RBSC in BED-MW30.

Throughout all of the sampling events, no nitroaromatics were detected above the screening criteria in BED-MW19 and BED-MW22. No nitroaromatics at all were detected in BED-MW33 and off-site private well PT-5912.

8.2.2.2 Organic Compounds

The VOC compounds BTEX were frequently detected above RBSC and/or BSC values during sampling of downgradient perimeter wells. BTEX compounds were detected in each of the 8 monitoring wells sampled and in a total of 32 samples out of the 34 samples collected since November 1997. Benzene concentrations above both the RBSC and BSC ranged from 2.4 µg/L (well BED-MW30, May 2004 wet season) to 130 µg/L (well BED-MW27, October 2001 dry season). Other VOC compounds that were above RBSC levels included methylene chloride (all wells except BED-MW30 and PT-5912), acetone and chlorobenzene (well BED-MW17), and bromomethane (well BED-MW19). The detection of acetone was B qualified, and chlorobenzene may be associated with natural hydrocarbons. The VOC contaminant exceeding the RBSC level that may be considered related to former DOD site activities is bromomethane (7.9 µg/L), from well BED-MW19, downgradient of the WARWP and AA2. Three SVOCs were detected above the RBSCs. The SVOC (bis[2-ethylhexyl]phthalate) was detected in the samples from BED-MW19 in the 1997 dry season sampling event (November), BED-MW17 and

BED-MW19 in the 1998 wet season event (May), and BED-MW19 in the 2002 wet season sampling event (April). With the exception of the 2004 wet season sampling event (March), naphthalene was detected at concentrations above the RBSC in all sampling events, particularly in BED-MW17, BED-MW-19, BED-MW24, BED-MW27, and BED-MW30. Another SVOC (2-methylnaphthalene) was detected at concentrations above the RBSC in the 1998 wet season event (May), 2001 dry season event (October), 2002 wet season event (April), and 2002 dry season event (October). These detections above the RBSC were always in BED-MW17 and BED-MW27.

8.2.2.3 Inorganic Compounds

Many filtered and unfiltered metals were detected in the bedrock water-bearing zone during monitoring well sampling activities. Most of the metals were removed during the field filtration process but several metals (aluminum, arsenic, barium, manganese, thallium, and vanadium) remained above the RBSC and/or BSC values.

Only one well showed concentrations of sulfate consistently above chloride. Bedrock well BED-MW27 was abandoned due to nuisance hydrogen sulfide. It is thought that the release of hydrogen sulfide into the well and subsequent oxidation of the metal casing is the source of this sulfate.

8.2.3 Background Well Samples

Using groundwater elevation measurements and analytical data results, monitoring wells BG8-BEDGW-001, BED-MW20, BED-MW25, BED-MW28, and BED-MW29 were determined to be background monitoring wells upgradient of any former PBOW activities. A total of 12 groundwater sampling events have taken place at these wells. Although monitoring well BED-MW20 was determined to be a background well, the groundwater analytical data from this well was not used to determine BSCs of BTEX and inorganics because of the abundance of natural gas (methane) within the bedrock around the well. This gas was believed to be causing high and irregular recordings of inorganic analytical data.

8.2.3.1 Nitroaromatic Compounds

Three nitroaromatic compounds (4A-2,6-DNT, nitrobenzene, and RDX) were detected at low levels in the background bedrock groundwater. Nitroaromatics nitrobenzene (April 2002 wet season [0.088 µg/L]), RDX (April 2003 wet season [0.17 µg/L]), and 4A-2,6-DNT (September 2003 dry season [0.19 µg/L]) were detected in monitoring well BED-MW20. Nitrobenzene was detected in well BED-MW25 during the April 2002 wet season (0.076 µg/L) and October 2002

dry season (0.12 µg/L). RDX is not known to have ever been used or manufactured at PBOW and is not a degradation product of nitroaromatics formerly produced. Based on information and analyses at a similar site, the reported concentrations of RDX at PBOW are likely a laboratory artifact.

8.2.3.2 Organic Compounds

The VOC compounds carbon disulfide, benzene, acetone, and toluene were the top 4 compounds most frequently detected during sampling of the background wells. Carbon disulfide was detected 24 times from 42 samples with a maximum concentration of 13 µg/L in well BED-MW29 (December 2003 dry season). Benzene was detected in 19 samples, predominantly from wells BED-MW20, BED-MW25, BED-MW28, and BED-MW29, with a maximum concentration of 3.2 µg/L in well BED-MW20 (July 2002 dry season). Acetone was detected in 18 samples with a maximum concentration of 17 µg/L in well BED-MW29 (September 2003 dry season). Although acetone was detected in 18 samples, the results from 9 were B qualified. Toluene was detected in 16 samples with a maximum concentration of 2.4 µg/L in well BED-MW20 (January 2002 wet season), and 6 of the results were B qualified. All of these qualified results were associated with samples from BED-MW20.

Only 2 SVOC compounds were detected in the 42 background groundwater samples. Bis[2-ethylhexyl]phthalate was detected in 7 of the 42 samples at a maximum concentration of 5.4 µg/L in well BED-MW20, but this result was B qualified. In fact, from the 7 detections, 4 of the results were B qualified. SVOC 2-methylnaphthalene was detected once, and it was found in well BED-MW20 in the November 1997 dry season.

Based upon the analytical results, monitoring wells BG8-BEDGW-001, BED-MW25, BED-MW28, and BED-MW29 exhibit no impact from former PBOW site activities and should be used to construct groundwater BSCs.

8.2.3.3 Inorganic Compounds

Manganese was the most common unfiltered metal detected. It was encountered 42 times in the 42 samples collected (i.e., in each well every time a sample was collected). The maximum concentration detected was 2,240 µg/L in well BG8-BEDGW-001 during the dry season of November 1997. Barium was detected in 40 unfiltered samples at a maximum value of 26,900 µg/L in well BED-MW20 during the wet season of April 2003. Aluminum and iron were each encountered 39 times in the 42 unfiltered samples. Aluminum was detected at a maximum concentration of 9,020 µg/L in well BG8-BEDGW-001 (November 1997 dry season), and it was

B qualified 20 of the 39 times. Unfiltered iron was detected at a maximum concentration of 22,600 µg/L from the same well during the same time and was only B qualified once. In the filtered groundwater samples, like the unfiltered samples, manganese was the most common metal to be detected. It was encountered in 42 samples at a maximum value of 1,300 µg/L in well BG8-BEDGW-001 during the November 1997 dry season. Barium was detected in 41 samples at a maximum concentration of 26,200 µg/L in BED-MW20 during the April 2003 wet season. Filtered iron and zinc were each detected in 33 samples. Iron was found at a maximum concentration of 6,180 µg/L in a sample from well BED-MW20 in January 2002, and zinc was found at 673 µg/L in well BED-MW20 in the December 2003 dry season.

The background overburden well (IT-MW01) had concentrations of sulfate that were more than an order of magnitude higher than those of chloride. This may be the result of more oxygen-rich groundwater oxidizing sulfide minerals present in the overburden and shallow bedrock. The background bedrock wells were all chloride-dominant, with only limited sampling events having sulfate detected at higher concentrations. Bedrock well BG8-BEDGW-001 had three sampling events in which sulfate was detected at a higher concentration than chloride. This may reflect the fact that the well is screened near the overburden/shale contact, which could result in seasonal recharge to the well. In addition, one sample from bedrock well BED-MW25 had sulfate present at a concentration greater than chloride. The background data suggest that the presence of sulfate in source wells could potentially be an indicator of site impacts. Caution should be used in interpreting sulfate data, given that the overburden groundwater appears to have naturally-elevated levels of sulfate.

8.2.3.4 Background Screening Concentrations

BSCs of the bedrock groundwater were derived only from groundwater samples collected by the low-flow sampling methodology and are calculated from the upper tolerance limit or the MDC, whichever is less. Screening values are:

VOCs	**BSC (µg/L)**
Benzene	2.4
Ethyl benzene	0.87
Toluene	1.7
Total Xylenes	5.5

Metals – Unfiltered	**BSC (µg/L)**
Aluminum	309
Arsenic	7.4
Barium	11,800

Calcium	316,000
Cobalt	12.1
Copper	19.8
Metals – Unfiltered	**BSC (µg/L)**
Iron	1,550
Magnesium	217,000
Manganese	636
Nickel	8.6
Potassium	116,000
Sodium	1,390,000
Zinc	507

8.2.3.5 Geochemical Evaluation of Elevated Inorganics

Water quality readings (alkalinity, chloride, and sulfate along with unfiltered metals calcium, magnesium, manganese, and sodium, and filtered iron) were plotted against time to ascertain if any long-term or seasonal trends could be observed (Figures 8-1 through 8-8). An examination of the data provides no clear evidence of either seasonal or long-term trends in the groundwater from the background wells.

8.3 Geologic and Hydrogeological Conclusions

Groundwater flow in the bedrock at the PBOW site is predominantly to the northeast, toward Lake Erie. In the far western corner of the PBOW site and in the western mid portion, groundwater flow is to the northwest. Bedrock groundwater flowing toward the northeast convenes in an area northeast of the reactor facility, exits PBOW, and flows northeast toward Lake Erie (Figure 6-5).

Based on the boring logs and monitoring well construction details from bedrock wells, there are currently 29 monitoring wells completed in the Delaware Limestone (Table 4-2). The large southwest trending trough, as seen on Figure 6-5, is thought to be caused by the pumping wells in the reactor facility and is structurally or fracture controlled based on the geologic map (Figure 2-1).

Groundwater elevations in the Delaware Limestone water-bearing zone showed significant elevation fluctuations since the initial recording of water levels in December 1994 (applicable date only to wells existing in December 1994). The greatest change in water level elevations, as compared to the other well measurements, was 62.30 ft in well BED-MW16. The next greatest change in water level elevations, in case the water level measurement is in error, was 39.10 ft in well BED-MW23. The minimal change in water level elevations was 0.79 ft in well REACTOR

2, but this change was determined from only 5 water level measurements. The average fluctuation of water levels in the Delaware Limestone monitoring wells was 17.25 ft.

Hydraulic conductivity in monitoring wells of the Delaware Limestone, as measured by slug tests, range from 0.002 in abandoned well BED-MW27 to 1.84 ft/day in downgradient well BED-MW24. This range also demonstrates the variability in hydraulic conductivity of the bedrock across the site. Vertical gradients indicated that there is a downward gradient from the overburden to the bedrock in the western and northern portions of the site. The greatest groundwater elevation difference was 25 ft in water levels of the overburden/Delaware Limestone well pair (AA1-GW002/AA1-BED-GW001) located in the north central portion of the site.

Natural petroleum hydrocarbon and hydrogen sulfide, a by-product of anaerobic petroleum degradation, have been present in monitoring wells screened within the Delaware Limestone at PBOW. Free-phase hydrocarbons were detected in bedrock cores of new monitoring wells (BED-MW30 and BED-MW33) and also on rock cores from the borings (BED-MW31, BED-MW32, and BED-MW34) during drilling (Table 6-2). Free-phase hydrocarbon was encountered during sampling episodes, and hydrogen sulfide vapors were detected in at least 14 wells during sampling. A minimum of 14 ft of petroleum hydrocarbon has been measured in monitoring well TNTA-BEDGW-001 during the quarterly water level measurements in the well, which began in February 2002. In addition, the occurrence of natural hydrocarbon is already known to be present in the Delaware Limestone (Appendix N).

Quarries mining the Delaware Limestone in the vicinity north of PBOW are reported to have encountered naturally occurring hydrocarbons and hydrogen sulfide. Free-phase hydrocarbons and BTEX analytical compounds detected in the groundwater of PBOW bedrock monitoring wells are also interpreted to have a similar origin. This similarity is based upon the following observations:

- A majority of wells with hydrocarbon detections are screened in the Delaware Limestone.
- The hydrocarbon-contaminated monitoring wells are widespread and are located from the northeast side of the site to the west side of the site.
- Drilling logs note hydrocarbons in the Delaware Limestone bedrock.

- Delaware Limestone rock core photographs show petroleum hydrocarbons on the rock cores.

- The detection of hydrogen sulfide associated with the petroleum hydrocarbon is typical of that found in the Delaware Limestone.

A discussion with OEPA indicated the presence of producing oil wells in Erie County. These oil wells reportedly are pumping from the Delaware Limestone and the Columbus Limestone (Swinford, 2002).

9.0 Recommendations

Based upon conclusions from groundwater analytical results during this investigation, the following are recommended:

- Toluene was detected at elevated concentrations in well MK-MW20 in the UTT area. Based on the relative absence of other aromatic hydrocarbons, the source of the contamination is interpreted to be from toluene storage used in the production of nitroaromatics. Based on these findings, further evaluation is warranted.

- Monitoring wells have not been installed at the Middle Toluene Tanks Area. Based upon the results from the UTT Area, consideration should be given to the installation of overburden water-bearing zone wells at the Middle Toluene Tank Area (assessment of possible toluene contamination in overburden groundwater) and bedrock wells at the Middle and Lower Toluene Tank Areas (assessment of possible toluene contamination in bedrock groundwater), if deemed necessary.

- Installation of one additional bedrock monitoring well in the PRRWP Area to monitor bedrock contamination.

- With consistent nitroaromatic contamination in overburden/shale well MK-MW17, the location of the well at the mouth of Ransom Brook, additional surface water samples should be collected in Ransom Brook during periods of groundwater discharge to verify no impact to the stream.

- During the 2000 RI soil sampling activities, a total of 9 open manholes (3 at TNTA and 6 at TNTC) were discovered. Several open manholes were also discovered in AA3 during recent investigations. For health and safety reasons, Shaw recommends a sitewide sweep of PBOW be conducted to identify the location of all former DOD open manholes followed by proper abandonment.

Planned Activities

- Complete site-wide groundwater model (2005).
- Complete site-wide groundwater risk assessment (2005).

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HISTORICAL TABLES

Summary of Off-Site Drinking Water Wells
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Well ID	Doc. No.	Well No. on Map	Estimated Coordinates (Ohio State Plane)[a]		OEPA Package No.	Well Owner	Township	Date Installed	Driller	Well Depth	Casing Diameter	Length of Casing	Top of Shale	Top of Prout Lime	Water Column	OB/SH Thickness	Top Del. Lm	Ground Elev.	DTW Enc.	Depth of Pump	Static DTW	Pump Test			Top Prout Lime Elev.	Top Del. Lm Elev.	Top SH Elev.	Water Quality/ Comments
			Northing (Y)	Easting (X)						(ft)	(in)	(ft)	(ft, bgs)	(ft, bgs)	(ft)	(ft)	(ft)	(ft, msl)	(ft, bgs)	(ft, bgs)	(ft)	o	Q (gpm)	DD (ft)	(ft, msl)	(ft, msl)	(ft, msl)	
PRW-001	313522	17	630315.43	1930316.60	1968	Barney Jackson	Huron	7/16/64	M.E. Tibboles	36	8	13	10	29-31	21	29		628		29	15	90	10	15	599		618	
PRW-002	323976	18	630223.98	1929950.82	1968	Keys Golf Course	Huron	6/22/65	M.E. Tibboles	48	8	12	10	25-28	41			627		45	7		20	40	602		617	
PRW-003	287598	19	631557.56	1934126.83	1968	Eugene Ommert	Huron	3/23/64	Hubble Drilling	61	6	20	5		53			631			8						626	
PRW-004	103966	20	623561.28	1930969.08	1968	F.G. Mileham	Huron	3/10/53	Alvin Koch	40	6	9	8		35			636	10		5	60	0.75	35			628	
PRW-005	399059	33	623347.53	1930801.14	1968	Charles Greene	Huron	7/30/69	Tibboles Well Drilling	50	6	12.9	6		38			639		48	12	60	2	40			633	
PRW-006	103980	1	623599.45	1929083.55	1983	Virgil Miller	Huron	6/3/53	Alvin Koch	70	6	8	4	16-18	65			627	8		5	60	0.5	65	611		623	
PRW-007	386813	2	621996.36	1929243.86	1983	Arther Feger	Huron	10/24/68	Tibboles Well Drilling	50	8	12.5	6	13-19	43			626	13	32	7	60	4	40	613		620	good
PRW-008	77091	3	616631.04	1933346.70	1983	E. C. Scheid	Huron	5/23/50	Neuberger Bros	70	5		18					640									622	Abandoned
PRW-009	103959	9	628242.66	1934134.45	1983	J.C. Klaholz Sr	Huron	1/23/53	Alvin Koch	40	6	12	11		33			628	25		7	60	28	13			617	
PRW-010	551062	10	629111.39	1932412.23	1983	Peter Cherubim	Huron	1/6/79	Jones Drilling	80	6	12	7		71	45	45	630	15		9	1440	3	65		585	623	cloudy
PRW-011	384161	11	631641.39	1933966.80	1983	Claude Ommert	Huron	4/2/69	Neuberger Bros	43	6	6	3		40			631	18	40	3		17				628	clear
PRW-012	276758	61A	607999.27	1934040.82	1968	Norman Wilcox	Milan	2/25/62	George Qates	59	5	58	54		44			641			15	120	8				587	
PRW-013	258313	61	607999.27	1934040.82	1968	John Stamm	Milan	7/14/61	Hubble Drilling	82	6	21	18		ND			641			ND						623	cloudy
PRW-014	303986	60	614929.77	1931825.37	1968	T. Crecelius	Milan	5/12/64	George Qates	155			12	72--78	0	72	135	643			dry				571	508	631	
PRW-015	462978	67	603254.24	1931569.82	1983	Walter Sauer	Milan	7/30/76	Neuberger Bros	72	4.25	26.5	26		59			660	26	65	13		1.5				634	clear, sweet
PRW-016	420356	68	603254.24	1930340.29	1983	James Crecelius	Milan	11/1/71	Ohlemached Drilling	30	6	17	17					667	19			30	1				650	cloudy
PRW-017	380287	69a	603516.86	1932477.05	1983	Jae Henry	Milan	1/15/71	George Qates	90	6	39	37		74			660			16	180	6				623	cloudy
PRW-018	521651	70a	605969.95	1933563.33	1983	Owen Landis	Milan	9/8/77	Norman Drilling	56	8	35	32		36	56	56	650			20	120	2	53		594	618	clear
PRW-019	309919	71	606477.28	1933706.58	1983	Phil Cheesman	Milan	1/8/66	Welec- Son & Prelipp	55	4.25	31	30		36			645		54	19	180	3	36			615	clear
PRW-020	165702	1	623514.30	1901938.76	1968	Victor Stark	Perkins	10/20/55	Hubble Drilling	65	6	30			50	0	27	656			15	720	14	6		629		
PRW-021	266835	2	636839.00	1902680.79	1968	W.P. Ackerman	Perkins	10/22/63	Robertson Drilling	108	6	13		0	85	0		614.7		34	23	60	3	75	614.7			
PRW-022	164055	3	637041.73	1902782.15	1968	Melron Silcox	Perkins	1/22/55	Marvin Crowell	20.5	6	5		3	16.5	3		612			4	180	8	8	609			
PRW-023	60102	4	643440.84	1905957.82	1968	J.S. Schoewe	Perkins	8/15/50	Hubble Drilling	48	6	10	20	7	39	20		604			9	720	8		597			
PRW-024	209495	5	623661.32	1902464.77	1968	Wilson Pollan	Perkins	3/5/59	M.E. Tibboles	70	4.25	31			60	0	28	652		60	10	60	3	50		624		
PRW-025	89762	6	627114.67	1911871.15	1968	Victor Tollesi JR	Perkins	3/14/52	Alvin Koch	85	6	19			75	0	18	630	50		10	60	0.5	74		612		
PRW-026	118595	7	641997.28	1912851.55	1968	Lake Erie Canning	Perkins	6/15/54	Robertson Drilling	402	8	10			383	9	9	601	92		19	150	15	220		592		Natural gas at 257 ft
PRW-027	99116	8	638453.46	1907297.58	1968	Richard Smith	Perkins	10/7/52	Hubble Drilling	74	6	19			59	15	15	610.5			15	720	15	40		595.5		
PRW-028	165717	9	630457.89	1909666.02	1968	August Dahs	Perkins	1/14/56	Hubble Drilling	96	6	10			84	10	10	625			12	720	6			615		
PRW-029	103995	10	630189.25	1912397.58	1968	Clyde J. Greer	Perkins	8/22/53	Alvin Koch	30	6	10			26	8	8	625.5	12		4	120	10	20		617.5		
PRW-030	94586	11	618626.87	1918231.46	1968	Wilson Plustion Inc	Perkins	1/21/53	Eldon E. King	120	6	10			114	6	6	661	30		6	60	40	0		655		
PRW-032	101033	13	641494.47	1927961.36	1968	Paul Berthboy	Perkins	7/15/54	M.E. Tibboles	50	6.25	42.3			41		41	576			9	60	18	8.5		535		
PRW-033	101030	13a	641494.47	1927961.36	1968	Kermit Price	Perkins	7/2/54	M.E. Tibboles	48	6	48			41		42	576			7	60	24	6		534		Heavy sulfur gas
PRW-034	313545	14	622352.87	1901692.61	1968	Curtis King	Perkins	11/28/64	M.E. Tibboles	36.5	6	32			18.5		29	658		34	18	90	15	6		629		Sulfer gas
PRW-035	144053	15	617924.67	1905835.74	1968	Myron McNulty	Perkins	1/22/55	Hubble Drilling	58	6	32			28		30	661			30	720	7	15		631		
PRW-036	235263	16	617478.41	1905821.19	1968	Arthur Miller	Perkins	11/11/59	Hubble Drilling	78	6	35	20		60	35	35	650			18	180	14			615	630	
PRW-037	183860	17	617264.98	1906024.92	1968	Edward Clark	Perkins	3/14/57	Neuberger Bros	75	6	38	22		47	37	37	662	62		28		8			625	640	Sulfer gas
PRW-038	118580	18	627782.79	1921838.03	1968	G.H. Waldock	Perkins	5/13/53	Robertson Drilling	300	6	35			275		34	627	200		25	120	15	245		593		Water good
PRW-039	103988	19	630172.45	1912644.00	1968	Milton Bellamy	Perkins	7/13/53	Alvin Koch	36	6	10			28		7	625.07	34		8	60	1	27		618.07		Water good
PRW-040	378082	20	628223.53	1910902.29	1968	Weslen Chuveh	Perkins	8/23/68	M.E. Tibboles	140	6	21			110		11	626		135	30		0.5			615		
PRW-041	151994	21	635117.02	1905224.77	1968	John Pener	Perkins	8/12/56	Neuberger Bros	30	6	22			15		20	617			15		2			597		
PRW-042	164054	22	637221.42	1902855.87	1968	Max Kasor	Perkins	8/30/55	Marvin Crowell	15.5	6	3			11.5		3	610	12		4	720	50	2		607		
PRW-043	187953	23	637391.90	1903178.41	1968	Howard Kaser	Perkins	10/12/56	Hubble Drilling	19	6	10			11		1	610			8	720	7	12		609		
PRW-044	118578	24	639692.41	1906522.27	1968	Dick Cremean	Perkins	8/7/53	Robertson Drilling	30	6	18.5			21		18	607	29		9	30	30	21		589		
PRW-045	204651	2	619397.03	1901487.34	1983	E. Subsky	Perkins	7/23/57	Magrurt + G	117	6	30			95		30	660	55		22	180	8	25		630		
BVR-1 (PRW-046)	221217	3	617691.84	1906015.22	1983	Bay View Reat	Perkins	9/22/58	Robertson Drilling	65.5	6	35.5	12		35.5	34	34	662			30	60	5	35		628	650	
PRW-047	606041	4	625282.53	1907529.30	1983	Donald M. Ortner	Perkins	4/5/83	Jones Drilling	55	6	27	3		37		25	638	36		18	720	8	20		613	635	Sulfer gas
PRW-049	221145	4	603857.15	1911488.00	1983	Julian Schill	Oxford	6/24/60	Neuberger Bros	43	6	10.5	3		40			702	35		3		7				699	
PRW-050	311115	14	611340.80	1902883.89	1968	Fred Rohrbacker	Oxford	11/2/64	Hubble Drilling	63	6	40			33		38	680			30		14	0		642		Sulfur gas
PRW-051	311141	15	613419.41	1903662.04	1968	Jerry Gionto	Oxford	10/7/65	Hubble Drilling	72	6	51	26		60		50	675			12	120	14	0		625	649	

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Well ID	Doc. No.	Well No. on Map	Estimated Coordinates (Ohio State Plane)[a]		OEPA Package No.	Well Owner	Township	Date Installed	Driller	Well Depth	Casing Diameter	Length of Casing	Top of Shale	Top of Prout Lime	Water Column	OB/SH Thickness	Top Del. Lm	Ground Elev.	DTW Enc.	Depth of Pump	Static DTW	Pump Test			Top Prout Lime Elev.	Top Del. Lm Elev.	Top SH Elev.	Water Quality/ Comments
			Northing (Y)	Easting (X)						(ft)	(in)	(ft)	(ft, bgs)	(ft, bgs)	(ft)	(ft)	(ft)	(ft, msl)	(ft, bgs)	(ft, bgs)	(ft)	o	Q (gpm)	DD (ft)	(ft, msl)	(ft, msl)	(ft, msl)	
PRW-052	165726	16	614666.57	19044909.20	1968	Wesley Olda	Oxford	4/19/56	Hubble Drilling	73	6	51	8		71		50	676			2		14	30		626	668	
PRW-053	118017	17	615226.20	1905532.79	1968	Ellsworth Weiland	Oxford	3/15/54	Alvin Koch	40	5.5	20.5	14	4-14	34			685	14.5		6	60	3.5	33	681		671	
PRW-054	317106	18	614753.23	1909142.81	1968	Edward Clark	Oxford	7/29/64	Neuberger Bros	29	6	9.5	9	29	24	29		692	29		5		3		663		683	clear
PRW-055	307900	19	614602.20	1909973.48	1968	Clarence Isceac	Oxford	7/25/64	Neuberger Bros	54	6	20	18	39--45	38			696	30	51	16		2.5		657		678	clear
PRW-056	266809	20	616093.63	1909754.49	1968	Tom Brown	Oxford	10/31/62	Robertson Drilling	49	6	21	7		41			686		47	8	60	4	41			679	
PRW-057	103952	21	613118.29	1914287.64	1968	Ed Leber	Oxford	11/21/52	Alvin Koch	38	5	12	10		29			700	25		9	60	1.5	28			690	
PRW-058	205964	22	610992.36	1920947.30	1968	Earl Mowery	Oxford	7/18/58	L.U. Lirengood	50	5	23	17		36			685			14	60	7				668	
PRW-059	121880	23	609406.76	1923499.47	1968	Bob Justi	Oxford	11/26/54	Neuberger Bros	40	7	10	4		30			675			10		20				671	
PRW-060	311147	24	605839.16	1920692.09	1968	Curtis Jeffers	Oxford	12/23/65	Hubble Drilling	70	6	22	10		0			687			dry						677	
PRW-061	287583	25	605654.53	1920702.95	1968	W.J. Whiley	Oxford	10/12/63	Hubble Drilling	33	6	20	12		18			687		30	15	120	14				675	very good
PRW-062	332967	33	606609.19	1915723.61	1968	Fred Deering	Oxford	8/11/65	Neuberger Bros	62	6	8	6		56			697.5	40	50	6	45	25	18			691.5	clear
PRW-063	103954	33a	606609.19	1915723.61	1968	Fred Deering	Oxford	12/2/52	Alvin Koch	35	7	11	9		25			697.5	12		10	60	10	20			688.5	
PRW-064	244852	33b	606609.19	1915723.61	1968	Fred Deering	Oxford	12/11/59	Robertson Drilling	40	6		7		37			697.5			3		2				690.5	
PRW-065	205967	34	609707.86	1915213.46	1968	W. Spencer	Oxford	8/14/58	L.U. Lirengood	20.5	5	10	9		12.5			702			8	60	14				693	
PRW-066	341159	35	611077.70	1915133.16	1968	Bert Stewart	Oxford	1/4/66	Neuberger Bros	50	6	5.5	3		43.5			702	35	48	6.5		3				699	clear, sweet
PRW-067	89770	36	612211.36	1915307.93	1968	Stewart Bro's	Oxford	6/20/52	Alvin Koch	58	6	10	3		51			695	30		7	60	4	50			692	
PRW-068	276765	37	616036.99	1907685.37	1968	Paul Works	Oxford	4/23/62	George Qates	55	6	9		5	43			685	18		12	120	6		680			clear, sulfer odor
PRW-069	259086	38	613852.22	1906143.24	1968	Newman Smith	Oxford	5/19/61	M.E. Tibboles	60	6	11.75		4	54			692.5	15	25	6	60	1	25	688.5			
PRW-070	281746	39	608840.04	1907298.33	1968	Blaine Emmorick	Oxford	7/13/63	Neuberger Bros	37	6	15	7		29			670	28	35	8		18				663	
PRW-071	165711	48	604272.21	1902473.44	1968	Clare Sargeant	Oxford	12/15/55	Hubble Drilling	40	6	12		2	25			714		35	15	720	20		712			
PRW-072	112875	49	603928.51	1908738.56	1968	Frank Furly	Oxford	5/19/54	Hubble Drilling	40	6	16	9		35			711			5	720	20	0			702	
PRW-073	89771	50	603710.54	1916380.55	1968	Leroy Borsick	Oxford	6/24/52	Alvin Koch	38	5.5	12	3		34			700	12		4	60	10	28			697	
PRW-074	207924	51	603439.03	1918373.42	1968	Bob Trimble	Oxford	2/24/58	Hubble Drilling	114	6		5		102	91	91	690			12		2			599	685	
PRW-075	118013	52	603373.61	1923589.81	1968	Carl Weilnau	Oxford	2/6/53	Alvin Koch	60	10.75	14.5	13		47			675	14		13	60	2	45			662	
PRW-076	341160	52a	603373.61	1923589.81	1968	Edward Schecker	Oxford	1/20/66	Neuberger Bros	30	6	16	14		18			675	14	27	12	15	8	18			661	clear, sweet odor
PRW-077	89791	53	603552.67	1923404.79	1968	Henry Scheid	Oxford	9/27/52	Alvin Koch	60	7	22	21		48			676	25		12	120	15	47			655	
PRW-078	531044	13	605095.23	1920882.14	1983	Dennis Weilnau	Oxford	4/14/78	Tibboles Well Drilling	75	8	15	10		67			685		74	8	60	14.02	60			675	good
PRW-079	508932	14	608271.86	1920816.98	1983	James Stewart	Oxford	12/16/76	Tibboles Well Drilling	28	6	20	5	28--	23			685		26	5	60	15	10	657		680	Sulfer gas
PRW-080	446642	15	610655.69	1922359.14	1983	Fredrick Gfell	Oxford	12/20/72	Tibboles Well Drilling	75	6	16.5	6	63--70	70			677		72	5	60	1	70	614		671	good
PRW-081	440123	16	610677.41	1921995.32	1983	Woodrow Moyer	Oxford	7/25/72	Tibboles Well Drilling	30	6	19.6	7		27			690	7	27	3	60	20	15			683	Sulfer gas
PRW-082	382690	17	611301.88	1920925.58	1983	Dean Reese	Oxford	3/26/71	Ohlemached Drilling	24	6	15	10		20			680	13		4	30	4				670	
PRW-083	424334	18	612508.95	1915114.27	1983	David Willnger	Oxford	11/10/72	Hubble Drilling	53	6	21.4	3		43			695		43	10	120	1				692	
PRW-084	412051	19	612792.37	1914674.97	1983	Urial Nertz	Oxford	9/1/70	Tibboles Well Drilling	35	6	21	3		25			700		32	10	60	5	20			697	good
PRW-085	380417	20	613576.48	1913725.53	1983	Central Erie Supply	Oxford	4/2/71	Welch	65	6	18	15		58	60	60	698		60	7	60	4	55		638	683	
PRW-086	524069	21	615119.48	1908078.05	1983	Craig Wood	Oxford	9/12/77	Tibboles Well Drilling	75	6	19	5	18--27	69	5		698		72	6	90	1	60	680		693	Sulfer odor
PRW-087	398087	22	615901.06	1907674.04	1983	Ed Dagg	Oxford	5/31/71	Robertson Drilling	98	5.5	10		6--15	90	72	72	670			8	60	15	20	664	598		
PRW-088	472359	23	615568.80	1907443.72	1983	Thomas Cooper	Oxford	4/11/74	Tibboles Well Drilling	13.25	6	10.5	9	13	9.25	9		677	9	12	4	60	5.5	5	664		668	good
PRW-089	533009	24	615284.82	1906353.57	1983	Noen Family	Oxford	9/6/80	Rowon Well Drilling	75	7	24	18	23--75	60			675			15	60	10	72	652		657	clear
PRW-090	165701	25	615066.30	1905666.03	1983	G. Moyer	Oxford	10/14/55	Hubble Drilling	36	6	36.75	7	5--7	26			687			10	600	14		682		680	
PRW-091	368081	26	612833.13	1902212.34	1983	P. Ghateier	Oxford	7/22/68	Hubble Drilling	67	6	42		39--	64			685		25	3		14	0	646			clear
PRW-092	409099	27	612971.71	1903214.34	1983	Frank Koehenstarge	Oxford	8/31/70	Tibboles Well Drilling	69	6	45.5	20	44.5	63			675	67	35	6	60	25	15	630.5		655	Sulfer odor
PRW-093	103992	28	610477.38	1902132.40	1983	Geo Beatty	Oxford	8/5/53	Alvin Koch	50.5	6	16.5		10	41.5			695	45		9	60	28	20	685			
PRW-094	553355	29	610189.57	1901817.94	1983	Len Brown	Oxford	12/13/78	Sowders Colahan	30	6	16		14	21			695	27		9	120	7	12	681			clear
PRW-095	498819	30	607436.07	1906150.14	1983	E. Daha	Oxford	7/18/78	Sowders Colahan	40	6	18	6	11--17	35			716	12		5	180	3.5	4	705		710	clear
PRW-096	553380	31	607379.13	1913980.61	1983	Robert Wensink	Oxford	6/13/79	Sowders Colahan	45	6	16	9		19			707	26	42	26	60	3.5				698	clear
PRW-097	368056	32	603656.24	1908042.18	1983	Raymond Bauchmar	Oxford	10/9/67	Hubble Drilling	30	10	14	5		25			691	15		5		1	25			686	clear
PRW-098	420358	33	603428.17	1917770.67	1983	Gary Wondesland	Oxford	12/3/71	Ohlemached Drilling	36	6	4	2		5			691	31		31	30	0.5				689	Sulfer gas
PRW-099	424312	34	603824.57	1912883.54	1983	Don Winkel	Oxford	12/16/71	Hubble Drilling	73	6	14	4		68			707			5	120	1				703	clear
PRW-100	382658	35	603857.15	1911335.95	1983	Norbert Wensink	Oxford	10/10/68	Ohlemached Drilling	46	6	7	3		20			709	26		26	120	2				706	clear
PRW-101	179825	50	604446.83	1908601.86	1983	Jack Ferdinandsch	Oxford	9/15/56	M.E. Tibboles	28	6	8	6		24			712		26	4	60	3	24			706	

Summary of Off-Site Drinking Water Wells
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Well ID	Doc. No.	Well No. on Map	Estimated Coordinates (Ohio State Plane)[a]		OEPA Package No.	Well Owner	Township	Date Installed	Driller	Well Depth	Casing Diameter	Length of Casing	Top of Shale	Top of Prout Lime	Water Column	OB/SH Thickness	Top Del. Lm	Ground Elev.	DTW Enc.	Depth of Pump	Static DTW	Pump Test			Top Prout Lime Elev.	Top Del. Lm Elev.	Top SH Elev.	Water Quality/ Comments
			Northing (Y)	Easting (X)						(ft)	(in)	(ft)	(ft, bgs)	(ft, bgs)	(ft)	(ft)	(ft)	(ft, msl)	(ft, bgs)	(ft, bgs)	(ft)	o	Q (gpm)	DD (ft)	(ft, msl)	(ft, msl)	(ft, msl)	
PRW-102	184391	51	605113.23	1908470.86	1983	James T. Schaffer	Oxford	6/25/57	L.U. Lirengood	42	5	6	7		34			712.5			8	60	6				705.5	
PRW-103	498813	52	605916.34	1908277.21	1983	Wensink	Oxford	6/11/78	Sowders Colahan	40			5	21--23	ND			712.5			ND				691.5		707.5	
PRW-104	503228	53	607397.24	1907929.76	1983	M.Wensink	Oxford	7/17/78	Sowders Colahan	40	6	11	4	16--17	35			712.1	18	38	5	60	2	10	696.1		708.1	clear
PRW-105	355600	54	610621.02	1907104.97	1983	Russell Schwanger	Oxford	11/2/67	Neuberger Bros	35	6	9	6		26			705	20	30	9		30				699	clear
PRW-106	545175	55	612381.64	1906738.60	1983	Camell	Oxford	9/21/78	Tibboles Well Drilling	80	8	13.5	4	7.5--14	76			698		75	4	60	1.5	75	690.5		694	Water good
PRW-107	571044	56	611394.18	1914552.16	1983	Les Schippel Bdlg	Oxford	11/19/80	Tibboles Well Drilling	68	8	15	2		58			710		67	10	60	0.5	55			708	Water good
PRW-108	423813	57	610336.10	1915374.07	1983	Robert Stewart	Oxford	7/20/71	Tibboles Well Drilling	55	6	22	6		ND			701		50	ND	60	5	30			695	
PRW-109	503231	58	604195.43	1915515.77	1983	Dan David	Oxford	7/26/78	Sowders Colahan	43	6	11	6	39--41	35			698	18		8	60	1		659		692	
TPCB-1	9922001	58	618853.65	1918516.45		Trojan Powder Co	Oxford	6/9/42	Sowders Colahan	336.83			3		276.83	85	85	698	18		60		20.6		659		695	Natural gas 58-60', Oil intermittently

Notes:

[a]Coordinates estimated based on placement of well on map using the Ohio State Plane survey coordinate system.

bgs - Below ground surface.
Doc. No. - Document Number.
DTW - Depth to water.
Elev. - Elevation.
ft - Feet.
gpm - Gallons per minute.
ID - Identification.
in - Inches.
msl - Mean sea level.
ND - No data.
OEPA - Ohio Environmental Protection Agency.

Table 3-1

TNTA - Historical Surface Water Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

	Location Code:		MK-PMU4-SW-SD16		MK-PMU4-SW-SD17		TNTA-SO080		TNTA-SW02		TNTA-SW03		TNTA-SW04		TNTA-SW05		TNTA-SW06	
	Sample No:		MK04SW16		MK04SW17		AA2018		AA2002		AA2003		AA2004		AA2005		AA2006	
	Sample Date:		12-Jul-93		12-Jul-93		17-Jul-00		20-Sep-00		20-Sep-00		20-Sep-00		20-Sep-00		20-Sep-00	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																		
Amino-2,6-dinitrotoluene, 4-	ug/L	58.6					58.6		2.34		-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	ug/L	64.7					64.7		1.96		-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	ug/L	466	-	-	-	-	466		-	-	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	ug/L	11000	-	-	-	-	11000		-	-	-	-	-	-	-	-	-	-
Volatiles																		
Acetone	ug/L	13.3	-	-	-	-			-	-	-	-	-	-	-	-	-	-
Carbon disulfide	ug/L	11.5	-	-	-	-			11.5		4.41		1.04		4.69		6.45	
Methylene chloride	ug/L	NA	-	-	-	-			3.51	B	3.69	B	3.65	B	3.75	B	2.05	B
Semivolatiles																		
Di-n-butyl phthalate	ug/L	1.3	-	-	-	-			-	-	-	-	-	-	-	-	1.3	J
Metals - Unfiltered																		
Aluminum	ug/L	2880	-	-	-	-			92.1	J	2880		72.6	J	400		101	J
Arsenic	ug/L	3.75	-	-	-	-			-	-	3.75	J	-	-	-	-	-	-
Barium	ug/L	53.9	23.2	B	97.5	B			22.5		53.9		22.7		26.9		24.2	
Beryllium	ug/L	0.24	-	-	-	-			-	-	0.134	J	-	-	-	-	0.109	J
Cadmium	ug/L	NA	-	-	-	-			0.78	B	-	-	0.75	B	-	-	-	-
Calcium	ug/L	168000	45400	BN	-	-			138000		164000		168000		152000		35700	
Chromium	ug/L	4.49	-	-	-	-			0.857	B	3.76	B	-	-	2.51	B	4.49	J
Cobalt	ug/L	6.19	-	-	-	-			-	-	3.34	J	-	-	-	-	-	-
Copper	ug/L	8.93	-	-	-	-			2.42	J	5.02		1.62	J	2.63	J	6.63	
Iron	ug/L	9850	-	-	-	-			193	B	9850	J	39.6	B	581	J	687	J
Lead	ug/L	5.49	-	-	-	-			1.51	J	5.49		-	-	1.74	J	2.55	J
Magnesium	ug/L	44400	10300		37800				44400		34900		29300		35000		8970	
Manganese	ug/L	1030	151		591				237		1030		30.2		75.8		48.6	
Nickel	ug/L	15	-	-	35.4	B			-	-	5.7	B	-	-	-	-	-	-
Potassium	ug/L	6430	2340	B	6430				1830		2320		5550		2680		2000	
Selenium	ug/L	2.63	-	-	-	-			-	-	-	-	-	-	-	-	-	-
Silver	ug/L	0.941	-	-	-	-			0.941	J	-	-	0.781	J	-	-	-	-
Sodium	ug/L	54300	11700		35500				7710	J	12700	J	54300	J	9290	J	10100	J
Vanadium	ug/L	6.23	-	-	-	-			0.935	J	6.23		-	-	1.59	J	-	-
Zinc	ug/L	61.7	-	-	40.8				36.8		61.7		11.2	J	7.69	J	-	-
Metals - Filtered																		
Barium	ug/L	NA	-	-	86.2													
Calcium	ug/L	95700	42100		95700													
Iron	ug/L	175	175		-	-												
Magnesium	ug/L	37900	10700		37900													
Manganese	ug/L	457	74.9		457													
Potassium	ug/L	6000	2150		6000													
Sodium	ug/L	35200	11600		35200													
Zinc	ug/L	59.3	-	-	59.3													

Table 3-1

TNTA - Historical Surface Water Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

	Location Code:		TNTA-SW07		TNTA-SW09		TNTA-SW10		TNTA-SW14	
	Sample No:		AA2007		AA2009		AA2010		AA2016	
	Sample Date:		20-Sep-00		20-Sep-00		20-Sep-00		18-Oct-00	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives										
Amino-2,6-dinitrotoluene, 4-	ug/L	58.6	-	-	0.165	J	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	ug/L	64.7	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	ug/L	466	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	ug/L	11000	-	-	-	-	-	-	-	-
Volatiles										
Acetone	ug/L	13.3	2.95	J	-	-	-	-	13.3	J
Carbon disulfide	ug/L	11.5	3.59		1.59		6.8		-	-
Methylene chloride	ug/L	NA	3.55	B	3.74	B	3.32	B	1	B
Semivolatiles										
Di-n-butyl phthalate	ug/L	1.3	1.17	J	-	-	-	-	-	-
Metals - Unfiltered										
Aluminum	ug/L	2880	195	J	608		1500		892	
Arsenic	ug/L	3.75	-	-	-	-	-	-	3.69	B
Barium	ug/L	53.9	23.2		29.4		47.8		42.4	
Beryllium	ug/L	0.24	0.135	J	0.204	J	0.24	J	0.123	J
Cadmium	ug/L	NA	-	-	-	-	-	-	-	-
Calcium	ug/L	168000	37500		52300		86200		64600	
Chromium	ug/L	4.49	-	-	2.33	B	4.37	J	2.72	J
Cobalt	ug/L	6.19	-	-	1.3	J	6.19		1.57	J
Copper	ug/L	8.93	1.75	J	3.21	J	6.02		8.93	
Iron	ug/L	9850	190	J	848	J	2010	J	1330	
Lead	ug/L	5.49	1.7	J	-	-	2.45	J	-	-
Magnesium	ug/L	44400	9430		15100		30600		20600	
Manganese	ug/L	1030	24.9		90.5		266		57.7	
Nickel	ug/L	15	-	-	3.43	B	15		6.76	
Potassium	ug/L	6430	2040		2670		3620		3720	
Selenium	ug/L	2.63	-	-	2.63	J	-	-	-	-
Silver	ug/L	0.941	-	-	-	-	0.779	J	1.35	B
Sodium	ug/L	54300	10400	J	14700	J	18200	J	22700	
Vanadium	ug/L	6.23	-	-	1.38	J	2.45	J	3.31	J
Zinc	ug/L	61.7	5.03	J	6.25	J	19.9		13.3	J
Metals - Filtered										
Barium	ug/L	NA								
Calcium	ug/L	95700								
Iron	ug/L	175								
Magnesium	ug/L	37900								
Manganese	ug/L	457								
Potassium	ug/L	6000								
Sodium	ug/L	35200								
Zinc	ug/L	59.3								

MDC - Maximum detected concentration for the AOC ("B" qualified data excluded).
NA - Not applicable; detection is the result of blank contamination.
µg/L - Micrograms per liter.

Validation Qualifiers (VQ)
B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.
J - The analyte was positively identified; the reported value is estimated.
N - The analyte was tentatively identified; consider present.

Table 3-2

TNTA - Historical Sediment Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

			Location Code:		MK-PMU4-SW-SD16		MK-PMU4-SW-SD17		TNTA-SD01		TNTA-SD02		TNTA-SD03		TNTA-SD04		TNTA-SD05		TNTA-SD06	
			Sample No:		MK04SD16		MK04SD17		AA1001		AA1002		AA1003		AA1004		AA1005		AA1006	
			Sample Date:		15-Jul-93		15-Jul-93		19-Sep-00		20-Sep-00		20-Sep-00		20-Sep-00		20-Sep-00		20-Sep-00	
			Sample Depth (ft):		0 - 1		0 - 1		0 - 0		0 - 0		0 - 0		0 - 0		0 - 0		0 - 0	
Parameter	Units	MDC		VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	1.19							-	-	-	-	0.384		-	-	0.11		1.19	
Amino-4,6-dinitrotoluene, 2-	mg/kg	2.92							-	-	-	-	0.731		-	-	0.0963		2.92	
Dinitrotoluene, total	mg/kg	0.576							0.237		-	-	-	-	-	-	0.364		0.576	
Nitrobenzene	mg/kg	0.27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	0.168	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	mg/kg	4.6	-	-	-	-	-	-	-	-	-	-	0.773		-	-	0.685		4.6	
Volatiles																				
Acetone	mg/kg	0.0284	0.025		0.021		-	-	0.0202		0.017		0.00859	J	0.0207		0.0163			
Carbon disulfide	mg/kg	0.0102	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methylene chloride	mg/kg	0.00459	0.0009	J	-	-	0.00459	J	0.0625	B	0.0454	B	0.0283	B	0.0433	B	0.034	B		
Toluene	mg/kg	0.001	-	-	0.001	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Semivolatiles																				
Acenaphthene	mg/kg	0.109	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Acenaphthylene	mg/kg	0.298	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Anthracene	mg/kg	0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(a)anthracene	mg/kg	2.81	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.286	J
Benzo(a)pyrene	mg/kg	1.93	0.07	J	0.076	J	-	-	-	-	-	-	-	-	-	-	0.044	J	0.136	J
Benzo(b)fluoranthene	mg/kg	2.34	0.19	J	0.2	J	-	-	-	-	-	-	-	-	-	-	-	-	0.182	J
Benzo(ghi)perylene	mg/kg	0.861	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	mg/kg	1.11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bis(2-ethylhexyl)phthalate	mg/kg	0.0686	-	-	-	-	-	-	0.0216	J	-	-	-	-	-	-	-	-	-	-
Carbazole	mg/kg	0.0896					-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chrysene	mg/kg	2.92	0.12	J	0.091	J	-	-	-	-	-	-	-	-	-	-	-	-	0.163	J
Dibenz(a,h)anthracene	mg/kg	0.327	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	0.17	0.17	J	-	-	0.147	J	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	0.0844	-	-	-	-	0.0844	J	-	-	0.0492	J	-	-	-	-	-	-	-	-
Fluoranthene	mg/kg	5.95	0.22	J	0.18	J	-	-	-	-	-	-	-	-	-	-	-	-	0.688	
Fluorene	mg/kg	0.223	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-cd)pyrene	mg/kg	0.778	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phenanthrene	mg/kg	3.58	0.082	J	0.052	J	-	-	-	-	-	-	-	-	-	-	-	-	0.107	J
Pyrene	mg/kg	4.74	0.16	J	0.14	J	-	-	-	-	-	-	-	-	-	-	-	-	0.458	
Pesticides/PCBs																				
Aroclor 1260	mg/kg	0.731	-	-			0.0844	J	-	-	0.121	J	-	-	0.731		-	-		
DDT, 4,4'-	mg/kg	0.0098	0.0098	J																
Dieldrin	mg/kg	0.0027	0.0027	J																
Methoxychlor	mg/kg	0.029	0.029																	

Table 3-2

TNTA - Historical Sediment Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

	Location Code:		MK-PMU4-SW-SD16		MK-PMU4-SW-SD17		TNTA-SD01		TNTA-SD02		TNTA-SD03		TNTA-SD04		TNTA-SD05		TNTA-SD06	
	Sample No:		MK04SD16		MK04SD17		AA1001		AA1002		AA1003		AA1004		AA1005		AA1006	
	Sample Date:		15-Jul-93		15-Jul-93		19-Sep-00		20-Sep-00		20-Sep-00		20-Sep-00		20-Sep-00		20-Sep-00	
	Sample Depth (ft):		0 - 1		0 - 1		0 - 0		0 - 0		0 - 0		0 - 0		0 - 0		0 - 0	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals																		
Aluminum	mg/kg	14300	-	-	-	-	3020		8800		7220		7730		10500		12200	
Arsenic	mg/kg	30.3	30.3		6.1		4.97		4.82		6.8		2.09		21.1		5.88	
Barium	mg/kg	177	131		113		24.7		26.8		41.3		18.6		46.2		35.1	
Beryllium	mg/kg	2.7	2.2		2.7		0.172	J	0.448	B	0.441	B	0.452	B	0.772		0.636	
Cadmium	mg/kg	2.3	1.8		2.3		0.372	B	-	-	-	-	-	-	0.164	J	-	-
Calcium	mg/kg	68700	28000		29600		64900	J	18600		2730		4080		8820		61600	
Chromium	mg/kg	31.8	8.3		10.3		8.08		14.3		11.3		12.8		17.4		21.3	
Cobalt	mg/kg	107	107		68.3		2.9		11.2		5.69		4.27		12.2		16.9	
Copper	mg/kg	29.5	18.9		21		7.68	B	15.7		12.7		5.38		18.4		14.6	
Iron	mg/kg	58300	47900		33500		13200		14900		16600		11700		40600		21700	
Lead	mg/kg	59	38.3		19.1		13.1		10.5		47		5.8		48.6		10.7	
Magnesium	mg/kg	9510	-	-	-	-	9510		6520		1650		1950		2630		6750	
Manganese	mg/kg	2770	-	-	-	-	169		277		205		97.5		243		973	
Mercury	mg/kg	0.207	-	-	0.05		0.036	J	-	-	0.035	J	0.025	J	0.05		-	-
Nickel	mg/kg	183	183		128		7.22	B	27.6		15.3		12.6		28.6		44	
Potassium	mg/kg	3030	912		1110		524	J	1740		566		1140		1290		3030	
Selenium	mg/kg	1.39	-	-	-	-	-	-	-	-	-	-	-	-	1.13	B	-	-
Silver	mg/kg	0.557	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/kg	255	178		255		252	J	89.8	J	71.6	J	108	J	-	-	179	J
Vanadium	mg/kg	32.7	32.7		-	-	15.3		20.5		18.8		18.1		29		17	
Zinc	mg/kg	201	-	-	-	-	18.4		53.7		44.2		27.5		109		78.5	

Table 3-2

TNTA - Historical Sediment Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

	Location Code:		TNTA-SD07		TNTA-SD08		TNTA-SD09		TNTA-SD10		TNTA-SD11		TNTA-SD12		TNTA-SD13		TNTA-SD14		TNTA-SD15	
	Sample No:		AA1007		AA1008		AA1009		AA1010		AA1013		AA1014		AA1015		AA1016		AA1017	
	Sample Date:		20-Sep-00		19-Sep-00		20-Sep-00		20-Sep-00		20-Sep-00		20-Sep-00		20-Sep-00		20-Sep-00		20-Sep-00	
	Sample Depth (ft):		0 - 0		0 - 0		0 - 0		0 - 0		0 - 0		0 - 0		0 - 0		0 - 0		0 - 0	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	1.19	0.0707	J	0.0859	J	0.714		-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	2.92	-	-	0.063	J	2.65		-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, total	mg/kg	0.576	0.555		0.133		-	-	0.0455	J	-	-	-	-	-	-	-	-	-	-
Nitrobenzene	mg/kg	0.27	-	-	-	-	-	-	-	-	0.0501	J	0.0765	J	0.27		0.0631	J	0.055	J
Nitrotoluene, 2-	mg/kg	0.168	0.168	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	mg/kg	4.6	0.14		0.132		1.93		0.0635	J	-	-	-	-	-	-	-	-	-	-
Volatiles																				
Acetone	mg/kg	0.0284	0.0145		-	-	0.0119	J	-	-	0.0283		0.0284		0.0168		0.0283		-	-
Carbon disulfide	mg/kg	0.0102	0.0102		-	-	-	-	-	-	0.00262	J	-	-	-	-	0.00458	J	-	-
Methylene chloride	mg/kg	0.00459	0.0356	B	0.00373	J	0.0344	B	0.0277	B	0.0357	B	0.024	B	0.0202	B	0.0203	B	0.0141	B
Toluene	mg/kg	0.001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Semivolatiles																				
Acenaphthene	mg/kg	0.109	-	-	-	-	-	-	-	-	0.109	J	-	-	-	-	-	-	-	-
Acenaphthylene	mg/kg	0.298	-	-	-	-	-	-	-	-	0.298	J	-	-	-	-	-	-	-	-
Anthracene	mg/kg	0.6	-	-	-	-	-	-	-	-	0.6	J	-	-	-	-	-	-	-	-
Benzo(a)anthracene	mg/kg	2.81	-	-	-	-	-	-	-	-	2.81		0.0881	J	-	-	-	-	0.0683	J
Benzo(a)pyrene	mg/kg	1.93	-	-	-	-	-	-	-	-	1.93		0.077	J	-	-	0.0578	J	0.0791	J
Benzo(b)fluoranthene	mg/kg	2.34	-	-	-	-	-	-	-	-	2.34		-	-	-	-	-	-	0.104	J
Benzo(ghi)perylene	mg/kg	0.861	-	-	-	-	-	-	-	-	0.861		-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	mg/kg	1.11	-	-	-	-	-	-	-	-	1.11		-	-	-	-	-	-	-	-
Bis(2-ethylhexyl)phthalate	mg/kg	0.0686	-	-	-	-	-	-	-	-	-	-	0.0686	J	0.0354	J	-	-	-	-
Carbazole	mg/kg	0.0896	-	-	-	-	-	-	-	-	0.0896	J	-	-	-	-	-	-	-	-
Chrysene	mg/kg	2.92	-	-	-	-	-	-	-	-	2.92		0.0742	J	-	-	-	-	0.0664	J
Dibenz(a,h)anthracene	mg/kg	0.327	-	-	-	-	-	-	-	-	0.327	J	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	0.17	0.116	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	0.0844	0.0535	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fluoranthene	mg/kg	5.95	-	-	-	-	-	-	-	-	5.95		0.161	J	-	-	0.143	J	0.175	J
Fluorene	mg/kg	0.223	-	-	-	-	-	-	-	-	0.223	J	-	-	-	-	-	-	-	-
Indeno(1,2,3-cd)pyrene	mg/kg	0.778	-	-	-	-	-	-	-	-	0.778		-	-	-	-	-	-	-	-
Phenanthrene	mg/kg	3.58	-	-	-	-	-	-	-	-	3.58		-	-	-	-	-	-	0.101	J
Pyrene	mg/kg	4.74	-	-	-	-	-	-	-	-	4.74		0.119	J	-	-	-	-	0.132	J
Pesticides/PCBs																				
Aroclor 1260	mg/kg	0.731	-	-	0.0204	J	-	-	-	-	0.116	J	0.0586	J	0.0293	J	-	-	0.0194	J
DDT, 4,4'-	mg/kg	0.0098																		
Dieldrin	mg/kg	0.0027																		
Methoxychlor	mg/kg	0.029																		

Table 3-2

TNTA - Historical Sediment Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

	Location Code:		TNTA-SD07		TNTA-SD08		TNTA-SD09		TNTA-SD10		TNTA-SD11		TNTA-SD12		TNTA-SD13		TNTA-SD14		TNTA-SD15	
	Sample No:		AA1007		AA1008		AA1009		AA1010		AA1013		AA1014		AA1015		AA1016		AA1017	
	Sample Date:		20-Sep-00		19-Sep-00		20-Sep-00		20-Sep-00		20-Sep-00		20-Sep-00		20-Sep-00		20-Sep-00		20-Sep-00	
	Sample Depth (ft):		0 - 0		0 - 0		0 - 0		0 - 0		0 - 0		0 - 0		0 - 0		0 - 0		0 - 0	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals																				
Aluminum	mg/kg	14300	14100		14300		11400		11800		10400		9860		10500		11400		9750	
Arsenic	mg/kg	30.3	2.82		3.3		25		10.5		6.69		3.53		6.48		6.67		3.66	
Barium	mg/kg	177	38.4		60.7		177		110		63.6		62.3		60.5		68.2		70	
Beryllium	mg/kg	2.7	0.689		0.87		1.56		1.28		0.732		0.528		0.665		0.695		0.525	
Cadmium	mg/kg	2.3	-	-	0.551	B	1.16		0.268	J	0.673	J	0.228	J	0.487	J	0.584	J	0.274	J
Calcium	mg/kg	68700	38100		5490	J	24500		68700		15800		6300		14500		10200		5360	
Chromium	mg/kg	31.8	24.2		24.1		20.1		19.1		20.8		15.8		25.6		31.8		16.4	
Cobalt	mg/kg	107	15		9.17		84.9		60		17.6		7.87		13.4		12.2		7.39	
Copper	mg/kg	29.5	13.9		9.17	B	26.5		20.3		29.5		21.8		27.6		28.7		20.1	
Iron	mg/kg	58300	21100		19000		58300		27600		21900		14500		18600		20200		13400	
Lead	mg/kg	59	8.87		9		59		14.5		31.3		13.4		25.3		32.4		31.4	
Magnesium	mg/kg	9510	6910		3430		5280		5820		4850		3230		4850		4210		2680	
Manganese	mg/kg	2770	615		149		2770		2480		331		178		273		277		144	
Mercury	mg/kg	0.207	-	-	0.207		-	-	-	-	0.117		0.037	J	0.087		0.097		0.044	J
Nickel	mg/kg	183	44.7		26.2		117		99.6		49.9		24.8		39.3		39.6		21.1	
Potassium	mg/kg	3030	2900		2170	J	2090		2470		1380		1010		1290		1400		860	
Selenium	mg/kg	1.39	-	-	0.851	J	-	-	-	-	-	-	1.23	J	1.39	B	-	-	-	-
Silver	mg/kg	0.557	-	-	-	-	-	-	0.557	J	-	-	-	-	-	-	-	-	-	-
Sodium	mg/kg	255	149	J	177	J	-	-	99.3	J	168	J	-	-	174	J	-	-	132	J
Vanadium	mg/kg	32.7	18.8		29.4		26.4		17.8		19.7		20.6		20.3		20.6		20.1	
Zinc	mg/kg	201	76.5		55.7		201		118		107		54.5		115		107		56	

"-" - Not detected.
ft - Feet.
MDC - Maximum detected concentration for the AOC ("B" qualified data excluded).
NA - Not applicable; detection is the result of blank contamination.
mg/kg - Milligrams per kilogram.

Validation Qualifiers (VQ)
B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.
J - The analyte was positively identified; the reported value is estimated.

TNTA - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

	Location Code:		MK-MW22		MK-MW23		MK-MW24		MK-PMU4-SB17		MK-PMU4-SS23		MK-PMU4-SS24		MK-PMU4-SS25		MK-PMU4-SS27		PB-TNTA-S1				PB-TNTA-S10		PB-TNTA-S11		PB-TNTA-S12		PB-TNTA-S13	
	Sample No:		MK04SB14		MK04SB15		MK04SB16		MK04SB17		MK04SS23		MK04SS24		MK04SS25		MK04SS27		PB-TNTA-S1-0_0-1_5		PB-TNTA-S1-1_5-5_0		PB-TNTA-S10-2_5-3_5		PB-TNTA-S11-2_5-3_5		PB-TNTA-S12-1_0-1_5		PB-TNTA-S13-1_0-1_5	
	Sample Date:		9-Jul-93		9-Jul-93		12-Jul-93		12-Jul-93		18-Jul-93		18-Jul-93		18-Jul-93		12-Jul-93		28-Oct-94		28-Oct-94		26-Oct-94		26-Oct-94		13-Dec-94		13-Dec-94	
	Sample Depth (ft)		0 - 2		0 - 2		0 - 2		0 - 2		0 - 2		0 - 2		0 - 2		0 - 2		0 - 1.5		1.5 - 5		2.5 - 3.5		2.5 - 3.5		1 - 1.5		1 - 1.5	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																														
Amino-2,6-dinitrotoluene, 4-	mg/kg	16																	1		5.6		-	-	-	-	-	-	-	-
Amino-2-nitrotoluene, 4-	mg/kg	0.4																	-	-	0.3		-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	33.6																	1.7		7		-	-	-	-	-	-	-	-
Dinitrobenzene, 1,3-	mg/kg	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.4		-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	4600	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.8		-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	5600	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.6		-	-	-	-	-	-	-	-
Dinitrotoluene, 3,4-	mg/kg	8.9																	-	-	0.7		-	-	-	-	-	-	-	-
Dinitrotoluene, total	mg/kg	2708																												
Nitrobenzene	mg/kg	0.205	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	582	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 3-	mg/kg	59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 4-	mg/kg	484	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	mg/kg	2.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.5		-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	mg/kg	12000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.9		580		-	-	-	-	-	-	-	-
Volatiles																														
Acetone	mg/kg	4.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-												
Benzene	mg/kg	0.00285	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-												
Butanone, 2-	mg/kg	0.0098	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-												
Carbon disulfide	mg/kg	0.00917	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-												
Methylene chloride	mg/kg	0.0913	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-												
Toluene	mg/kg	0.023	0.011		0.003	J	0.004	J	-	-	0.0009	J	0.005	J	0.023		0.008													
Xylene, o-	mg/kg	0.0027																												
Xylenes, m,p-	mg/kg	0.00787																												
Semivolatiles																														
Acenaphthylene	mg/kg	0.033	0.033	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-												
Benzo(a)anthracene	mg/kg	0.295	0.22	J	-	-	0.055	J	0.091	J	-	-	-	-	-	-	-	-												
Benzo(a)pyrene	mg/kg	0.218	0.16	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-												
Benzo(b)fluoranthene	mg/kg	0.305	0.23	J	-	-	0.078	J	0.11	J	-	-	-	-	0.032	J	-	-												
Benzo(ghi)perylene	mg/kg	0.0981	0.074	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-												
Benzo(k)fluoranthene	mg/kg	0.158	0.11	J	-	-	0.036	J	0.05	J	-	-	-	-	-	-	-	-												
Bis(2-ethylhexyl)phthalate	mg/kg	1.2	-	-	-	-	-	-	1.2		0.075	J	-	-	-	-	-	-												
Chrysene	mg/kg	0.202	0.16	J	-	-	0.073	J	0.11	J	-	-	-	-	-	-	-	-												
Di-n-butyl phthalate	mg/kg	0.216	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-												
Dinitrotoluene, 2,4-	mg/kg	8912	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-												
Dinitrotoluene, 2,6-	mg/kg	10274	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-												
Fluoranthene	mg/kg	0.3	0.3	J	-	-	0.11	J	0.18	J	-	-	-	-	-	-	-	-												
Indeno(1,2,3-cd)pyrene	mg/kg	0.0996	0.096	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-												
Methylnaphthalene, 2-	mg/kg	1.15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-												
Naphthalene	mg/kg	0.652	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-												
Phenanthrene	mg/kg	0.45	0.091	J	-	-	0.041	J	0.068	J	-	-	-	-	-	-	-	-												
Pyrene	mg/kg	0.25	0.25	J	-	-	-	-	0.16	J	-	-	-	-	-	-	-	-												
Polychlorinated biphenyls																														
Aroclor 1260	mg/kg	69.8																												

TNTA - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

	Location Code:		MK-MW22		MK-MW23		MK-MW24		MK-PMU4-SB17		MK-PMU4-SS23		MK-PMU4-SS24		MK-PMU4-SS25		MK-PMU4-SS27		PB-TNTA-S1				PB-TNTA-S10		PB-TNTA-S11		PB-TNTA-S12		PB-TNTA-S13	
	Sample No:		MK04SB14		MK04SB15		MK04SB16		MK04SB17		MK04SS23		MK04SS24		MK04SS25		MK04SS27		PB-TNTA-S1-0_0-1_5		PB-TNTA-S1-1_5-5_0		PB-TNTA-S10-2_5-3_5		PB-TNTA-S11-2_5-3_5		PB-TNTA-S12-1_0-1_5		PB-TNTA-S13-1_0-1_5	
	Sample Date:		9-Jul-93		9-Jul-93		12-Jul-93		12-Jul-93		18-Jul-93		18-Jul-93		18-Jul-93		12-Jul-93		28-Oct-94		28-Oct-94		26-Oct-94		26-Oct-94		13-Dec-94		13-Dec-94	
	Sample Depth (ft)		0 - 2		0 - 2		0 - 2		0 - 2		0 - 2		0 - 2		0 - 2		0 - 2		0 - 1.5		1.5 - 5		2.5 - 3.5		2.5 - 3.5		1 - 1.5		1 - 1.5	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals																														
Aluminum	mg/kg	23500	4770		3640		3710		23500		-	-	-	-	-	-	-	-												
Antimony	mg/kg	13	-	-	-	-	-	-	-	-	-	-	3.7		-	-	-	-	-	-	-	-	-	-	5.8		-	-	-	-
Arsenic	mg/kg	23.2	3.1		2.8		2.2		10.9		2.3		2		3		2.1		4.1		4.6		-	-	4.8		6.5		3.8	
Barium	mg/kg	124	18.4		20.9		14.9		102		17.5		16.2		19.7		20.9													
Beryllium	mg/kg	0.796	-	-	-	-	-	-	0.71		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	mg/kg	1.59	0.09		0.1		0.07		0.07		0.06		0.07		0.43		0.1		-	-	-	-	-	-	-	-	-	-	-	-
Calcium	mg/kg	146000	3150		4920		2100		6010		-	-	-	-	-	-	-	-												
Chromium	mg/kg	53	9		5.3		3.7		17		-	-	-	-	-	-	-	-	13		13		19		22		21		30	
Cobalt	mg/kg	21.5	3.1		3.1		3.1		21.5		2.5		-	-	2.3		3.2													
Copper	mg/kg	489	6		6.9		-	-	62.1		-	-	-	-	19.2		-	-	5.5		6.9		12		-	-	-	-	-	-
Iron	mg/kg	44800	12600		10300		5140		37800		-	-	-	-	-	-	-	-												
Lead	mg/kg	11900	6.2		7.5		5.6		28		-	-	-	-	-	-	-	-	13		10.4		60		15		9.1		44	
Magnesium	mg/kg	44400	1000		915		630		1520		-	-	-	-	-	-	-	-												
Manganese	mg/kg	7600	124		162		63.1		124		-	-	-	-	-	-	-	-	187		178		325		270		330		310	
Mercury	mg/kg	0.134	0.03		-	-	0.08		0.1		-	-	-	-	0.04		0.08		-	-	-	-	-	-	-	-	-	-	-	-
Nickel	mg/kg	108	7.9		8.3		4.7		108		4.9		4.6		7.1		6		13		17		25		29		21		23	
Potassium	mg/kg	3660	456		478		175		1120		298		242		299		272													
Selenium	mg/kg	2.05	-	-	-	-	-	-	0.56		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Silver	mg/kg	0.704	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/kg	454	170		153		145		295		137		129		137		135													
Thallium	mg/kg	2.38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	mg/kg	26.3	20.2		10.8		7.4		26.3		-	-	-	-	-	-	-	-												
Zinc	mg/kg	751	20.7		22.6		65.3		76.9		18.1		17.4		24.7				38		41		180		60		37		86	

TNTA - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Location Code:			PB-TNTA-S14		PB-TNTA-S15		PB-TNTA-S16		PB-TNTA-S17		PB-TNTA-S18		PB-TNTA-S19		PB-TNTA-S2				PB-TNTA-S20		PB-TNTA-S21		PB-TNTA-S22		PB-TNTA-S23	
Sample No:			PB-TNTA-S14-0_0-2_0		PB-TNTA-S15-0_0-2_0		PB-TNTA-S16-0_0-2_0		PB-TNTA-S17-0_0-2_0		PB-TNTA-S18-0_5-1_5		PB-TNTA-S19-0_5-1_5		PB-TNTA-S2-0_0-1_5		PB-TNTA-S2-1_5-3_0		PB-TNTA-S20-0_5-1_5		PB-TNTA-S21-0_0-2_0		PB-TNTA-S22-0_0-2_0		PB-TNTA-S23-0_0-2_0	
Sample Date:			29-Oct-94		29-Oct-94		29-Oct-94		29-Oct-94		29-Oct-94		29-Oct-94		28-Oct-94		28-Oct-94		29-Oct-94		29-Oct-94		29-Oct-94		29-Oct-94	
Sample Depth (ft)			0 - 2		0 - 2		0 - 2		0 - 2		0.5 - 1.5		0.5 - 1.5		0 - 1.5		1.5 - 3		0.5 - 1.5		0 - 2		0 - 2		0 - 2	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																										
Amino-2,6-dinitrotoluene, 4-	mg/kg	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.7		-	-	-	-	-	-
Amino-2-nitrotoluene, 4-	mg/kg	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	33.6	-	-	-	-	-	-	-	-	0.5		-	-	-	-	-	-	1.1		-	-	-	-	-	-
Dinitrobenzene, 1,3-	mg/kg	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	4600	-	-	0.5		1.5		0.5		-	-	-	-	-	-	-	-	0.6		0.6		45		-	-
Dinitrotoluene, 2,6-	mg/kg	5600	-	-	0.8		1.3		-	-	-	-	-	-	-	-	-	-	0.7		0.7		47		0.4	
Dinitrotoluene, 3,4-	mg/kg	8.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, total	mg/kg	2708																								
Nitrobenzene	mg/kg	0.205	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	582	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 3-	mg/kg	59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 4-	mg/kg	484	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	mg/kg	2.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	mg/kg	12000	-	-	53		19		1.1		0.5		0.3		-	-	-	-	4.3		0.3		-	-	-	-
Volatiles																										
Acetone	mg/kg	4.4																								
Benzene	mg/kg	0.00285																								
Butanone, 2-	mg/kg	0.0098																								
Carbon disulfide	mg/kg	0.00917																								
Methylene chloride	mg/kg	0.0913																								
Toluene	mg/kg	0.023																								
Xylene, o-	mg/kg	0.0027																								
Xylenes, m,p-	mg/kg	0.00787																								
Semivolatiles																										
Acenaphthylene	mg/kg	0.033																								
Benzo(a)anthracene	mg/kg	0.295																								
Benzo(a)pyrene	mg/kg	0.218																								
Benzo(b)fluoranthene	mg/kg	0.305																								
Benzo(ghi)perylene	mg/kg	0.0981																								
Benzo(k)fluoranthene	mg/kg	0.158																								
Bis(2-ethylhexyl)phthalate	mg/kg	1.2																								
Chrysene	mg/kg	0.202																								
Di-n-butyl phthalate	mg/kg	0.216																								
Dinitrotoluene, 2,4-	mg/kg	8912																								
Dinitrotoluene, 2,6-	mg/kg	10274																								
Fluoranthene	mg/kg	0.3																								
Indeno(1,2,3-cd)pyrene	mg/kg	0.0996																								
Methylnaphthalene, 2-	mg/kg	1.15																								
Naphthalene	mg/kg	0.652																								
Phenanthrene	mg/kg	0.45																								
Pyrene	mg/kg	0.25																								
Polychlorinated biphenyls																										
Aroclor 1260	mg/kg	69.8																								

			Location Code:		PB-TNTA-S14		PB-TNTA-S15		PB-TNTA-S16		PB-TNTA-S17		PB-TNTA-S18		PB-TNTA-S19		PB-TNTA-S2				PB-TNTA-S20		PB-TNTA-S21		PB-TNTA-S22		PB-TNTA-S23	
			Sample No:		PB-TNTA-S14-0_0-2_0		PB-TNTA-S15-0_0-2_0		PB-TNTA-S16-0_0-2_0		PB-TNTA-S17-0_0-2_0		PB-TNTA-S18-0_5-1_5		PB-TNTA-S19-0_5-1_5		PB-TNTA-S2-0_0-1_5		PB-TNTA-S2-1_5-3_0		PB-TNTA-S20-0_5-1_5		PB-TNTA-S21-0_0-2_0		PB-TNTA-S22-0_0-2_0		PB-TNTA-S23-0_0-2_0	
			Sample Date:		29-Oct-94		29-Oct-94		29-Oct-94		29-Oct-94		29-Oct-94		29-Oct-94		28-Oct-94		28-Oct-94		29-Oct-94		29-Oct-94		29-Oct-94		29-Oct-94	
			Sample Depth (ft)		0 - 2		0 - 2		0 - 2		0 - 2		0.5 - 1.5		0.5 - 1.5		0 - 1.5		1.5 - 3		0.5 - 1.5		0 - 2		0 - 2		0 - 2	
Parameter	Units	MDC		VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals																												
Aluminum	mg/kg	23500																										
Antimony	mg/kg	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.9		7		-	-	13		-	-		
Arsenic	mg/kg	23.2	3.5		-	-	-	-	-	-	3.3		-	-	3.7		5.9		4.1		-	-	-	-	-	-		
Barium	mg/kg	124																										
Beryllium	mg/kg	0.796	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	mg/kg	1.59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	mg/kg	146000																										
Chromium	mg/kg	53	11		6.2		46		7.4		8.4		7.4		13		14		28		11		7.3		14			
Cobalt	mg/kg	21.5																										
Copper	mg/kg	489	4.3		5.2		-	-	-	-	7.4		-	-	-	-	5.5		489		-	-	3.1		7.7			
Iron	mg/kg	44800																										
Lead	mg/kg	11900	8.8		48		38		20		9.4		14		9.1		11		1809		26		22		187			
Magnesium	mg/kg	44400																										
Manganese	mg/kg	7600	170		165		132		106		168		245		236		1000		181		290		125		165			
Mercury	mg/kg	0.134	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	mg/kg	108	6.4		5.2		6.6		5.3		6.3		5.3		9		14		32		6.5		4.2		5.5			
Potassium	mg/kg	3660																										
Selenium	mg/kg	2.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Silver	mg/kg	0.704	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/kg	454																										
Thallium	mg/kg	2.38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	mg/kg	26.3																										
Zinc	mg/kg	751	51		30		209		26		39		28		24		33		447		34		56		154			

			Location Code:	PB-TNTA-S24		PB-TNTA-S24		PB-TNTA-S25		PB-TNTA-S26		PB-TNTA-S27		PB-TNTA-S28		PB-TNTA-S29		PB-TNTA-S3				PB-TNTA-S30		PB-TNTA-S31	
			Sample No:	PB-TNTA-S24-0_0-1_5		PB-TNTA-S24-1_5-3_0		PB-TNTA-S25-0_0-1_5		PB-TNTA-S26-0_0-1_5		PB-TNTA-S27-2_5-3_5		PB-TNTA-S28-1_5-5_0		PB-TNTA-S29-0_0-2_0		PB-TNTA-S3-0_0-1_5		PB-TNTA-S3-1_5-3_0		PB-TNTA-S30-1_5-3_0		PB-TNTA-S31-0_0-1_0	
			Sample Date:	29-Oct-94		29-Oct-94		29-Oct-94		29-Oct-94		26-Oct-94		26-Oct-94		29-Oct-94		26-Oct-94		26-Oct-94		29-Oct-94		29-Oct-94	
			Sample Depth (ft)	0 - 1.5		1.5 - 3		0 - 1.5		0 - 1.5		2.5 - 3.5		1.5 - 5		0 - 2		0 - 1.5		1.5 - 3		1.5 - 3		0 - 1	
Parameter	Units	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																									
Amino-2,6-dinitrotoluene, 4-	mg/kg	16		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-2-nitrotoluene, 4-	mg/kg	0.4		-	-	-	-	0.4		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	33.6		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrobenzene, 1,3-	mg/kg	0.4		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	4600		-	-	0.3		2.7		0.6		-	-	-	-	2.7		-	-	-	-	0.3		-	-
Dinitrotoluene, 2,6-	mg/kg	5600		-	-	-	-	0.4		0.6		-	-	-	-	1.5		-	-	-	-	0.5		-	-
Dinitrotoluene, 3,4-	mg/kg	8.9		-	-	0.6		-	-	8.9		-	-	-	-	0.4		-	-	-	-	0.8		-	-
Dinitrotoluene, total	mg/kg	2708																							
Nitrobenzene	mg/kg	0.205		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	582		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 3-	mg/kg	59		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 4-	mg/kg	484		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	mg/kg	2.5		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	mg/kg	12000		-	-	-	-	-	-	-	-	-	-	-	-	5.5		-	-	-	-	-	-	0.9	
Volatiles																									
Acetone	mg/kg	4.4																							
Benzene	mg/kg	0.00285																							
Butanone, 2-	mg/kg	0.0098																							
Carbon disulfide	mg/kg	0.00917																							
Methylene chloride	mg/kg	0.0913																							
Toluene	mg/kg	0.023																							
Xylene, o-	mg/kg	0.0027																							
Xylenes, m,p-	mg/kg	0.00787																							
Semivolatiles																									
Acenaphthylene	mg/kg	0.033																							
Benzo(a)anthracene	mg/kg	0.295																							
Benzo(a)pyrene	mg/kg	0.218																							
Benzo(b)fluoranthene	mg/kg	0.305																							
Benzo(ghi)perylene	mg/kg	0.0981																							
Benzo(k)fluoranthene	mg/kg	0.158																							
Bis(2-ethylhexyl)phthalate	mg/kg	1.2																							
Chrysene	mg/kg	0.202																							
Di-n-butyl phthalate	mg/kg	0.216																							
Dinitrotoluene, 2,4-	mg/kg	8912																							
Dinitrotoluene, 2,6-	mg/kg	10274																							
Fluoranthene	mg/kg	0.3																							
Indeno(1,2,3-cd)pyrene	mg/kg	0.0996																							
Methylnaphthalene, 2-	mg/kg	1.15																							
Naphthalene	mg/kg	0.652																							
Phenanthrene	mg/kg	0.45																							
Pyrene	mg/kg	0.25																							
Polychlorinated biphenyls																									
Aroclor 1260	mg/kg	69.8																							

TNTA - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

			Location Code:	PB-TNTA-S24		PB-TNTA-S24		PB-TNTA-S25		PB-TNTA-S26		PB-TNTA-S27		PB-TNTA-S28		PB-TNTA-S29		PB-TNTA-S3				PB-TNTA-S30		PB-TNTA-S31	
			Sample No:	PB-TNTA-S24-0_0-1_5		PB-TNTA-S24-1_5-3_0		PB-TNTA-S25-0_0-1_5		PB-TNTA-S26-0_0-1_5		PB-TNTA-S27-2_5-3_5		PB-TNTA-S28-1_5-5_0		PB-TNTA-S29-0_0-2_0		PB-TNTA-S3-0_0-1_5		PB-TNTA-S3-1_5-3_0		PB-TNTA-S30-1_5-3_0		PB-TNTA-S31-0_0-1_0	
			Sample Date:	29-Oct-94		29-Oct-94		29-Oct-94		29-Oct-94		26-Oct-94		26-Oct-94		29-Oct-94		26-Oct-94		26-Oct-94		29-Oct-94		29-Oct-94	
			Sample Depth (ft)	0 - 1.5		1.5 - 3		0 - 1.5		0 - 1.5		2.5 - 3.5		1.5 - 5		0 - 2		0 - 1.5		1.5 - 3		1.5 - 3		0 - 1	
Parameter	Units	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals																									
Aluminum	mg/kg	23500																							
Antimony	mg/kg	13		-	-	-	-	-	-	7.4	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	mg/kg	23.2		-	-	-	-	-	-	-	-	4.8		-	-	-	-	9.1		3.5		-	-	4.6	
Barium	mg/kg	124																							
Beryllium	mg/kg	0.796		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	mg/kg	1.59		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	mg/kg	146000																							
Chromium	mg/kg	53		23		6.2		23		22		18		10.2		52		14		12		5.2		22	
Cobalt	mg/kg	21.5																							
Copper	mg/kg	489		19		-	-	3.9		6.2		-	-	-	-	4.4		4.4		-	-	-	-	8.6	
Iron	mg/kg	44800																							
Lead	mg/kg	11900		256		3.3		1400		130		13		5.3		5.5		15		6.6		3.4		34	
Magnesium	mg/kg	44400																							
Manganese	mg/kg	7600		344		86		130		140		590		259		121		473		175		80		300	
Mercury	mg/kg	0.134		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	mg/kg	108		10.7		5.2		8.6		7.5		26		9.4		6.6		19		8.4		5.2		23	
Potassium	mg/kg	3660																							
Selenium	mg/kg	2.05		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Silver	mg/kg	0.704		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/kg	454																							
Thallium	mg/kg	2.38		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	mg/kg	26.3																							
Zinc	mg/kg	751		267		19		73		56		57		30		253		47		25		17		63	

			Location Code:	PB-TNTA-S32		PB-TNTA-S4				PB-TNTA-S5				PB-TNTA-S6				PB-TNTA-S7				PB-TNTA-S8		PB-TNTA-S9		TNTA-SO012	
			Sample No:	PB-TNTA-S32-0_0-1_0		PB-TNTA-S4-0_0-1_5		PB-TNTA-S4-1_5-5_0		PB-TNTA-S5-1_0-2_0		PB-TNTA-S5-2_5-3_5		PB-TNTA-S6-1_0-2_0		PB-TNTA-S6-2_5-3_5		PB-TNTA-S7-1_0-2_0		PB-TNTA-S7-2_5-3_5		PB-TNTA-S8-2_5-3_5		PB-TNTA-S9-0_0-1_0		AA0426	
			Sample Date:	29-Oct-94		26-Oct-94		26-Oct-94		26-Oct-94		26-Oct-94		25-Oct-94		26-Oct-94		25-Oct-94		25-Oct-94		26-Oct-94		26-Oct-94		25-Sep-00	
			Sample Depth (ft)	0 - 1		0 - 1.5		1.5 - 5		1 - 2		2.5 - 3.5		1 - 2		2.5 - 3.5		1 - 2		2.5 - 3.5		2.5 - 3.5		0 - 1		2 - 3	
Parameter	Units	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																											
Amino-2,6-dinitrotoluene, 4-	mg/kg	16		0.5		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-2-nitrotoluene, 4-	mg/kg	0.4		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Amino-4,6-dinitrotoluene, 2-	mg/kg	33.6		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrobenzene, 1,3-	mg/kg	0.4		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	4600		0.3		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Dinitrotoluene, 2,6-	mg/kg	5600		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Dinitrotoluene, 3,4-	mg/kg	8.9		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Dinitrotoluene, total	mg/kg	2708																								2708	
Nitrobenzene	mg/kg	0.205		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.205	
Nitrotoluene, 2-	mg/kg	582		-	-	-	-	-	-	-	-	0.7		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 3-	mg/kg	59		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.41	
Nitrotoluene, 4-	mg/kg	484		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.455	
Trinitrobenzene, 1,3,5-	mg/kg	2.5		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.621	
Trinitrotoluene, 2,4,6-	mg/kg	12000		3.2		-	-	-	-	-	-	0.3		-	-	-	-	-	-	-	-	-	-	-	-	259	
Volatiles																											
Acetone	mg/kg	4.4																								0.0608	
Benzene	mg/kg	0.00285																								-	-
Butanone, 2-	mg/kg	0.0098																								-	-
Carbon disulfide	mg/kg	0.00917																								-	-
Methylene chloride	mg/kg	0.0913																								0.0957	J
Toluene	mg/kg	0.023																								-	-
Xylene, o-	mg/kg	0.0027																								-	-
Xylenes, m,p-	mg/kg	0.00787																								-	-
Semivolatiles																											
Acenaphthylene	mg/kg	0.033																								-	-
Benzo(a)anthracene	mg/kg	0.295																								-	-
Benzo(a)pyrene	mg/kg	0.218																								-	-
Benzo(b)fluoranthene	mg/kg	0.305																								-	-
Benzo(ghi)perylene	mg/kg	0.0981																								-	-
Benzo(k)fluoranthene	mg/kg	0.158																								-	-
Bis(2-ethylhexyl)phthalate	mg/kg	1.2																								-	-
Chrysene	mg/kg	0.202																								-	-
Di-n-butyl phthalate	mg/kg	0.216																								-	-
Dinitrotoluene, 2,4-	mg/kg	8912																								8912	
Dinitrotoluene, 2,6-	mg/kg	10274																								10274	
Fluoranthene	mg/kg	0.3																								-	-
Indeno(1,2,3-cd)pyrene	mg/kg	0.0996																								-	-
Methylnaphthalene, 2-	mg/kg	1.15																								-	-
Naphthalene	mg/kg	0.652																								-	-
Phenanthrene	mg/kg	0.45																								-	-
Pyrene	mg/kg	0.25																								-	-
Polychlorinated biphenyls																											
Aroclor 1260	mg/kg	69.8																								0.357	

TNTA - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

	Location Code:		PB-TNTA-S32		PB-TNTA-S4				PB-TNTA-S5				PB-TNTA-S6				PB-TNTA-S7				PB-TNTA-S8		PB-TNTA-S9		TNTA-SO012	
	Sample No:		PB-TNTA-S32-0_0-1_0		PB-TNTA-S4-0_0-1_5		PB-TNTA-S4-1_5-5_0		PB-TNTA-S5-1_0-2_0		PB-TNTA-S5-2_5-3_5		PB-TNTA-S6-1_0-2_0		PB-TNTA-S6-2_5-3_5		PB-TNTA-S7-1_0-2_0		PB-TNTA-S7-2_5-3_5		PB-TNTA-S8-2_5-3_5		PB-TNTA-S9-0_0-1_0		AA0426	
	Sample Date:		29-Oct-94		26-Oct-94		26-Oct-94		26-Oct-94		26-Oct-94		25-Oct-94		26-Oct-94		25-Oct-94		25-Oct-94		26-Oct-94		26-Oct-94		25-Sep-00	
	Sample Depth (ft)		0 - 1		0 - 1.5		1.5 - 5		1 - 2		2.5 - 3.5		1 - 2		2.5 - 3.5		1 - 2		2.5 - 3.5		2.5 - 3.5		0 - 1		2 - 3	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals																										
Aluminum	mg/kg	23500																							3040	J
Antimony	mg/kg	13	6.8		-	-	-	-	-	-	-	-	-	-	6.6		-	-	-	-	-	-	-	-	1.23	B
Arsenic	mg/kg	23.2	-	-	5		-	-	5.3		-	-	3.9		6.9		-	-	-	-	6.8		-	-	14.4	J
Barium	mg/kg	124																							38.7	
Beryllium	mg/kg	0.796	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.28	
Cadmium	mg/kg	1.59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	mg/kg	146000																							1180	
Chromium	mg/kg	53	24		12		9.8		11		8.2		53		19		34		14		20		8.9		5.43	
Cobalt	mg/kg	21.5																							3.14	
Copper	mg/kg	489	38		-	-	3.1		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14.6	J
Iron	mg/kg	44800																							25300	
Lead	mg/kg	11900	31		4.7		4.8		5.6		5.1		13		18		4.7		6.3		9.3		8.3		65.9	J
Magnesium	mg/kg	44400																							533	
Manganese	mg/kg	7600	200		138		349		74		55		91		7600		240		55		500		88		79.4	J
Mercury	mg/kg	0.134	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	mg/kg	108	23		8.6		9.3		5.2		6.3		7.3		54		6.4		5.1		32		7.6		10.2	
Potassium	mg/kg	3660																							609	
Selenium	mg/kg	2.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Silver	mg/kg	0.704	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/kg	454																							115	B
Thallium	mg/kg	2.38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	mg/kg	26.3																							18.9	
Zinc	mg/kg	751	64		24		27		26		25		290		81		300		150		52		46		53.7	

TNTA - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

	Location Code:		TNTA-SO012						TNTA-SO016				TNTA-SO035		TNTA-SO040		TNTA-SO062				TNTA-SO077		TNTA-SO080								TNTA-SO081		TNTA-SO094			
	Sample No:		AA0460		BD0007		BD0008		AA0427		AA0428		AA0431		AA0432		AA0461		AA0462		AA0433		AA0463		AA0464		BD0009		BD0012		AA0434		AA0437		AA0465	
	Sample Date:		29-Sep-00		26-Sep-01		26-Sep-01		25-Sep-00		25-Sep-00		25-Sep-00		25-Sep-00		29-Sep-00		29-Sep-00		25-Sep-00		29-Sep-00		29-Sep-00		26-Sep-01		26-Sep-01		25-Sep-00		22-Sep-00		29-Sep-00	
	Sample Depth (ft)		4 - 6		0.5 - 1.5		4 - 6		0 - 1		2 - 3		1.5 - 2.5		2 - 3		4 - 6		6 - 8		0.7 - 1.7		4 - 6		8 - 10		0.5 - 1.5		8 - 10		0.8 - 1.8		2 - 3		5 - 7	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																																					
Amino-2,6-dinitrotoluene, 4-	mg/kg	16	-	-	-	-	-	-	0.132		1.87		0.409		2.43		2.24		9.44		0.329		16		0.551		-	-	-	-	5.84		-	-	-	-
Amino-2-nitrotoluene, 4-	mg/kg	0.4																																		
Amino-4,6-dinitrotoluene, 2-	mg/kg	33.6	-	-	-	-	-	-	-	-	3.53		0.501		-	-	1.05		9.49		1.04		32.6		1.22		-	-	-	-	9.59		-	-	-	-
Dinitrobenzene, 1,3-	mg/kg	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	4600			4600		8																				130	J	-	-						
Dinitrotoluene, 2,6-	mg/kg	5600			5600		6.5																				-	-	-	-						
Dinitrotoluene, 3,4-	mg/kg	8.9																																		
Dinitrotoluene, total	mg/kg	2708	195						1.46		0.534		0.349		40.8		3.43		61.8		0.677		-	-	-	-					-	-	-	-	76.2	
Nitrobenzene	mg/kg	0.205	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.119		0.136		-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	582	-	-	-	-	-	-	-	-	-	-	-	-	1.05		0.528		152		-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.245	
Nitrotoluene, 3-	mg/kg	59	-	-	-	-	-	-	-	-	0.16	J	-	-	0.199	J	-	-	16.9		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 4-	mg/kg	484	-	-	-	-	-	-	-	-	-	-	-	-	0.827		0.249		98.4		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	mg/kg	2.5	-	-	-	-	-	-	-	-	0.0665	J	-	-	0.902		-	-	-	-	-	-	0.123		0.0761	J	-	-	-	-	0.178		-	-	-	-
Trinitrotoluene, 2,4,6-	mg/kg	12000	104		-	-	-	-	0.806		0.896		0.245		7.21		1.31		15.9		1.27		530		92.5		12000	J	260		163		-	-	-	-
Volatiles																																				
Acetone	mg/kg	4.4	0.0359		0.012	B	0.052	B	0.188		0.0277		0.06		0.0837		0.125		0.0544		0.055		0.0401		0.015		4.4	J	0.0079	J	0.0636		0.0579		0.0228	
Benzene	mg/kg	0.00285	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Butanone, 2-	mg/kg	0.0098	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbon disulfide	mg/kg	0.00917	0.002	J	-	-	-	-	-	-	0.00671		-	-	-	-	0.00909		-	-	-	-	0.00202	J	-	-	-	-	-	-	-	-	-	-	-	-
Methylene chloride	mg/kg	0.0913	0.00297	B	0.0068	B	0.0059	B	0.0567	B	0.0522	J	0.0357	B	0.0325	B	0.00428	B	0.00217	B	0.0795	J	0.00201	B	0.00242	B	0.0061	B	0.0042	B	0.037	B	0.00666	B	0.00369	B
Toluene	mg/kg	0.023	-	-	0.0014	J	0.0014	J	-	-	0.00254	J	-	-	-	-	0.00295	J	0.00484	J	-	-	-	-	-	-	0.00086	J	0.00074	J	-	-	-	-	-	-
Xylene, o-	mg/kg	0.0027	-	-					-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					-	-	-	-	-	-
Xylenes, m,p-	mg/kg	0.00787	-	-					-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					-	-	-	-	-	-
Semivolatiles																																				
Acenaphthylene	mg/kg	0.033	-	-					-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					-	-	-	-	-	-
Benzo(a)anthracene	mg/kg	0.295	-	-					-	-	-	-	0.295	J	-	-	-	-	-	-	-	-	-	-	-	-					-	-	-	-	-	-
Benzo(a)pyrene	mg/kg	0.218	-	-					-	-	-	-	0.218	J	-	-	-	-	-	-	-	-	-	-	-	-					-	-	-	-	-	-
Benzo(b)fluoranthene	mg/kg	0.305	-	-					-	-	-	-	0.305	J	-	-	-	-	-	-	-	-	-	-	-	-					-	-	-	-	-	-
Benzo(ghi)perylene	mg/kg	0.0981	-	-					-	-	-	-	0.0981	J	-	-	-	-	-	-	-	-	-	-	-	-					-	-	-	-	-	-
Benzo(k)fluoranthene	mg/kg	0.158	-	-					-	-	-	-	0.158	J	-	-	-	-	-	-	-	-	-	-	-	-					-	-	-	-	-	-
Bis(2-ethylhexyl)phthalate	mg/kg	1.2	-	-					-	-	-	-	-	-	-	-	0.0595	J	-	-	-	-	0.0231	J	-	-					-	-	-	-	-	-
Chrysene	mg/kg	0.202	-	-					-	-	-	-	0.202	J	0.0733	J	-	-	-	-	-	-	-	-	-	-					-	-	-	-	-	-
Di-n-butyl phthalate	mg/kg	0.216	-	-					-	-	-	-	-	-	0.0568	J	-	-	-	-	-	-	0.216	J	-	-					-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	8912	47.7						0.0761	J	0.551		0.301	J	4.72		1.73		15.2		0.092	J	0.296	J	-	-					0.173	J	0.803		17.5	
Dinitrotoluene, 2,6-	mg/kg	10274	96.9						-	-	0.179	J	0.347	J	1.32		1.5		7.29		-	-	-	-	-	-					-	-	0.108	J	10.1	
Fluoranthene	mg/kg	0.3	-	-					-	-	-	-	0.193	J	-	-	-	-	-	-	-	-	-	-	-	-					-	-	-	-	-	-
Indeno(1,2,3-cd)pyrene	mg/kg	0.0996	-	-					-	-	-	-	0.0996	J	-	-	-	-	-	-	-	-	-	-	-	-					-	-	-	-	-	-
Methylnaphthalene, 2-	mg/kg	1.15	-	-					-	-	-	-	-	-	0.0907	J	-	-	0.386	J	-	-	-	-	-	-					-	-	-	-	1.15	J
Naphthalene	mg/kg	0.652	-	-					-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					-	-	-	-	0.652	J
Phenanthrene	mg/kg	0.45	-	-					-	-	-	-	-	-	0.06	J	-	-	-	-	-	-	-	-	-	-					-	-	-	-	0.45	J
Pyrene	mg/kg	0.25	-	-					-	-	-	-	0.175	J	-	-	-	-	-	-	-	-	-	-	-	-					-	-	-	-	-	-
Polychlorinated biphenyls																																				
Aroclor 1260	mg/kg	69.8	-	-					2.48	J	0.0328	J	0.053	J	69.8	J	0.108	J	0.251		0.24		0.152	J	-	-					0.0634	J	0.0479	J	-	-

TNTA - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
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	Location Code:		TNTA-SO012						TNTA-SO016				TNTA-SO035		TNTA-SO040		TNTA-SO062				TNTA-SO077		TNTA-SO080								TNTA-SO081		TNTA-SO094			
	Sample No:		AA0460		BD0007		BD0008		AA0427		AA0428		AA0431		AA0432		AA0461		AA0462		AA0433		AA0463		AA0464		BD0009		BD0012		AA0434		AA0437		AA0465	
	Sample Date:		29-Sep-00		26-Sep-01		26-Sep-01		25-Sep-00		25-Sep-00		25-Sep-00		25-Sep-00		29-Sep-00		29-Sep-00		25-Sep-00		29-Sep-00		29-Sep-00		26-Sep-01		26-Sep-01		25-Sep-00		22-Sep-00		29-Sep-00	
	Sample Depth (ft)		4 - 6		0.5 - 1.5		4 - 6		0 - 1		2 - 3		1.5 - 2.5		2 - 3		4 - 6		6 - 8		0.7 - 1.7		4 - 6		8 - 10		0.5 - 1.5		8 - 10		0.8 - 1.8		2 - 3		5 - 7	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals																																				
Aluminum	mg/kg	23500	9060		3080	J	3370	J	3520	J	4810	J	4960	J	2490	J	5970		4840		5400	J	11000		13200		3680	J	11200	J	6290	J	7060	J	4940	
Antimony	mg/kg	13	-	-	-	-	0.61	J	3.69	J	-	-	0.8	B	3.14	J	-	-	0.669	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.6	J
Arsenic	mg/kg	23.2	20.3		6.6	J	9.8	J	2.76	J	3.71	J	2.86	J	4.67	J	4.09		10.4		3.67	J	7.52		11		3	J	8.2	J	2.94	J	10.9	J	23.2	
Barium	mg/kg	124	16.5		24.2		16.3	J	124		23.7		22.9		61.6		27.7		73.3		20.5		23		21.2		41.7	J	16.6	J	27.5		20.1	J	21.3	
Beryllium	mg/kg	0.796	0.758		0.22	B	0.4	B	0.243		0.368		0.33		0.234	J	0.448		0.503		0.331		0.61		0.707		0.31	B	0.7	B	0.396		0.497		0.796	
Cadmium	mg/kg	1.59	-	-	-	-	0.66	B	1.59		-	-	0.204	J	0.198	J	0.494	J	0.494	J	0.198	J	-	-	-	-	0.31	B	0.093	B	0.193	J	0.189	B	-	-
Calcium	mg/kg	146000	47900		2430	J	146000	J	51000		6860		3240		2830		24300		97600		5150		30400		47300		34000	J	47500	J	11500		1330	J	1180	
Chromium	mg/kg	53	11.6		6	J	5.5	J	15.4		9.4		6.57		8.49		9.93		9.01		8.25		19.6		24.2		8.1	J	21	J	11.9		10.2	J	13.6	
Cobalt	mg/kg	21.5	6.31		3.4	B	7	J	2.85		3.58		4.01		2.04		5.48		7.48		4.17		12.9		18.7		3.8	B	17.2	J	3.76		5.38		9.95	
Copper	mg/kg	489	27.9		10.3		19.9		88.4	J	6.31	J	7.9	J	21.1	J	9.41		30.7		7.86	J	12.8		14.6		7.2	B	12.8		17.3	J	22.3	J	93.8	
Iron	mg/kg	44800	44800		20500	J	26100	J	8290		19900		8720		6920		9800		14200		10400		18400		24500		9780	J	22900	J	11500		19400		38400	
Lead	mg/kg	11900	38.6		43.3	J	10.8	J	588	J	12.2	J	9.77	J	11900	J	35		108		25.9	J	22.5		6.65		60.4	J	8	J	50.3	J	19.8	J	32.8	
Magnesium	mg/kg	44400	19100		796	J	44400	J	3610		1460		1050		597		3030		11900		1220		6600		8980		3990	J	8740	J	2190		1060	J	737	
Manganese	mg/kg	7600	834		101	J	1390	J	223	J	547	J	187	J	59.9	J	418		567		221	J	336		501		177	J	512	J	267	J	276	J	40.4	
Mercury	mg/kg	0.134	-	-	-	-	0.036	B	0.134		-	-	-	-	0.078		0.033	J	0.084		0.022	J	0.034	J	-	-	0.051	B	-	-	0.08		0.035		0.068	
Nickel	mg/kg	108	22.9		9.4	J	23.8	J	13.1		9.65		11.5		7.79		14.8		23.7		11.2		35.4		50.6		9.4	J	44.6	J	9.38		22.7		48.5	
Potassium	mg/kg	3660	2260		425	J	938		481		713		361		649		413		940		516		3190		3660		524		2900		632		1080		2240	
Selenium	mg/kg	2.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.84		-	-	-	-	-	-	-	-	-	-	-	-	1.24		2.05	
Silver	mg/kg	0.704	-	-	-	-	-	-	-	-	-	-	-	-	0.704	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/kg	454	223		-	-	155	J	299	B	135	B	106	B	178	B	175	J	202	J	151	B	338		324		73.6	J	274	J	147	B	158	B	92.1	J
Thallium	mg/kg	2.38	1.34	J	-	-	1	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.38	
Vanadium	mg/kg	26.3	24.1		19.3	J	9.9	J	10.6		18		13		8.51		13.8		15.7		15.3		19.1		18.9		14.5	J	16.9	J	20.4		21.7		26.2	
Zinc	mg/kg	751	234		65.9	J	111	J	751		35.8		52.5		60.7		104		146		50.3		45.5		41		63.4	J	44.4	J	51.4		76.5	J	133	

TNTA - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

			TNTA-SO105				TNTA-SO111						TNTA-SO123		TNTA-SO128		TNTA-SO128				TNTA-SO196		TNTA-SO201				TNTA-SO225		TNTA-SO261				TNTA-SO261	
	Location Code:																																	
	Sample No:		AA0440		AA0466		AA0441		AA0468		AA0469		AA0442		AA0445		AA0470		AA0471		AA0446		AA0472		AA0473		AA0480		AA0447		AA0474		AA0475	
	Sample Date:		25-Sep-00		28-Sep-00		22-Sep-00		28-Sep-00		28-Sep-00		22-Sep-00		25-Sep-00		28-Sep-00		28-Sep-00		25-Sep-00		26-Sep-00		26-Sep-00		11-Oct-00		25-Sep-00		26-Sep-00		26-Sep-00	
	Sample Depth (ft)		2 - 3		4 - 6		1 - 2		4 - 6		8 - 10		2 - 3		1.5 - 2.5		4 - 6		8 - 10		1 - 2		4 - 6		8 - 10		2 - 3		1.5 - 2.5		4 - 6		8 - 10	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																																		
Amino-2,6-dinitrotoluene, 4-	mg/kg	16	9.91		10.6		-	-	0.373		-	-	-	-	1.78		3.96		1.62		-	-	0.0915		-	-	7.45		0.358		-	-	-	-
Amino-2-nitrotoluene, 4-	mg/kg	0.4																																
Amino-4,6-dinitrotoluene, 2-	mg/kg	33.6	-	-	33.6		-	-	-	-	-	-	-	-	1.24		1.18		2.43		-	-	0.358		-	-	20.7		0.467		-	-	-	-
Dinitrobenzene, 1,3-	mg/kg	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	4600																																
Dinitrotoluene, 2,6-	mg/kg	5600																																
Dinitrotoluene, 3,4-	mg/kg	8.9																																
Dinitrotoluene, total	mg/kg	2708	275		356		-	-	3.14		0.17		-	-	-	-	0.549		0.645		0.188		-	-	0.133		-	-	-	-	-	-	-	-
Nitrobenzene	mg/kg	0.205	-	-	-	-	-	-	0.0778	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0713	J	-	-	-	-
Nitrotoluene, 2-	mg/kg	582	27.1		582		-	-	1.41		0.38		-	-	-	-	0.276		0.235		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 3-	mg/kg	59	5.43		59		-	-	0.476		-	-	-	-	-	-	0.823		0.335		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 4-	mg/kg	484	3.54		484		-	-	0.376		0.423		-	-	-	-	0.555		0.278		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	mg/kg	2.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.562		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	mg/kg	12000	21		0.817		-	-	0.213		-	-	-	-	3.99		7.89		8.57		-	-	0.0875	J	0.169		205		62.8		4.81		259	
Volatiles																																		
Acetone	mg/kg	4.4	0.0291		0.0437		0.0582		-	-	0.0221	J	0.114		0.0217		0.0314	J	0.051	J	0.0242		0.0127		-	-	0.0368	J	0.08	J	0.00713	J	-	-
Benzene	mg/kg	0.00285	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0026	J	-	-	-	-	0.00285	u	-	-
Butanone, 2-	mg/kg	0.0098	-	-	-	-	0.0098	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbon disulfide	mg/kg	0.00917	-	-	-	-	-	-	-	-	0.00917		0.00218	J	-	-	0.00185	J	0.00287	J	0.00324	J	-	-	-	-	-	-	0.00267	J	-	-	-	-
Methylene chloride	mg/kg	0.0913	0.00727	B	0.00264	B	0.00398	B	0.00714	B	0.00612	B	0.00376	B	0.0323	B	0.00878	B	0.00392	B	0.0805		0.00907	B	0.00611	B	0.00695	B	0.0629		0.00972	B	0.00327	B
Toluene	mg/kg	0.023	-	-	-	-	-	-	0.013	J	0.00196	J	-	-	-	-	-	-	-	-	-	-	-	-	0.0032	J	-	-	-	-	0.0049	J	-	-
Xylene, o-	mg/kg	0.0027	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Xylenes, m,p-	mg/kg	0.00787	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Semivolatiles																																		
Acenaphthylene	mg/kg	0.033	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(a)anthracene	mg/kg	0.295	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(a)pyrene	mg/kg	0.218	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0424	J	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	mg/kg	0.305	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(ghi)perylene	mg/kg	0.0981	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	mg/kg	0.158	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bis(2-ethylhexyl)phthalate	mg/kg	1.2	-	-	-	-	-	-	0.026	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0242	J	-	-	-	-	-	-
Chrysene	mg/kg	0.202	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Di-n-butyl phthalate	mg/kg	0.216	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	8912			30.2		-	-	0.558		-	-	-	-	-	-	-	-	0.831		-	-	-	-	-	-	0.165	J	0.48		-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	10274	61.8		5.01		-	-	0.208	J	-	-	-	-	-	-	-	-	0.248	J	-	-	-	-	-	-	0.058	J	0.0622	J	-	-	-	-
Fluoranthene	mg/kg	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-cd)pyrene	mg/kg	0.0996	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methylnaphthalene, 2-	mg/kg	1.15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Naphthalene	mg/kg	0.652	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phenanthrene	mg/kg	0.45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyrene	mg/kg	0.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polychlorinated biphenyls																																		
Aroclor 1260	mg/kg	69.8	5.55	J	0.113		0.133	J	0.0125	J	-	-	0.507	J	0.0352	J	0.0448	J	-	-	0.00862	J	-	-	-	-	-	-	0.346	J	-	-	-	-

TNTA - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Location Code:			TNTA-SO105				TNTA-SO111						TNTA-SO123		TNTA-SO128		TNTA-SO128				TNTA-SO196		TNTA-SO201				TNTA-SO225		TNTA-SO261				TNTA-SO261	
Sample No:			AA0440		AA0466		AA0441		AA0468		AA0469		AA0442		AA0445		AA0470		AA0471		AA0446		AA0472		AA0473		AA0480		AA0447		AA0474		AA0475	
Sample Date:			25-Sep-00		28-Sep-00		22-Sep-00		28-Sep-00		28-Sep-00		22-Sep-00		25-Sep-00		28-Sep-00		28-Sep-00		25-Sep-00		26-Sep-00		26-Sep-00		11-Oct-00		25-Sep-00		26-Sep-00		26-Sep-00	
Sample Depth (ft)			2 - 3		4 - 6		1 - 2		4 - 6		8 - 10		2 - 3		1.5 - 2.5		4 - 6		8 - 10		1 - 2		4 - 6		8 - 10		2 - 3		1.5 - 2.5		4 - 6		8 - 10	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals																																		
Aluminum	mg/kg	23500	1090	J	3170		5530	J	5670	J	6630	J	4660	J	2980	J	4490	J	4730	J	6820	J	7120	J	11900	J	11700		9000	J	10800	J	11700	J
Antimony	mg/kg	13	1.31	J	1.78	J	1.38	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.13	UJ
Arsenic	mg/kg	23.2	5.89		12.6		4.11	J	4.23		3.27		3.71	J	2.21	J	2.34		7.59		8.59	J	3.03		7.31		5.07		6.01	J	5.29		7.97	
Barium	mg/kg	124	109	J	66.6		33.5	J	26.6		23		24.6	J	19		23.8		14.5		27.8		26.5	J	15.9	J	68.7		67.3		33.6	J	20.3	J
Beryllium	mg/kg	0.796	0.166	J	0.372		0.226		0.346		0.398		0.179		0.16	J	0.269		0.305		0.45		0.438		0.646		0.759		0.671		0.704		0.641	
Cadmium	mg/kg	1.59	-	-	-	-	0.518	B	0.131	J	-	-	1.15		-	-	-	-	-	-	0.131	J	-	-	-	-	0.133	J	-	-	-	-	-	-
Calcium	mg/kg	146000	1700	J	1600		4080	J	3200		1770		13600	J	1260		1250		2240		5150		4060	J	56900	J	7120	J	57200		75800	J	65500	J
Chromium	mg/kg	53	3.09		7.01		10.8	J	8.4		9.31		7.52	J	5.51		6.29		7.23		19.9		9.62		22.7		19.3	J	14.3		20.4		22.2	
Cobalt	mg/kg	21.5	0.803	J	5.88		2.82		2.97		3.64		3.05		1.54		1.54		3.8		9.1		5.32		19		11.1		9.9		15.2		15.5	
Copper	mg/kg	489	7.11		26.5		18.4	J	5.52		4.9		8.26	J	5.92	J	5.82		8.14		8.3	J	5.28		13.4		9.23		14.3	J	17.6		13.2	
Iron	mg/kg	44800	6060		15000		10400		9140		10000		9280		7820		7420		10500		21900		10100		21800		19700		22000		28600		23000	
Lead	mg/kg	11900	1660	J	257		122	J	21.7		9.55		115	J	26.5	J	15.4		4.91	B	7.24	J	7.17	J	4.11	J	11.1	J	19.4	J	8.47	J	4.76	J
Magnesium	mg/kg	44400	235		721		1090	J	990		920		3350	J	598		695		1150		2040		1420		7820		3040	J	3320		5000		7500	
Manganese	mg/kg	7600	26.7		47.4		230	J	124		132		218	J	86.9	J	107		217		220	J	256		563		423		1370	J	873		703	
Mercury	mg/kg	0.134	0.049	B	0.067		0.077		-	-	0.022	J	0.049		-	-	0.021	J	-	-	-	-	0.027	B	-	-	0.078	J	0.022	J	-	-	-	-
Nickel	mg/kg	108	3.26		21.4		7.42		7.88		8.67		8.96		4.27		4.98		9.48		18.3		12		50.7		26.8		25.5		44.1		44.1	
Potassium	mg/kg	3660	678		1560		481		393		425		572		348		334		635		939		665		2770		1960	J	1700		2690		2940	
Selenium	mg/kg	2.05	1.15	J	0.97	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	B	-	-	-	-	-	-
Silver	mg/kg	0.704	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/kg	454	191	B	182	J	217	B	140	B	145	B	249	B	99.6	B	96.3	B	231	B	113	B	244	B	454		201	J	381	B	433		350	B
Thallium	mg/kg	2.38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	mg/kg	26.3	6.54		16.2		16.1		15.8		18.2		14.7		11.3		11.4		16.8		17.9		14.2		16.9		22.4		19.3		15.2		16.2	
Zinc	mg/kg	751	12.8		27.5		148	J	36.5		29		241	J	20.8		25.2		38.3		214		29.4		56.3		47.2	J	41.5		30.3		33.8	

			Location Code:	TNTA-SO263		TNTA-SO276		TNTA-SO279		TNTA-SO297		TNTA-SO303		TNTA-SO334		TNTA-SO399				TNTA-SO409	
			Sample No:	AA0448		AA0449		AA0450		AA0451		AA0452		AA0453		AA0478		AA0479		AA0481	
			Sample Date:	25-Sep-00		25-Sep-00		25-Sep-00		25-Sep-00		26-Sep-00		25-Sep-00		26-Sep-00		26-Sep-00		11-Oct-00	
			Sample Depth (ft)	2 - 3		1.5 - 2.5		2 - 3		1 - 2		2 - 3		1 - 2		4 - 6		8 - 9		0.5 - 1.5	
Parameter	Units	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																					
Amino-2,6-dinitrotoluene, 4-	mg/kg	16		0.599		-	-	-	-	4.22		-	-	-	-	-	-	-	-	0.739	
Amino-2-nitrotoluene, 4-	mg/kg	0.4																			
Amino-4,6-dinitrotoluene, 2-	mg/kg	33.6		0.878		-	-	-	-	4.83		-	-	-	-	-	-	-	-	0.59	
Dinitrobenzene, 1,3-	mg/kg	0.4		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	4600																			
Dinitrotoluene, 2,6-	mg/kg	5600																			
Dinitrotoluene, 3,4-	mg/kg	8.9																			
Dinitrotoluene, total	mg/kg	2708		0.114		0.411		199		7.36		-	-	-	-	0.252		1.54		-	-
Nitrobenzene	mg/kg	0.205		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	582		-	-	-	-	-	-	0.374		-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 3-	mg/kg	59		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 4-	mg/kg	484		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	mg/kg	2.5		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	mg/kg	12000		0.72		-	-	-	-	11.5		-	-	-	-	-	-	0.159		0.704	
Volatiles																					
Acetone	mg/kg	4.4		0.00949	J	0.188	J	0.0381	J	0.194	J	0.02		0.0159	J	-	-	-	-	0.0134	J
Benzene	mg/kg	0.00285		-	-	-	-	-	-	0.00244	J	-	-	-	-	-	-	-	-	-	-
Butanone, 2-	mg/kg	0.0098		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbon disulfide	mg/kg	0.00917		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methylene chloride	mg/kg	0.0913		0.0913		0.0738		0.00928	B	0.0272	B	0.0053	B	0.107	B	0.004	B	0.0564	J	0.00917	B
Toluene	mg/kg	0.023		0.0027	J	-	-	0.00229	J	0.00339	J	0.00209	J	-	-	0.004	J	0.00857	J	-	-
Xylene, o-	mg/kg	0.0027		-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0027	J	-	-
Xylenes, m,p-	mg/kg	0.00787		-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00787	J	-	-
Semivolatiles																					
Acenaphthylene	mg/kg	0.033		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(a)anthracene	mg/kg	0.295		-	-	-	-	-	-	0.0496	J	0.0386	J	0.117	J	-	-	-	-	-	-
Benzo(a)pyrene	mg/kg	0.218		-	-	-	-	-	-	0.0484	J	-	-	0.107	J	-	-	-	-	-	-
Benzo(b)fluoranthene	mg/kg	0.305		-	-	-	-	-	-	0.127	J	-	-	0.162	J	-	-	-	-	-	-
Benzo(ghi)perylene	mg/kg	0.0981		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	mg/kg	0.158		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bis(2-ethylhexyl)phthalate	mg/kg	1.2		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0355	J
Chrysene	mg/kg	0.202		-	-	-	-	-	-	0.107	J	-	-	0.109	J	-	-	-	-	-	-
Di-n-butyl phthalate	mg/kg	0.216		-	-	-	-	-	-	-	-	-	-	0.0729	J	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	8912		-	-	0.316	J	80.9		2.03		-	-	-	-	0.222	J			-	-
Dinitrotoluene, 2,6-	mg/kg	10274		-	-	0.0529	J	3201		0.694		-	-	-	-	-	-	0.342	J	-	-
Fluoranthene	mg/kg	0.3		-	-	-	-	-	-	-	-	-	-	0.176	J	-	-	-	-	-	-
Indeno(1,2,3-cd)pyrene	mg/kg	0.0996		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methylnaphthalene, 2-	mg/kg	1.15		-	-	-	-	-	-	0.0999	J	-	-	-	-	-	-	-	-	-	-
Naphthalene	mg/kg	0.652		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phenanthrene	mg/kg	0.45		-	-	-	-	-	-	0.0633	J	0.0516	J	0.0807	J	-	-	-	-	-	-
Pyrene	mg/kg	0.25		-	-	-	-	-	-	-	-	-	-	0.153	J	-	-	-	-	-	-
Polychlorinated biphenyls																					
Aroclor 1260	mg/kg	69.8		0.0174	J	0.0134	J	0.131	J	0.215		0.0486	J	0.014	J	-	-	-	-	1.34	J

	Location Code:		TNTA-SO263		TNTA-SO276		TNTA-SO279		TNTA-SO297		TNTA-SO303		TNTA-SO334		TNTA-SO399				TNTA-SO409	
	Sample No:		AA0448		AA0449		AA0450		AA0451		AA0452		AA0453		AA0478		AA0479		AA0481	
	Sample Date:		25-Sep-00		25-Sep-00		25-Sep-00		25-Sep-00		26-Sep-00		25-Sep-00		26-Sep-00		26-Sep-00		11-Oct-00	
	Sample Depth (ft)		2 - 3		1.5 - 2.5		2 - 3		1 - 2		2 - 3		1 - 2		4 - 6		8 - 9		0.5 - 1.5	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals																				
Aluminum	mg/kg	23500	6690	J	2130	J	4630	J	4660	J	5350	J	5890	J	3130	J	2760	J	5000	
Antimony	mg/kg	13	-	-	-	-	-	-	1.21	B	-	-	2.24	J	-	-	1.22	UJ	1.02	B
Arsenic	mg/kg	23.2	5.42	J	-	-	3.23	J	3.83	J	3.44		3.13	J	3.23		3.66		4.95	
Barium	mg/kg	124	26.9		11.1		29.4		22.2		20.5	J	23.7		9.08	J	9.88	J	29.8	
Beryllium	mg/kg	0.796	0.405		0.16	J	0.299		0.367		0.302		0.357		0.246		0.246		0.344	
Cadmium	mg/kg	1.59	0.103	J	-	-	0.695	J	0.579	J	-	-	0.686	J	-	-	0.103		0.719	
Calcium	mg/kg	146000	7330		31000		17400		125000		5990	J	14500		10600	J	32500	J	4610	J
Chromium	mg/kg	53	13.2		4.71		40.3		8.75		7.04		11.6		4.96		6.4		8.09	J
Cobalt	mg/kg	21.5	4.62		2.01		3.69		4.79		3.62		3		3.08		2.97		2.87	
Copper	mg/kg	489	20.5	J	2.06	J	19.9	J	35.9	J	5.34		80.5	J	5.59		5.86		10.2	
Iron	mg/kg	44800	14600		3910		9460		12300		8760		10600		7050		6710		11000	
Lead	mg/kg	11900	17.4	J	8.37	J	142	J	119	J	11.1	J	69.5	J	3.15	J	3.32	J	254	J
Magnesium	mg/kg	44400	2060		9140		6450		10400		1480		2070		2880		6690		1350	J
Manganese	mg/kg	7600	340	J	109	J	140	J	515	J	241		93.3	J	287		220		240	
Mercury	mg/kg	0.134	0.03	J	-	-	0.028	J	-	-	-	-	0.041		-	-	-	-	0.042	J
Nickel	mg/kg	108	12		5.69		14.4		15.9		9.18		9.14		8.95		8.02		8.88	
Potassium	mg/kg	3660	727		245		522		810		535		542		413		405		393	J
Selenium	mg/kg	2.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Silver	mg/kg	0.704	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/kg	454	346	B	196	B	178	B	230	B	156	B	249	B	178	B	294	B	181	J
Thallium	mg/kg	2.38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	mg/kg	26.3	18		9.06		13.4		12.8		11.9		16.3		9.65		9.51		13.8	
Zinc	mg/kg	751	109		15.1		140		255		25		348		20.9		30.7		178	J

"-" - Not detected.
ft - Feet.
MDC - Maximum detected concentration for the AOC ("B" qualified data excluded).
mg/kg - Milligrams per kilogram.

Validation Qualifiers (VQ)
B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.
J - The analyte was positively identified; the reported value is estimated.

Table 3-4

TNTA - Historical Groundwater Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Fomer Plum Brook Ordnance Works, Sandusky, Ohio

				Location Code:		MK-MW22						MK-MW23							
				Sample No:		5280		5820		5825	PB-TNTA-MK-MW22		5290		5830		5835		PB-TNTA-MK-MW23	
				Sample Date:		22-Oct-96		14-Nov-97		18-May-98	13-Dec-94		23-Oct-96		16-Nov-97		29-May-98		13-Dec-94	
Parameter	Units	RBSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives - Unfiltered																			
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	8.7	1.1		0.62		0.86		-	-	-	-	-	-	-	-	-	-
Amino-2-nitrotoluene, 4-	ug/L	NE	2.4							-	-							-	-
Amino-4,6-dinitrotoluene, 2-	ug/L	0.73	31							0.43								-	-
Amino-4-nitrotoluene, 2-	ug/L	NE	1.3							-	-							-	-
Dinitrobenzene, 1,3-	ug/L	0.37	1.7	0.26		-	-	-	-	0.75		-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	ug/L	0.099	11	0.24		0.2		0.35		1.9		-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	ug/L	0.099	3.6	0.87		0.53		1.2		1.1		0.44		-	-	-	-	-	-
Dinitrotoluene, 3,4-	ug/L	NE	2.2							-	-							-	-
Nitrobenzene	ug/L	0.34	2	0.91		-	-	0.26		-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	ug/L	0.049	0.33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 3-	ug/L	12.2	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	
Trinitrobenzene, 1,3,5-	ug/L	110	1.5	0.34	J	0.24		0.43		-	-	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	ug/L	1.83	10	0.99		0.74		1.7		1.6		-	-	-	-	-	-	-	-
Explosives - Filtered																			
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	21	0.63															
Dinitrotoluene, 2,4-	ug/L	0.099	0.22	0.22															
Dinitrotoluene, 2,6-	ug/L	0.099	0.69	0.69															
Nitrobenzene	ug/L	0.34	0.68	0.68															
Trinitrotoluene, 2,4,6-	ug/L	1.83	0.62	0.62															
Volatiles																			
Acetone	ug/L	548	68	-	-	-	-	-	-			-	-	68	J	-	-		
Benzene	ug/L	0.35	14	-	-	-	-	-	-			-	-	-	-	0.17	J		
Carbon disulfide	ug/L	104	160	-	-	-	-	-	-			-	-	0.37	J	-	-		
Chloroform	ug/L	0.17	NA	-	-	-	-	-	-			5	U	-	-	-	-		
Ethylbenzene	ug/L	134	130	-	-	-	-	-	-			-	-	-	-	-	-		
Methylene chloride	ug/L	4.3	4.2	-	-	-	-	0.52	B			-	-	0.27	B	4.2	B		
Toluene	ug/L	72	73	-	-	-	-	7.8				-	-	-	-	0.16	B		
Xylenes, total	ug/L	21	560	-	-	-	-	-	-			-	-	-	-	-	-		
Semivolatiles																			
Bis(2-ethylhexyl)phthalate	ug/L	4.8	890	-	-	-	-	-	-			-	-	-	-	890	D		
Dimethylphenol, 2,4-	ug/L	73	19	-	-	-	-	-	-			-	-	-	-	-	-		
Di-n-octyl phthalate	ug/L	146	9.3	-	-	-	-	-	-			-	-	9.3	J	-	-		
Methylnaphthalene, 2-	ug/L	12	11	-	-	-	-	-	-			-	-	-	-	-	-		
Methylphenol, 2-	ug/L	182	5.7	-	-	-	-	-	-			-	-	-	-	-	-		
Methylphenol, 4-	ug/L	18	7.3	-	-	-	-	-	-			-	-	-	-	-	-		
Naphthalene	ug/L	0.62	18	-	-	-	-	-	-			-	-	-	-	-	-		
Phenol	ug/L	1,095	21	-	-	-	-	-	-			-	-	-	-	-	-		

Table 3-4

TNTA - Historical Groundwater Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Fomer Plum Brook Ordnance Works, Sandusky, Ohio

			Location Code:	MK-MW22								MK-MW23							
			Sample No:	5280		5820		5825		PB-TNTA-MK-MW22		5290		5830		5835		PB-TNTA-MK-MW23	
			Sample Date:	22-Oct-96		14-Nov-97		18-May-98		13-Dec-94		23-Oct-96		16-Nov-97		29-May-98		13-Dec-94	
Parameter	Units	RBSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Unfiltered																			
Aluminum	ug/L	3,650	143000	2,040		7,790		6,200						27,300		143,000	J		
Antimony	ug/L	1.5	109	-	-	-	-	-	-	-	-			-	-	82		-	-
Arsenic	ug/L	0.045	113	-	-	-	-	-	-	-	-			59.8		113		-	-
Barium	ug/L	255	1290	-	-	-	-	-	-					-	-	232			
Beryllium	ug/L	7.3	6.9	-	-	-	-	-	-	-	-			-	-	6.9		-	-
Cadmium	ug/L	1.8	0.4	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Calcium	ug/L	NE	1610000	185,000		118,000	J	112,000						236,000		1,010,000	J		
Chromium	ug/L	11	258	-	-	16.6		13.7		-	-			57.1		258		-	-
Cobalt	ug/L	73	222	-	-	-	-	-	-					50.8		222			
Copper	ug/L	146	225	-	-	-	-	-	-	-	-			47.3		225		-	-
Iron	ug/L	1,095	304000	4,520		10,900		10,900	J					68,200		304,000			
Lead	ug/L	15	108	7.6		6.7		4.3		-	-			29.8		108		-	-
Magnesium	ug/L	NE	1050000	28,900		17,500		16,200						61,400		172,000			
Manganese	ug/L	88	7550	643		185		142		280				1,370		7,550		460	
Mercury	ug/L	1.1	1	-	-	-	-	-	-	-	-			-	-	0.25		-	-
Nickel	ug/L	73	628	-	-	-	-	-	-	-	-			125		628		47	
Potassium	ug/L	NE	211000	-	-	-	-	-	-					14,400		35,700			
Selenium	ug/L	18	4	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Sodium	ug/L	NE	4490000	10,900		7,100		5,720						60,200		60,000			
Vanadium	ug/L	3.7	244	-	-	-	-	-	-					75.2		244			
Zinc	ug/L	1,095	735	89		35.6		36.2	B	20				167		735		53	
Metals - Filtered																			
Aluminum	ug/L	3,650	999	-	-	-	-	-	-			-	-	-	-	-	-		
Antimony	ug/L	1.5	66.8	-	-	-	-	-	-	-	-	61.6	R	-	-	-	-	-	-
Arsenic	ug/L	0.045	13.8	-	-	-	-	-	-	-	-	10.4		13.8		-	-	-	-
Barium	ug/L	255	1160	-	-	-	-	-	-			-	-	-	-	-	-		
Calcium	ug/L	NE	1480000	129,000		127,000		114,000				135,000		140,000	J	152,000	J		
Chromium	ug/L	11	14.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Copper	ug/L	146	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iron	ug/L	1,095	19500	-	-	-	-	-	-			-	-	139	B	-	-		
Magnesium	ug/L	NE	1020000	21,800		17,900		17,700				50,400		49,900		57,100	J		
Manganese	ug/L	88	2580	269		149		114		190		327	R	265		134		240	
Mercury	ug/L	1.1	0.76	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	ug/L	73	66.3	-	-	-	-	-	-	-	-	66.3	R	-	-	-	-	30	
Potassium	ug/L	NE	189000	-	-	-	-	-	-			8,680	R	8,540		12,300			
Sodium	ug/L	NE	4140000	13,100		8,360		10,100				71,700	R	68,500		66,800			
Vanadium	ug/L	3.7	67.6	-	-	-	-	-	-			-	-	-	-	-	-		
Zinc	ug/L	1,095	45.4	24.8		-	-	-	-	-	-	20.6	R	-	-	23.6	B	20	

Table 3-4

TNTA - Historical Groundwater Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Fomer Plum Brook Ordnance Works, Sandusky, Ohio

			Location Code:	MK-MW22								MK-MW23							
			Sample No:	5280		5820		5825		PB-TNTA-MK-MW22		5290		5830		5835		PB-TNTA-MK-MW23	
			Sample Date:	22-Oct-96		14-Nov-97		18-May-98		13-Dec-94		23-Oct-96		16-Nov-97		29-May-98		13-Dec-94	
Parameter	Units	RBSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Water Quality Parameter																			
Alkalinity	ug/L	NE	550000			280,000		370,000											
Chloride	ug/L	NE	6900000			7,000		3,000											
Hardness	ug/L	NE	10000000			420,000		520,000											
Nitrate	ug/L	1000	500					-	-	300								300	
Sulfate	ug/L	NE	1200000			36,000		30,000											
Total dissolved solids	ug/L	NE	33000000			360,000		370,000											
Total organic carbon	ug/L	NE	21000			11,000		2,000								-	-		
Total suspended solids	ug/L	NE	400000			150,000		130,000											

Table 3-4

TNTA - Historical Groundwater Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Fomer Plum Brook Ordnance Works, Sandusky, Ohio

				MK-MW24										PB-BED-MW18							
Location Code:				5300		5840		5845		MK04MW24		PB-TNTA-MK-MW24		5210		5940		5945		PB-BED-MW18	
Sample No:				22-Oct-96		13-Nov-97		20-May-98		12-Jul-93		9-Dec-94		22-Oct-96		19-Nov-97		19-May-98		13-Dec-94	
Sample Date:																					
Parameter	Units	RBSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives - Unfiltered																					
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	8.7	-	-	-	-	-	-			-	-	4		-	-	-	-	-	-
Amino-2-nitrotoluene, 4-	ug/L	NE	2.4									-	-							-	-
Amino-4,6-dinitrotoluene, 2-	ug/L	0.73	31									-	-							-	-
Amino-4-nitrotoluene, 2-	ug/L	NE	1.3									-	-							-	-
Dinitrobenzene, 1,3-	ug/L	0.37	1.7	-	-	-	-	-	-	-	-			0.31		1		-	-	-	-
Dinitrotoluene, 2,4-	ug/L	0.099	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.49		-	-
Dinitrotoluene, 2,6-	ug/L	0.099	3.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.6		1.4	
Dinitrotoluene, 3,4-	ug/L	NE	2.2									-	-							2.2	
Nitrobenzene	ug/L	0.34	2	-	-	-	-	-	-	-	-	-	-	-	-	2		-	-	-	-
Nitrotoluene, 2-	ug/L	0.049	0.33	-	-	-	-	-	-	-	-	-	-	0.33	J	-	-	-	-	-	-
Nitrotoluene, 3-	ug/L	12.2	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	ug/L	110	1.5	-	-	-	-	-	-	-	-	-	-	-	-	1.5		-	-	-	-
Trinitrotoluene, 2,4,6-	ug/L	1.83	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Explosives - Filtered																					
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	21	-	-									21							
Dinitrotoluene, 2,4-	ug/L	0.099	0.22	-	-									-	-						
Dinitrotoluene, 2,6-	ug/L	0.099	0.69	-	-									-	-						
Nitrobenzene	ug/L	0.34	0.68	-	-									-	-						
Trinitrotoluene, 2,4,6-	ug/L	1.83	0.62	-	-									-	-						
Volatiles																					
Acetone	ug/L	548	68	-	-	-	-	-	-	-	-			-	-	-	-	34	J	-	-
Benzene	ug/L	0.35	14	-	-	-	-	-	-	-	-			7.9		11		5.7		14	
Carbon disulfide	ug/L	104	160	-	-	-	-	-	-	-	-			3.1	J	32		7.9		160	
Chloroform	ug/L	0.17	NA	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Ethylbenzene	ug/L	134	130	-	-	-	-	-	-	-	-			130		32		88		79	
Methylene chloride	ug/L	4.3	4.2	-	-	-	-	0.29	B	-	-			-	-	-	-	2.4	B	-	-
Toluene	ug/L	72	73	-	-	-	-	10		-	-			73		21		53		72	
Xylenes, total	ug/L	21	560	-	-	-	-	-	-	-	-			560		170		420		350	
Semivolatiles																					
Bis(2-ethylhexyl)phthalate	ug/L	4.8	890	-	-	-	-	-	-	22				-	-	3.5	J	16	B	-	-
Dimethylphenol, 2,4-	ug/L	73	19	-	-	-	-	-	-	-	-			16		5.1	J	11		19	
Di-n-octyl phthalate	ug/L	146	9.3	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Methylnaphthalene, 2-	ug/L	12	11	-	-	-	-	-	-	-	-			11		2.2	J	5	J	-	-
Methylphenol, 2-	ug/L	182	5.7	-	-	-	-	-	-	-	-			5.7	J	2.6	J	3.3	J	-	-
Methylphenol, 4-	ug/L	18	7.3	-	-	-	-	-	-	-	-			7.3	J	2.8	J	4	J	-	-
Naphthalene	ug/L	0.62	18	-	-	-	-	-	-	-	-			18		3.8	J	10		17	
Phenol	ug/L	1,095	21	-	-	-	-	-	-	-	-			-	-	21	J	-	-	-	-

Table 3-4

TNTA - Historical Groundwater Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Fomer Plum Brook Ordnance Works, Sandusky, Ohio

				MK-MW24										PB-BED-MW18							
Location Code:				5300		5840		5845		MK04MW24		PB-TNTA-MK-MW24		5210		5940		5945		PB-BED-MW18	
Sample No:				22-Oct-96		13-Nov-97		20-May-98		12-Jul-93		9-Dec-94		22-Oct-96		19-Nov-97		19-May-98		13-Dec-94	
Sample Date:																					
Parameter	Units	RBSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Unfiltered																					
Aluminum	ug/L	3,650	143000	1,210		6,620		242	J	26,000				317		283	J	-	-		
Antimony	ug/L	1.5	109	-	-	-	-	-	-	-	-	-	-	109		-	-	-	-	-	-
Arsenic	ug/L	0.045	113	-	-	-	-	-	-	21		-	-	-	-	-	-	-	-	-	-
Barium	ug/L	255	1290	-	-	-	-	-	-	184				1,290		893		942			
Beryllium	ug/L	7.3	6.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	ug/L	1.8	0.4	-	-	-	-	-	-	0.4		-	-	-	-	-	-	-	-	-	-
Calcium	ug/L	NE	1610000	629,000		641,000	J	612,000		-	-			1,610,000		809,000		1,370,000			
Chromium	ug/L	11	258	16.2		25.2		-	-	51.8		-	-	-	-	-	-	-	-	-	-
Cobalt	ug/L	73	222	-	-	-	-	-	-	26.5				-	-	-	-	-	-		
Copper	ug/L	146	225	-	-	-	-	-	-	35		-	-	-	-	-	-	-	-	36	
Iron	ug/L	1,095	304000	4,720		13,500		1,960		93,800				358		476	B	166			
Lead	ug/L	15	108	4		13.1		-	-	18		-	-	-	-	-	-	-	-	-	-
Magnesium	ug/L	NE	1050000	31,300		47,400		29,700		70,800				1,050,000		384,000		938,000			
Manganese	ug/L	88	7550	348		788		458		-	-	310		131		36.8		80.8		89	
Mercury	ug/L	1.1	1	-	-	-	-	-	-	-	-	-	-	0.24		1		-	-	-	-
Nickel	ug/L	73	628	-	-	-	-	-	-	115		-	-	-	-	-	-	-	-	-	-
Potassium	ug/L	NE	211000	-	-	5,640		-	-	12,700				211,000		148,000		155,000			
Selenium	ug/L	18	4	-	-	-	-	-	-	4		-	-	-	-	-	-	-	-	-	-
Sodium	ug/L	NE	4490000	5,930		8,130		5,530		11,300				4,490,000	R	2,190,000		3,530,000			
Vanadium	ug/L	3.7	244	68.2		60.9		52.3	B	51				-	-	-	-	-	-		
Zinc	ug/L	1,095	735	126		127		20	B	166		21		36.7		31		-	-	20	
Metals - Filtered																					
Aluminum	ug/L	3,650	999	-	-	-	-	-	-	999				-	-	-	-	-	-		
Antimony	ug/L	1.5	66.8	-	-	-	-	-	-	-	-	-	-	66.8	R	-	-	-	-	-	-
Arsenic	ug/L	0.045	13.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Barium	ug/L	255	1160	-	-	-	-	-	-	58				1,160	R	1,010		994			
Calcium	ug/L	NE	1480000	681,000		984,000		643,000		-	-			1,480,000		1,010,000		1,470,000			
Chromium	ug/L	11	14.2	13.3	R	14.2		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Copper	ug/L	146	23	-	-	-	-	-	-	23		-	-	-	-	-	-	-	-	-	-
Iron	ug/L	1,095	19500	1,400	R	2,920		1,440		1,180				-	-	-	-	-	-		
Magnesium	ug/L	NE	1020000	35,000		41,300		33,900		49,600				969,000		572,000		1,020,000			
Manganese	ug/L	88	2580	377	R	562		454		-	-	220		98.6	R	35.9		80.9		80	
Mercury	ug/L	1.1	0.76	-	-	0.76		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	ug/L	73	66.3	-	-	-	-	-	-	34		-	-	-	-	-	-	-	-	-	-
Potassium	ug/L	NE	189000	-	-	-	-	-	-	7,970				189,000	R	172,000		163,000			
Sodium	ug/L	NE	4140000	6,520	R	8,250		6,820		9,970				4,140,000	R	3,010,000		3,820,000			
Vanadium	ug/L	3.7	67.6	67.6		53		57.3	B	-	-			-	-	-	-	-	-		
Zinc	ug/L	1,095	45.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	23.5	B	-	-

Table 3-4

TNTA - Historical Groundwater Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Fomer Plum Brook Ordnance Works, Sandusky, Ohio

				Location Code:		MK-MW24								PB-BED-MW18							
				Sample No:		5300		5840		5845		MK04MW24		PB-TNTA-MK-MW24		5210		5940		5945		PB-BED-MW18	
				Sample Date:		22-Oct-96		13-Nov-97		20-May-98		12-Jul-93		9-Dec-94		22-Oct-96		19-Nov-97		19-May-98		13-Dec-94	
Parameter	Units	RBSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Water Quality Parameter																							
Alkalinity	ug/L	NE	550000			370,000		370,000										120,000		550,000			
Chloride	ug/L	NE	6900000			6,000		7,000										6,900,000		1,200,000			
Hardness	ug/L	NE	10000000			1,900,000		1,600,000										4,000,000		10,000,000			
Nitrate	ug/L	1000	500					-	-					500						-	-	200	
Sulfate	ug/L	NE	1200000			1,200,000		1,100,000										16,000		18,000			
Total dissolved solids	ug/L	NE	33000000			2,400,000		2,000,000										12,000,000		33,000,000			
Total organic carbon	ug/L	NE	21000			21,000		9,000										6,500		3,000			
Total suspended solids	ug/L	NE	400000			400,000		7,000										61,000		100,000			

Table 3-4

TNTA - Historical Groundwater Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Fomer Plum Brook Ordnance Works, Sandusky, Ohio

				PB-TNTA-MW10								PB-TNTA-MW11								PB-TNTA-MW23	
Location Code:																					
Sample No:				5050		5610		5615		PB-TNTA-DM-MW10		5060		5620		5625		PB-TNTA-DM-MW11		PB-TNTA-DM-MW23	
Sample Date:				27-Sep-96		18-Nov-97		29-May-98		12-Dec-94		27-Sep-96		18-Nov-97		29-May-98		12-Dec-94		12-Dec-94	
Parameter	Units	RBSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives - Unfiltered																					
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	8.7	-	-	-	-	-	-	8.7		-	-	-	-	-	-	-	-	7.9	
Amino-2-nitrotoluene, 4-	ug/L	NE	2.4							2.4								-	-	2.2	
Amino-4,6-dinitrotoluene, 2-	ug/L	0.73	31							31								-	-	29	
Amino-4-nitrotoluene, 2-	ug/L	NE	1.3							1.3								-	-	1.3	
Dinitrobenzene, 1,3-	ug/L	0.37	1.7	-	-	-	-	-	-	1.7		-	-	-	-	-	-	0.2		1.5	
Dinitrotoluene, 2,4-	ug/L	0.099	11	-	-	-	-	-	-	11		-	-	-	-	-	-	0.2		10	
Dinitrotoluene, 2,6-	ug/L	0.099	3.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.2		-	-
Dinitrotoluene, 3,4-	ug/L	NE	2.2							-	-							-	-	0.3	
Nitrobenzene	ug/L	0.34	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	ug/L	0.049	0.33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 3-	ug/L	12.2	13	1.2	J	-	-	-	-	-	-	-	-	-	-	-	-	1.9		-	-
Trinitrobenzene, 1,3,5-	ug/L	110	1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5	
Trinitrotoluene, 2,4,6-	ug/L	1.83	10	-	-	-	-	-	-	10		-	-	-	-	-	-	-	-	10	
Explosives - Filtered																					
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	21	-	-							-	-								
Dinitrotoluene, 2,4-	ug/L	0.099	0.22	-	-							-	-								
Dinitrotoluene, 2,6-	ug/L	0.099	0.69	-	-							-	-								
Nitrobenzene	ug/L	0.34	0.68	-	-							-	-								
Trinitrotoluene, 2,4,6-	ug/L	1.83	0.62	-	-							-	-								
Volatiles																					
Acetone	ug/L	548	68	23	J	35	J	7.6	J			-	-	-	-	-	-				
Benzene	ug/L	0.35	14	-	-	-	-	-	-			-	-	-	-	-	-				
Carbon disulfide	ug/L	104	160	-	-	-	-	-	-			-	-	-	-	-	-				
Chloroform	ug/L	0.17	NA	5	U	-	-	-	-			-	-	-	-	-	-				
Ethylbenzene	ug/L	134	130	-	-	-	-	-	-			-	-	-	-	-	-				
Methylene chloride	ug/L	4.3	4.2	-	-	-	-	2.1	B			-	-	-	-	0.95	B				
Toluene	ug/L	72	73	-	-	-	-	0.25	B			-	-	-	-	0.26	B				
Xylenes, total	ug/L	21	560	-	-	-	-	-	-			-	-	-	-	-	-				
Semivolatiles																					
Bis(2-ethylhexyl)phthalate	ug/L	4.8	890	-	-	-	-	-	-			-	-	-	-	-	-				
Dimethylphenol, 2,4-	ug/L	73	19	-	-	-	-	-	-			-	-	-	-	-	-				
Di-n-octyl phthalate	ug/L	146	9.3	-	-	-	-	-	-			-	-	-	-	-	-				
Methylnaphthalene, 2-	ug/L	12	11	-	-	-	-	-	-			-	-	-	-	-	-				
Methylphenol, 2-	ug/L	182	5.7	-	-	-	-	-	-			-	-	-	-	-	-				
Methylphenol, 4-	ug/L	18	7.3	-	-	-	-	-	-			-	-	-	-	-	-				
Naphthalene	ug/L	0.62	18	-	-	-	-	-	-			-	-	-	-	-	-				
Phenol	ug/L	1,095	21	-	-	-	-	-	-			-	-	-	-	-	-				

Table 3-4

TNTA - Historical Groundwater Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Fomer Plum Brook Ordnance Works, Sandusky, Ohio

				Location Code:	PB-TNTA-MW10							PB-TNTA-MW11								PB-TNTA-MW23	
				Sample No:	5050		5610		5615		PB-TNTA-DM-MW10	5060		5620		5625		PB-TNTA-DM-MW11		PB-TNTA-DM-MW23	
				Sample Date:	27-Sep-96		18-Nov-97		29-May-98		12-Dec-94	27-Sep-96		18-Nov-97		29-May-98		12-Dec-94		12-Dec-94	
Parameter	Units	RBSC	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Unfiltered																						
Aluminum	ug/L	3,650	143000		-	-	877	J	2,280	J			1,920		3,170	J	2,990	J				
Antimony	ug/L	1.5	109		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	ug/L	0.045	113		12.2		12.2		14.5		-	-	12.5		10.5		-	-	10		10	
Barium	ug/L	255	1290		229		373		-	-			-	-	-	-	-	-				
Beryllium	ug/L	7.3	6.9		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	ug/L	1.8	0.4		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	ug/L	NE	1610000		250,000		186,000		136,000	J			157,000		180,000		162,000	J				
Chromium	ug/L	11	258		-	-	-	-	-	-	-	-	17.5		15.6		12.2		29		-	-
Cobalt	ug/L	73	222		-	-	-	-	-	-			-	-	-	-	-	-				
Copper	ug/L	146	225		33.1		-	-	-	-	-	-	-	-	-	-	-	-	21		-	-
Iron	ug/L	1,095	304000		26,200		18,200		18,700				11,500		13,300		6,610					
Lead	ug/L	15	108		-	-	-	-	5.6		7		12.9		10.4		3.2		14		7	
Magnesium	ug/L	NE	1050000		66,400		52,900		46,900				64,100		63,000		58,700					
Manganese	ug/L	88	7550		2,740		1,530		1,250		980		457		1,030		444		1,300		880	
Mercury	ug/L	1.1	1		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	ug/L	73	628		-	-	-	-	-	-	-	-	-	-	-	-	-	-	46		-	-
Potassium	ug/L	NE	211000		6,290		-	-	7,500				19,400		17,400		16,500					
Selenium	ug/L	18	4		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	ug/L	NE	4490000		41,600		39,300		52,100				101,000		91,400		90,500					
Vanadium	ug/L	3.7	244		-	-	-	-	-	-			-	-	-	-	-	-				
Zinc	ug/L	1,095	735		36		27		48.1	B	110		79.1		47.1		37.5	B	74		34	
Metals - Filtered																						
Aluminum	ug/L	3,650	999		-	-	-	-	-	-			-	-	-	-	-	-				
Antimony	ug/L	1.5	66.8		-	-	-	-	-	-	-	-	-	-	-	-	-	-	5		-	-
Arsenic	ug/L	0.045	13.8		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Barium	ug/L	255	1160		212		338		-	-			-	-	-	-	-	-				
Calcium	ug/L	NE	1480000		238,000		191,000		131,000	J			203,000		167,000		183,000	J				
Chromium	ug/L	11	14.2		10		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Copper	ug/L	146	23		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iron	ug/L	1,095	19500		19,500		7,610		9,330				-	-	-	-	-	-				
Magnesium	ug/L	NE	1020000		64,900		54,800		48,100	J			87,300		62,900		67,600	J				
Manganese	ug/L	88	2580		2,580		1,440		1,370		960		526		865		355		710		830	
Mercury	ug/L	1.1	0.76		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	ug/L	73	66.3		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potassium	ug/L	NE	189000		6,520		-	-	7,710				27,000		17,800		18,400					
Sodium	ug/L	NE	4140000		41,900		41,000		55,900				142,000		96,500		107,000					
Vanadium	ug/L	3.7	67.6		-	-	-	-	-	-			-	-	-	-	-	-				
Zinc	ug/L	1,095	45.4		26.3		25		22.7	B	-	-	-	-	45.4		-	-	-	-	-	-

Table 3-4

TNTA - Historical Groundwater Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Fomer Plum Brook Ordnance Works, Sandusky, Ohio

			Location Code:	PB-TNTA-MW10								PB-TNTA-MW11								PB-TNTA-MW23	
			Sample No:	5050		5610		5615		PB-TNTA-DM-MW10		5060		5620		5625		PB-TNTA-DM-MW11		PB-TNTA-DM-MW23	
			Sample Date:	27-Sep-96		18-Nov-97		29-May-98		12-Dec-94		27-Sep-96		18-Nov-97		29-May-98		12-Dec-94		12-Dec-94	
Parameter	Units	RBSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Water Quality Parameter																					
Alkalinity	ug/L	NE	550000			490,000		410,000						450,000		460,000					
Chloride	ug/L	NE	6900000			47,000		100,000						140,000		180,000					
Hardness	ug/L	NE	10000000			1,100,000		730,000						940,000		680,000					
Nitrate	ug/L	1000	500					-	-	300						-	-	200		300	
Sulfate	ug/L	NE	1200000			160,000		100,000						150,000		93,000					
Total dissolved solids	ug/L	NE	33000000			780,000		760,000						1,000,000		1,000,000					
Total organic carbon	ug/L	NE	21000			4,200		2,000						4,500		3,000					
Total suspended solids	ug/L	NE	400000			7,000		-	-					140,000		7,000					

Table 3-4

TNTA - Historical Groundwater Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Fomer Plum Brook Ordnance Works, Sandusky, Ohio

Shaded cell indicates value is greater than the RBSC.
BSC - Background screening concentration.
MDC - Maximum detected concentration for the AOC ("B" qualified data not included).
RBSC - Values reflect an incremental lifetime cancer risk (ILCR) of 1E-6 or a noncancer hazard quotient (HQ) of 0.1. For chemicals that exhibit both cancer and noncancer effects, whichever type of effect results in a lower concentration (using an ILCR of 1E-6 and an HQ of 0.1), that concentration is selected as the RBSC.
"-" - Not detected.
NA - Not applicable; detection is the result of blank contamination.
NE - Not established (RBSCs), not evaluated (BSCs).
NTU - Nephelometric turbidity unit.
µg/L - Micrograms per liter.

Validation Qualifiers (VQ)
B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.
J - The analyte was positively identified; the reported value is estimated.
R - Rejected
U - Not detected due to blank contamination

Table 3-5

TNTB - Historical Surface Water Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

			Location Code:		MK-PMU2-SW-SD07		MK-PMU2-SW-SD08		TNTB-SW01		TNTB-SW02	
			Sample Number:		MK02SW07		MK02SW08		12000		12010	
			Sample Date:		5-Jul-93		5-Jul-93		4-Nov-98		4-Nov-98	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Volatiles												
Acetone	ug/L	NA	-	-	-	-	13	B	4.7	B		
Butanone, 2-	ug/L	1.2	-	-	-	-	1.2	J	-	-		
Carbon disulfide	ug/L	1.2	-	-	-	-	1.2		-	-		
Dichloroethane, 1,1-	ug/L	0.51	-	-	-	-	-	-	0.51	J		
Toluene	ug/L	3.4	-	-	-	-	3.4		0.47	B		
Semivolatiles												
Phenol	ug/L	NA	-	-	-	-	2.2	B	4.8	B		
Metals - Unfiltered												
Aluminum	ug/L	14900	891		2000		14900	J	969	J		
Arsenic	ug/L	30.9	21		8	B	21.1		30.9	J		
Barium	ug/L	NA	74.2	B	99.4	B	-	-	-	-		
Calcium	ug/L	140000	95700		8400	B	140000		126000			
Chromium	ug/L	18.8	-	-	-	-	18.8		11.5	J		
Copper	ug/L	34.2	10.5	B	-	-	34.2		-	-		
Iron	ug/L	167000	48400		3920		35000		167000	J		
Lead	ug/L	20.5	4		-	-	20.5		7.8	J		
Magnesium	ug/L	34200	25500		26000		34200		23900	J		
Manganese	ug/L	1960	1930		1960		793		1440	J		
Nickel	ug/L	43.1	32.2	B	36.9	B	43.1		-	-		
Potassium	ug/L	16200	3450	B	8150		16200		-	-		
Selenium	ug/L	6	-	-	-	-	-	-	6	J		
Sodium	ug/L	20600	16900		14600		20600		17600			
Zinc	ug/L	58.8	34.5		21.2		58.8		57.8	J		
Metals - Filtered												
Barium	ug/L	NA	38.7	B	68.2	B	-	-	-	-		
Calcium	ug/L	132000	93600		76900		132000		124000			
Iron	ug/L	683	-	-	80	B	267		683	J		
Magnesium	ug/L	31900	26400		26700		31900		24400			
Manganese	ug/L	2020	1860		2020		555		855			
Potassium	ug/L	13300	3410	B	8110		13300		-	-		
Sodium	ug/L	20700	16900		14800		20700		18500			

"-" - Not detected.
MDC - Maximum detected concentration for the AOC ("B" qualified data not included).
NA - Not applicable; detection is the result of blank contamination.
µg/L - Micrograms per liter.

Validation Qualifiers (VQ)
B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.
J - The analyte was positively identified; the reported value is estimated.

Table 3-6

TNTB - Historical Sediment Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

	Location Code:		MK-PMU2-SW-SD07		MK-PMU2-SW-SD08		TNTB-SD01		TNTB-SD02		TNTB-SD03		TNTB-SD04		TNTB-SD05	
	Sample No:		MK02SD07		MK02SD08		11000		11010		11020		11030		11040	
	Sample Date:		5-Jul-93		9-Jul-93		4-Nov-98		4-Nov-98		4-Nov-98		4-Nov-98		4-Nov-98	
	Sample Purpose:		REG		REG		REG		REG		REG		REG		REG	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.56					-	-	0.56		-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	mg/kg	25	25		-	-	-	-	0.96		-	-	-	-	-	-
Volatiles																
Acetone	mg/kg	0.27	0.053		0.021		0.27	J	0.061	J	0.24	J	-	-	0.048	J
Bromomethane	mg/kg	0.012	-	-	-	-	-	-	-	-	-	-	0.012	B	-	-
Butanone, 2-	mg/kg	0.062	0.01	J	-	-	0.062	J	0.012	J	0.047	J	-	-	0.0072	J
Carbon disulfide	mg/kg	0.0025	-	-	-	-	-	-	0.0025	J	-	-	-	-	-	-
Dichloroethane, 1,1-	mg/kg	0.002	0.002	J	-	-	-	-	-	-	-	-	-	-	-	-
Methylene chloride	mg/kg	0.001	0.001	J	-	-	0.016	B	0.0084	B	0.028	B	0.029	B	0.0095	B
Toluene	mg/kg	0.001	-	-	0.001	J	-	-	-	-	-	-	-	-	-	-
Semivolatiles																
Benzo(a)anthracene	mg/kg	0.06			0.06	J	-	-	-	-	-	-	-	-	-	-
Benzo(a)pyrene	mg/kg	0.047			0.046	J	-	-	-	-	-	-	-	-	0.047	J
Benzo(b)fluoranthene	mg/kg	0.066			0.066	J	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	mg/kg	0.028			0.028	J	-	-	-	-	-	-	-	-	-	-
Bis(2-ethylhexyl)phthalate	mg/kg	0.061			0.061	J	-	-	-	-	-	-	-	-	0.1	B
Chrysene	mg/kg	0.049			0.049	J	-	-	-	-	-	-	-	-	-	-
Fluoranthene	mg/kg	0.1			0.1	J	-	-	-	-	-	-	-	-	0.082	J
Methylnaphthalene, 2-	mg/kg	0.38			-	-	-	-	0.38	J	-	-	-	-	-	-
Naphthalene	mg/kg	0.078			-	-	-	-	0.078	J	-	-	-	-	-	-
Phenanthrene	mg/kg	0.17			0.026	J	-	-	0.17	J	-	-	-	-	-	-
Pyrene	mg/kg	0.08			0.08	J	-	-	-	-	-	-	-	-	0.059	J

Table 3-6

TNTB - Historical Sediment Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

	Location Code:		MK-PMU2-SW-SD07		MK-PMU2-SW-SD08		TNTB-SD01		TNTB-SD02		TNTB-SD03		TNTB-SD04		TNTB-SD05	
	Sample No:		MK02SD07		MK02SD08		11000		11010		11020		11030		11040	
	Sample Date:		5-Jul-93		9-Jul-93		4-Nov-98		4-Nov-98		4-Nov-98		4-Nov-98		4-Nov-98	
	Sample Purpose:		REG		REG		REG		REG		REG		REG		REG	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals																
Aluminum	mg/kg	20000	-	-	8650		10200		4210		20000		19500		10700	
Arsenic	mg/kg	32.5	29.3		12.6		15.9	J	17.4	J	26.4	J	19.2	J	32.5	J
Barium	mg/kg	285	56.5		285		91.7		57.4		174		116		71.1	
Beryllium	mg/kg	6.9	-	-	0.84		-	-	-	-	6.9		6.9		1.4	
Cadmium	mg/kg	0.96	0.5		0.96		-	-	-	-	-	-	-	-	-	-
Calcium	mg/kg	11200	5740		11200		3650		1580		6290		10200		2240	
Chromium	mg/kg	24.9	13.6		18.1		14.4		11.3		24.9		19.1		15.8	
Cobalt	mg/kg	137	54.2		47.1		-	-	-	-	137		74.2		-	-
Copper	mg/kg	66	46		23.6		43.5		40.2		58.9		54.3		66	
Iron	mg/kg	196000	59500		44700		28800		26400		175000		196000		42800	
Lead	mg/kg	27.5	27.5		24.7		22.7	J	15.4	J	24.8	J	16.4	J	25.8	J
Magnesium	mg/kg	4330	-	-	4330		-	-	-	-	-	-	-	-	1350	
Manganese	mg/kg	3450	-	-	3450		58.1		89.2		2060		542		104	
Mercury	mg/kg	0.03	-	-	0.03		-	-	-	-	-	-	-	-	-	-
Nickel	mg/kg	178	110		136		31.2		15.9		165		178		36.4	
Potassium	mg/kg	3320	1680		2420		1710		1450		-	-	3320		1810	
Selenium	mg/kg	4	-	-	-	-	-	-	0.86	J	3.4	J	4	J	1.8	J
Sodium	mg/kg	335	335		237		-	-	-	-	-	-	-	-	-	-
Vanadium	mg/kg	31.8	-	-	31.8		-	-	-	-	-	-	-	-	-	-
Zinc	mg/kg	340	-	-	174		31.7		31.3		313		340		90.2	

MDC - Maximum detected concentration for the AOC ("B" qualified data not included).
mg/kg - Milligrams per kilogram.
REG - Regular.

Validation Qualifiers (VQ)
B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.
J - The analyte was positively identified; the reported value is estimated.

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	MK-MW16		MK-MW17		MK-PMU2-SB10		MK-PMU2-SS13		MK-PMU2-SS14		PB-TNTB-S1				PB-TNTB-S10	
				Sample No:	MK02SB08		MK02SB09		MK02SB10		MK02SS13		MK02SS14		PB-TNTB-S1-0_0-1_5		PB-TNTB-S1-1_5-3_0		PB-TNTB-S10-1_5-2_5	
				Sample Date:	1-Jul-93		5-Jul-93		5-Jul-93		9-Jul-93		9-Jul-93		14-Oct-94		14-Oct-94		15-Oct-94	
				Sample Depth:	0 - 2 Ft		0 - 2 Ft		0 - 2 Ft		0 - 2 Ft		0 - 2 Ft		0 - 1.5 Ft		1.5 - 3 Ft		1.5 - 2.5 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45												0.3		0.4		0.8	
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93												0.5		0.8		1.6	
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-					0.5		0.4		-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	0.06		-	-					-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82		-	-	-	-	-	-					-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		-	-	12		-	-					6.9		2.3		0.9	
PCBs																				
Aroclor 1254	mg/kg	0.16	0.53																	
Aroclor 1260	mg/kg	2.87	15																	
Semivolatiles																				
Benzo(a)anthracene	mg/kg	5.43	2.4		-	-	-	-	-	-	-	-	-	-						
Benzo(a)pyrene	mg/kg	0.54	2		-	-	-	-	-	-	-	-	-	-						
Benzo(b)fluoranthene	mg/kg	5.43	1.8		0.032	J	-	-	-	-	-	-	-	-						
Dibenz(a,h)anthracene	mg/kg	0.65	0.55		-	-	-	-	-	-	-	-	-	-						
Dinitrotoluene, 2,4-	mg/kg	7.5	110		-	-	-	-	-	-	-	-	-	-						
Dinitrotoluene, 2,6-	mg/kg	2.75	68		-	-	-	-	-	-	-	-	-	-						
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1		-	-	-	-	-	-	-	-	-	-						

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	PB-TNTB-S11		PB-TNTB-S12		PB-TNTB-S13		PB-TNTB-S14		PB-TNTB-S15		PB-TNTB-S16		PB-TNTB-S17	
				Sample No:	PB-TNTB-S11-2_5-3_5		PB-TNTB-S12-1_0-2_0		PB-TNTB-S13-1_0-2_0		PB-TNTB-S14-0_0-2_0		PB-TNTB-S15-0_0-2_0		PB-TNTB-S16-0_0-2_0		PB-TNTB-S17-0_0-1_5	
				Sample Date:	15-Oct-94		15-Oct-94		15-Oct-94		15-Oct-94		15-Oct-94		16-Oct-94		15-Oct-94	
				Sample Depth:	2.5 - 3.5 Ft		1 - 2 Ft		1 - 2 Ft		0 - 2 Ft		0 - 2 Ft		0 - 2 Ft		0 - 1.5 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																		
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		1.3		-	-	-	-	-	-	-	-	-	-	3	
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		3.8		-	-	-	-	-	-	-	-	-	-	2	
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-	0.9	
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	1.3	
Nitrotoluene, 2-	mg/kg	74	82		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		2.2		-	-	-	-	-	-	-	-	-	-	390	
PCBs																		
Aroclor 1254	mg/kg	0.16	0.53															
Aroclor 1260	mg/kg	2.87	15															
Semivolatiles																		
Benzo(a)anthracene	mg/kg	5.43	2.4															
Benzo(a)pyrene	mg/kg	0.54	2															
Benzo(b)fluoranthene	mg/kg	5.43	1.8															
Dibenz(a,h)anthracene	mg/kg	0.65	0.55															
Dinitrotoluene, 2,4-	mg/kg	7.5	110															
Dinitrotoluene, 2,6-	mg/kg	2.75	68															
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1															

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	PB-TNTB-S18		PB-TNTB-S19		PB-TNTB-S2				PB-TNTB-S20		PB-TNTB-S21		PB-TNTB-S22	
				Sample No:	PB-TNTB-S18-0_05-1_5		PB-TNTB-S19-0_5-2_0		PB-TNTB-S2-0_0-1_0		PB-TNTB-S2-1_0-2_5		PB-TNTB-S20-0_5-1_5		PB-TNTB-S21-0_0-2_0		PB-TNTB-S22-0_0-2_0	
				Sample Date:	16-Oct-94		16-Oct-94		19-Oct-94		19-Oct-94		16-Oct-94		16-Oct-94		16-Oct-94	
				Sample Depth:	.5 - 1.5 Ft		.5 - 2 Ft		0 - 1 Ft		1 - 2.5 Ft		.5 - 1.5 Ft		0 - 2 Ft		0 - 2 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																		
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		11		-	-	0.3		-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	-	-	1		0.6		-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		150		-	-	0.8		0.4		-	-	-	-	0.4	
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		170		-	-	-	-	-	-	-	-	-	-	0.9	
Nitrotoluene, 2-	mg/kg	74	82		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		20,000		4.2		1.6		1.2		0.4		0.3		-	-
PCBs																		
Aroclor 1254	mg/kg	0.16	0.53															
Aroclor 1260	mg/kg	2.87	15															
Semivolatiles																		
Benzo(a)anthracene	mg/kg	5.43	2.4															
Benzo(a)pyrene	mg/kg	0.54	2															
Benzo(b)fluoranthene	mg/kg	5.43	1.8															
Dibenz(a,h)anthracene	mg/kg	0.65	0.55															
Dinitrotoluene, 2,4-	mg/kg	7.5	110															
Dinitrotoluene, 2,6-	mg/kg	2.75	68															
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1															

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	PB-TNTB-S23		PB-TNTB-S24		PB-TNTB-S24		PB-TNTB-S25		PB-TNTB-S26		PB-TNTB-S27		PB-TNTB-S28	
				Sample No:	PB-TNTB-S23-0_0-2_0		PB-TNTB-S24-0_0-1_5		PB-TNTB-S24-1_5-3_0		PB-TNTB-S25-0_0-1_0		PB-TNTB-S26-0_0-1_5		PB-TNTB-S27-2_5-3_5		PB-TNTB-S28-0_5-1_5	
				Sample Date:	16-Oct-94		16-Oct-94		16-Oct-94		16-Oct-94		16-Oct-94		16-Oct-94		16-Oct-94	
				Sample Depth:	0 - 2 Ft		0 - 1.5 Ft		1.5 - 3 Ft		0 - 1 Ft		0 - 1.5 Ft		2.5 - 3.5 Ft		.5 - 1.5 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																		
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		0.4		-	-	-	-	-	-	-	-	1.1		-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	-	-	-	-	1.8		-	-	3.3		2.5	
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		1.1		1,600		75		11,000		7,700		-	-	810	
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		2.2		-	-	0.9		12,000		8,300		-	-	230	
Nitrotoluene, 2-	mg/kg	74	82		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		0.3		0.8		-	-	0.7		-	-	1.8		29,000	
PCBs																		
Aroclor 1254	mg/kg	0.16	0.53															
Aroclor 1260	mg/kg	2.87	15															
Semivolatiles																		
Benzo(a)anthracene	mg/kg	5.43	2.4															
Benzo(a)pyrene	mg/kg	0.54	2															
Benzo(b)fluoranthene	mg/kg	5.43	1.8															
Dibenz(a,h)anthracene	mg/kg	0.65	0.55															
Dinitrotoluene, 2,4-	mg/kg	7.5	110															
Dinitrotoluene, 2,6-	mg/kg	2.75	68															
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1															

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	PB-TNTB-S29		PB-TNTB-S3				PB-TNTB-S4				PB-TNTB-S5			
				Sample No:	PB-TNTB-S29-0_0-2_0		PB-TNTB-S3-0_0-1_0		PB-TNTB-S3-1_0-2_0		PB-TNTB-S4-0_0-1_0		PB-TNTB-S4-1_0-1_5		PB-TNTB-S5-1_0-2_0		PB-TNTB-S5-2_5-3_0	
				Sample Date:	16-Oct-94		19-Oct-94		19-Oct-94		19-Oct-94		19-Oct-94		15-Oct-94		15-Oct-94	
				Sample Depth:	0 - 2 Ft		1 - 2.5 Ft		1 - 2 Ft		0 - 1 Ft		1 - 1.5 Ft		1 - 2 Ft		2.5 - 3 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																		
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	1		0.7		0.5		1.2		0.6		-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	2.4		2.4		2.4		4.1		1.5		-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	0.3		0.6		3.2		4.5		-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	0.3		0.3		0.5		-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		-	-	1.4		2.7		5		8.8		1.5		-	-
PCBs																		
Aroclor 1254	mg/kg	0.16	0.53															
Aroclor 1260	mg/kg	2.87	15															
Semivolatiles																		
Benzo(a)anthracene	mg/kg	5.43	2.4															
Benzo(a)pyrene	mg/kg	0.54	2															
Benzo(b)fluoranthene	mg/kg	5.43	1.8															
Dibenz(a,h)anthracene	mg/kg	0.65	0.55															
Dinitrotoluene, 2,4-	mg/kg	7.5	110															
Dinitrotoluene, 2,6-	mg/kg	2.75	68															
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1															

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	PB-TNTB-S6				PB-TNTB-S7				PB-TNTB-S8			
				Sample No:	PB-TNTB-S6-1_0-2_0		PB-TNTB-S6-2_5-3_5		PB-TNTB-S7-1_0-2_0		PB-TNTB-S7-2_5-3_5		PB-TNTB-S8-2_5-3_0		PB-TNTB-S9-1_5-2_7	
				Sample Date:	15-Oct-94		15-Oct-94		15-Oct-94		15-Oct-94		15-Oct-94		15-Oct-94	
				Sample Depth:	1 - 2 Ft		2.5 - 3.5 Ft		1 - 2 Ft		2.5 - 3.5 Ft		2.5 - 3 Ft		1.5 - 2.7 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		0.4		7.7		0.4		-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		0.4		37		0.5		30		-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	4.9		-	-	18		-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	14		-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82		-	-	-	-	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		1.2		51		1.9		910		-	-	-	-
PCBs																
Aroclor 1254	mg/kg	0.16	0.53													
Aroclor 1260	mg/kg	2.87	15													
Semivolatiles																
Benzo(a)anthracene	mg/kg	5.43	2.4													
Benzo(a)pyrene	mg/kg	0.54	2													
Benzo(b)fluoranthene	mg/kg	5.43	1.8													
Dibenz(a,h)anthracene	mg/kg	0.65	0.55													
Dinitrotoluene, 2,4-	mg/kg	7.5	110													
Dinitrotoluene, 2,6-	mg/kg	2.75	68													
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1													

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SO01			TNTB-SO02				TNTB-SO03				TNTB-SO04			
				Sample No:	10500		10505		10510		10515		10520		10525		10530		10535	
				Sample Date:	9-Nov-98		9-Nov-98		9-Nov-98		9-Nov-98		9-Nov-98		9-Nov-98		9-Nov-98		9-Nov-98	
				Sample Depth:	.5 - 2 Ft		.5 - 2 Ft		3.5 - 4 Ft		3.5 - 4 Ft		3 - 4 Ft		3 - 4 Ft		5 - 6 Ft		5 - 6 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	1.7		-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	-	-	-	-	-	-	93		11		1		0.06	
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	1.6		-	-	27		-	-	1.4		-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	0.49		-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82		-	-			-	-			-	-			-	-		
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		-	-	0.03		0.27		0.06		620		100		4.8		0.82	
PCBs																				
Aroclor 1254	mg/kg	0.16	0.53		-	-			0.14	NJ			-	-			0.063	N		
Aroclor 1260	mg/kg	2.87	15		-	-			-	-			1.3	N			-	-		
Semivolatiles																				
Benzo(a)anthracene	mg/kg	5.43	2.4		-	-			-	-			0.037	J			-	-		
Benzo(a)pyrene	mg/kg	0.54	2		-	-			-	-			0.033	J			-	-		
Benzo(b)fluoranthene	mg/kg	5.43	1.8		-	-			-	-			0.053	J			-	-		
Dibenz(a,h)anthracene	mg/kg	0.65	0.55		-	-			-	-			-	-			-	-		
Dinitrotoluene, 2,4-	mg/kg	7.5	110		-	-			0.66				13				0.28	J		
Dinitrotoluene, 2,6-	mg/kg	2.75	68		-	-			0.15	J			3				-	-		
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1		-	-			-	-			-	-			-	-		

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SO05			TNTB-SO06						TNTB-SO07				TNTB-SO08			
				Sample No:	10540		10545		10550		10551		10555		10560		10565		10570		10575	
				Sample Date:	9-Nov-98		9-Nov-98		9-Nov-98		9-Nov-98		9-Nov-98		10-Nov-98		10-Nov-98		9-Nov-98		9-Nov-98	
				Sample Depth:	2.5 - 3.5 Ft		2.5 - 3.5 Ft		4 - 5 Ft		4 - 5 Ft		4 - 5 Ft		3 - 4 Ft		3 - 4 Ft		6 - 8 Ft		6 - 8 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																						
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		15		-	-	-	-	-	-	-	-	5.1	J	-	-	3.8		-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		12		-	-	-	-	11	J	-	-	5.1	J	1.2		2.3		-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	5.4	J	-	-	1.9	J	-	-	2.1		-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	1		-	-
Nitrotoluene, 2-	mg/kg	74	82		-	-			-	-	-	-			-	-			-	-		
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		44		56		2,200	J	140	J	650		5.8	J	3		11		-	-
PCBs																						
Aroclor 1254	mg/kg	0.16	0.53		-	-			-	-	-	-			-	-			-	-		
Aroclor 1260	mg/kg	2.87	15		-	-			2.8	NJ	0.55	NJ			4.6	N			0.11	N		
Semivolatiles																						
Benzo(a)anthracene	mg/kg	5.43	2.4		-	-			-	-	-	-			-	-			-	-		
Benzo(a)pyrene	mg/kg	0.54	2		-	-			-	-	-	-			-	-			-	-		
Benzo(b)fluoranthene	mg/kg	5.43	1.8		-	-			0.041	J	-	-			-	-			-	-		
Dibenz(a,h)anthracene	mg/kg	0.65	0.55		-	-			-	-	-	-			-	-			-	-		
Dinitrotoluene, 2,4-	mg/kg	7.5	110		-	-			3.6		3.4				0.43				3.2			
Dinitrotoluene, 2,6-	mg/kg	2.75	68		-	-			2.4		1.6				0.15	J			0.49			
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1		-	-			-	-	-	-			-	-			-	-		

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SO09			TNTB-SO10				TNTB-SO11				TNTB-SO12			
				Sample No:	10580		10585		10590		10595		10600		10605		10610		10615	
				Sample Date:	11-Nov-98		11-Nov-98		10-Nov-98		10-Nov-98		10-Nov-98		10-Nov-98		10-Nov-98		10-Nov-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		4 - 6 Ft		4 - 6 Ft		8 - 10 Ft		8 - 10 Ft		4 - 5 Ft		4 - 5 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	45		-	-	11		-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	-	-	-	-	-	-	70		12		4		-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	240		-	-	2.6		-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	180		-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82		-	-			-	-			82				-	-		
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		92		36		1.1		0.36		24		43		39		11	
PCBs																				
Aroclor 1254	mg/kg	0.16	0.53		0.32	N			-	-			-	-			-	-		
Aroclor 1260	mg/kg	2.87	15		-	-			-	-			-	-			-	-		
Semivolatiles																				
Benzo(a)anthracene	mg/kg	5.43	2.4		-	-			-	-			-	-			-	-		
Benzo(a)pyrene	mg/kg	0.54	2		0.028	J			-	-			-	-			-	-		
Benzo(b)fluoranthene	mg/kg	5.43	1.8		0.037	J			-	-			-	-			-	-		
Dibenz(a,h)anthracene	mg/kg	0.65	0.55		-	-			-	-			-	-			-	-		
Dinitrotoluene, 2,4-	mg/kg	7.5	110		0.15	J			0.044	J			110				4.4			
Dinitrotoluene, 2,6-	mg/kg	2.75	68		0.046	J			-	-			68				0.62			
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1		-	-			-	-			-	-			-	-		

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SO13				TNTB-SO14						TNTB-SO15				TNTB-SO16			
				Sample No:	10620		10625		10630		10631		10635		10640		10645		10650		10655	
				Sample Date:	11-Nov-98		11-Nov-98		11-Nov-98		11-Nov-98		11-Nov-98		11-Nov-98		11-Nov-98		11-Nov-98		11-Nov-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																						
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	4.2		-	-	3.5		-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	-	-	-	-	-	-	-	-	4.2		0.29		4.4		0.27	
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	0.39		-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82		-	-			-	-	-	-			-	-			-	-		
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		6,900		5,200		490	J	320	J	450		4.6		0.78		4.3		0.8	
PCBs																						
Aroclor 1254	mg/kg	0.16	0.53						-	-	-	-			0.53	N			0.12	N		
Aroclor 1260	mg/kg	2.87	15						0.23	N	0.28	N			-	-			-	-		
Semivolatiles																						
Benzo(a)anthracene	mg/kg	5.43	2.4						0.04	J	-	-			0.1	J			0.16	J		
Benzo(a)pyrene	mg/kg	0.54	2						0.056	J	0.043	J			0.11	J			0.21	J		
Benzo(b)fluoranthene	mg/kg	5.43	1.8						0.073	J	0.047	J			0.14	J			0.18	J		
Dibenz(a,h)anthracene	mg/kg	0.65	0.55						-	-	-	-			0.032	J			0.068	J		
Dinitrotoluene, 2,4-	mg/kg	7.5	110						0.49		0.21	J			0.19	J			0.16	J		
Dinitrotoluene, 2,6-	mg/kg	2.75	68						0.065	J	-	-			0.093	J			0.072	J		
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1						0.037	J	-	-			0.076	J			0.13	J		

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SO17			TNTB-SO18				TNTB-SO19				TNTB-SO20			
				Sample No:	10660		10665		10670		10675		10680		10685		10690		10695	
				Sample Date:	11-Nov-98		11-Nov-98		11-Nov-98		11-Nov-98		11-Nov-98		11-Nov-98		11-Nov-98		11-Nov-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		3		-	-	2		-	-	-	-	-	-	0.6		-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		3.6		0.19		3.8		0.04		-	-	-	-	0.78		0.16	
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		0.76		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82		-	-			-	-			-	-			-	-		
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		3.8		0.59		2.9		0.24		-	-	0.08		0.59		0.35	
PCBs																				
Aroclor 1254	mg/kg	0.16	0.53		-	-			-	-			-	-			-	-		
Aroclor 1260	mg/kg	2.87	15		0.099	N			0.05	N			0.11	N			0.16	N		
Semivolatiles																				
Benzo(a)anthracene	mg/kg	5.43	2.4		0.07	J			0.056	J			-	-			-	-		
Benzo(a)pyrene	mg/kg	0.54	2		0.081	J			0.057	J			-	-			0.039	J		
Benzo(b)fluoranthene	mg/kg	5.43	1.8		0.078	J			0.063	J			-	-			0.039	J		
Dibenz(a,h)anthracene	mg/kg	0.65	0.55		-	-			-	-			-	-			-	-		
Dinitrotoluene, 2,4-	mg/kg	7.5	110		0.18	J			0.059	J			-	-			0.1	J		
Dinitrotoluene, 2,6-	mg/kg	2.75	68		0.081	J			-	-			-	-			-	-		
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1		0.059	J			-	-			-	-			-	-		

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SO21			TNTB-SO22				TNTB-SO23				TNTB-SO24			
				Sample No:	10700		10705		10710		10715		10720		10725		10730		10735	
				Sample Date:	11-Nov-98		11-Nov-98		11-Nov-98		11-Nov-98		11-Nov-98		11-Nov-98		11-Nov-98		11-Nov-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	2		-	-	0.35		-	-	5.9		-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		0.3		0.05		2.6		0.13		-	-	-	-	4.6		-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82		-	-			-	-			-	-			-	-		
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		0.31		0.09		2.5		0.53		0.68		33		14		8.1	
PCBs																				
Aroclor 1254	mg/kg	0.16	0.53		-	-			-	-			-	-			-	-		
Aroclor 1260	mg/kg	2.87	15		0.27	N			0.1	N			0.14	N			15	N		
Semivolatiles																				
Benzo(a)anthracene	mg/kg	5.43	2.4		-	-			0.06	J			-	-			0.08	J		
Benzo(a)pyrene	mg/kg	0.54	2		0.035	J			0.068	J			-	-			0.085	J		
Benzo(b)fluoranthene	mg/kg	5.43	1.8		-	-			0.086	J			-	-			0.1	J		
Dibenz(a,h)anthracene	mg/kg	0.65	0.55		-	-			-	-			-	-			-	-		
Dinitrotoluene, 2,4-	mg/kg	7.5	110		0.082	J			0.41				-	-			0.23	J		
Dinitrotoluene, 2,6-	mg/kg	2.75	68		-	-			0.044	J			-	-			0.11	J		
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1		-	-			0.069	J			-	-			0.05	J		

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SO25			TNTB-SO26						TNTB-SO27				TNTB-SO28			
				Sample No:	10740		10745		10750		10751		10755		10760		10765		10770		10775	
				Sample Date:	11-Nov-98		11-Nov-98		11-Nov-98		11-Nov-98		11-Nov-98		11-Nov-98		11-Nov-98		11-Nov-98		11-Nov-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																						
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		1.1		-	-	-	-	-	-	-	-	5.4		-	-	0.99		-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		1.7		0.56		-	-	-	-	-	-	7.6		4.9		1.3		3.2	
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82		-	-			-	-	-	-			-	-			-	-		
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		0.26		0.32		0.43		-	-	0.22		4		5.6		1.1		2.2	
PCBs																						
Aroclor 1254	mg/kg	0.16	0.53		-	-			-	-	-	-			0.21	N			0.24	N		
Aroclor 1260	mg/kg	2.87	15		0.089	N			0.048	N	0.06	N			-	-			-	-		
Semivolatiles																						
Benzo(a)anthracene	mg/kg	5.43	2.4		-	-			-	-	0.34	J			0.04	J			-	-		
Benzo(a)pyrene	mg/kg	0.54	2		-	-			-	-	0.3	J			0.045	J			-	-		
Benzo(b)fluoranthene	mg/kg	5.43	1.8		-	-			-	-	0.23	J			0.07	J			-	-		
Dibenz(a,h)anthracene	mg/kg	0.65	0.55		-	-			-	-	0.079	J			-	-			-	-		
Dinitrotoluene, 2,4-	mg/kg	7.5	110		-	-			-	-	-	-			0.4	J			-	-		
Dinitrotoluene, 2,6-	mg/kg	2.75	68		-	-			-	-	-	-			0.1	J			-	-		
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1		-	-			-	-	0.14	J			-	-			-	-		

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SO29			TNTB-SO30				TNTB-SO31			
				Sample No:	10780		10785		10790		10795		10800		10805	
				Sample Date:	11-Nov-98		11-Nov-98		11-Nov-98		11-Nov-98		12-Nov-98		12-Nov-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		1.1		-	-	0.34		-	-	8.8		-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		1.5		0.38		-	-	-	-	4.7		-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82		-	-			-	-			-	-		
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		1		0.74		0.56		0.03		22		26	
PCBs																
Aroclor 1254	mg/kg	0.16	0.53		0.19	N			-	-			-	-		
Aroclor 1260	mg/kg	2.87	15		-	-			-	-			0.19	N		
Semivolatiles																
Benzo(a)anthracene	mg/kg	5.43	2.4		0.046	J			0.044	J			0.046	J		
Benzo(a)pyrene	mg/kg	0.54	2		0.048	J			0.064	J			0.068	J		
Benzo(b)fluoranthene	mg/kg	5.43	1.8		0.057	J			0.062	J			0.075	J		
Dibenz(a,h)anthracene	mg/kg	0.65	0.55		-	-			-	-			-	-		
Dinitrotoluene, 2,4-	mg/kg	7.5	110		0.079	J			-	-			0.11	J		
Dinitrotoluene, 2,6-	mg/kg	2.75	68		-	-			-	-			-	-		
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1		-	-			-	-			0.053	J		

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SO32			TNTB-SO33				TNTB-SO34			
				Sample No:	10810		10815		10820		10825		10830		10835	
				Sample Date:	12-Nov-98		12-Nov-98		12-Nov-98		12-Nov-98		12-Nov-98		12-Nov-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		4		-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		3.7		0.22		-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		0.38		-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82		-	-			-	-			-	-		
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		7.6		1.1		-	-	-	-	-	-	-	-
PCBs																
Aroclor 1254	mg/kg	0.16	0.53		-	-			-	-			-	-		
Aroclor 1260	mg/kg	2.87	15		0.99	N			0.54	N			-	-		
Semivolatiles																
Benzo(a)anthracene	mg/kg	5.43	2.4		2.4				-	-			-	-		
Benzo(a)pyrene	mg/kg	0.54	2		2				-	-			-	-		
Benzo(b)fluoranthene	mg/kg	5.43	1.8		1.8				-	-			-	-		
Dibenz(a,h)anthracene	mg/kg	0.65	0.55		0.55				-	-			-	-		
Dinitrotoluene, 2,4-	mg/kg	7.5	110		0.17	J			-	-			-	-		
Dinitrotoluene, 2,6-	mg/kg	2.75	68		-	-			-	-			-	-		
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1		1				-	-			-	-		

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SO35						TNTB-SO36				TNTB-SO37			
				Sample No:	10840		10841		10845		10850		10855		10860		10865	
				Sample Date:	11-Nov-98		11-Nov-98		11-Nov-98		12-Nov-98		12-Nov-98		12-Nov-98		12-Nov-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																		
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	2.5		-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		0.48		-	-	-	-	-	-	-	-	1.7		0.14	
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		1.6	J	-	-	-	-	-	-	-	-	2.3		-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		0.28	J	-	-	-	-	-	-	-	-	0.83		-	-
Nitrotoluene, 2-	mg/kg	74	82		-	-	-	-			-	-			-	-		
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		7.6	J	0.41	J	0.1		0.4		0.27		4.3		0.3	
PCBs																		
Aroclor 1254	mg/kg	0.16	0.53		-	-	-	-			-	-			-	-		
Aroclor 1260	mg/kg	2.87	15		0.041	NJ	0.066	NJ			0.041	N			0.45	N		
Semivolatiles																		
Benzo(a)anthracene	mg/kg	5.43	2.4		-	-	-	-			1.6				0.05	J		
Benzo(a)pyrene	mg/kg	0.54	2		0.037	J	0.029	J			1.7				0.055	J		
Benzo(b)fluoranthene	mg/kg	5.43	1.8		0.039	J	-	-			1.8				0.061	J		
Dibenz(a,h)anthracene	mg/kg	0.65	0.55		-	-	-	-			0.48				-	-		
Dinitrotoluene, 2,4-	mg/kg	7.5	110		-	-	-	-			0.057	J			0.53			
Dinitrotoluene, 2,6-	mg/kg	2.75	68		-	-	-	-			-	-			0.16	J		
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1		-	-	-	-			0.96				0.037	J		

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SO38			TNTB-SO39				TNTB-SO40				TNTB-SS001		TNTB-SS002		TNTB-SS003	
				Sample No:	10870		10875		10880		10885		10890		10895		10000		10001		10002	
				Sample Date:	12-Nov-98		12-Nov-98		12-Nov-98		12-Nov-98		12-Nov-98		12-Nov-98		21-Oct-98		21-Oct-98		21-Oct-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																						
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		0.35		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		0.34		-	-	-	-	-	-	0.26		-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82		-	-			-	-			-	-								
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		0.78		-	-	-	-	-	-	-	-	-	-	-	-	0.11		-	-
PCBs																						
Aroclor 1254	mg/kg	0.16	0.53		-	-			-	-			-	-								
Aroclor 1260	mg/kg	2.87	15		1.1	N			-	-			-	-								
Semivolatiles																						
Benzo(a)anthracene	mg/kg	5.43	2.4		0.049	J			0.05	J			-	-								
Benzo(a)pyrene	mg/kg	0.54	2		0.077	J			0.055	J			-	-								
Benzo(b)fluoranthene	mg/kg	5.43	1.8		0.1	J			0.044	J			-	-								
Dibenz(a,h)anthracene	mg/kg	0.65	0.55		-	-			-	-			-	-								
Dinitrotoluene, 2,4-	mg/kg	7.5	110		0.083	J			-	-			0.054	J								
Dinitrotoluene, 2,6-	mg/kg	2.75	68		-	-			-	-			-	-								
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1		0.062	J			-	-			-	-								

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS004		TNTB-SS005		TNTB-SS006		TNTB-SS007		TNTB-SS008		TNTB-SS009		TNTB-SS010		TNTB-SS011		TNTB-SS012	
				Sample No:	10003		10004		10005		10006		10007		10008		10009		10010		10011	
				Sample Date:	21-Oct-98		22-Oct-98		22-Oct-98		22-Oct-98		22-Oct-98		22-Oct-98		22-Oct-98		22-Oct-98		22-Oct-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																						
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	-	-	-	-	-	-	0.13		0.02		-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																			
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		-	-	-	-	-	-	-	-	0.01		-	-	-	-	-	-	-	-
PCBs																						
Aroclor 1254	mg/kg	0.16	0.53																			
Aroclor 1260	mg/kg	2.87	15																			
Semivolatiles																						
Benzo(a)anthracene	mg/kg	5.43	2.4																			
Benzo(a)pyrene	mg/kg	0.54	2																			
Benzo(b)fluoranthene	mg/kg	5.43	1.8																			
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																			
Dinitrotoluene, 2,4-	mg/kg	7.5	110																			
Dinitrotoluene, 2,6-	mg/kg	2.75	68																			
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																			

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS013		TNTB-SS014		TNTB-SS015		TNTB-SS016		TNTB-SS017		TNTB-SS018		TNTB-SS019		TNTB-SS020		TNTB-SS021	
				Sample No:	10012		10013		10014		10015		10016		10017		10018		10019		10020	
				Sample Date:	22-Oct-98		22-Oct-98		22-Oct-98		22-Oct-98		22-Oct-98		22-Oct-98		22-Oct-98		22-Oct-98		22-Oct-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																						
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	-	-	-	-	-	-	0.25		-	-	-	-	0.12		0.13	
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																			
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		0.01		-	-	-	-	-	-	0.01		0.01		-	-	0.83		0.82	
PCBs																						
Aroclor 1254	mg/kg	0.16	0.53																			
Aroclor 1260	mg/kg	2.87	15																			
Semivolatiles																						
Benzo(a)anthracene	mg/kg	5.43	2.4																			
Benzo(a)pyrene	mg/kg	0.54	2																			
Benzo(b)fluoranthene	mg/kg	5.43	1.8																			
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																			
Dinitrotoluene, 2,4-	mg/kg	7.5	110																			
Dinitrotoluene, 2,6-	mg/kg	2.75	68																			
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																			

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS022		TNTB-SS023		TNTB-SS024		TNTB-SS025		TNTB-SS026		TNTB-SS027		TNTB-SS028		TNTB-SS029		TNTB-SS030	
				Sample No:	10021		10022		10023		10024		10025		10026		10027		10028		10029	
				Sample Date:	22-Oct-98		22-Oct-98		22-Oct-98		22-Oct-98		22-Oct-98		22-Oct-98		22-Oct-98		22-Oct-98		22-Oct-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																						
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																			
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		0.07		-	-	-	-	0.01		-	-	0.14		-	-	-	-	-	-
PCBs																						
Aroclor 1254	mg/kg	0.16	0.53																			
Aroclor 1260	mg/kg	2.87	15																			
Semivolatiles																						
Benzo(a)anthracene	mg/kg	5.43	2.4																			
Benzo(a)pyrene	mg/kg	0.54	2																			
Benzo(b)fluoranthene	mg/kg	5.43	1.8																			
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																			
Dinitrotoluene, 2,4-	mg/kg	7.5	110																			
Dinitrotoluene, 2,6-	mg/kg	2.75	68																			
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																			

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS031		TNTB-SS032		TNTB-SS033		TNTB-SS034		TNTB-SS035		TNTB-SS037		TNTB-SS038		TNTB-SS039		TNTB-SS040	
				Sample No:	10030		10031		10032		10033		10034		10036		10037		10038		10039	
				Sample Date:	22-Oct-98		22-Oct-98		22-Oct-98		22-Oct-98		22-Oct-98		22-Oct-98		22-Oct-98		22-Oct-98		22-Oct-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																						
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	-	-	-	-	-	-	-	-	2		0.09		0.15		0.17	
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																			
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		-	-	-	-	-	-	-	-	0.05		4.7		0.31		0.63		0.39	
PCBs																						
Aroclor 1254	mg/kg	0.16	0.53																			
Aroclor 1260	mg/kg	2.87	15																			
Semivolatiles																						
Benzo(a)anthracene	mg/kg	5.43	2.4																			
Benzo(a)pyrene	mg/kg	0.54	2																			
Benzo(b)fluoranthene	mg/kg	5.43	1.8																			
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																			
Dinitrotoluene, 2,4-	mg/kg	7.5	110																			
Dinitrotoluene, 2,6-	mg/kg	2.75	68																			
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																			

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS042		TNTB-SS043		TNTB-SS044		TNTB-SS045		TNTB-SS046		TNTB-SS047		TNTB-SS048		TNTB-SS049		TNTB-SS050	
				Sample No:	10041		10042		10043		10044		10045		10046		10047		10048		10049	
				Sample Date:	22-Oct-98		22-Oct-98		22-Oct-98		22-Oct-98		27-Oct-98		27-Oct-98		27-Oct-98		27-Oct-98		27-Oct-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																						
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	-	-	-	-	-	-	0.09		0.07		0.44		-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																			
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		0.2		-	-	0.06		-	-	0.1		0.45		0.83		0.55		0.53	
PCBs																						
Aroclor 1254	mg/kg	0.16	0.53																			
Aroclor 1260	mg/kg	2.87	15																			
Semivolatiles																						
Benzo(a)anthracene	mg/kg	5.43	2.4																			
Benzo(a)pyrene	mg/kg	0.54	2																			
Benzo(b)fluoranthene	mg/kg	5.43	1.8																			
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																			
Dinitrotoluene, 2,4-	mg/kg	7.5	110																			
Dinitrotoluene, 2,6-	mg/kg	2.75	68																			
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																			

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS051		TNTB-SS052		TNTB-SS053		TNTB-SS054		TNTB-SS055		TNTB-SS056		TNTB-SS057		TNTB-SS058		TNTB-SS059	
				Sample No:	10050		10051		10052		10053		10054		10055		10056		10057		10058	
				Sample Date:	27-Oct-98		27-Oct-98		27-Oct-98		27-Oct-98		27-Oct-98		27-Oct-98		27-Oct-98		27-Oct-98		23-Oct-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																						
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	0.01		-	-	0.1		0.04		-	-	0.6		0.03		-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																			
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		0.11		0.61		-	-	0.51		0.46		0.01		0.93		0.76		0.11	
PCBs																						
Aroclor 1254	mg/kg	0.16	0.53																			
Aroclor 1260	mg/kg	2.87	15																			
Semivolatiles																						
Benzo(a)anthracene	mg/kg	5.43	2.4																			
Benzo(a)pyrene	mg/kg	0.54	2																			
Benzo(b)fluoranthene	mg/kg	5.43	1.8																			
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																			
Dinitrotoluene, 2,4-	mg/kg	7.5	110																			
Dinitrotoluene, 2,6-	mg/kg	2.75	68																			
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																			

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS060		TNTB-SS061		TNTB-SS062		TNTB-SS063		TNTB-SS064		TNTB-SS065		TNTB-SS066		TNTB-SS067		TNTB-SS068	
				Sample No:	10059		10060		10061		10062		10063		10064		10065		10066		10067	
				Sample Date:	23-Oct-98		23-Oct-98		23-Oct-98		23-Oct-98		23-Oct-98		25-Oct-98		25-Oct-98		25-Oct-98		25-Oct-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																						
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		0.01		-	-	0.02		0.06		-	-	0.2		0.7		0.64		-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																			
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		0.18		0.14		0.5		0.43		0.18		0.2		0.27		0.72		-	-
PCBs																						
Aroclor 1254	mg/kg	0.16	0.53																			
Aroclor 1260	mg/kg	2.87	15																			
Semivolatiles																						
Benzo(a)anthracene	mg/kg	5.43	2.4																			
Benzo(a)pyrene	mg/kg	0.54	2																			
Benzo(b)fluoranthene	mg/kg	5.43	1.8																			
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																			
Dinitrotoluene, 2,4-	mg/kg	7.5	110																			
Dinitrotoluene, 2,6-	mg/kg	2.75	68																			
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																			

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS069		TNTB-SS070		TNTB-SS071		TNTB-SS072		TNTB-SS073		TNTB-SS074		TNTB-SS075		TNTB-SS076		TNTB-SS077	
				Sample No:	10068		10069		10070		10071		10072		10073		10074		10075		10076	
				Sample Date:	25-Oct-98		25-Oct-98		25-Oct-98		25-Oct-98		25-Oct-98		26-Oct-98		26-Oct-98		26-Oct-98		26-Oct-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																						
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	-	-	0.28		-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																			
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		0.01		-	-	0.48		-	-	-	-	0.08		-	-	0.07		0.01	
PCBs																						
Aroclor 1254	mg/kg	0.16	0.53																			
Aroclor 1260	mg/kg	2.87	15																			
Semivolatiles																						
Benzo(a)anthracene	mg/kg	5.43	2.4																			
Benzo(a)pyrene	mg/kg	0.54	2																			
Benzo(b)fluoranthene	mg/kg	5.43	1.8																			
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																			
Dinitrotoluene, 2,4-	mg/kg	7.5	110																			
Dinitrotoluene, 2,6-	mg/kg	2.75	68																			
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																			

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS078		TNTB-SS079		TNTB-SS080		TNTB-SS081		TNTB-SS082		TNTB-SS083		TNTB-SS084		TNTB-SS085		TNTB-SS086	
				Sample No:	10077		10078		10079		10080		10081		10082		10083		10084		10085	
				Sample Date:	26-Oct-98		26-Oct-98		26-Oct-98		23-Oct-98		23-Oct-98		23-Oct-98		23-Oct-98		23-Oct-98		23-Oct-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																						
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	0.04		0.21		-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																			
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		0.02		0.01		0.11		0.02		0.01		0.01		0.01		-	-	0.01	
PCBs																						
Aroclor 1254	mg/kg	0.16	0.53																			
Aroclor 1260	mg/kg	2.87	15																			
Semivolatiles																						
Benzo(a)anthracene	mg/kg	5.43	2.4																			
Benzo(a)pyrene	mg/kg	0.54	2																			
Benzo(b)fluoranthene	mg/kg	5.43	1.8																			
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																			
Dinitrotoluene, 2,4-	mg/kg	7.5	110																			
Dinitrotoluene, 2,6-	mg/kg	2.75	68																			
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																			

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS087		TNTB-SS088		TNTB-SS089		TNTB-SS090		TNTB-SS091		TNTB-SS092		TNTB-SS093		TNTB-SS094	
				Sample No:	10086		10087		10088		10089		10090		10091		10092		10093	
				Sample Date:	23-Oct-98		23-Oct-98		23-Oct-98		23-Oct-98		27-Oct-98		27-Oct-98		27-Oct-98		27-Oct-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	-	-	-	-	-	-	0.03		0.01		-	-	0.01	
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	0.3		6.2		-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																	
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		0.87		0.57		0.43		0.01		0.18		0.89		0.3		1.2	
PCBs																				
Aroclor 1254	mg/kg	0.16	0.53																	
Aroclor 1260	mg/kg	2.87	15																	
Semivolatiles																				
Benzo(a)anthracene	mg/kg	5.43	2.4																	
Benzo(a)pyrene	mg/kg	0.54	2																	
Benzo(b)fluoranthene	mg/kg	5.43	1.8																	
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																	
Dinitrotoluene, 2,4-	mg/kg	7.5	110																	
Dinitrotoluene, 2,6-	mg/kg	2.75	68																	
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																	

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS095		TNTB-SS096		TNTB-SS097		TNTB-SS098		TNTB-SS099		TNTB-SS100		TNTB-SS101	
				Sample No:	10094		10095		10096		10097		10098		10099		10100	
				Sample Date:	27-Oct-98		23-Oct-98		23-Oct-98		23-Oct-98		23-Oct-98		23-Oct-98		23-Oct-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																		
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	2.6		-	-	4.3		-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82															
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		0.54		0.39		-	-	0.01		-	-	-	-	-	-
PCBs																		
Aroclor 1254	mg/kg	0.16	0.53															
Aroclor 1260	mg/kg	2.87	15															
Semivolatiles																		
Benzo(a)anthracene	mg/kg	5.43	2.4															
Benzo(a)pyrene	mg/kg	0.54	2															
Benzo(b)fluoranthene	mg/kg	5.43	1.8															
Dibenz(a,h)anthracene	mg/kg	0.65	0.55															
Dinitrotoluene, 2,4-	mg/kg	7.5	110															
Dinitrotoluene, 2,6-	mg/kg	2.75	68															
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1															

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

			Location Code:	TNTB-SS102		TNTB-SS103		TNTB-SS104		TNTB-SS105		TNTB-SS106		TNTB-SS107		TNTB-SS108		TNTB-SS109	
			Sample No:	10101		10102		10103		10104		10105		10106		10107		10108	
			Sample Date:	23-Oct-98		23-Oct-98		23-Oct-98		23-Oct-98		23-Oct-98		26-Oct-98		26-Oct-98		26-Oct-98	
			Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																			
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000	0.25		-	-	-	-	0.01		0.01		-	-	-	-	-	-
PCBs																			
Aroclor 1254	mg/kg	0.16	0.53																
Aroclor 1260	mg/kg	2.87	15																
Semivolatiles																			
Benzo(a)anthracene	mg/kg	5.43	2.4																
Benzo(a)pyrene	mg/kg	0.54	2																
Benzo(b)fluoranthene	mg/kg	5.43	1.8																
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																
Dinitrotoluene, 2,4-	mg/kg	7.5	110																
Dinitrotoluene, 2,6-	mg/kg	2.75	68																
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:		TNTB-SS110		TNTB-SS111		TNTB-SS112		TNTB-SS113		TNTB-SS114		TNTB-SS115		TNTB-SS116	
				Sample No:		10109		10110		10111		10112		10113		10114		10115	
				Sample Date:		26-Oct-98		26-Oct-98		26-Oct-98		26-Oct-98		26-Oct-98		26-Oct-98		26-Oct-98	
				Sample Depth:		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																			
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000	-	-	9.7		-	-	-	-	23		-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PCBs																			
Aroclor 1254	mg/kg	0.16	0.53																
Aroclor 1260	mg/kg	2.87	15																
Semivolatiles																			
Benzo(a)anthracene	mg/kg	5.43	2.4																
Benzo(a)pyrene	mg/kg	0.54	2																
Benzo(b)fluoranthene	mg/kg	5.43	1.8																
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																
Dinitrotoluene, 2,4-	mg/kg	7.5	110																
Dinitrotoluene, 2,6-	mg/kg	2.75	68																
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS117		TNTB-SS118		TNTB-SS119		TNTB-SS120		TNTB-SS121		TNTB-SS122		TNTB-SS123		TNTB-SS124	
				Sample No:	10116		10117		10118		10119		10120		10121		10122		10123	
				Sample Date:	26-Oct-98		26-Oct-98		26-Oct-98		26-Oct-98		26-Oct-98		26-Oct-98		26-Oct-98		26-Oct-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																	
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000	-	-	-	-	-	-	-	-	-	-	0.15		0.01		-	-	-
PCBs																				
Aroclor 1254	mg/kg	0.16	0.53																	
Aroclor 1260	mg/kg	2.87	15																	
Semivolatiles																				
Benzo(a)anthracene	mg/kg	5.43	2.4																	
Benzo(a)pyrene	mg/kg	0.54	2																	
Benzo(b)fluoranthene	mg/kg	5.43	1.8																	
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																	
Dinitrotoluene, 2,4-	mg/kg	7.5	110																	
Dinitrotoluene, 2,6-	mg/kg	2.75	68																	
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																	

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS125		TNTB-SS126		TNTB-SS127		TNTB-SS128		TNTB-SS129		TNTB-SS130		TNTB-SS131		TNTB-SS132	
				Sample No:	10124		10125		10126		10127		10128		10129		10130		10131	
				Sample Date:	26-Oct-98		26-Oct-98		23-Oct-98		23-Oct-98		23-Oct-98		23-Oct-98		23-Oct-98		23-Oct-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	-	-	0.01		-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																	
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		-	-	-	-	0.09		-	-	-	-	0.01		-	-	-	-
PCBs																				
Aroclor 1254	mg/kg	0.16	0.53																	
Aroclor 1260	mg/kg	2.87	15																	
Semivolatiles																				
Benzo(a)anthracene	mg/kg	5.43	2.4																	
Benzo(a)pyrene	mg/kg	0.54	2																	
Benzo(b)fluoranthene	mg/kg	5.43	1.8																	
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																	
Dinitrotoluene, 2,4-	mg/kg	7.5	110																	
Dinitrotoluene, 2,6-	mg/kg	2.75	68																	
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																	

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS133		TNTB-SS134		TNTB-SS135		TNTB-SS136		TNTB-SS137		TNTB-SS138		TNTB-SS139		TNTB-SS140	
				Sample No:	10132		10133		10134		10135		10136		10137		10138		10139	
				Sample Date:	23-Oct-98		23-Oct-98		23-Oct-98		23-Oct-98		25-Oct-98		25-Oct-98		25-Oct-98		25-Oct-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	-	-	-	-	-	-	-	-	-	-	0.01		-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																	
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		-	-	-	-	-	-	-	-	-	-	-	-	0.05		-	-
PCBs																				
Aroclor 1254	mg/kg	0.16	0.53																	
Aroclor 1260	mg/kg	2.87	15																	
Semivolatiles																				
Benzo(a)anthracene	mg/kg	5.43	2.4																	
Benzo(a)pyrene	mg/kg	0.54	2																	
Benzo(b)fluoranthene	mg/kg	5.43	1.8																	
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																	
Dinitrotoluene, 2,4-	mg/kg	7.5	110																	
Dinitrotoluene, 2,6-	mg/kg	2.75	68																	
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																	

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS141		TNTB-SS142		TNTB-SS143		TNTB-SS144		TNTB-SS145		TNTB-SS146		TNTB-SS147		TNTB-SS148	
				Sample No:	10140		10141		10142		10143		10144		10145		10146		10147	
				Sample Date:	25-Oct-98		25-Oct-98		25-Oct-98		25-Oct-98		25-Oct-98		25-Oct-98		25-Oct-98		25-Oct-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																	
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PCBs																				
Aroclor 1254	mg/kg	0.16	0.53																	
Aroclor 1260	mg/kg	2.87	15																	
Semivolatiles																				
Benzo(a)anthracene	mg/kg	5.43	2.4																	
Benzo(a)pyrene	mg/kg	0.54	2																	
Benzo(b)fluoranthene	mg/kg	5.43	1.8																	
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																	
Dinitrotoluene, 2,4-	mg/kg	7.5	110																	
Dinitrotoluene, 2,6-	mg/kg	2.75	68																	
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																	

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS149		TNTB-SS150		TNTB-SS151		TNTB-SS152		TNTB-SS153		TNTB-SS154		TNTB-SS155		TNTB-SS156	
				Sample No:	10148		10149		10150		10151		10152		10153		10154		10155	
				Sample Date:	25-Oct-98		25-Oct-98		25-Oct-98		25-Oct-98		25-Oct-98		25-Oct-98		25-Oct-98		25-Oct-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																	
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		-	-	-	-	0.01		-	-	0.17		0.2		0.2		-	-
PCBs																				
Aroclor 1254	mg/kg	0.16	0.53																	
Aroclor 1260	mg/kg	2.87	15																	
Semivolatiles																				
Benzo(a)anthracene	mg/kg	5.43	2.4																	
Benzo(a)pyrene	mg/kg	0.54	2																	
Benzo(b)fluoranthene	mg/kg	5.43	1.8																	
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																	
Dinitrotoluene, 2,4-	mg/kg	7.5	110																	
Dinitrotoluene, 2,6-	mg/kg	2.75	68																	
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																	

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS157		TNTB-SS158		TNTB-SS159		TNTB-SS160		TNTB-SS161		TNTB-SS162		TNTB-SS163		TNTB-SS164	
				Sample No:	10156		10157		10158		10159		10160		10161		10162		10163	
				Sample Date:	25-Oct-98		25-Oct-98		25-Oct-98		25-Oct-98		25-Oct-98		25-Oct-98		25-Oct-98		25-Oct-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																	
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		-	-	-	-	-	-	-	-	0.15		0.32		-	-	-	-
PCBs																				
Aroclor 1254	mg/kg	0.16	0.53																	
Aroclor 1260	mg/kg	2.87	15																	
Semivolatiles																				
Benzo(a)anthracene	mg/kg	5.43	2.4																	
Benzo(a)pyrene	mg/kg	0.54	2																	
Benzo(b)fluoranthene	mg/kg	5.43	1.8																	
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																	
Dinitrotoluene, 2,4-	mg/kg	7.5	110																	
Dinitrotoluene, 2,6-	mg/kg	2.75	68																	
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																	

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS165		TNTB-SS166		TNTB-SS167		TNTB-SS168		TNTB-SS169		TNTB-SS170		TNTB-SS171		TNTB-SS172	
				Sample No:	10164		10165		10166		10167		10168		10169		10170		10171	
				Sample Date:	25-Oct-98		25-Oct-98		25-Oct-98		25-Oct-98		25-Oct-98		25-Oct-98		27-Oct-98		27-Oct-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93	-	-	-	-	-	-	-	-	-	-	-	-	0.09		-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000	-	-	-	-	-	-	-	-	-	-	-	-	0.01		-	-
PCBs																				
Aroclor 1254	mg/kg	0.16	0.53																
Aroclor 1260	mg/kg	2.87	15																
Semivolatiles																				
Benzo(a)anthracene	mg/kg	5.43	2.4																
Benzo(a)pyrene	mg/kg	0.54	2																
Benzo(b)fluoranthene	mg/kg	5.43	1.8																
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																
Dinitrotoluene, 2,4-	mg/kg	7.5	110																
Dinitrotoluene, 2,6-	mg/kg	2.75	68																
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS173		TNTB-SS174		TNTB-SS175		TNTB-SS176		TNTB-SS177		TNTB-SS178		TNTB-SS179		TNTB-SS180	
				Sample No:	10172		10173		10174		10175		10176		10177		10178		10179	
				Sample Date:	27-Oct-98		27-Oct-98		27-Oct-98		27-Oct-98		27-Oct-98		27-Oct-98		27-Oct-98		27-Oct-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		0.36		-	-	0.19		2.4		0.18		0.17		-	-	0.16	
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																	
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		0.1		250		0.72		3.7		0.13		0.28		-	-	0.65	
PCBs																				
Aroclor 1254	mg/kg	0.16	0.53																	
Aroclor 1260	mg/kg	2.87	15																	
Semivolatiles																				
Benzo(a)anthracene	mg/kg	5.43	2.4																	
Benzo(a)pyrene	mg/kg	0.54	2																	
Benzo(b)fluoranthene	mg/kg	5.43	1.8																	
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																	
Dinitrotoluene, 2,4-	mg/kg	7.5	110																	
Dinitrotoluene, 2,6-	mg/kg	2.75	68																	
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																	

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS181		TNTB-SS182		TNTB-SS183		TNTB-SS184		TNTB-SS185		TNTB-SS186		TNTB-SS187		TNTB-SS188	
				Sample No:	10180		10181		10182		10183		10184		10185		10186		10187	
				Sample Date:	27-Oct-98		27-Oct-98		26-Oct-98		26-Oct-98		26-Oct-98		26-Oct-98		26-Oct-98		26-Oct-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																	
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		-	-	0.76		0.01		-	-	0.01		-	-	-	-	-	-
PCBs																				
Aroclor 1254	mg/kg	0.16	0.53																	
Aroclor 1260	mg/kg	2.87	15																	
Semivolatiles																				
Benzo(a)anthracene	mg/kg	5.43	2.4																	
Benzo(a)pyrene	mg/kg	0.54	2																	
Benzo(b)fluoranthene	mg/kg	5.43	1.8																	
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																	
Dinitrotoluene, 2,4-	mg/kg	7.5	110																	
Dinitrotoluene, 2,6-	mg/kg	2.75	68																	
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																	

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS189		TNTB-SS190		TNTB-SS191		TNTB-SS192		TNTB-SS193		TNTB-SS194		TNTB-SS195		TNTB-SS196	
				Sample No:	10188		10189		10190		10191		10192		10193		10194		10195	
				Sample Date:	26-Oct-98		27-Oct-98		27-Oct-98		29-Oct-98		29-Oct-98		29-Oct-98		29-Oct-98		29-Oct-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	-	-	-	-	-	-	-	-	0.03		-	-	0.1	
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																	
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		-	-	-	-	-	-	0.01		-	-	0.01		0.07		0.68	
PCBs																				
Aroclor 1254	mg/kg	0.16	0.53																	
Aroclor 1260	mg/kg	2.87	15																	
Semivolatiles																				
Benzo(a)anthracene	mg/kg	5.43	2.4																	
Benzo(a)pyrene	mg/kg	0.54	2																	
Benzo(b)fluoranthene	mg/kg	5.43	1.8																	
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																	
Dinitrotoluene, 2,4-	mg/kg	7.5	110																	
Dinitrotoluene, 2,6-	mg/kg	2.75	68																	
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																	

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS197		TNTB-SS198		TNTB-SS199		TNTB-SS200		TNTB-SS204		TNTB-SS205		TNTB-SS206		TNTB-SS207	
				Sample No:	10196		10197		10198		10199		10203		10204		10205		10206	
				Sample Date:	29-Oct-98		29-Oct-98		29-Oct-98		2-Nov-98		30-Oct-98		30-Oct-98		30-Oct-98		30-Oct-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	-	-	-	-	-	-	0.03		0.27		0.12		1.6	
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	7		-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																	
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		0.04		0.06		0.31		-	-	0.3		0.81		0.89		1.4	
PCBs																				
Aroclor 1254	mg/kg	0.16	0.53																	
Aroclor 1260	mg/kg	2.87	15																	
Semivolatiles																				
Benzo(a)anthracene	mg/kg	5.43	2.4																	
Benzo(a)pyrene	mg/kg	0.54	2																	
Benzo(b)fluoranthene	mg/kg	5.43	1.8																	
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																	
Dinitrotoluene, 2,4-	mg/kg	7.5	110																	
Dinitrotoluene, 2,6-	mg/kg	2.75	68																	
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																	

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS208		TNTB-SS209		TNTB-SS210		TNTB-SS211		TNTB-SS212		TNTB-SS213		TNTB-SS215		TNTB-SS216	
				Sample No:	10207		10208		10209		10210		10211		10212		10214		10215	
				Sample Date:	30-Oct-98		30-Oct-98		30-Oct-98		30-Oct-98		30-Oct-98		30-Oct-98		30-Oct-98		30-Oct-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	-	-	-	-	-	-	-	-	0.51		0.11		0.01	
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																	
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		23		-	-	1,200		2,800		470		1.4		0.5		0.73	
PCBs																				
Aroclor 1254	mg/kg	0.16	0.53																	
Aroclor 1260	mg/kg	2.87	15																	
Semivolatiles																				
Benzo(a)anthracene	mg/kg	5.43	2.4																	
Benzo(a)pyrene	mg/kg	0.54	2																	
Benzo(b)fluoranthene	mg/kg	5.43	1.8																	
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																	
Dinitrotoluene, 2,4-	mg/kg	7.5	110																	
Dinitrotoluene, 2,6-	mg/kg	2.75	68																	
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																	

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

			Location Code:	TNTB-SS217		TNTB-SS218		TNTB-SS219		TNTB-SS220		TNTB-SS221		TNTB-SS222		TNTB-SS223		TNTB-SS224	
			Sample No:	10216		10217		10218		10219		10220		10221		10222		10223	
			Sample Date:	30-Oct-98		2-Nov-98		2-Nov-98		2-Nov-98		2-Nov-98		2-Nov-98		2-Nov-98		2-Nov-98	
			Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																			
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93	0.15		-	-	0.01		0.01		-	-	3.1		0.08		-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000	0.65		-	-	0.47		0.19		0.03		13		0.11		0.06	
PCBs																			
Aroclor 1254	mg/kg	0.16	0.53																
Aroclor 1260	mg/kg	2.87	15																
Semivolatiles																			
Benzo(a)anthracene	mg/kg	5.43	2.4																
Benzo(a)pyrene	mg/kg	0.54	2																
Benzo(b)fluoranthene	mg/kg	5.43	1.8																
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																
Dinitrotoluene, 2,4-	mg/kg	7.5	110																
Dinitrotoluene, 2,6-	mg/kg	2.75	68																
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS225		TNTB-SS226		TNTB-SS227		TNTB-SS228		TNTB-SS229		TNTB-SS230		TNTB-SS231		TNTB-SS232	
				Sample No:	10224		10225		10226		10227		10228		10229		10230		10231	
				Sample Date:	2-Nov-98		2-Nov-98		2-Nov-98		2-Nov-98		2-Nov-98		2-Nov-98		2-Nov-98		2-Nov-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	0.31		-	-	-	-	-	-	0.06		0.09		-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																	
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		0.16		0.01		-	-	-	-	-	-	0.22		0.21		0.13	
PCBs																				
Aroclor 1254	mg/kg	0.16	0.53																	
Aroclor 1260	mg/kg	2.87	15																	
Semivolatiles																				
Benzo(a)anthracene	mg/kg	5.43	2.4																	
Benzo(a)pyrene	mg/kg	0.54	2																	
Benzo(b)fluoranthene	mg/kg	5.43	1.8																	
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																	
Dinitrotoluene, 2,4-	mg/kg	7.5	110																	
Dinitrotoluene, 2,6-	mg/kg	2.75	68																	
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																	

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS233		TNTB-SS234		TNTB-SS235		TNTB-SS236		TNTB-SS237		TNTB-SS238		TNTB-SS239		TNTB-SS240	
				Sample No:	10232		10233		10234		10235		10236		10237		10238		10239	
				Sample Date:	2-Nov-98		2-Nov-98		2-Nov-98		2-Nov-98		2-Nov-98		2-Nov-98		2-Nov-98		2-Nov-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	-	-	0.79		0.24		1.4		0.13		1.1		-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																	
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		-	-	0.02		2.3		0.47		3.4		0.48		6.1		-	-
PCBs																				
Aroclor 1254	mg/kg	0.16	0.53																	
Aroclor 1260	mg/kg	2.87	15																	
Semivolatiles																				
Benzo(a)anthracene	mg/kg	5.43	2.4																	
Benzo(a)pyrene	mg/kg	0.54	2																	
Benzo(b)fluoranthene	mg/kg	5.43	1.8																	
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																	
Dinitrotoluene, 2,4-	mg/kg	7.5	110																	
Dinitrotoluene, 2,6-	mg/kg	2.75	68																	
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																	

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS241		TNTB-SS242		TNTB-SS243		TNTB-SS244		TNTB-SS245		TNTB-SS246		TNTB-SS247		TNTB-SS248	
				Sample No:	10240		10241		10242		10243		10244		10245		10246		10247	
				Sample Date:	2-Nov-98		2-Nov-98		2-Nov-98		2-Nov-98		2-Nov-98		2-Nov-98		2-Nov-98		2-Nov-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																			
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000	0.08		0.47		0.01		-	-	0.07		0.39		0.01		0.18	
PCBs																			
Aroclor 1254	mg/kg	0.16	0.53																
Aroclor 1260	mg/kg	2.87	15																
Semivolatiles																			
Benzo(a)anthracene	mg/kg	5.43	2.4																
Benzo(a)pyrene	mg/kg	0.54	2																
Benzo(b)fluoranthene	mg/kg	5.43	1.8																
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																
Dinitrotoluene, 2,4-	mg/kg	7.5	110																
Dinitrotoluene, 2,6-	mg/kg	2.75	68																
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS249		TNTB-SS250		TNTB-SS251		TNTB-SS252		TNTB-SS253		TNTB-SS254		TNTB-SS255		TNTB-SS256	
				Sample No:	10248		10249		10250		10251		10252		10253		10254		10255	
				Sample Date:	2-Nov-98		2-Nov-98		3-Nov-98		3-Nov-98		3-Nov-98		3-Nov-98		3-Nov-98		3-Nov-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	0.1		-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	4.2		-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																	
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		0.01		0.4		-	-	-	-	-	-	-	-	-	-	-	-
PCBs																				
Aroclor 1254	mg/kg	0.16	0.53																	
Aroclor 1260	mg/kg	2.87	15																	
Semivolatiles																				
Benzo(a)anthracene	mg/kg	5.43	2.4																	
Benzo(a)pyrene	mg/kg	0.54	2																	
Benzo(b)fluoranthene	mg/kg	5.43	1.8																	
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																	
Dinitrotoluene, 2,4-	mg/kg	7.5	110																	
Dinitrotoluene, 2,6-	mg/kg	2.75	68																	
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																	

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS257		TNTB-SS258		TNTB-SS259		TNTB-SS260		TNTB-SS261		TNTB-SS262		TNTB-SS263		TNTB-SS264	
				Sample No:	10256		10257		10258		10259		10260		10261		10262		10263	
				Sample Date:	3-Nov-98		3-Nov-98		3-Nov-98		3-Nov-98		3-Nov-98		3-Nov-98		3-Nov-98		3-Nov-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	-	-	-	-	-	-	-	-	-	-	0.23		-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																	
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		-	-	0.13		-	-	-	-	-	-	66		0.62		-	-
PCBs																				
Aroclor 1254	mg/kg	0.16	0.53																	
Aroclor 1260	mg/kg	2.87	15																	
Semivolatiles																				
Benzo(a)anthracene	mg/kg	5.43	2.4																	
Benzo(a)pyrene	mg/kg	0.54	2																	
Benzo(b)fluoranthene	mg/kg	5.43	1.8																	
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																	
Dinitrotoluene, 2,4-	mg/kg	7.5	110																	
Dinitrotoluene, 2,6-	mg/kg	2.75	68																	
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																	

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS265		TNTB-SS266		TNTB-SS267		TNTB-SS268		TNTB-SS269		TNTB-SS270		TNTB-SS271		TNTB-SS272	
				Sample No:	10264		10265		10266		10267		10268		10269		10270		10271	
				Sample Date:	3-Nov-98		3-Nov-98		3-Nov-98		3-Nov-98		3-Nov-98		3-Nov-98		3-Nov-98		3-Nov-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	0.06		-	-	0.05		-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																	
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		0.06		0.66		-	-	0.77		-	-	0.01		-	-	-	-
PCBs																				
Aroclor 1254	mg/kg	0.16	0.53																	
Aroclor 1260	mg/kg	2.87	15																	
Semivolatiles																				
Benzo(a)anthracene	mg/kg	5.43	2.4																	
Benzo(a)pyrene	mg/kg	0.54	2																	
Benzo(b)fluoranthene	mg/kg	5.43	1.8																	
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																	
Dinitrotoluene, 2,4-	mg/kg	7.5	110																	
Dinitrotoluene, 2,6-	mg/kg	2.75	68																	
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																	

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS273		TNTB-SS274		TNTB-SS275		TNTB-SS276		TNTB-SS277		TNTB-SS278		TNTB-SS279		TNTB-SS280	
				Sample No:	10272		10273		10274		10275		10276		10277		10278		10279	
				Sample Date:	3-Nov-98		3-Nov-98		3-Nov-98		3-Nov-98		3-Nov-98		4-Nov-98		4-Nov-98		4-Nov-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	7.6		-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																	
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		-	-	-	-	-	-	-	-	-	-	0.23		0.21		-	-
PCBs																				
Aroclor 1254	mg/kg	0.16	0.53																	
Aroclor 1260	mg/kg	2.87	15																	
Semivolatiles																				
Benzo(a)anthracene	mg/kg	5.43	2.4																	
Benzo(a)pyrene	mg/kg	0.54	2																	
Benzo(b)fluoranthene	mg/kg	5.43	1.8																	
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																	
Dinitrotoluene, 2,4-	mg/kg	7.5	110																	
Dinitrotoluene, 2,6-	mg/kg	2.75	68																	
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																	

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

			Location Code:	TNTB-SS281		TNTB-SS282		TNTB-SS283		TNTB-SS284		TNTB-SS285		TNTB-SS286		TNTB-SS287		TNTB-SS288	
			Sample No:	10280		10281		10282		10283		10284		10285		10286		10287	
			Sample Date:	4-Nov-98		4-Nov-98		4-Nov-98		4-Nov-98		6-Nov-98		6-Nov-98		6-Nov-98		6-Nov-98	
			Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																			
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93	-	-	-	-	-	-	0.34		-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000	0.36		0.46		0.45		0.22		-	-	-	-	-	-	0.1	
PCBs																			
Aroclor 1254	mg/kg	0.16	0.53																
Aroclor 1260	mg/kg	2.87	15																
Semivolatiles																			
Benzo(a)anthracene	mg/kg	5.43	2.4																
Benzo(a)pyrene	mg/kg	0.54	2																
Benzo(b)fluoranthene	mg/kg	5.43	1.8																
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																
Dinitrotoluene, 2,4-	mg/kg	7.5	110																
Dinitrotoluene, 2,6-	mg/kg	2.75	68																
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS289		TNTB-SS290		TNTB-SS291		TNTB-SS292		TNTB-SS293		TNTB-SS294		TNTB-SS295		TNTB-SS295	
				Sample No:	10288		10289		10290		10291		10292		10293		10294		BD0013	
				Sample Date:	6-Nov-98		6-Nov-98		6-Nov-98		6-Nov-98		6-Nov-98		6-Nov-98		8-Nov-98		27-Sep-01	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.3	
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	-	-	-	-	2		-	-	0.21		0.21		2.4	
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.8	
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	
Nitrotoluene, 2-	mg/kg	74	82																-	-
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		0.02		14		-	-	3.9		19		0.72		0.2		2.7	
PCBs																				
Aroclor 1254	mg/kg	0.16	0.53																	
Aroclor 1260	mg/kg	2.87	15																	
Semivolatiles																				
Benzo(a)anthracene	mg/kg	5.43	2.4																	
Benzo(a)pyrene	mg/kg	0.54	2																	
Benzo(b)fluoranthene	mg/kg	5.43	1.8																	
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																	
Dinitrotoluene, 2,4-	mg/kg	7.5	110																	
Dinitrotoluene, 2,6-	mg/kg	2.75	68																	
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																	

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS295		TNTB-SS295		TNTB-SS296		TNTB-SS297		TNTB-SS298		TNTB-SS299		TNTB-SS300		TNTB-SS301	
				Sample No:	BD0014		BD0031		10295		10296		10297		10298		10299		10300	
				Sample Date:	27-Sep-01		27-Sep-01		8-Nov-98		8-Nov-98		8-Nov-98		8-Nov-98		8-Nov-98		8-Nov-98	
				Sample Depth:	2.5 - 3.5 Ft		2.5 - 3.5 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		0.35		0.5	J	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		0.43		1.1	J	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		0.54		0.18	J	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		0.4		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82		-	-	-	-												
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		0.55		0.2	J	0.12		-	-	-	-	-	-	0.28		-	-
PCBs																				
Aroclor 1254	mg/kg	0.16	0.53																	
Aroclor 1260	mg/kg	2.87	15																	
Semivolatiles																				
Benzo(a)anthracene	mg/kg	5.43	2.4																	
Benzo(a)pyrene	mg/kg	0.54	2																	
Benzo(b)fluoranthene	mg/kg	5.43	1.8																	
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																	
Dinitrotoluene, 2,4-	mg/kg	7.5	110																	
Dinitrotoluene, 2,6-	mg/kg	2.75	68																	
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																	

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS302		TNTB-SS303		TNTB-SS304		TNTB-SS305		TNTB-SS306		TNTB-SS307		TNTB-SS308		TNTB-SS309	
				Sample No:	10301		10302		10303		10304		10305		10306		10307		10308	
				Sample Date:	8-Nov-98		8-Nov-98		8-Nov-98		8-Nov-98		8-Nov-98		8-Nov-98		8-Nov-98		8-Nov-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.07	
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	8.2		-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																	
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.55	
PCBs																				
Aroclor 1254	mg/kg	0.16	0.53																	
Aroclor 1260	mg/kg	2.87	15																	
Semivolatiles																				
Benzo(a)anthracene	mg/kg	5.43	2.4																	
Benzo(a)pyrene	mg/kg	0.54	2																	
Benzo(b)fluoranthene	mg/kg	5.43	1.8																	
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																	
Dinitrotoluene, 2,4-	mg/kg	7.5	110																	
Dinitrotoluene, 2,6-	mg/kg	2.75	68																	
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																	

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS310		TNTB-SS311		TNTB-SS312		TNTB-SS313		TNTB-SS314		TNTB-SS315		TNTB-SS316		TNTB-SS317	
				Sample No:	10309		10310		10311		10312		10313		10314		10315		10316	
				Sample Date:	8-Nov-98		8-Nov-98		8-Nov-98		8-Nov-98		8-Nov-98		8-Nov-98		8-Nov-98		8-Nov-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	-	-	0.18		-	-	0.35		0.27		-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																	
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		0.06		720		0.26		0.23		0.86		0.6		-	-	0.15	
PCBs																				
Aroclor 1254	mg/kg	0.16	0.53																	
Aroclor 1260	mg/kg	2.87	15																	
Semivolatiles																				
Benzo(a)anthracene	mg/kg	5.43	2.4																	
Benzo(a)pyrene	mg/kg	0.54	2																	
Benzo(b)fluoranthene	mg/kg	5.43	1.8																	
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																	
Dinitrotoluene, 2,4-	mg/kg	7.5	110																	
Dinitrotoluene, 2,6-	mg/kg	2.75	68																	
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																	

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS318		TNTB-SS319		TNTB-SS320		TNTB-SS321		TNTB-SS322		TNTB-SS323		TNTB-SS324		TNTB-SS325	
				Sample No:	10317		10318		10319		10320		10321		10322		10323		10324	
				Sample Date:	8-Nov-98		9-Nov-98		9-Nov-98		9-Nov-98		9-Nov-98		9-Nov-98		9-Nov-98		9-Nov-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	-	-	0.08		-	-	-	-	-	-	0.01		-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-	1.3		-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																	
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		0.03		-	-	0.47		0.09		0.15		-	-	0.01		0.2	
PCBs																				
Aroclor 1254	mg/kg	0.16	0.53																	
Aroclor 1260	mg/kg	2.87	15																	
Semivolatiles																				
Benzo(a)anthracene	mg/kg	5.43	2.4																	
Benzo(a)pyrene	mg/kg	0.54	2																	
Benzo(b)fluoranthene	mg/kg	5.43	1.8																	
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																	
Dinitrotoluene, 2,4-	mg/kg	7.5	110																	
Dinitrotoluene, 2,6-	mg/kg	2.75	68																	
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																	

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS326		TNTB-SS327		TNTB-SS328		TNTB-SS329		TNTB-SS330		TNTB-SS331		TNTB-SS332		TNTB-SS333	
				Sample No:	10325		10326		10327		10328		10329		10330		10331		10332	
				Sample Date:	9-Nov-98		9-Nov-98		9-Nov-98		9-Nov-98		9-Nov-98		9-Nov-98		9-Nov-98		9-Nov-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		0.09		-	-	0.01		-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																	
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		0.56		0.05		0.4		0.25		3.5		0.16		-	-	0.28	
PCBs																				
Aroclor 1254	mg/kg	0.16	0.53																	
Aroclor 1260	mg/kg	2.87	15																	
Semivolatiles																				
Benzo(a)anthracene	mg/kg	5.43	2.4																	
Benzo(a)pyrene	mg/kg	0.54	2																	
Benzo(b)fluoranthene	mg/kg	5.43	1.8																	
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																	
Dinitrotoluene, 2,4-	mg/kg	7.5	110																	
Dinitrotoluene, 2,6-	mg/kg	2.75	68																	
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																	

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS334		TNTB-SS335		TNTB-SS336		TNTB-SS337		TNTB-SS362		TNTB-SS362		TNTB-SS365		TNTB-SS366	
				Sample No:	10333		10334		10335		10336		10360		10361		10364		10365	
				Sample Date:	9-Nov-98		9-Nov-98		10-Nov-98		10-Nov-98		5-Nov-98		5-Nov-98		5-Nov-98		5-Nov-98	
				Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		3 - 4 Ft		3 - 4 Ft		4 - 4.5 Ft		3 - 4 Ft	
Parameter	Units	RGO	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93	0.18		0.01		0.27		0.02		-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000	0.78		0.27		0.84		0.36		-	-	0.28		-	-	-	-
PCBs																				
Aroclor 1254	mg/kg	0.16	0.53																
Aroclor 1260	mg/kg	2.87	15																
Semivolatiles																				
Benzo(a)anthracene	mg/kg	5.43	2.4																
Benzo(a)pyrene	mg/kg	0.54	2																
Benzo(b)fluoranthene	mg/kg	5.43	1.8																
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																
Dinitrotoluene, 2,4-	mg/kg	7.5	110																
Dinitrotoluene, 2,6-	mg/kg	2.75	68																
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS368		TNTB-SS368		TNTB-SS369		TNTB-SS369		TNTB-SS370		TNTB-SS370		TNTB-SS371		TNTB-SS372	
				Sample No:	10367		10368		10369		10370		10371		10372		10373		10374	
				Sample Date:	6-Nov-98		6-Nov-98		6-Nov-98		6-Nov-98		6-Nov-98		6-Nov-98		6-Nov-98		6-Nov-98	
				Sample Depth:	3 - 4 Ft		6 - 7 Ft		2 - 4.5 Ft		7 - 7.5 Ft		2 - 2.5 Ft		4 - 4.5 Ft		2 - 2.5 Ft		1.5 - 2 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	0.01		-	-	-	-	0.38		-	-	0.18		-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																	
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		-	-	-	-	-	-	-	-	0.52		25		0.07		-	-
PCBs																				
Aroclor 1254	mg/kg	0.16	0.53																	
Aroclor 1260	mg/kg	2.87	15																	
Semivolatiles																				
Benzo(a)anthracene	mg/kg	5.43	2.4																	
Benzo(a)pyrene	mg/kg	0.54	2																	
Benzo(b)fluoranthene	mg/kg	5.43	1.8																	
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																	
Dinitrotoluene, 2,4-	mg/kg	7.5	110																	
Dinitrotoluene, 2,6-	mg/kg	2.75	68																	
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																	

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:		TNTB-SS373		TNTB-SS374		TNTB-SS375		TNTB-SS375		TNTB-SS375		TNTB-SS375		TNTB-SS376	
				Sample No:		10375		10377		10378		10379		BD0015		BD0016		10380	
				Sample Date:		6-Nov-98		6-Nov-98		6-Nov-98		6-Nov-98		27-Sep-01		27-Sep-01		6-Nov-98	
				Sample Depth:		3.5 - 4 Ft		3 - 4 Ft		4 - 6 Ft		8 - 10 Ft		4 - 6 Ft		4 - 6 Ft		3 - 4 Ft	
Parameter	Units	RGO	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																			
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93	-	-	-	-	-	-	-	-	-	-	-	-	150	U	17	
Dinitrotoluene, 2,4-	mg/kg	7.5	11000	-	-	-	-	-	-	-	-	-	-	2,400		2,100		-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000	-	-	-	-	-	-	-	-	-	-	1,500		630		-	-
Nitrotoluene, 2-	mg/kg	74	82											-	-	-	-		
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000	-	-	-	-	0.5		6,100		76		3,100		2,200		110	
PCBs																			
Aroclor 1254	mg/kg	0.16	0.53																
Aroclor 1260	mg/kg	2.87	15																
Semivolatiles																			
Benzo(a)anthracene	mg/kg	5.43	2.4																
Benzo(a)pyrene	mg/kg	0.54	2																
Benzo(b)fluoranthene	mg/kg	5.43	1.8																
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																
Dinitrotoluene, 2,4-	mg/kg	7.5	110																
Dinitrotoluene, 2,6-	mg/kg	2.75	68																
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:		TNTB-SS376		TNTB-SS377		TNTB-SS378		TNTB-SS379		TNTB-SS379		TNTB-SS380		TNTB-SS380		TNTB-SS381	
				Sample No:		10381		10382		10383		10384		10385		10386		10387		10388	
				Sample Date:		6-Nov-98		6-Nov-98		8-Nov-98		8-Nov-98		8-Nov-98		8-Nov-98		8-Nov-98		8-Nov-98	
				Sample Depth:		7 - 7.5 Ft		3 - 3.5 Ft		2.5 - 3.5 Ft		4 - 5 Ft		7.5 - 8.5 Ft		4 - 6 Ft		8 - 10 Ft		4 - 6 Ft	
Parameter	Units	RGO	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																					
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93	-	-	-	-	0.49		-	-	-	-	0.08		0.12		-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																		
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000	2.7		-	-	0.07		18		-	-	0.15		0.5		-	-	-	-
PCBs																					
Aroclor 1254	mg/kg	0.16	0.53																		
Aroclor 1260	mg/kg	2.87	15																		
Semivolatiles																					
Benzo(a)anthracene	mg/kg	5.43	2.4																		
Benzo(a)pyrene	mg/kg	0.54	2																		
Benzo(b)fluoranthene	mg/kg	5.43	1.8																		
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																		
Dinitrotoluene, 2,4-	mg/kg	7.5	110																		
Dinitrotoluene, 2,6-	mg/kg	2.75	68																		
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																		

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:		TNTB-SS381		TNTB-SS382		TNTB-SS382		TNTB-SS383		TNTB-SS383		TNTB-SS384		TNTB-SS384		TNTB-SS385	
				Sample No:		10389		10390		10391		10392		10393		10394		10395		10396	
				Sample Date:		8-Nov-98		8-Nov-98		8-Nov-98		8-Nov-98		8-Nov-98		8-Nov-98		8-Nov-98		8-Nov-98	
				Sample Depth:		8 - 10 Ft		4 - 6 Ft		8 - 10 Ft		4 - 6 Ft		8 - 10 Ft		4 - 6 Ft		8 - 10 Ft		2.5 - 3.5 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	
Explosives																					
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		0.02		-	-	-	-	-	-	-	-	-	-	0.06		-	-	
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Nitrotoluene, 2-	mg/kg	74	82																		
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		-	-	-	-	-	-	-	-	-	-	-	-	0.84		-	-	
PCBs																					
Aroclor 1254	mg/kg	0.16	0.53																		
Aroclor 1260	mg/kg	2.87	15																		
Semivolatiles																					
Benzo(a)anthracene	mg/kg	5.43	2.4																		
Benzo(a)pyrene	mg/kg	0.54	2																		
Benzo(b)fluoranthene	mg/kg	5.43	1.8																		
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																		
Dinitrotoluene, 2,4-	mg/kg	7.5	110																		
Dinitrotoluene, 2,6-	mg/kg	2.75	68																		
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																		

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:		TNTB-SS386		TNTB-SS387		TNTB-SS387		TNTB-SS388		TNTB-SS389		TNTB-SS389		TNTB-SS390		TNTB-SS391	
				Sample No:		10397		10398		10399		10400		10401		10402		10403		10404	
				Sample Date:		8-Nov-98		8-Nov-98		8-Nov-98		8-Nov-98		8-Nov-98		8-Nov-98		8-Nov-98		8-Nov-98	
				Sample Depth:		4 - 4.5 Ft		2.5 - 3 Ft		5 - 6 Ft		3 - 4 Ft		4 - 6 Ft		8 - 10 Ft		4 - 5 Ft		4 - 5 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																					
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	-	-	-	-	-	-	-	-	42		2.4		-	-	
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	17.3		-	-	-	-	-	-	254.5		-	-	-	-	
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Nitrotoluene, 2-	mg/kg	74	82																		
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		-	-	-	-	-	-	5.2		1.6		46		19		2.4		
PCBs																					
Aroclor 1254	mg/kg	0.16	0.53																		
Aroclor 1260	mg/kg	2.87	15																		
Semivolatiles																					
Benzo(a)anthracene	mg/kg	5.43	2.4																		
Benzo(a)pyrene	mg/kg	0.54	2																		
Benzo(b)fluoranthene	mg/kg	5.43	1.8																		
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																		
Dinitrotoluene, 2,4-	mg/kg	7.5	110																		
Dinitrotoluene, 2,6-	mg/kg	2.75	68																		
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																		

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:		TNTB-SS392		TNTB-SS393		TNTB-SS393		TNTB-SS394		TNTB-SS394		TNTB-SS395		TNTB-SS395	
				Sample No:		10405		10406		10407		10408		10409		10410		10411		10412	
				Sample Date:		8-Nov-98		8-Nov-98		10-Nov-98		10-Nov-98		10-Nov-98		10-Nov-98		10-Nov-98		10-Nov-98	
				Sample Depth:		3 - 5 Ft		6 - 8 Ft		4 - 5 Ft		8 - 9 Ft		4 - 5 Ft		8 - 9 Ft		4 - 5 Ft		8 - 9 Ft	
Parameter	Units	RGO	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																					
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93	0.37		0.04		3.07		-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82																		
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000	0.37		0.64		18		-	-	27		-	-	0.15		-	-		
PCBs																					
Aroclor 1254	mg/kg	0.16	0.53																		
Aroclor 1260	mg/kg	2.87	15																		
Semivolatiles																					
Benzo(a)anthracene	mg/kg	5.43	2.4																		
Benzo(a)pyrene	mg/kg	0.54	2																		
Benzo(b)fluoranthene	mg/kg	5.43	1.8																		
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																		
Dinitrotoluene, 2,4-	mg/kg	7.5	110																		
Dinitrotoluene, 2,6-	mg/kg	2.75	68																		
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																		

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:		TNTB-SS396		TNTB-SS396		TNTB-SS397		TNTB-SS397		TNTB-SS398		TNTB-SS398		TNTB-SS399		TNTB-SS399	
				Sample No:		10413		10414		10415		10416		10417		10418		10419		10420	
				Sample Date:		10-Nov-98		10-Nov-98		10-Nov-98		10-Nov-98		10-Nov-98		10-Nov-98		10-Nov-98		10-Nov-98	
				Sample Depth:		3 - 4 Ft		8 - 10 Ft		3 - 4 Ft		5 - 6 Ft		3 - 4 Ft		5 - 6 Ft		4 - 6 Ft		8 - 10 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																					
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		0.12		-	-	0.03		-	-	0.39		0.53		-	-	-	-	
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Nitrotoluene, 2-	mg/kg	74	82																		
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		0.14		-	-	0.02		0.21		0.28		0.29		-	-	-	-	
PCBs																					
Aroclor 1254	mg/kg	0.16	0.53																		
Aroclor 1260	mg/kg	2.87	15																		
Semivolatiles																					
Benzo(a)anthracene	mg/kg	5.43	2.4																		
Benzo(a)pyrene	mg/kg	0.54	2																		
Benzo(b)fluoranthene	mg/kg	5.43	1.8																		
Dibenz(a,h)anthracene	mg/kg	0.65	0.55																		
Dinitrotoluene, 2,4-	mg/kg	7.5	110																		
Dinitrotoluene, 2,6-	mg/kg	2.75	68																		
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1																		

Table 3-7

TNTB - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	TNTB-SS400		TNTB-SS400		TNTB-SS401		TNTB-SS401		TNTB-SS402		TNTB-SS402	
				Sample No:	10421		10422		10423		10424		10425		10426	
				Sample Date:	10-Nov-98		10-Nov-98		10-Nov-98		10-Nov-98		10-Nov-98		10-Nov-98	
				Sample Depth:	4 - 5 Ft		8 - 9 Ft		4 - 5 Ft		8 - 10 Ft		4 - 5 Ft		8 - 10 Ft	
Parameter	Units	RGO	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																
Amino-2,6-dinitrotoluene, 4-	mg/kg	0.4	45		-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.4	93		-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	7.5	11000		-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.75	12000		-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	74	82													
Trinitrotoluene, 2,4,6-	mg/kg	3.36	29000		-	-	-	-	0.05		-	-	-	-	-	-
PCBs																
Aroclor 1254	mg/kg	0.16	0.53													
Aroclor 1260	mg/kg	2.87	15													
Semivolatiles																
Benzo(a)anthracene	mg/kg	5.43	2.4													
Benzo(a)pyrene	mg/kg	0.54	2													
Benzo(b)fluoranthene	mg/kg	5.43	1.8													
Dibenz(a,h)anthracene	mg/kg	0.65	0.55													
Dinitrotoluene, 2,4-	mg/kg	7.5	110													
Dinitrotoluene, 2,6-	mg/kg	2.75	68													
Indeno(1,2,3-cd)pyrene	mg/kg	5.43	1													

RGO - Remedial goal option.
MDC - Maximum detected concentration for the AOC ("B" qualified data excluded).
"-" - Not detected.
Ft - Feet.
mg/kg - Milligrams per kilogram.
PCB - Polychlorinated biphenyl

Validation Qualifiers (VQ)
B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.
J - The analyte was positively identified; the reported value is estimated.
N - Tentatively identified

Table 3-8

TNTB - Historical Groundwater Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

				Location Code:		IT-TNTB-BEDGW-001		IT-TNTB-BEDGW-002		IT-TNTB-BEDGW-002		MK-MW16		MK-MW16		MK-MW16	
				Sample No:		5420		5425		5430		5435		5260		5780		5785	
				Sample Date:		17-Nov-97		18-May-98		16-Nov-97		18-May-98		30-Sep-96		21-Nov-97		18-May-98	
Parameter	Units	RBSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives - Unfiltered																	
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	8.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	ug/L	0.73	2.3														
Dinitrobenzene, 1,3-	ug/L	0.37	2.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	ug/L	0.099	1.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	ug/L	0.099	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 3,4-	ug/L	NE	2.7														
Nitrotoluene, 3-	ug/L	12.2	5.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	ug/L	1.83	6.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Explosives - Filtered																	
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	5.8														
Dinitrotoluene, 2,4-	ug/L	0.099	2.2														
Dinitrotoluene, 2,6-	ug/L	0.099	11														
Trinitrobenzene, 1,3,5-	ug/L	110	2.3														
Trinitrotoluene, 2,4,6-	ug/L	1.83	3.4														
Volatiles																	
Acetone	ug/L	548	5.2	-	-	1.9	B	-	-	-	-	-	-	-	-	5.2	J
Benzene	ug/L	0.35	0.91	0.14	J	-	-	0.91	J	-	-	-	-	-	-	-	-
Carbon disulfide	ug/L	104	7.2	0.82	J	7.2		6.4		-	-	-	-	-	-	-	-
Chlorobenzene	ug/L	10.6	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dichloroethane, 1,1-	ug/L	81	0.19	-	-	0.19	J	-	-	-	-	-	-	-	-	-	-
Ethylbenzene	ug/L	134	0.85	-	-	-	-	0.85	J	-	-	-	-	-	-	-	-
Methylene chloride	ug/L	4.3	NA	-	-	-	-	4.8	B	3.1	B	6.6	U	0.4	B	0.52	B
Toluene	ug/L	72	1.8	0.22	B	-	-	-	-	-	-	-	-	-	-	-	-
Xylenes, total	ug/L	21	12	0.44	B	-	-	12		-	-	-	-	-	-	-	-
Semivolatiles																	
Bis(2-ethylhexyl)phthalate	ug/L	4.8	12	3.6	J	13	B	3	J	3.1	B	-	-	2.4	J	2.8	B
Dinitrotoluene, 2,4-	ug/L	0.099	1.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phenol	ug/L	1,095	2.3	-	-	-	-	2.3	J	-	-	-	-	-	-	-	-

Table 3-8

TNTB - Historical Groundwater Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

				Location Code:		IT-TNTB-BEDGW-001		IT-TNTB-BEDGW-002		IT-TNTB-BEDGW-002		MK-MW16		MK-MW16		MK-MW16	
				Sample No:		5420		5425		5430		5435		5260		5780		5785	
				Sample Date:		17-Nov-97		18-May-98		16-Nov-97		18-May-98		30-Sep-96		21-Nov-97		18-May-98	
Parameter	Units	RBSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Unfiltered																	
Aluminum	ug/L	3,650	116000	654		1,130	J	317		-	-	3,760		4,990	J	1,180	
Arsenic	ug/L	0.045	124	-	-	12.9		-	-	-	-	-	-	-	-	-	-
Barium	ug/L	255	1480	-	-	1,100		326		406		-	-	-	-	-	-
Beryllium	ug/L	7.3	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	ug/L	1.8	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	ug/L	NE	183000	105,000		101,000		114,000	J	92,600		183,000		146,000	J	133,000	
Chromium	ug/L	11	159	-	-	-	-	-	-	-	-	10.6		-	-	-	-
Cobalt	ug/L	73	207	-	-	-	-	-	-	-	-	-	-	-	-	69.8	
Copper	ug/L	146	659	33.9		80.9		-	-	-	-	26.2		-	-	-	-
Iron	ug/L	1,095	361000	41,700		13,000		1,030		168	J	12,100		19,800		20,700	J
Lead	ug/L	15	340	3.9		6.2		4.8		7.1		34.8		8	B	-	-
Magnesium	ug/L	NE	68400	22,800		57,800		43,800		37,400		68,400		53,800		52,700	
Manganese	ug/L	88	14000	677		196		85.4		36.6		12,000		6,970		13,600	
Mercury	ug/L	1.1	0.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	ug/L	73	542	42.1		-	-	-	-	-	-	114		61.8		108	
Potassium	ug/L	NE	37000	7,240		37,000		10,400		8,190		-	-	5,460		-	-
Selenium	ug/L	18	5.1	-	-	-	-	-	-	-	-	-	-	5		-	-
Sodium	ug/L	NE	415000	34,900		415,000		127,000		109,000		9,010	J	6,560	J	10,500	
Thallium	ug/L	0.24	2.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	ug/L	3.7	294	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc	ug/L	1,095	852	48.8		150	J	73.9		39.6	B	95.4		75.5		209	
Metals - Filtered																	
Aluminum	ug/L	3,650	7430	-	-	-	-	-	-	-	-	1,110		1,080		663	
Antimony	ug/L	1.5	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	ug/L	0.045	47.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Barium	ug/L	255	1040	-	-	1,040		384		414		-	-	-	-	-	-
Beryllium	ug/L	7.3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	ug/L	NE	197000	116,000	J	104,000		130,000		96,800		197,000		147,000		127,000	
Cobalt	ug/L	73	95.9	-	-	-	-	-	-	-	-	95.9		-	-	51.9	
Copper	ug/L	146	48.9	-	-	-	-	-	-	-	-	48.9		-	-	39.2	
Iron	ug/L	1,095	78600	16,300		302		586		-	-	391		2,410		5,970	
Lead	ug/L	15	17	-	-	-	-	3		-	-	-	-	-	-	7.4	
Magnesium	ug/L	NE	71100	25,600		60,400		51,100		38,600		71,100	J	52,300		47,900	
Manganese	ug/L	88	17000	694		278		71		36.5		11,600	J	6,900		8,850	
Mercury	ug/L	1.1	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	ug/L	73	320	-	-	-	-	-	-	-	-	148		47.2		81.7	
Potassium	ug/L	NE	36700	8,130		36,700		10,700		7,990		-	-	-	-	-	-
Selenium	ug/L	18	5	-	-	-	-	-	-	-	-	-	-	5		-	-
Sodium	ug/L	NE	419000	36,100		419,000		153,000		112,000		10,600		6,470		9,070	
Thallium	ug/L	0.24	2.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc	ug/L	1,095	200	-	-	-	-	-	-	40.4	B	121		54.7	J	141	B

Table 3-8

TNTB - Historical Groundwater Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

				Location Code:		IT-TNTB-BEDGW-001		IT-TNTB-BEDGW-002		IT-TNTB-BEDGW-002		MK-MW16		MK-MW16		MK-MW16	
				Sample No:		5420		5425		5430		5435		5260		5780		5785	
				Sample Date:		17-Nov-97		18-May-98		16-Nov-97		18-May-98		30-Sep-96		21-Nov-97		18-May-98	
Parameter	Units	RBSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Water Quality Parameters																	
Alkalinity	ug/L	NE	380000	180,000		360,000		220,000		380,000				36,000		320,000	
Chloride	ug/L	NE	600000	90,000		600,000		91,000		74,000				3,000	B	3,000	
Hardness	ug/L	NE	750000	360,000		650,000		450,000		530,000				490,000		750,000	
Nitrate	ug/L	1000	200			-	-			-	-					-	-
Sulfate	ug/L	NE	550000	140,000		120,000		90,000		140,000				470,000		550,000	
Total dissolved solids	ug/L	NE	7600000	730,000		1,200,000		760,000		7,600,000				290,000		800,000	
Total organic carbon	ug/L	NE	12000	12,000		5,000		5,000		4,000				2,500		2,000	
Total suspended solids	ug/L	NE	480000	480,000		9,000		5,000		6,000				-	-	9,000	

Table 3-8

TNTB - Historical Groundwater Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

				Location Code:															
				Sample No:															
				Sample Date:															
Parameter	Units	RBSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives - Unfiltered																			
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	8.7			-	-	8.7	J	4.4	J	3.6		5.7				1.6	
Amino-4,6-dinitrotoluene, 2-	ug/L	0.73	2.3			-	-											2.3	
Dinitrobenzene, 1,3-	ug/L	0.37	2.2	-	-	-	-	2.2		-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	ug/L	0.099	1.7	-	-	-	-	-	-	-	-	-	-	1.7		-	-	1.2	
Dinitrotoluene, 2,6-	ug/L	0.099	11	-	-	-	-	11	J	6.4	J	-	-	-	-	-	-	0.2	
Dinitrotoluene, 3,4-	ug/L	NE	2.7			-	-											2.7	
Nitrotoluene, 3-	ug/L	12.2	5.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.3	
Trinitrotoluene, 2,4,6-	ug/L	1.83	6.5	-	-	-	-	-	-	-	-	-	-	0.68		-	-	6.5	
Explosives - Filtered																			
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	5.8					5.8		4.6									
Dinitrotoluene, 2,4-	ug/L	0.099	2.2					2.2		-	-								
Dinitrotoluene, 2,6-	ug/L	0.099	11					11	J	8.5	J								
Trinitrobenzene, 1,3,5-	ug/L	110	2.3					2.3		-	-								
Trinitrotoluene, 2,4,6-	ug/L	1.83	3.4					3.4	J	2.5	J								
Volatiles																			
Acetone	ug/L	548	5.2	-	-			-	-	-	-	-	-	-	-	-	-		
Benzene	ug/L	0.35	0.91	-	-			-	-	-	-	-	-	-	-	-	-		
Carbon disulfide	ug/L	104	7.2	-	-			-	-	-	-	-	-	-	-	-	-		
Chlorobenzene	ug/L	10.6	1.1	-	-			-	-	1.1	J	-	-	-	-	-	-		
Dichloroethane, 1,1-	ug/L	81	0.19	-	-			-	-	-	-	-	-	-	-	-	-		
Ethylbenzene	ug/L	134	0.85	-	-			-	-	-	-	-	-	-	-	-	-		
Methylene chloride	ug/L	4.3	NA	-	-			-	-	-	-	0.39	B	0.28	B	-	-		
Toluene	ug/L	72	1.8	-	-			1.8	J	-	-	-	-	0.21	B	-	-		
Xylenes, total	ug/L	21	12	-	-			-	-	-	-	-	-	-	-	-	-		
Semivolatiles																			
Bis(2-ethylhexyl)phthalate	ug/L	4.8	12	-	-			-	-	-	-	-	-	-	-	12			
Dinitrotoluene, 2,4-	ug/L	0.099	1.8	-	-			-	-	-	-	-	-	1.8	J	-	-		
Phenol	ug/L	1,095	2.3	-	-			-	-	-	-	-	-	-	-	-	-		

Table 3-8

TNTB - Historical Groundwater Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

				Location Code:															
				Sample No:															
				Sample Date:															
Parameter	Units	RBSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Unfiltered																			
Aluminum	ug/L	3,650	116000	-	-			658		-	-	1,830	J	6,920	J	116,000			
Arsenic	ug/L	0.045	124	-	-	-	-	10.2		-	-	12.6		18.7		124		13	
Barium	ug/L	255	1480	206				-	-	-	-	-	-	-	-	1,480			
Beryllium	ug/L	7.3	9	-	-	2		-	-	-	-	-	-	-	-	9		-	-
Cadmium	ug/L	1.8	2	0.6		-	-	-	-	-	-	-	-	-	-	2		2	
Calcium	ug/L	NE	183000	135,000				124,000		146,000		127,000	J	104,000	J	-	-		
Chromium	ug/L	11	159	24.6		-	-	-	-	-	-	-	-	-	-	159		-	-
Cobalt	ug/L	73	207	64.3				78.5		89.6		78.8		54.9		207			
Copper	ug/L	146	659	121		35		-	-	-	-	-	-	32.9		659		37	
Iron	ug/L	1,095	361000	-	-			34,800		38,100		44,300		41,900		361,000			
Lead	ug/L	15	340	-	-	6		3.4		-	-	4.4	B	16.4		340		9	
Magnesium	ug/L	NE	68400	55,800				29,900		35,000		29,900		24,300		49,700			
Manganese	ug/L	88	14000	-	-	14,000		1,430		1,690		1,410		1,120		-	-	2,200	
Mercury	ug/L	1.1	0.25	-	-	-	-	-	-	-	-	-	-	-	-	0.25		-	-
Nickel	ug/L	73	542	209		150		156		196		156		130		542		320	
Potassium	ug/L	NE	37000	18,100				-	-	-	-	-	-	5,040		19,400			
Selenium	ug/L	18	5.1	-	-	-	-	-	-	-	-	5.1		-	-	3		-	-
Sodium	ug/L	NE	415000	10,300				5,980		7,030		6,090	J	6,030		10,800			
Thallium	ug/L	0.24	2.3	-	-	2.3		-	-	-	-	-	-	-	-	-	-	0.9	
Vanadium	ug/L	3.7	294	37				-	-	-	-	-	-	-	-	294			
Zinc	ug/L	1,095	852	191		160		119		144		137		152		852		250	
Metals - Filtered																			
Aluminum	ug/L	3,650	7430	2,450				-	-	4,330		-	-	7,430		-	-		
Antimony	ug/L	1.5	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	
Arsenic	ug/L	0.045	47.4	4		-	-	11.4		47.4		-	-	22		-	-	-	-
Barium	ug/L	255	1040	83.4				-	-	-	-	-	-	-	-	32.6			
Beryllium	ug/L	7.3	2	-	-	2		-	-	-	-	-	-	-	-	-	-	-	-
Calcium	ug/L	NE	197000	118,000				145,000		142,000		114,000		106,000	J	-	-		
Cobalt	ug/L	73	95.9	-	-			79.5		81.5		72.9		56.7		21.6			
Copper	ug/L	146	48.9	-	-	-	-	-	-	36		-	-	32.2		9.2		-	-
Iron	ug/L	1,095	78600	774				38,300		78,600		34,100		41,600		19,500			
Lead	ug/L	15	17	-	-	-	-	-	-	16.7		-	-	17		-	-	-	-
Magnesium	ug/L	NE	71100	49,800				35,100		33,700		26,300		25,100	J	27,600			
Manganese	ug/L	88	17000	2,440		17,000		1,680		1,640		1,260		1,170		-	-	2,300	
Mercury	ug/L	1.1	0.3	-	-	-	-	-	-	-	-	0.3		-	-	-	-	-	-
Nickel	ug/L	73	320	98		180		182		205		140		131		71.7		320	
Potassium	ug/L	NE	36700	14,200				-	-	-	-	-	-	-	-	4,700			
Selenium	ug/L	18	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	ug/L	NE	419000	9,590				7,140		6,680		5,170		6,010		9,100			
Thallium	ug/L	0.24	2.6	-	-	2.6		-	-	-	-	-	-	10.1	B	-	-	-	-
Zinc	ug/L	1,095	200	-	-	140		114		198		87.7	J	157		-	-	200	

Table 3-8

TNTB - Historical Groundwater Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

				Location Code:		MK-MW16		MK-MW17		MK-MW17		MK-MW17		MK-MW17		MK-MW17		MK-MW17	
				Sample No:		PB-TNTB-MK-MW16		5270		5271		5790		5795		MK02MW17		PB-TNTB-MK-MW17	
				Sample Date:		9-Dec-94		21-Oct-96		21-Oct-96		21-Nov-97		27-May-98		6-Jul-93		13-Dec-94	
Parameter	Units	RBSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Water Quality Parameters																			
Alkalinity	ug/L	NE	380000									38,000		-	-				
Chloride	ug/L	NE	600000									4,000	B	6,000					
Hardness	ug/L	NE	750000									440,000		490,000					
Nitrate	ug/L	1000	200			200								-	-			200	
Sulfate	ug/L	NE	550000									300,000		330,000					
Total dissolved solids	ug/L	NE	7600000									660,000		590,000					
Total organic carbon	ug/L	NE	12000									3,400		3,000					
Total suspended solids	ug/L	NE	480000									5,000		120,000					

Shaded cell indicates value is greater than the RBSC.
BSC - Background screening concentration.
MDC - Maximum detected concentration for the AOC ("B" qualified data not included).
RBSC - Values reflect an incremental lifetime cancer risk (ILCR) of 1E-6 or a noncancer hazard quotient (HQ) of 0.1. For chemicals that exhibit both cancer and noncancer effects, whichever type of effect results in a lower concentration (using an ILCR of 1E-6 and an HQ of 0.1), that concentration is selected as the RBSC.
"-" - Not detected.
NA - Not applicable; detection is the result of blank contamination.
NE - Not established (RBSCs), not evaluated (BSCs).
NTU - Nephelometric turbidity unit.
µg/L - Micrograms per liter.

Validation Qualifiers (VQ)
B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.
J - The analyte was positively identified; the reported value is estimated.
U - Not detected due to blank contamination.

Table 3-9

TNTC - Historical Surface Water Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

	Location Code:		MK-PMU1-SW-SD04		TNTC-SW01		TNTC-SW02		TNTC-SW03		TNTC-SW04		TNTC-SW05	
	Sample No:		MK01SW04		AB2001		AB2002		AB2003		AB2004		AB2005	
	Sample Date:		29-Jun-93		18-Sep-00		18-Sep-00		18-Sep-00		18-Sep-00		19-Sep-00	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives														
Amino-2,6-dinitrotoluene, 4-	ug/L	0.549			-	-	-	-	-	-	-	-	0.549	
Amino-4,6-dinitrotoluene, 2-	ug/L	0.984			-	-	-	-	-	-	-	-	0.984	
Dinitrotoluene, total	ug/L	7.92			-	-	-	-	-	-	7.92		0.969	
Nitrotoluene, 2-	ug/L	10.4	-	-	-	-	-	-	-	-	10.4		-	-
Nitrotoluene, 3-	ug/L	1.47	-	-	-	-	-	-	-	-	1.47		-	-
Nitrotoluene, 4-	ug/L	4.3	-	-	-	-	-	-	-	-	4.3		-	-
Trinitrotoluene, 2,4,6-	ug/L	0.344	-	-	-	-	-	-	-	-	-	-	0.344	
Volatiles														
Acetone	ug/L	10.8	-	-	-	-	-	-	-	-	-	-	-	-
Carbon disulfide	ug/L	23.1	-	-	0.59	J	12.7		2.43		8.09		1.72	
Methylene chloride	ug/L	NA	-	-	1.13	UB	0.74	B	0.68	B	0.6	B	0.93	B
Semivolatiles														
Di-n-butyl phthalate	ug/L	4.95	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	ug/L	2.57	-	-	-	-	-	-	-	-	2.57	J	-	-
Dinitrotoluene, 2,6-	ug/L	2.95	-	-	-	-	-	-	-	-	2.95	J	-	-
Metals														
Aluminum	ug/L	3830	2370		454		876		176	B	1190		1360	
Barium	ug/L	125	49.7		40.9		28.1		28		125		48.2	
Beryllium	ug/L	NA	-	-	0.144	B	0.162	B	0.122	B	0.206	B	0.119	B
Cadmium	ug/L	2.12	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	ug/L	235000	87800		195000		103000		99700		162000		156000	
Chromium	ug/L	4.45	-	-	1.35	J	1.93	J	2.04	J	2.23	J	2	J
Cobalt	ug/L	4.4	-	-	-	-	-	-	-	-	-	-	2.77	J
Copper	ug/L	5.81	-	-	1.36	J	3.82	J	-	-	1.95	J	3	J
Iron	ug/L	15300	4660		455		1370		555		15300		5540	
Lead	ug/L	6.89	-	-	-	-	2.57	J	2.2	J	6.89		-	-
Magnesium	ug/L	51700	21600		43900		25600		27200		25700		33300	
Manganese	ug/L	3010	114		69.2		167		74		1230		694	
Nickel	ug/L	8.69	-	-	3.49	J	-	-	-	-	-	-	2.86	J
Potassium	ug/L	4600	4600		2090		1490		967		1880		2050	
Selenium	ug/L	3.09	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	ug/L	22700	22700		5300		1820		1350		2990		2750	
Vanadium	ug/L	7.12	-	-	1.07	J	2.05	J	-	-	3	J	1.73	J
Zinc	ug/L	33	33		4.52	J	22.3		6.88	J	18.2		21.3	

Table 3-9

TNTC - Historical Surface Water Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

	Location Code:		TNTC-SW06		TNTC-SW07		TNTC-SW08		TNTC-SW10		TNTC-SW11	
	Sample No:		AB2006		AB2007		AB2008		AB2010		AB2011	
	Sample Date:		18-Sep-00		19-Sep-00		19-Sep-00		19-Sep-00		19-Sep-00	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives												
Amino-2,6-dinitrotoluene, 4-	ug/L	0.549	-	-	-	-	-	-	0.332		-	-
Amino-4,6-dinitrotoluene, 2-	ug/L	0.984	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, total	ug/L	7.92	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	ug/L	10.4	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 3-	ug/L	1.47	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 4-	ug/L	4.3	-	-	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	ug/L	0.344	-	-	-	-	-	-	-	-	-	-
Volatiles												
Acetone	ug/L	10.8	-	-	-	-	-	-	10.8	J	-	-
Carbon disulfide	ug/L	23.1	10.5		23.1		8.32		10.5		3.12	
Methylene chloride	ug/L	NA	0.71	B	0.75	B	0.69	B	0.75	B	0.71	B
Semivolatiles												
Di-n-butyl phthalate	ug/L	4.95	-	-	-	-	4.95	J	-	-	-	-
Dinitrotoluene, 2,4-	ug/L	2.57	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	ug/L	2.95	-	-	-	-	-	-	-	-	-	-
Metals												
Aluminum	ug/L	3830	3830		543		80.9	B	152	B	815	
Barium	ug/L	125	76.3		39.5		32.2		80.4		67.1	
Beryllium	ug/L	NA	0.316	B	0.154	B	-	-	0.101	B	0.123	B
Cadmium	ug/L	2.12	-	-	2.12	J	-	-	-	-	-	-
Calcium	ug/L	235000	146000		199000		199000		235000		193000	
Chromium	ug/L	4.45	4.45	J	1.16	J	-	-	-	-	1.01	J
Cobalt	ug/L	4.4	2.43	J	1.23	J	-	-	-	-	4.4	J
Copper	ug/L	5.81	5.81		1.81	J	-	-	-	-	1.29	J
Iron	ug/L	15300	7510		1180		103	B	383		1520	
Lead	ug/L	6.89	5.84		-	-	-	-	1.62	J	-	-
Magnesium	ug/L	51700	32300		43600		42200		51700		37900	
Manganese	ug/L	3010	621		392		156		1370		3010	
Nickel	ug/L	8.69	5.99		5.48		5.61		-	-	8.69	
Potassium	ug/L	4600	2520		1730		1300		3100		2820	
Selenium	ug/L	3.09	-	-	3.09	J	-	-	-	-	2.78	J
Sodium	ug/L	22700	5290		5250		5090		4120		5480	
Vanadium	ug/L	7.12	7.12		1.32	J	-	-	-	-	1.98	J
Zinc	ug/L	33	24.3		9.84	J	4.76	J	27.9		17.5	

MDC - Maximum detected concentration for the AOC ("B" qualified data not included).
NA - Not applicable; detection is the result of blank contamination.
"-" - Not detected.
µg/L - Micrograms per liter.

Validation Qualifiers (VQ)
B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.
J - The analyte was positively identified; the reported value is estimated.
U - Not detected, due to blank contamination

Table 3-10

TNTC - Historical Sediment Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

	Location Code:		MK-PMU1-SW-SD04		TNTC-SD01		TNTC-SD02		TNTC-SD03		TNTC-SD04		TNTC-SD05		TNTC-SD06	
	Sample No:		MK01SD04		AB1001		AB1002		AB1003		AB1004		AB1005		AB1006	
	Sample Date:		29-Sep-93		18-Sep-00		18-Sep-00		18-Sep-00		18-Sep-00		19-Sep-00		18-Sep-00	
	Sample Depth:		0 - 1 Ft		0 - 0 Ft		0 - 0 Ft		0 - 0 Ft		0 - 0 Ft		0 - 0 Ft		0 - 0 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																
Amino-2,6-dinitrotoluene, 4-	mg/kg	11.2	-	-	-	-	-	-	-	-	-	-	0.126		-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	12.8	-	-	-	-	-	-	-	-	-	-	0.214		-	-
Dinitrotoluene, total	mg/kg	0.354	-	-	-	-	-	-	-	-	0.354		0.204		-	-
Nitrobenzene	mg/kg	0.051	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RDX	mg/kg	0.521	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	mg/kg	0.832	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	mg/kg	1496	-	-	-	-	-	-	-	-	-	-	0.176		0.0715	J
Volatiles																
Acetone	mg/kg	0.0379	-	-	0.0187	B	0.0179	B	0.0298	B	0.0137	B	-	-	0.0379	
Benzene	mg/kg	0.0034	-	-	0.00341	J	-	-	-	-	-	-	-	-	-	-
Butanone, 2-	mg/kg	0.0099	-	-	0.00987	J	-	-	-	-	-	-	-	-	-	-
Methylene chloride	mg/kg	0.074	-	-	0.0275	B	0.074		0.0327	B	0.039	B	0.00447	J	0.0542	
Toluene	mg/kg	0.0068	-	-	0.00683		-	-	0.0034	J	-	-	-	-	0.00633	J
Semivolatiles																
Benzo(a)anthracene	mg/kg	0.0947	-	-	-	-	0.0693	J	-	-	-	-	-	-	-	-
Benzo(a)pyrene	mg/kg	0.0699	-	-	-	-	0.0602	J	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	mg/kg	0.12	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bis(2-ethylhexyl)phthalate	mg/kg	0.0553	-	-	-	-	-	-	-	-	-	-	-	-	0.0553	J
Chrysene	mg/kg	0.0737	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Di-n-butyl phthalate	mg/kg	0.0677	-	-	0.0677	J	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	0.276	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	0.183	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fluoranthene	mg/kg	0.147	-	-	-	-	0.147	J	-	-	-	-	-	-	-	-
Pyrene	mg/kg	0.11	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PCBs																
Aroclor 1260	mg/kg	0.769			-	-	-	-	0.0374	J	0.712	J	-	-	0.0733	J

Table 3-10

TNTC - Historical Sediment Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

	Location Code:		MK-PMU1-SW-SD04		TNTC-SD01		TNTC-SD02		TNTC-SD03		TNTC-SD04		TNTC-SD05		TNTC-SD06	
	Sample No:		MK01SD04		AB1001		AB1002		AB1003		AB1004		AB1005		AB1006	
	Sample Date:		29-Sep-93		18-Sep-00		18-Sep-00		18-Sep-00		18-Sep-00		19-Sep-00		18-Sep-00	
	Sample Depth:		0 - 1 Ft		0 - 0 Ft		0 - 0 Ft		0 - 0 Ft		0 - 0 Ft		0 - 0 Ft		0 - 0 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals																
Aluminum	mg/kg	15600	3650		15600		4990		8000		3950		7520		11000	
Arsenic	mg/kg	25.3	-	-	20		-	-	3.27		4.97		10.7		25.3	
Barium	mg/kg	324	29		94.2		33.6		42.6		324		61.9		98.2	
Beryllium	mg/kg	0.941	-	-	0.941		0.272	J	0.646		0.356		0.774		0.77	
Cadmium	mg/kg	1.24	0.15		0.728	J	0.365	B	0.381	B	0.737	J	0.907		1.24	
Calcium	mg/kg	182000	18600		6740	J	11500	J	182000	J	5070	J	73300	J	9160	J
Chromium	mg/kg	25.2	-	-	25.2		9.35		12.6		9.39		13.8		19.5	
Cobalt	mg/kg	18.5	14.6		18.5		3.84		7.7		3.93		11.9		18.4	
Copper	mg/kg	38.8	14.9		30.5		15.4		13	B	10	B	35.9		38.8	
Iron	mg/kg	64600	21800		44800		11500		16200		34800		26800		64600	
Lead	mg/kg	86.3	7.6		15.9		22.5		14.4		86.3		24.9		38.9	
Magnesium	mg/kg	8230	4440		5450		1790		3190		1130		3180		4210	
Manganese	mg/kg	1230	550		943		154		1130		696		405		1040	
Mercury	mg/kg	0.156	0.03		0.046		0.04	J	-	-	0.034	J	0.037		0.033	J
Nickel	mg/kg	47.3	-	-	46.5		12.1		19.3		11.5		45.5		47.3	
Potassium	mg/kg	3310	719		3280	J	1230	J	2160	J	674	J	3310	J	2760	J
Selenium	mg/kg	2.47	-	-	1.17	J	1.72		-	-	2.47		2.23		2.04	
Sodium	mg/kg	272	182		229	B	196	B	263	B	169	B	272		164	B
Vanadium	mg/kg	37.9	11		37.9		12.9		13.4		15.4		17.6		24.6	
Zinc	mg/kg	131	-	-	86.7		52.9		19.8		58.5		105		131	

Table 3-10

TNTC - Historical Sediment Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

	Location Code:		TNTC-SD07		TNTC-SD08		TNTC-SD09		TNTC-SD10		TNTC-SD11		TNTC-SD12		TNTC-SD13		TNTC-SD14		TNTC-SD15	
	Sample No:		AB1007		AB1008		AB1009		AB1010		AB1011		AB1012		AB1013		AB1014		AB1015	
	Sample Date:		19-Sep-00		19-Sep-00		19-Sep-00		19-Sep-00		19-Sep-00		19-Sep-00		19-Sep-00		19-Sep-00		19-Sep-00	
	Sample Depth:		0 - 0 Ft		0 - 0 Ft		0 - 0 Ft		0 - 0 Ft		0 - 0 Ft		0 - 0 Ft		0 - 0 Ft		0 - 0 Ft		0 - 0 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	11.2	-	-	0.385		11.2		-	-	-	-	-	-	-	-	-	-	2.79	
Amino-4,6-dinitrotoluene, 2-	mg/kg	12.8	-	-	0.299		12.8		-	-	-	-	-	-	-	-	-	-	3.25	
Dinitrotoluene, total	mg/kg	0.354	-	-	0.246		-	-	-	-	-	-	0.104		0.102		0.112		0.414	
Nitrobenzene	mg/kg	0.051	-	-	-	-	-	-	0.051	J	-	-	-	-	-	-	-	-	-	-
RDX	mg/kg	0.521	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.521	
Trinitrobenzene, 1,3,5-	mg/kg	0.832	-	-	-	-	0.832		-	-	-	-	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	mg/kg	1496	-	-	0.706		1496		0.198		-	-	0.0918	J	-	-	0.11		2.9	
Volatiles																				
Acetone	mg/kg	0.0379	-	-	0.00563	J	-	-	0.00475	J	0.00351	J	-	-	-	-	-	-	-	-
Benzene	mg/kg	0.0034	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Butanone, 2-	mg/kg	0.0099	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methylene chloride	mg/kg	0.074	0.00547	J	0.00476	J	0.00485	J	0.00414	J	0.00366	J	0.00379	J	0.00412	J	0.00395	B	-	-
Toluene	mg/kg	0.0068	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Semivolatiles																				
Benzo(a)anthracene	mg/kg	0.0947	-	-	-	-	0.0947	J	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(a)pyrene	mg/kg	0.0699	-	-	-	-	0.0699	J	-	-	-	-	-	-	-	-	-	-	0.0324	J
Benzo(b)fluoranthene	mg/kg	0.12	-	-	-	-	0.12	J	-	-	-	-	-	-	-	-	-	-	-	-
Bis(2-ethylhexyl)phthalate	mg/kg	0.0553	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0299	J	-	-
Chrysene	mg/kg	0.0737	-	-	-	-	0.0737	J	-	-	-	-	-	-	-	-	-	-	-	-
Di-n-butyl phthalate	mg/kg	0.0677	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	0.276	-	-	0.101	J	0.276	J	-	-	-	-	-	-	-	-	-	-	0.134	J
Dinitrotoluene, 2,6-	mg/kg	0.183	-	-	-	-	0.183	J	-	-	-	-	-	-	-	-	-	-	-	-
Fluoranthene	mg/kg	0.147	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyrene	mg/kg	0.11	-	-	-	-	0.11	J	-	-	-	-	-	-	-	-	-	-	-	-
PCBs																				
Aroclor 1260	mg/kg	0.769	-	-	0.0224	J	0.769	J	-	-	-	-	0.0807	J	-	-	0.506	J	0.287	J

Table 3-10

TNTC - Historical Sediment Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

	Location Code:		TNTC-SD07		TNTC-SD08		TNTC-SD09		TNTC-SD10		TNTC-SD11		TNTC-SD12		TNTC-SD13		TNTC-SD14		TNTC-SD15	
	Sample No:		AB1007		AB1008		AB1009		AB1010		AB1011		AB1012		AB1013		AB1014		AB1015	
	Sample Date:		19-Sep-00		19-Sep-00		19-Sep-00		19-Sep-00		19-Sep-00		19-Sep-00		19-Sep-00		19-Sep-00		19-Sep-00	
	Sample Depth:		0 - 0 Ft		0 - 0 Ft		0 - 0 Ft		0 - 0 Ft		0 - 0 Ft		0 - 0 Ft		0 - 0 Ft		0 - 0 Ft		0 - 0 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals																				
Aluminum	mg/kg	15600	7160		4610		9210		11300		1600		2900		6310		1200		2510	
Arsenic	mg/kg	25.3	10.3		4.13		12.6		12.2		-	-	2.41		9.37		1.14	J	2.39	
Barium	mg/kg	324	65.9		32.4		84.9		52.3		15.3		22.6		52.8		84.3		21	
Beryllium	mg/kg	0.941	0.613		0.21	J	0.498		0.657		0.128	J	0.165	J	0.413		-	-	0.101	J
Cadmium	mg/kg	1.24	0.801		0.371	B	0.675	J	0.673	J	0.144	B	0.303	B	0.754		0.297	B	0.254	B
Calcium	mg/kg	182000	83600	J	6480	J	14300	J	4090	J	1320	J	5430	J	3180	J	1760	J	1610	J
Chromium	mg/kg	25.2	16.6		8.73		12.3		18.3		4.05		5.25		12.5		5.24		5.15	
Cobalt	mg/kg	18.5	11.4		4.7		14		9.83		3.44		2.65		8.64		0.871	J	1.31	
Copper	mg/kg	38.8	25.5		9.7	B	23.8		24		3.22	B	8.31	B	12		2.49	B	6.35	B
Iron	mg/kg	64600	26000		12900		21200		27900		5320		7890		24400		9180		6240	
Lead	mg/kg	86.3	14.4		14		46.2		15		2.83		8.66		8.24		52.5		24.4	
Magnesium	mg/kg	8230	8230		1790		2660		3700		528		1060		1980		297		532	
Manganese	mg/kg	1230	516		239		1230		428		116		58.9		656		53.4		37.3	
Mercury	mg/kg	0.156	-	-	0.023	J	0.156		-	-	-	-	-	-	0.04		0.146		0.034	J
Nickel	mg/kg	47.3	31.3		14.6		29.1		29.9		7.53	B	6.36	B	22.5		2.23	B	4.14	B
Potassium	mg/kg	3310	2680	J	943	J	1240	J	2300	J	284	J	413	J	1010	J	155	J	341	J
Selenium	mg/kg	2.47	0.945	J	-	-	-	-	2.2		-	-	1.46		0.953	J	0.904	J	1.16	
Sodium	mg/kg	272	239	J	160	J	190	J	201	J	193	J	211	J	195	J	187	J	180	J
Vanadium	mg/kg	37.9	20.1		14.2		21.3		24.8		6.93		13.8		21.2		18.1		9.86	
Zinc	mg/kg	131	71.9		33		61.3		83.4		14.5		21.8		43.9		11.1		17.8	

MDC - Maximum detected concentration for the AOC ("B" qualified data excluded).
mg/kg - Milligrams per kilogram.
PCB - Polychlorinated biphenyl
"-" - Not detected.
Ft - Feet.

Validation Qualifiers (VQ)
B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.
J - The analyte was positively identified; the reported value is estimated.

TNTC - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

			Location Code:	MK-PMU1-SS10		MK-PMU1-SS11		MK-PMU1-SS12		PB-TNTC-S1		PB-TNTC-S10		PB-TNTC-S11		PB-TNTC-S12		PB-TNTC-S13		PB-TNTC-S14		PB-TNTC-S15		PB-TNTC-S16		PB-TNTC-S17	
			Sample No:	MK01SS10		MK01SS11		MK01SS12		PB-TNTC-S1-0_5-1_0		PB-TNTC-S10-2_5-3_5		PB-TNTC-S11-2_5-3_5		PB-TNTC-S12-2_3-3_5		PB-TNTC-S13-2_5-3_5		PB-TNTC-S14-1_0-2_0		PB-TNTC-S15-1_0-2_0		PB-TNTC-S16-0_5-1_0		PB-TNTC-S17-0_0-1_5	
			Sample Date:	29-Jun-93		29-Jun-93		29-Jun-93		12-Oct-94		14-Oct-94		14-Oct-94		14-Oct-94		14-Oct-94		14-Oct-94		14-Oct-94		16-Oct-94		16-Oct-94	
			Sample Depth:	0 - 2 Ft		0 - 2 Ft		0 - 2 Ft		0.5 - 1 Ft		2.5 - 3.5 Ft		2.5 - 3.5 Ft		2.3 - 3.5 Ft		2.5 - 3.5 Ft		1 - 2 Ft		1 - 2 Ft		0.5 - 1 Ft		1. - 1.5 Ft	
Parameter	Units	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																											
Amino-2,6-dinitrotoluene, 4-	mg/kg	14.6								-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	38								-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4-nitrotoluene, 2-	mg/kg	0.4								-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrobenzene, 1,3-	mg/kg	0.751	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1		-	-
Dinitrotoluene, 2,6-	mg/kg	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1		-	-
Dinitrotoluene, 3,4-	mg/kg	1.2								-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, total	mg/kg	297																									
Nitrobenzene	mg/kg	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	50.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 3-	mg/kg	8.61	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 4-	mg/kg	67.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tetryl	mg/kg	0.626	-	-	-	-	-	-	-																		
Trinitrobenzene, 1,3,5-	mg/kg	10.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	mg/kg	54969	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Volatiles																											
Acetone	mg/kg	0.456	-	-	-	-	-	-	-																		
Benzene	mg/kg	0.00601	-	-	-	-	-	-	-																		
Butanone, 2-	mg/kg	0.0818	-	-	-	-	-	-	-																		
Carbon disulfide	mg/kg	0.0272	-	-	-	-	-	-	-																		
Ethylbenzene	mg/kg	0.00248	-	-	-	-	-	-	-																		
Methylene chloride	mg/kg	0.0514	-	-	-	-	-	-	-																		
Styrene	mg/kg	0.00197	-	-	-	-	-	-	-																		
Toluene	mg/kg	0.0781	-	-	-	-	-	-	-																		
Xylene, o-	mg/kg	0.00323																									
Xylenes, m,p-	mg/kg	0.0075																									
Semivolatiles																											
Acenaphthylene	mg/kg	0.545	-	-	-	-	-	-	-																		
Anthracene	mg/kg	4.14	-	-	-	-	-	-	-																		
Benzo(a)anthracene	mg/kg	11.1	-	-	-	-	-	-	-																		
Benzo(a)pyrene	mg/kg	8.2	0.14	J	-	-	-	-	-																		
Benzo(b)fluoranthene	mg/kg	10.2	0.19	J	-	-	-	-	-																		
Benzo(ghi)perylene	mg/kg	3.4	-	-	-	-	-	-	-																		
Benzo(k)fluoranthene	mg/kg	4.38	0.079	J	-	-	-	-	-																		
Bis(2-ethylhexyl)phthalate	mg/kg	0.24	-	-	0.24	J	-	-	-																		
Carbazole	mg/kg	0.109																									
Chrysene	mg/kg	8.74	-	-	-	-	-	-	-																		
Dibenz(a,h)anthracene	mg/kg	1.4	-	-	-	-	-	-	-																		
Diethyl phthalate	mg/kg	NA	-	-	-	-	-	-	-																		
Di-n-butyl phthalate	mg/kg	0.169	-	-	-	-	-	-	-																		
Dinitrotoluene, 2,4-	mg/kg	275	-	-	-	-	-	-	-																		
Dinitrotoluene, 2,6-	mg/kg	65.5	-	-	-	-	-	-	-																		
Fluoranthene	mg/kg	20.3	0.34	J	-	-	-	-	-																		
Indeno(1,2,3-cd)pyrene	mg/kg	3.64	-	-	-	-	-	-	-																		
Methylnaphthalene, 2-	mg/kg	0.0381	-	-	-	-	-	-	-																		
Phenanthrene	mg/kg	5.21	0.16	J	-	-	-	-	-																		
Pyrene	mg/kg	17.1	0.35	J	-	-	-	-	-																		
PCBs																											
Aroclor 1254	mg/kg	0.969																									
Aroclor 1260	mg/kg	5.07																									

TNTC - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

			Location Code:		MK-PMU1-SS10		MK-PMU1-SS11		MK-PMU1-SS12		PB-TNTC-S1		PB-TNTC-S10		PB-TNTC-S11		PB-TNTC-S12		PB-TNTC-S13		PB-TNTC-S14		PB-TNTC-S15		PB-TNTC-S16		PB-TNTC-S17	
			Sample No:		MK01SS10		MK01SS11		MK01SS12		PB-TNTC-S1-0_5-1_0		PB-TNTC-S10-2_5-3_5		PB-TNTC-S11-2_5-3_5		PB-TNTC-S12-2_3-3_5		PB-TNTC-S13-2_5-3_5		PB-TNTC-S14-1_0-2_0		PB-TNTC-S15-1_0-2_0		PB-TNTC-S16-0_5-1_0		PB-TNTC-S17-0_0-1_5	
			Sample Date:		29-Jun-93		29-Jun-93		29-Jun-93		12-Oct-94		14-Oct-94		14-Oct-94		14-Oct-94		14-Oct-94		14-Oct-94		14-Oct-94		16-Oct-94		16-Oct-94	
			Sample Depth:		0 - 2 Ft		0 - 2 Ft		0 - 2 Ft		0.5 - 1 Ft		2.5 - 3.5 Ft		2.5 - 3.5 Ft		2.3 - 3.5 Ft		2.5 - 3.5 Ft		1 - 2 Ft		1 - 2 Ft		0.5 - 1 Ft		1. - 1.5 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals																												
Aluminum	mg/kg	11900	11900		2010		11200																					
Antimony	mg/kg	13.2	-	-	-	-	-	-	-	-	8		7.2		-	-	-	-	-	-	9		-	-	13.2	J
Arsenic	mg/kg	18.5	-	-	-	-	-	-	10.9		7.6		8.3		8.5		-	-	-	-	-	-	-	-	-	-
Barium	mg/kg	427	101		44		79.6																			
Beryllium	mg/kg	0.823	0.57		-	-	0.6		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	mg/kg	2.19	0.35		0.1		0.13		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	mg/kg	252000	11700		19400		4370																			
Chromium	mg/kg	202	18.7		3.6		17.8		15		22		24		23		11		6		8.6		15		7.8	
Cobalt	mg/kg	21	9.1		-	-	21																			
Copper	mg/kg	99.8	17.7		-	-	23.9		15		9.1		15		5.5		3.1		-	-	-	-	8		7.1	
Iron	mg/kg	35500	22100		4960		31000																			
Lead	mg/kg	934	-	-	-	-	-	-	15		22		20		14		9.2		4.5		6.4		15		75	
Magnesium	mg/kg	18700	-	-	-	-	-	-																		
Manganese	mg/kg	5160	376		73.7		834		322		824		663		598		244		137		98		642		1074	
Mercury	mg/kg	0.98	0.1		0.11		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	mg/kg	90.8	24.3		-	-	50.2		26		34		39		34		14		5.7		7.2		36		12.6	
Potassium	mg/kg	2830	2620		315		1040																			
Selenium	mg/kg	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Silver	mg/kg	0.497	0.04		-	-	0.04		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/kg	403	172		150		146																			
Vanadium	mg/kg	28.8	-	-	5.1		-	-																		
Zinc	mg/kg	708	-	-	-	-	-	-	69		67		135		74		39		20		25		22		144	

TNTC - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

	Location Code:		PB-TNTC-S18		PB-TNTC-S19		PB-TNTC-S2		PB-TNTC-S20		PB-TNTC-S21		PB-TNTC-S22		PB-TNTC-S23		PB-TNTC-S24		PB-TNTC-S25		PB-TNTC-S26		PB-TNTC-S27	
	Sample No:		PB-TNTC-S18-0_0-1_5		PB-TNTC-S19-0_5-2_0		PB-TNTC-S2-0_5-1_0		PB-TNTC-S20-0_0-1_25		PB-TNTC-S21-0_5-1_0		PB-TNTC-S22-0_5-1_0		PB-TNTC-S23-0_0-2_0		PB-TNTC-S24-0_0-1_75		PB-TNTC-S25-0_0-1_2		PB-TNTC-S26-0_0-1_3		PB-TNTC-S27-0_5-1_0	
	Sample Date:		16-Oct-94		17-Oct-94		12-Oct-94		17-Oct-94		16-Oct-94		19-Oct-94		17-Oct-94		17-Oct-94		17-Oct-94		17-Oct-94		16-Oct-94	
	Sample Depth:		1. - 1.5 Ft		0.5 - 2 Ft		0.5 - 1 Ft		0.5 - 1.25 Ft		0.5 - 1 Ft		0.5 - 1 Ft		0 - 2 Ft		0 - 1.75 Ft		0 - 1.2 Ft		1 - 1.3 Ft		0.5 - 1 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																								
Amino-2,6-dinitrotoluene, 4-	mg/kg	14.6	-	-	-	-	-	-	-	-	-	-	1		-	-	-	-	-	-	0.4		-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	38	-	-	-	-	-	-	-	-	-	-	4.7		-	-	-	-	-	-	0.4		-	-
Amino-4-nitrotoluene, 2-	mg/kg	0.4	-	-	-	-	-	-	-	-	-	-	0.4		-	-	-	-	-	-	-	-	-	-
Dinitrobenzene, 1,3-	mg/kg	0.751	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	33	-	-	-	-	-	-	-	-	-	-	8.7		-	-	-	-	-	-	0.3		0.5	
Dinitrotoluene, 2,6-	mg/kg	18	-	-	-	-	-	-	-	-	-	-	1		-	-	-	-	-	-	-	-	0.4	
Dinitrotoluene, 3,4-	mg/kg	1.2	-	-	-	-	-	-	-	-	-	-	0.4		-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, total	mg/kg	297																						
Nitrobenzene	mg/kg	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	50.8	-	-	-	-	-	-	-	-	-	-	2.7		-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 3-	mg/kg	8.61	-	-	-	-	-	-	-	-	-	-	0.5		-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 4-	mg/kg	67.4	-	-	-	-	-	-	-	-	-	-	0.4		-	-	-	-	-	-	-	-	-	-
Tetryl	mg/kg	0.626																						
Trinitrobenzene, 1,3,5-	mg/kg	10.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	mg/kg	54969	-	-	-	-	-	-	-	-	-	-	2.7		-	-	-	-	-	-	0.5		-	-
Volatiles																								
Acetone	mg/kg	0.456																						
Benzene	mg/kg	0.00601																						
Butanone, 2-	mg/kg	0.0818																						
Carbon disulfide	mg/kg	0.0272																						
Ethylbenzene	mg/kg	0.00248																						
Methylene chloride	mg/kg	0.0514																						
Styrene	mg/kg	0.00197																						
Toluene	mg/kg	0.0781																						
Xylene, o-	mg/kg	0.00323																						
Xylenes, m,p-	mg/kg	0.0075																						
Semivolatiles																								
Acenaphthylene	mg/kg	0.545																						
Anthracene	mg/kg	4.14																						
Benzo(a)anthracene	mg/kg	11.1																						
Benzo(a)pyrene	mg/kg	8.2																						
Benzo(b)fluoranthene	mg/kg	10.2																						
Benzo(ghi)perylene	mg/kg	3.4																						
Benzo(k)fluoranthene	mg/kg	4.38																						
Bis(2-ethylhexyl)phthalate	mg/kg	0.24																						
Carbazole	mg/kg	0.109																						
Chrysene	mg/kg	8.74																						
Dibenz(a,h)anthracene	mg/kg	1.4																						
Diethyl phthalate	mg/kg	NA																						
Di-n-butyl phthalate	mg/kg	0.169																						
Dinitrotoluene, 2,4-	mg/kg	275																						
Dinitrotoluene, 2,6-	mg/kg	65.5																						
Fluoranthene	mg/kg	20.3																						
Indeno(1,2,3-cd)pyrene	mg/kg	3.64																						
Methylnaphthalene, 2-	mg/kg	0.0381																						
Phenanthrene	mg/kg	5.21																						
Pyrene	mg/kg	17.1																						
PCBs																								
Aroclor 1254	mg/kg	0.969																						
Aroclor 1260	mg/kg	5.07																						

TNTC - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Location Code:			PB-TNTC-S18		PB-TNTC-S19		PB-TNTC-S2		PB-TNTC-S20		PB-TNTC-S21		PB-TNTC-S22		PB-TNTC-S23		PB-TNTC-S24		PB-TNTC-S25		PB-TNTC-S26		PB-TNTC-S27	
Sample No:			PB-TNTC-S18-0_0-1_5		PB-TNTC-S19-0_5-2_0		PB-TNTC-S2-0_5-1_0		PB-TNTC-S20-0_0-1_25		PB-TNTC-S21-0_5-1_0		PB-TNTC-S22-0_5-1_0		PB-TNTC-S23-0_0-2_0		PB-TNTC-S24-0_0-1_75		PB-TNTC-S25-0_0-1_2		PB-TNTC-S26-0_0-1_3		PB-TNTC-S27-0_5-1_0	
Sample Date:			16-Oct-94		17-Oct-94		12-Oct-94		17-Oct-94		16-Oct-94		19-Oct-94		17-Oct-94		17-Oct-94		17-Oct-94		17-Oct-94		16-Oct-94	
Sample Depth:			1. - 1.5 Ft		0.5 - 2 Ft		0.5 - 1 Ft		0.5 - 1.25 Ft		0.5 - 1 Ft		0.5 - 1 Ft		0 - 2 Ft		0 - 1.75 Ft		0 - 1.2 Ft		1 - 1.3 Ft		0.5 - 1 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals																								
Aluminum	mg/kg	11900																						
Antimony	mg/kg	13.2	8.1		5.5		-	-	-	-	-	-	7.6		-	-	-	-	-	-	-	-	-	-
Arsenic	mg/kg	18.5	6		3.2		10.4		-	-	-	-	9		-	-	-	-	-	-	-	-	-	-
Barium	mg/kg	427																						
Beryllium	mg/kg	0.823	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	mg/kg	2.19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	mg/kg	252000																						
Chromium	mg/kg	202	5.2		5.9		24		5.8		20		21		6.6		17		11		24		20	
Cobalt	mg/kg	21																						
Copper	mg/kg	99.8	5.9		4.5		10		-	-	-	-	13		-	-	26		-	-	-	-	-	-
Iron	mg/kg	35500																						
Lead	mg/kg	934	35		90		23		12		10.1		22		6		19		125		34		8	
Magnesium	mg/kg	18700																						
Manganese	mg/kg	5160	1376		925		310		325		830		756		164		123		188		330		617	
Mercury	mg/kg	0.98	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	mg/kg	90.8	8.5		7.8		36		5.7		15		45		7.8		6.4		7.6		15		31	
Potassium	mg/kg	2830																						
Selenium	mg/kg	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Silver	mg/kg	0.497	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/kg	403																						
Vanadium	mg/kg	28.8																						
Zinc	mg/kg	708	72		80		76		25		35		90		29		71		49		44		23	

TNTC - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

			PB-TNTC-S28		PB-TNTC-S29		PB-TNTC-S3				PB-TNTC-S4				PB-TNTC-S5				PB-TNTC-S6				PB-TNTC-S7		PB-TNTC-S8	
Location Code:																										
Sample No:			PB-TNTC-S28-0_0-1_5		PB-TNTC-S29-0_0-2_0		PB-TNTC-S3-0_0-1_5		PB-TNTC-S3-1_5-3_5		PB-TNTC-S4-0_0-1_5		PB-TNTC-S4-1_5-5_0		PB-TNTC-S5-0_0-1_5		PB-TNTC-S5-1_5-5_0		PB-TNTC-S6-0_0-1_5		PB-TNTC-S6-1_5-4_5		PB-TNTC-S7-0_5-1_0		PB-TNTC-S8-0_5-1_0	
Sample Date:			16-Oct-94		17-Oct-94		13-Oct-94		13-Oct-94		13-Oct-94		13-Oct-94		13-Oct-94		13-Oct-94		13-Oct-94		13-Oct-94		13-Oct-94		13-Oct-94	
Sample Depth:			0 - 1.5 Ft		0 - 2 Ft		0 - 1.5 Ft		1.5 - 3.5 Ft		0 - 1.5 Ft		1.5 - 5 Ft		0 - 1.5 Ft		1.5 - 5 Ft		0 - 1.5 Ft		1.5 - 4.5 Ft		0.5 - 1 Ft		0.5 - 1 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																										
Amino-2,6-dinitrotoluene, 4-	mg/kg	14.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.4	
Amino-4-nitrotoluene, 2-	mg/kg	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrobenzene, 1,3-	mg/kg	0.751	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.6	
Dinitrotoluene, 2,6-	mg/kg	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.9	
Dinitrotoluene, 3,4-	mg/kg	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.2	
Dinitrotoluene, total	mg/kg	297																								
Nitrobenzene	mg/kg	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3	
Nitrotoluene, 2-	mg/kg	50.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.1	
Nitrotoluene, 3-	mg/kg	8.61	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 4-	mg/kg	67.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tetryl	mg/kg	0.626																								
Trinitrobenzene, 1,3,5-	mg/kg	10.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	mg/kg	54969	-	-	-	-	0.8		-	-	0.6		-	-	-	-	-	-	-	-	-	-	-	-	1.2	
Volatiles																										
Acetone	mg/kg	0.456																								
Benzene	mg/kg	0.00601																								
Butanone, 2-	mg/kg	0.0818																								
Carbon disulfide	mg/kg	0.0272																								
Ethylbenzene	mg/kg	0.00248																								
Methylene chloride	mg/kg	0.0514																								
Styrene	mg/kg	0.00197																								
Toluene	mg/kg	0.0781																								
Xylene, o-	mg/kg	0.00323																								
Xylenes, m,p-	mg/kg	0.0075																								
Semivolatiles																										
Acenaphthylene	mg/kg	0.545																								
Anthracene	mg/kg	4.14																								
Benzo(a)anthracene	mg/kg	11.1																								
Benzo(a)pyrene	mg/kg	8.2																								
Benzo(b)fluoranthene	mg/kg	10.2																								
Benzo(ghi)perylene	mg/kg	3.4																								
Benzo(k)fluoranthene	mg/kg	4.38																								
Bis(2-ethylhexyl)phthalate	mg/kg	0.24																								
Carbazole	mg/kg	0.109																								
Chrysene	mg/kg	8.74																								
Dibenz(a,h)anthracene	mg/kg	1.4																								
Diethyl phthalate	mg/kg	NA																								
Di-n-butyl phthalate	mg/kg	0.169																								
Dinitrotoluene, 2,4-	mg/kg	275																								
Dinitrotoluene, 2,6-	mg/kg	65.5																								
Fluoranthene	mg/kg	20.3																								
Indeno(1,2,3-cd)pyrene	mg/kg	3.64																								
Methylnaphthalene, 2-	mg/kg	0.0381																								
Phenanthrene	mg/kg	5.21																								
Pyrene	mg/kg	17.1																								
PCBs																										
Aroclor 1254	mg/kg	0.969																								
Aroclor 1260	mg/kg	5.07																								

TNTC - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Location Code:			PB-TNTC-S28		PB-TNTC-S29		PB-TNTC-S3				PB-TNTC-S4				PB-TNTC-S5				PB-TNTC-S6				PB-TNTC-S7		PB-TNTC-S8	
Sample No:			PB-TNTC-S28-0_0-1_5		PB-TNTC-S29-0_0-2_0		PB-TNTC-S3-0_0-1_5		PB-TNTC-S3-1_5-3_5		PB-TNTC-S4-0_0-1_5		PB-TNTC-S4-1_5-5_0		PB-TNTC-S5-0_0-1_5		PB-TNTC-S5-1_5-5_0		PB-TNTC-S6-0_0-1_5		PB-TNTC-S6-1_5-4_5		PB-TNTC-S7-0_5-1_0		PB-TNTC-S8-0_5-1_0	
Sample Date:			16-Oct-94		17-Oct-94		13-Oct-94		13-Oct-94		13-Oct-94		13-Oct-94		13-Oct-94		13-Oct-94		13-Oct-94		13-Oct-94		13-Oct-94		13-Oct-94	
Sample Depth:			0 - 1.5 Ft		0 - 2 Ft		0 - 1.5 Ft		1.5 - 3.5 Ft		0 - 1.5 Ft		1.5 - 5 Ft		0 - 1.5 Ft		1.5 - 5 Ft		0 - 1.5 Ft		1.5 - 4.5 Ft		0.5 - 1 Ft		0.5 - 1 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals																										
Aluminum	mg/kg	11900																								
Antimony	mg/kg	13.2	5.8		-	-	-	-	-	-	-	-	-	-	-	-	-	-	7		7.2		-	-	-	-
Arsenic	mg/kg	18.5	4.8		-	-	5.7		4.2		5.9		6.7		5.3		7.4		6		7.4		6.2		7.5	
Barium	mg/kg	427																								
Beryllium	mg/kg	0.823	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	mg/kg	2.19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	mg/kg	252000																								
Chromium	mg/kg	202	5.8		5.2		10.9		10.4		15		18		15		22		14		19		14		21	
Cobalt	mg/kg	21																								
Copper	mg/kg	99.8	7		-	-	11		19		9.5		10		8.1		8		18		6.2		8.4		9.7	
Iron	mg/kg	35500																								
Lead	mg/kg	934	32		5.6		79		85		173		16		51		20		23		15		18		19	
Magnesium	mg/kg	18700																								
Manganese	mg/kg	5160	1682		123		231		194		333		386		236		367		356		618		456		472	
Mercury	mg/kg	0.98	-	-	-	-	-	-	-	-	-	-	-	-	0.98		-	-	-	-	-	-	-	-	-	-
Nickel	mg/kg	90.8	10.1		5.3		13		9.4		20		26		17		26		23		29		23		31	
Potassium	mg/kg	2830																								
Selenium	mg/kg	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Silver	mg/kg	0.497	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/kg	403																								
Vanadium	mg/kg	28.8																								
Zinc	mg/kg	708	77		20		86		94		99		67		71		62		74		70		61		79	

TNTC - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

			Location Code:	PB-TNTC-S9	TNTC-SO001		TNTC-SO065	TNTC-SO066								TNTC-SO074		TNTC-SO100		TNTC-SO107	
			Sample No:	PB-TNTC-S9-0_5-1_0	AB0426	AB0460	AB0475	AB0429	AB0430	AB0461	AB0462	BD0017R	BD0018R	AB0431		AB0476		AB0432	AB0433	
			Sample Date:	13-Oct-94	12-Oct-00	28-Sep-00	12-Oct-00	27-Sep-00	12-Oct-00	28-Sep-00	28-Sep-00	2-Oct-01	2-Oct-01	12-Oct-00		12-Oct-00		10-Oct-00	10-Oct-00	
			Sample Depth:	0.5 - 1 Ft	0 - 1 Ft	4 - 6 Ft	2.5 - 3.5 Ft	0 - 1 Ft	2.5 - 3.5 Ft	5 - 7 Ft	8 - 10 Ft	2.5 - 3.4 Ft	8 - 10 Ft	2.5 - 3.5 Ft		2 - 3 Ft		0 - 1 Ft	3 - 4 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																										
Amino-2,6-dinitrotoluene, 4-	mg/kg	14.6	-	-	6.93		0.436		-	-	0.0721	J	-	-	-	-	-	-	0.12	J	-	-	0.784		-	-	-	-	0.293	
Amino-4,6-dinitrotoluene, 2-	mg/kg	38	-	-	3.76		-	-	-	-	0.0538	J	-	-	-	-	-	-	0.11	J	-	-	2.67		6.44		-	-	0.226	
Amino-4-nitrotoluene, 2-	mg/kg	0.4	-	-																										
Dinitrobenzene, 1,3-	mg/kg	0.751	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	33	-	-															0.23	J	-	-								
Dinitrotoluene, 2,6-	mg/kg	18	-	-															0.098	J	-	-								
Dinitrotoluene, 3,4-	mg/kg	1.2	-	-																										
Dinitrotoluene, total	mg/kg	297			8.33		3.65		-	-	0.451		165		297		36.3						-	-	-	-	-	-	-	-
Nitrobenzene	mg/kg	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.195		-	-	-	-
Nitrotoluene, 2-	mg/kg	50.8	-	-	-	-	3.27		-	-	-	-	2.05		50.8		6.32		-	-	0.59		-	-	-	-	-	-	-	-
Nitrotoluene, 3-	mg/kg	8.61	-	-	-	-	0.45		-	-	-	-	4.82		8.61		1.09		-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 4-	mg/kg	67.4	-	-	-	-	2.86		-	-	-	-	-	-	67.4		6.59		-	-	0.33		-	-	-	-	-	-	-	-
Tetryl	mg/kg	0.626			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	mg/kg	10.1	-	-	-	-	-	-	-	-	-	-	-	-	3.59		-	-	-	-	-	-	-	-	0.499		-	-	0.238	
Trinitrotoluene, 2,4,6-	mg/kg	54969	-	-	4.76		1.96		-	-	0.164		38		5.19		0.167		-	-	-	-	1.41		2226		0.566		47.3	
Volatiles																														
Acetone	mg/kg	0.456			0.456	J	0.0307	J	0.112		0.445		0.0495	J	-	-	-	-	0.27		0.017	J	0.0986		0.0196	J	0.0861	J	0.0204	J
Benzene	mg/kg	0.00601			-	-	-	-	0.00241	J	-	-	-	-	0.00342	J	0.00492	J	-	-	-	-	0.00216	J	-	-	-	-	-	-
Butanone, 2-	mg/kg	0.0818			-	-	-	-	-	-	0.0818		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbon disulfide	mg/kg	0.0272			-	-	0.00398	J	0.0109		0.0123		0.00365	J	-	-	-	-	-	-	-	-	0.00376	J	0.00175	J	-	-	-	-
Ethylbenzene	mg/kg	0.00248			0.00207	J	-	-	-	-	-	-	-	-	-	-	0.00248	J	-	-	-	-	-	-	-	-	-	-	-	-
Methylene chloride	mg/kg	0.0514			0.0355	J	0.00198	B	0.0061	B	0.0188	B	0.00902	B	0.00358	B	0.00456	B	0.0031	B	0.0034	B	0.00434	B	0.00798	B	0.0188	B	0.00523	B
Styrene	mg/kg	0.00197			0.00197	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Toluene	mg/kg	0.0781			0.0264	J	-	-	0.00385	J	-	-	-	-	0.0781	J	0.0186	J	-	-	-	-	0.00255	J	-	-	-	-	-	-
Xylene, o-	mg/kg	0.00323			0.00307	J	-	-	-	-	-	-	-	-	0.0019	J	0.00323	J					-	-	-	-	-	-	-	-
Xylenes, m,p-	mg/kg	0.0075			0.0075	J	-	-	-	-	-	-	-	-	-	-	0.00605	J					-	-	-	-	-	-	-	-
Semivolatiles																														
Acenaphthylene	mg/kg	0.545			-	-	-	-	-	-	-	-	-	-	-	-	-	-					-	-	-	-	-	-	-	-
Anthracene	mg/kg	4.14			-	-	-	-	-	-	-	-	-	-	-	-	-	-					0.151	J	-	-	-	-	-	-
Benzo(a)anthracene	mg/kg	11.1			0.0753	J	0.0465	J	0.0454	J	-	-	-	-	-	-	-	-					0.135	J	-	-	0.269	J	-	-
Benzo(a)pyrene	mg/kg	8.2			0.0787	J	0.0413	J	0.043	J	-	-	-	-	-	-	-	-					0.0536	J	-	-	0.305	J	-	-
Benzo(b)fluoranthene	mg/kg	10.2			0.176	J	-	-	-	-	-	-	-	-	-	-	-	-					0.116	J	-	-	0.443		-	-
Benzo(ghi)perylene	mg/kg	3.4			-	-	-	-	-	-	-	-	-	-	-	-	-	-					-	-	-	-	0.222	J	-	-
Benzo(k)fluoranthene	mg/kg	4.38			-	-	-	-	-	-	-	-	-	-	-	-	-	-					-	-	-	-	0.178	J	-	-
Bis(2-ethylhexyl)phthalate	mg/kg	0.24			0.0493	J	-	-	0.0237	J	-	-	-	-	-	-	-	-					-	-	0.0324	J	0.0328	J	0.0883	J
Carbazole	mg/kg	0.109			-	-	-	-	-	-	-	-	-	-	-	-	-	-					-	-	-	-	-	-	-	-
Chrysene	mg/kg	8.74			0.114	J	0.0535	J	-	-	-	-	-	-	-	-	-	-					0.113	J	-	-	0.31	J	-	-
Dibenz(a,h)anthracene	mg/kg	1.4			-	-	-	-	-	-	-	-	-	-	-	-	-	-					-	-	-	-	0.0817	J	-	-
Diethyl phthalate	mg/kg	NA			0.425	B	-	-	0.585	B	-	-	-	-	-	-	-	-					0.307	B	0.622	B	-	-	-	-
Di-n-butyl phthalate	mg/kg	0.169			-	-	-	-	-	-	-	-	-	-	-	-	-	-					-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	275			1.01		0.689		0.0558	J	0.239	J	43.1		170		13.2						0.068	J	0.496		-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	65.5			0.458		0.0977	J	-	-	0.0668	J	6.92		65.5		6.83						-	-	-	-	-	-	-	-
Fluoranthene	mg/kg	20.3			0.189	J	-	-	-	-	-	-	-	-	-	-	-	-					0.469		-	-	0.409	J	-	-
Indeno(1,2,3-cd)pyrene	mg/kg	3.64			-	-	-	-	-	-	-	-	-	-	-	-	-	-					-	-	-	-	0.21	J	-	-
Methylnaphthalene, 2-	mg/kg	0.0381			-	-	-	-	-	-	-	-	-	-	-	-	-	-					-	-	-	-	-	-	-	-
Phenanthrene	mg/kg	5.21			0.0543	J	-	-	-	-	-	-	-	-	-	-	-	-					0.227	J	-	-	0.107	J	-	-
Pyrene	mg/kg	17.1			0.131	J	-	-	-	-	-	-	-	-	-	-	-	-					0.248	J	-	-	0.33	J	-	-
PCBs																														
Aroclor 1254	mg/kg	0.969			-	-	-	-	0.969		-	-	-	-	-	-	-	-					-	-	-	-	-	-	-	-
Aroclor 1260	mg/kg	5.07			1.42		0.183		1.58		5.07		2.09	J	0.16	J	0.103	J					0.15	J	0.26		0.088		0.03	J

TNTC - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

	Location Code:		PB-TNTC-S9		TNTC-SO001				TNTC-SO065		TNTC-SO066												TNTC-SO074		TNTC-SO100		TNTC-SO107			
	Sample No:		PB-TNTC-S9-0_5-1_0		AB0426		AB0460		AB0475		AB0429		AB0430		AB0461		AB0462		BD0017R		BD0018R		AB0431		AB0476		AB0432		AB0433	
	Sample Date:		13-Oct-94		12-Oct-00		28-Sep-00		12-Oct-00		27-Sep-00		12-Oct-00		28-Sep-00		28-Sep-00		2-Oct-01		2-Oct-01		12-Oct-00		12-Oct-00		10-Oct-00		10-Oct-00	
	Sample Depth:		0.5 - 1 Ft		0 - 1 Ft		4 - 6 Ft		2.5 - 3.5 Ft		0 - 1 Ft		2.5 - 3.5 Ft		5 - 7 Ft		8 - 10 Ft		2.5 - 3.4 Ft		8 - 10 Ft		2.5 - 3.5 Ft		2 - 3 Ft		0 - 1 Ft		3 - 4 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals																														
Aluminum	mg/kg	11900			4560	J	1420	J	11200	J	6560	J	2330	J	7850	J	5180	J	4280	J	6100	J	8310	J	4540	J	5290	J	3750	J
Antimony	mg/kg	13.2	-	-	-	-	0.757	J	1.09	B	8.15	J	-	-	-	-	-	-	-	-	-	-	-	-	0.654	B	1.59		-	-
Arsenic	mg/kg	18.5	9.5		10.5		3.64		6.79		7.55		7.43		6.06		2.47		3.3	B	3	B	8.45		3.32		3.86	B	3.68	B
Barium	mg/kg	427			141		56.5		96.6		365		427		35.4		22.9		51.5	J	44.9	J	63.2		28.3		57.7		14.6	
Beryllium	mg/kg	0.823	-	-	0.442	J	0.178	J	0.721	J	0.602		0.219	J	0.595		0.5		0.41	B	0.45	B	0.543	J	0.36	J	0.403		0.28	
Cadmium	mg/kg	2.19	-	-	1.15		0.281	J	0.194	J	-	-	-	-	-	-	-	-	0.082	B	0.11	B	0.316	J	0.498	J	0.316	J	-	-
Calcium	mg/kg	252000			38300	J	252000		28700	J	18500	J	28200	J	157000		225000		7650	J	71300	J	15400	J	10700	J	10700		2790	
Chromium	mg/kg	202	15		8.13		3.86		14.3		11		3.71		13.7		9.53		8.4	J	12.3	J	16.5		9.85		13.7		7.44	
Cobalt	mg/kg	21			4.79		1.94		7.71		9.63		0.297	J	12		6.24		3.2	J	13	J	7.29		3.23		5.03		3.16	
Copper	mg/kg	99.8	13		21.3		8.19		12.9		17.1	J	3.56		19.2		11		8.2		17.6		30.1		35.9		99.8		5.36	
Iron	mg/kg	35500			18100		9790		30500		35500		4010		32600		11300		20200	J	16400	J	19100		11500		12900		8140	
Lead	mg/kg	934	18		355	J	76.4		41.1	J	132	J	761	J	9.86		4.86	B	24.7	J	21.5	J	134	J	111	J	361		15.3	
Magnesium	mg/kg	18700			11300	J	18700		3320	J	5780	J	422	J	3670		3390		2960	J	3620	J	3260	J	1910	J	1660		1660	
Manganese	mg/kg	5160	512		512	J	713		2120	J	5160		105	J	1130		1620		529	J	516	J	454	J	211	J	505		122	
Mercury	mg/kg	0.98	-	-	0.173	J	0.059		0.068	J	0.048		0.059	J	-	-	-	-	0.3		0.059	J	0.022	J	0.072	J	0.04	B	0.114	B
Nickel	mg/kg	90.8	30		21.1		7.55		21.8		15.8		4.17		46.6		18.5		9.3	J	30.1	J	23.8		8.95		11.9		9.44	
Potassium	mg/kg	2830			858	J	510		951	J	800		1180	J	2730		2410		220	J	2190		1640	J	706	J	1070		639	
Selenium	mg/kg	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Silver	mg/kg	0.497	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/kg	403			182	B	235	B	140	B	223	J	78.2	B	292	B	387		-	-	137	J	140	B	134	B	227	J	110	J
Vanadium	mg/kg	28.8			12.7		5.87		24.6		16		6.68		12		8.92		21	J	10.1	J	18.6		17.1		16.9		12.2	
Zinc	mg/kg	708	70		199		56.9		96.1		93.1		5.8		44.5		10.9		52.9	J	47.3	J	123		86.1		171		31.3	

			TNTC-SO123								TNTC-SO134				TNTC-SO150		TNTC-SO151				TNTC-SO165		TNTC-SO171				TNTC-SO173		TNTC-SO190		TNTC-SO192			
Location Code:																																		
Sample No:			AB0463		AB0464		BD0021R		BD0022R		AB0436		AB0465		AB0437		AB0438		AB0439		AB0442		AB0466		AB0467		AB0443		AB0444		AB0445		AB0446	
Sample Date:			27-Sep-00		27-Sep-00		2-Oct-01		2-Oct-01		26-Sep-00		27-Sep-00		10-Oct-00		10-Oct-00		10-Oct-00		27-Sep-00		28-Sep-00		28-Sep-00		11-Oct-00		11-Oct-00		11-Oct-00		11-Oct-00	
Sample Depth:			5 - 7 Ft		8 - 10 Ft		4 - 6 Ft		6 - 7 Ft		2.5 - 3.5 Ft		5 - 7 Ft		0.33 - 1 Ft		0 - 1 Ft		1.3 - 2.3 Ft		1.5 - 2.5 Ft		4 - 6 Ft		8 - 10 Ftt		1 - 2 Ft		1 - 2 Ft		0 - 1 Ft		2 - 2.5 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																																		
Amino-2,6-dinitrotoluene, 4-	mg/kg	14.6	0.934		0.896		3.7		-	-	0.146		-	-	14.6		10.8		-	-	7.28		-	-	3.76		2.26		0.99		6.62		4.76	
Amino-4,6-dinitrotoluene, 2-	mg/kg	38	3.61		10.3		2.5		-	-	0.108		-	-	38		9.41		4.8		11.9		-	-	0.647		1.28		1.24		5.14		3.27	
Amino-4-nitrotoluene, 2-	mg/kg	0.4																																
Dinitrobenzene, 1,3-	mg/kg	0.751	-	-	-	-	-	-	-	-	-	-	-	-	0.12		0.142		0.127		-	-	-	-	-	-	-	-	-	-	0.751		-	-
Dinitrotoluene, 2,4-	mg/kg	33					0.67		33																									
Dinitrotoluene, 2,6-	mg/kg	18					2.4		18																									
Dinitrotoluene, 3,4-	mg/kg	1.2																																
Dinitrotoluene, total	mg/kg	297	3.5		16.8						0.165		-	-	-	-	1.59		-	-	5.63		236		47.8		0.288		-	-	3.7		0.705	
Nitrobenzene	mg/kg	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0966	J	0.0963	J	-	-	-	-	-	-	-	-	0.212	
Nitrotoluene, 2-	mg/kg	50.8	0.27		2.8		-	-	4		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 3-	mg/kg	8.61	0.275		0.328		-	-	0.8	J	-	-	-	-	1.71		-	-	0.271		1.28		-	-	0.484		-	-	-	-	-	-	-	-
Nitrotoluene, 4-	mg/kg	67.4	-	-	1.47		-	-	2.4		-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.29		-	-	-	-	-	-	-	-
Tetryl	mg/kg	0.626	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.626		-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	mg/kg	10.1	0.205		0.507		0.3		0.5	J	-	-	-	-	0.902		2.43		2.69		7.93		0.146		0.119		0.153		-	-	0.723		0.811	
Trinitrotoluene, 2,4,6-	mg/kg	54969	5.26		15.1		6.5		4		0.049	J	0.119		51.1		5067		2588		1343		448		173		8.07		0.634		878		251	
Volatiles																																		
Acetone	mg/kg	0.456	0.0081	J	0.034		0.023		0.03		0.0535	J	0.015		0.187	J	0.0969	J	-	-	0.0114	J	-	-	-	-	0.0444	J	0.109	J	0.0975	J	-	-
Benzene	mg/kg	0.00601	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00194	J	-	-	-	-	-	-	-	-	-	-	-	-	0.00601		0.00291	J
Butanone, 2-	mg/kg	0.0818	-	-	-	-	-	-	-	-	-	-	0.00545	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbon disulfide	mg/kg	0.0272	-	-	0.00215	J	-	-	-	-	0.00379	J	0.00175	J	-	-	-	-	-	-	0.0022	J	0.00337	J	-	-	-	-	0.00598		-	-	0.00423	J
Ethylbenzene	mg/kg	0.00248	-	-	-	-	-	-	-	-	-	-	-	-	0.00156	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methylene chloride	mg/kg	0.0514	0.00443	B	0.00272	B	0.0044	B	0.0029	B	0.00878	B	0.0104		0.0266	B	0.00597	B	-	-	0.0155	B	0.00625	B	0.00668	B	0.00594	B	0.00731	B	0.0054	B	0.00443	B
Styrene	mg/kg	0.00197	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Toluene	mg/kg	0.0781	-	-	-	-	-	-	0.0008	J	-	-	-	-	0.0142	J	0.00324	J	0.00726	J	-	-	-	-	-	-	-	-	0.00302	J	0.00258	J	0.00692	
Xylene, o-	mg/kg	0.00323	-	-	-	-					-	-	-	-	0.00246	J	-	-	0.00166	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Xylenes, m,p-	mg/kg	0.0075	-	-	-	-					-	-	-	-	-	-	-	-	0.00399	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Semivolatiles																																		
Acenaphthylene	mg/kg	0.545	-	-	-	-					-	-	-	-	0.545	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Anthracene	mg/kg	4.14	-	-	-	-					-	-	-	-	0.351	J	1.34	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.14	
Benzo(a)anthracene	mg/kg	11.1	-	-	-	-					-	-	-	-	3.32		6.94		-	-	-	-	-	-	-	-	-	-	0.0648	J	1	J	11.1	
Benzo(a)pyrene	mg/kg	8.2	-	-	-	-					-	-	-	-	3.63		6.33		-	-	-	-	-	-	-	-	-	-	0.0596	J	0.704	J	8.2	
Benzo(b)fluoranthene	mg/kg	10.2	-	-	-	-					-	-	-	-	4.82		9.05		-	-	-	-	-	-	-	-	-	-	0.102	J	0.929	J	10.2	
Benzo(ghi)perylene	mg/kg	3.4	-	-	-	-					-	-	-	-	1.78		2.78	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.4	J
Benzo(k)fluoranthene	mg/kg	4.38	-	-	-	-					-	-	-	-	1.65		3.02	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.38	
Bis(2-ethylhexyl)phthalate	mg/kg	0.24	-	-	-	-					-	-	0.0264	J	-	-	-	-	-	-	-	-	-	-	-	-	0.0409	J	0.0302	J	-	-	-	-
Carbazole	mg/kg	0.109	-	-	-	-					-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chrysene	mg/kg	8.74	-	-	-	-					-	-	-	-	3.02		6.28		-	-	-	-	-	-	-	-	-	-	0.0656	J	0.831	J	8.74	
Dibenz(a,h)anthracene	mg/kg	1.4	-	-	-	-					-	-	-	-	0.601	J	1.03	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.4	J
Diethyl phthalate	mg/kg	NA	-	-	-	-					-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Di-n-butyl phthalate	mg/kg	0.169	-	-	-	-					-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	275	0.617	J	8.19						0.0732	J	-	-	-	-	1.65	J	-	-	10.6		275		24.1		0.0916	J	-	-	2.41	J	1.64	J
Dinitrotoluene, 2,6-	mg/kg	65.5	7.21		6.83						-	-	-	-	-	-	-	-	-	-	2.88	J	23.8	J	1.68	J	-	-	-	-	-	-	-	-
Fluoranthene	mg/kg	20.3	-	-	-	-					-	-	-	-	4.75		12.9		-	-	-	-	-	-	-	-	-	-	0.11	J	2.05	J	20.3	
Indeno(1,2,3-cd)pyrene	mg/kg	3.64	-	-	-	-					-	-	-	-	1.89		2.91	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.64	J
Methylnaphthalene, 2-	mg/kg	0.0381	-	-	-	-					-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phenanthrene	mg/kg	5.21	-	-	-	-					-	-	-	-	0.667	J	4.13	J	-	-	-	-	-	-	-	-	-	-	-	-	1.35	U	5.21	
Pyrene	mg/kg	17.1	-	-	-	-					-	-	-	-	4.61		10.1		-	-	-	-	-	-	-	-	-	-	0.0873	J	1.54	J	17.1	
PCBs																																		
Aroclor 1254	mg/kg	0.969	-	-	-	-					0.46		0.176		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aroclor 1260	mg/kg	5.07	-	-	-	-					-	-	0.135		1.37	J	2.11	J	1.02	J	0.509		0.0768	J	0.106	J	0.0366	J	-	-	0.373	J	0.3	

TNTC - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

	Location Code:		TNTC-SO123								TNTC-SO134				TNTC-SO150		TNTC-SO151				TNTC-SO165		TNTC-SO171				TNTC-SO173		TNTC-SO190		TNTC-SO192			
	Sample No:		AB0463		AB0464		BD0021R		BD0022R		AB0436		AB0465		AB0437		AB0438		AB0439		AB0442		AB0466		AB0467		AB0443		AB0444		AB0445		AB0446	
	Sample Date:		27-Sep-00		27-Sep-00		2-Oct-01		2-Oct-01		26-Sep-00		27-Sep-00		10-Oct-00		10-Oct-00		10-Oct-00		27-Sep-00		28-Sep-00		28-Sep-00		11-Oct-00		11-Oct-00		11-Oct-00		11-Oct-00	
	Sample Depth:		5 - 7 Ft		8 - 10 Ft		4 - 6 Ft		6 - 7 Ft		2.5 - 3.5 Ft		5 - 7 Ft		0.33 - 1 Ft		0 - 1 Ft		1.3 - 2.3 Ft		1.5 - 2.5 Ft		4 - 6 Ft		8 - 10 Ftt		1 - 2 Ft		1 - 2 Ft		0 - 1 Ft		2 - 2.5 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals																																		
Aluminum	mg/kg	11900	4310	J	6950	J	3950	J	4970	J	5490	J	5010	J	3630	J	3090	J	3690	J	2610	J	3150	J	3930	J	4110		7340		5580		2820	
Antimony	mg/kg	13.2	-	-	-	-	-	-	-	-	-	-	-	-	0.68	J	-	-	0.783	J	-	-	-	-	0.904	J	0.78	B	-	-	-	-	-	-
Arsenic	mg/kg	18.5	2.99		2.9		2.9	B	3.3	B	3.95		4.22		3.94	B	4.02	B	2.95	B	2.26		1.77		1.79		3.63		5.58		7.12		2.58	
Barium	mg/kg	427	24.4		21.5		12	J	43.7	J	30.5	J	25.3		24.1		26.4		22.5		28.2		31.9		33.3		42.8		50.3		89.8		398	
Beryllium	mg/kg	0.823	0.321		0.515		0.27	B	0.46	B	0.36		0.342		0.297		0.247	J	0.275		0.156	J	0.203	J	0.246		0.274		0.482		0.394		0.205	J
Cadmium	mg/kg	2.19	0.136	J	-	-	0.083	B	0.2	B	-	-	0.16	J	0.272	J	0.545	J	0.606	J	-	-	-	-	-	-	0.191	B	0.693		2.19		0.913	
Calcium	mg/kg	252000	65300	J	126000	J	9510	J	151000	J	35800	J	16600	J	35600		55100		13400		9330	J	1430		1420		2590	J	25000	J	45900	J	46800	J
Chromium	mg/kg	202	7.13		14.1		8.2	J	9.7	J	8.44		9.89		6.76		8.17		7.85		4.36		5.24		6.25		5.92	J	13.1	J	16.2	J	202	J
Cobalt	mg/kg	21	3.62		8.38		3.1	J	12	J	6.29		4.78		2.25		2.25		2.56		1.39		1.37		1.75		2.61		6.25		4.36		3.69	
Copper	mg/kg	99.8	11.2	J	11.5	J	10.6		15.4		11.1		28	J	43.7		28.6		30.3		4.54	B	1.36		2.96		5.09		9.9		52.2		16.4	
Iron	mg/kg	35500	10100		14000		11600	J	21600	J	13100		10600		10900		11400		9550		6600		4310		5200		8480		20600		21400		8120	
Lead	mg/kg	934	27.9	J	4.05	J	97.6	J	10.1	J	21.6	J	157	J	195		621		212		25.6	J	8.8		43.8		8.07	J	20.1	J	934	J	228	J
Magnesium	mg/kg	18700	1160	J	3960	J	644	J	2620	J	2230		1910	J	5890		6770		2710		1040	J	658		761		1170	J	2130	J	4660	J	5360	J
Manganese	mg/kg	5160	361		764		122	J	796	J	484		244		334		286		199		74		33.7		38.1		388		562		614		374	
Mercury	mg/kg	0.98	-	-	-	-	-	-	-	-	-	-	-	-	0.269		0.39		-	-	0.027	J	-	-	-	-	-	-	0.03	J	0.107	J	0.085	J
Nickel	mg/kg	90.8	10.4		23.1		8.2	J	30.2	J	18.4		13		8.17		8.74		8.26		4.48		3.72		4.8		6.73		18.8		22.1		90.8	
Potassium	mg/kg	2830	897		2640		349	J	2150		1250		1150		441		452		469		308		242		369		339	J	1140	J	878	J	492	J
Selenium	mg/kg	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.11	B	0.948	B	-	-
Silver	mg/kg	0.497	-	-	-	-	-	-	-	-	-	-	0.497	J	-	-	-	-	-	-	-	-	-	-	0.421	J	-	-	-	-	-	-	-	-
Sodium	mg/kg	403	288		355		-	-	251	J	196	B	263		223	J	173	J	207	J	195	J	249	B	118	B	170	J	185	J	403		146	J
Vanadium	mg/kg	28.8	8.95		9.79		10.1	J	8.6	J	9.69		12.7		10.9		10.5		11.7		7.9		8.01		9.2		11.9		21.9		28.8		19.9	
Zinc	mg/kg	708	41.2		17.3		56.2	J	75.6	J	55.1		33.8		121		240		193		25.6		23.9		25		45.8	J	204	J	708	J	170	J

TNTC - Historical Soil Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

			TNTC-SO206		TNTC-SO222		TNTC-SO241				TNTC-SO252						TNTC-SO280		TNTC-SO311		TNTC-SO320		TNTC-SO325		TNTC-SO327		TNTC-SO383		TNTC-SO397		TNTC-SO407	
		Sample No:	AB0447		AB0468		AB0448		AB0469		AB0451		AB0473		AB0474		AB0454		AB0455		AB0477		AB0478		AB0479		AB0470		AB0471		AB0472	
		Sample Date:	12-Oct-00		28-Sep-00		11-Oct-00		27-Sep-00		27-Sep-00		29-Sep-00		29-Sep-00		27-Sep-00		27-Sep-00		12-Oct-00		12-Oct-00		12-Oct-00		27-Sep-00		28-Sep-00		28-Sep-00	
		Sample Depth:	1 - 2 Ft		3 - 5 Ft		1 - 2 Ft		4 - 6 Ft		0.5 - 1.5 Ft		4 - 6 Ft		8 - 10 Ft		0.25 - 1.25 Ft		0.5 - 1.5 Ft		1.5 - 2.5 Ft		1 - 2 Ft		2 - 3 Ft		4 - 6 Ft		4 - 6 Ft		8 - 10 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																																
Amino-2,6-dinitrotoluene, 4-	mg/kg	14.6	4.48		0.151		11.5		0.589		4.78		-	-	-	-	-	-	0.588		2.6		2.45		2.2		0.192		0.946		0.333	
Amino-4,6-dinitrotoluene, 2-	mg/kg	38	6.9		-	-	17.3		0.911		3.77		0.275		-	-	-	-	0.948		6.23		11.4		3.02		0.182		0.359		0.433	
Amino-4-nitrotoluene, 2-	mg/kg	0.4																														
Dinitrobenzene, 1,3-	mg/kg	0.751	-	-	-	-	-	-	-	-	0.0829	J	-	-	-	-	0.566		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	33																														
Dinitrotoluene, 2,6-	mg/kg	18																														
Dinitrotoluene, 3,4-	mg/kg	1.2																														
Dinitrotoluene, total	mg/kg	297	-	-	0.483		2.75		0.257		0.57		0.121		-	-	22.1		0.781		-	-	-	-	-	-	0.156		2.03		0.824	
Nitrobenzene	mg/kg	0.3	-	-	-	-	-	-	-	-	0.283		-	-	-	-	0.227		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	50.8	-	-	1.94		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.921		0.295	
Nitrotoluene, 3-	mg/kg	8.61	-	-	0.263		-	-	-	-	0.462		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.31		-	-
Nitrotoluene, 4-	mg/kg	67.4	-	-	1.99		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.18		0.39	
Tetryl	mg/kg	0.626	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	mg/kg	10.1	-	-	-	-	2.6		0.0616	J	0.966		-	-	-	-	10.1		-	-	3.24		0.283		-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	mg/kg	54969	3.45		0.166		900		0.213		681		1.32		-	-	54969		1.35		38.7		33.7		9.91		0.0956	J	0.448		0.257	
Volatiles																																
Acetone	mg/kg	0.456	0.0846		0.0644	J	0.0503	J	0.0519		0.0438		-	-	-	-	0.118		0.0375		-	-	0.0602		0.0696		0.0228		0.151	J	-	-
Benzene	mg/kg	0.00601	0.00162	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00184	J	0.00185	J	-	-	-	-	-	-
Butanone, 2-	mg/kg	0.0818	-	-	-	-	-	-	-	-	0.015		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0165	J	-	-
Carbon disulfide	mg/kg	0.0272	0.01		0.0075		-	-	-	-	0.00347	J	-	-	-	-	-	-	0.00343	J	-	-	-	-	0.0272		-	-	0.00605	J	-	-
Ethylbenzene	mg/kg	0.00248	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00119	J	-	-	-	-	-	-
Methylene chloride	mg/kg	0.0514	0.00622	B	0.00308	B	0.00505	B	0.0162	B	0.00772	B	-	-	0.00138	B	0.00831	B	0.00864	B	0.0514	J	0.0122	B	0.00583	B	0.00706	B	0.0052	B	0.006	B
Styrene	mg/kg	0.00197	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Toluene	mg/kg	0.0781	0.00184	J	0.00194	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0139	J	0.0032	J	0.00296	J	-	-	0.00208	J	-	-
Xylene, o-	mg/kg	0.00323	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Xylenes, m,p-	mg/kg	0.0075	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00389	J	-	-	0.00114	J	-	-	-	-	-	-
Semivolatiles																																
Acenaphthylene	mg/kg	0.545	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Anthracene	mg/kg	4.14	-	-	0.113	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(a)anthracene	mg/kg	11.1	0.0498	J	0.289	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0384	J	-	-
Benzo(a)pyrene	mg/kg	8.2	0.0449	J	0.356	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0361	J	-	-
Benzo(b)fluoranthene	mg/kg	10.2	0.0826	J	0.492		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(ghi)perylene	mg/kg	3.4	-	-	0.352	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	mg/kg	4.38	-	-	0.155	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bis(2-ethylhexyl)phthalate	mg/kg	0.24	0.0419	J	0.202	J	-	-	-	-	-	-	0.0207	J	-	-	-	-	-	-	0.0335	J	-	-	0.0392	J	-	-	-	-	-	-
Carbazole	mg/kg	0.109	-	-	0.109	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chrysene	mg/kg	8.74	-	-	0.357	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	mg/kg	1.4	-	-	0.123	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diethyl phthalate	mg/kg	NA	0.624	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.672	B	0.529	B	-	-	-	-	-	-
Di-n-butyl phthalate	mg/kg	0.169	0.0494	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.169	J	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	275	-	-	-	-	5.68		0.0493	J	0.899	J	-	-	-	-	13.9		1.72		0.176	J	0.06	J	-	-	-	-	0.74		-	-
Dinitrotoluene, 2,6-	mg/kg	65.5	-	-	-	-	10.7		-	-	-	-	-	-	-	-	8.43		0.428		0.386		-	-	-	-	-	-	0.117	J	-	-
Fluoranthene	mg/kg	20.3	0.086	J	0.666		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-cd)pyrene	mg/kg	3.64	-	-	0.27	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methylnaphthalene, 2-	mg/kg	0.0381	-	-	0.0381	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phenanthrene	mg/kg	5.21	-	-	0.568		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyrene	mg/kg	17.1	-	-	0.605		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PCBs																																
Aroclor 1254	mg/kg	0.969	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aroclor 1260	mg/kg	5.07	0.14	J	0.0613	J	0.517		0.0196	J	0.41		-	-	-	-	0.883		0.162		0.0237	J	0.0542	J	0.00951	J	0.0244	J	0.0592	J	0.0405	J

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2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Location Code:			TNTC-SO206		TNTC-SO222		TNTC-SO241				TNTC-SO252						TNTC-SO280		TNTC-SO311		TNTC-SO320		TNTC-SO325		TNTC-SO327		TNTC-SO383		TNTC-SO397		TNTC-SO407	
Sample No:			AB0447		AB0468		AB0448		AB0469		AB0451		AB0473		AB0474		AB0454		AB0455		AB0477		AB0478		AB0479		AB0470		AB0471		AB0472	
Sample Date:			12-Oct-00		28-Sep-00		11-Oct-00		27-Sep-00		27-Sep-00		29-Sep-00		29-Sep-00		27-Sep-00		27-Sep-00		12-Oct-00		12-Cct-00		12-Oct-00		27-Sep-00		28-Sep-00		28-Sep-00	
Sample Depth:			1 - 2 Ft		3 - 5 Ft		1 - 2 Ft		4 - 6 Ft		0.5 - 1.5 Ft		4 - 6 Ft		8 - 10 Ft		0.25 - 1.25 Ft		0.5 - 1.5 Ft		1.5 - 2.5 Ft		1 - 2 Ft		2 - 3 Ft		4 - 6 Ft		4 - 6 Ft		8 - 10 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals																																
Aluminum	mg/kg	11900	7260	J	6810	J	5570		5360	J	3880	J	11000		10800		1870	J	4060	J	4170	J	3750	J	6190	J	7180	J	4630	J	1610	J
Antimony	mg/kg	13.2	-	-	-	-	-	-	-	-	1.03	J	-	-	1.15	J	-	-	0.82	J	-	-	-	-	0.633	B	-	-	-	-	0.779	J
Arsenic	mg/kg	18.5	6.59		9.27		9.38		3.43		3.75		18.5		13.2		3.83		5.59		9.88		2.14		4.07		2.9		6.08		3.39	
Barium	mg/kg	427	40.4		57.5		81.6		28.3		19.6		62.3		43		30.3		27.9		52.8		14.1		46		27.3		92.4		38.7	
Beryllium	mg/kg	0.823	0.823	J	0.487		0.46		0.325		0.294		0.683		0.633		0.159	J	0.311		0.42	J	0.277	J	0.408	J	0.389		0.376		0.154	J
Cadmium	mg/kg	2.19	0.345	J	0.385	J	1.19		-	-	0.163	J	-	-	-	-	-	-	0.285	J	0.159	J	-	-	-	-	-	-	-	-	-	-
Calcium	mg/kg	252000	34900	J	67600		24000	J	7710	J	5710	J	34700		50800		959	J	5300	J	45900	J	7300	J	6520	J	1410	J	26300		1610	
Chromium	mg/kg	202	13.2		11		9.87	J	6.49		38		17.2		17.3		3.04		12.5		8.08		6.27		10.1		6.34		8.03		3.84	
Cobalt	mg/kg	21	5.77		3.89		4.5		2.41		3.45		10.8		12.1		1.14		2.41		3.77		2.2		4.59		1.63		4.4		1.11	J
Copper	mg/kg	99.8	19		15.2		14.2		4.46	B	13.1	J	29.7		27.2		6.38	J	23.3	J	10.5		3.73		7.22		3.38	B	13		3.53	
Iron	mg/kg	35500	16900		15400		28800		9180		11500		27600		25600		5520		9560		28500		6800		18000		6930		23100		6370	
Lead	mg/kg	934	79.5	J	68.9		58.1	J	9.27	J	117	J	14.6		13.4		97	J	721	J	9.46	J	14.2	J	8.61	J	6.03	J	129		4.22	B
Magnesium	mg/kg	18700	4250	J	6710		5900	J	3030	J	1600	J	10300		14000		388	J	1270	J	13200	J	1870	J	1640	J	629	J	7380		434	
Manganese	mg/kg	5160	387	J	396		1400		263		119		295		426		46.7		63.7		1120	J	111	J	424	J	81.9		1700		34.2	
Mercury	mg/kg	0.98	0.086	J	0.113		0.043	J	0.024	J	0.247		0.019	J	0.019	J	0.034		0.022	J	-	-	0.021	J	0.031	J	0.02	J	0.026	J	-	-
Nickel	mg/kg	90.8	17		12		15.4		6		24.9		31.9		33		3.3		12.3		14		6.44		14.3		4.37		12.6		3.29	
Potassium	mg/kg	2830	1080	J	968		506	J	304		507		2690		2830		390		678		680	J	354	J	822	J	253		476		355	
Selenium	mg/kg	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Silver	mg/kg	0.497	-	-	-	-	0.455	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/kg	403	186	B	214	B	228		173	J	252		264		253		163	J	251		152	B	151	B	109	B	210	J	133	B	115	B
Vanadium	mg/kg	28.8	18.8		16.5		17.3		11		18		20.9		19.8		6.56		11.3		14.8		12.4		18		11.9		14.6		10.1	
Zinc	mg/kg	708	151		158		359	J	29.3		55.4		91.4		83.9		25.2		112		94.6		19.2		29.5		27.1		51		12.3	

MDC - Maximum detected concentration for the AOC ("B" qualified data excluded).
mg/kg - Milligrams per kilogram.
PCB - Polychlorinated biphenyl

Validation Qualifiers (VQ)
B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.
J - The analyte was positively identified; the reported value is estimated.

Table 3-12

TNTC - Historical Groundwater Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	IT-MW09			PB-BED-MW13								PB-TNTC-MW3						PB-TNTC-MW4					
				Sample No:	5590		5595	5160		5890		5895		PB-BED-MW13		5070		5630		5635		5080		5640		5645	
				Sample Date:	23-Nov-97		19-May-98	17-Oct-96		13-Nov-97		29-May-98		14-Dec-94		27-Sep-96		21-Nov-97		18-May-98		30-Sep-96		24-Nov-97		18-May-98	
Parameter	Units	RBSC	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives - Unfiltered																											
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	4.4		-	-	-	-	4.4		-	-	-	-	3.7		-	-	-	-	-	-	-	-	-	-	-	-
Dinitrobenzene, 1,3-	ug/L	0.37	0.22		-	-	-	-	0.22		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	ug/L	0.099	0.1		-	-	-	-	-	-	-	-	-	-	0.1		-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	ug/L	0.099	0.7		-	-	-	-	0.66		-	-	-	-	0.7		-	-	-	-	-	-	-	-	-	-	-	-
Nitrobenzene	ug/L	0.34	0.5		-	-	-	-	0.5		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	ug/L	0.049	1.9		-	-	-	-	0.34	UJ	-	-	-	-	1.9		-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 3-	ug/L	12.2	11		-	-	-	-	-	-	-	-	-	-	11		-	-	-	-	-	-	-	-	-	-	-	-
Tetryl	ug/L	37	NA		-	-	-	-	1.8	B	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	ug/L	110	2.2		-	-	-	-	-	-	-	-	-	-	2.2		-	-	-	-	-	-	-	-	-	-	-	-
Explosives - Filtered																											
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	3.9						3.9																			
Dinitrobenzene, 1,3-	ug/L	0.37	0.2						0.2																			
Volatiles																											
Acetone	ug/L	548	NA		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.5	B
Benzene	ug/L	0.35	190		-	-	0.16	J	190		130	D	47		50		-	-	-	-	-	-	-	-	-	-	-	-
Carbon disulfide	ug/L	104	5.8		-	-	-	-	3.7	J	5.8		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chlorobenzene	ug/L	10.6	0.17		0.17	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ethylbenzene	ug/L	134	86		-	-	-	-	86		73	D	57		82		-	-	-	-	-	-	-	-	-	-	-	-
Methylene chloride	ug/L	4.3	NA		-	-	-	-	-	-	-	-	51	B	-	-	6.9	U	-	-	0.47	B	5.9	U	-	-	-	-
Toluene	ug/L	72	190		-	-	17		190		170	D	120		190		-	-	-	-	-	-	-	-	-	-	-	-
Xylenes, total	ug/L	21	860		-	-	-	-	860		520	D	540		720		1	J	-	-	-	-	-	-	-	-	-	-
Semivolatiles																												
Bis(2-ethylhexyl)phthalate	ug/L	4.8	55		-	-	9.6	B	4.7	J	39		55	J	-	-	1.2	J	-	-	-	-	-	-	-	-	-	-
Dimethylphenol, 2,4-	ug/L	73	16		-	-	-	-	13	J	16		13	J	10		-	-	-	-	-	-	-	-	-	-	-	-
Isophorone	ug/L	71	2.7		-	-	-	-	-	-	-	-	2.7	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methylnaphthalene, 2-	ug/L	12	34		-	-	-	-	34		20		14	J	24		-	-	-	-	-	-	-	-	-	-	-	-
Methylphenol, 2-	ug/L	182	4.1		-	-	-	-	-	-	4.1	J	3.3	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methylphenol, 4-	ug/L	18	4.7		-	-	-	-	-	-	4.7	J	3.3	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Naphthalene	ug/L	0.62	36		-	-	-	-	36		15		10	J	28		-	-	-	-	-	-	-	-	-	-	-	-
Phenol	ug/L	1,095	69		-	-	-	-	-	-	62		69	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Metals - Unfiltered																												
Aluminum	ug/L	3,650	9540		1,200	J	-	-	-	-	-	-	-	-			9,540		-	-	6,030		6,590		3,820	J	4,570	J
Arsenic	ug/L	0.045	51.6		-	-	-	-	-	-	-	-	-	-	-	-	51.6		-	-	18.6		47.8		21.5		-	-
Barium	ug/L	255	3700		-	-	-	-	3,700		1,550		-	-			286		-	-	-	-	-	-	-	-	-	-
Calcium	ug/L	NE	566000		426,000	J	198,000		418,000		248,000	J	125,000	J			527,000		566,000	J	341,000		290,000		285,000	J	299,000	
Chromium	ug/L	11	57.5		10.4		-	-	10.8		-	-	-	-	-	-	57.5		-	-	30		46.9		25.2		11	
Cobalt	ug/L	73	131		-	-	-	-	-	-	-	-	-	-			131		67.5		-	-	-	-	-	-	-	-
Copper	ug/L	146	48.6		-	-	-	-	-	-	-	-	-	-	-	-	48.6		-	-	31.5		31.8		-	-	-	-
Iron	ug/L	1,095	41100		3,370		131		187		244	B	207				41,100		805		23,500	J	36,800		17,400		8,230	
Lead	ug/L	15	47.7		4.7	B	-	-	-	-	-	-	-	-	-	-	47.7		-	-	13.8		36.4		14.5		3.2	
Magnesium	ug/L	NE	308000		253,000		125,000		308,000	J	180,000		9,250				211,000		215,000		137,000		150,000		145,000		136,000	
Manganese	ug/L	88	5100		249		30.7		21		17.4		41.9		-	-	5,100		2,950		973		1,130		800		715	
Nickel	ug/L	73	198		-	-	-	-	-	-	-	-	-	-	-	-	198		120		-	-	46.6		52.4		-	-
Potassium	ug/L	NE	101000		25,600		11,100		79,000		101,000		-	-			25,300		26,700		10,100		28,100		28,200		22,100	
Selenium	ug/L	18	7.2		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.2		-	-
Sodium	ug/L	NE	1330000		146,000	J	73,200		1,080,000	J	1,330,000		29,500				77,000	J	86,100	J	58,900		79,200	J	79,700	J	62,100	
Vanadium	ug/L	3.7	87.7		-	-	-	-	52.4		-	-	-	-			87.7		-	-	-	-	70.1		-	-	-	-
Zinc	ug/L	1,095	133		27.2		-	-	34.9	UJ	47.2		-	-	23		133		34.5		80.8	B	112		58.7		41.2	B

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Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	IT-MW09			PB-BED-MW13								PB-TNTC-MW3						PB-TNTC-MW4					
				Sample No:	5590		5595	5160		5890		5895		PB-BED-MW13		5070		5630		5635		5080		5640		5645	
				Sample Date:	23-Nov-97		19-May-98	17-Oct-96		13-Nov-97		29-May-98		14-Dec-94		27-Sep-96		21-Nov-97		18-May-98		30-Sep-96		24-Nov-97		18-May-98	
Parameter	Units	RBSC	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Filtered																												
Aluminum	ug/L	3,650	432		-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	432		-	-
Antimony	ug/L	1.5	14		-	-	-	-	-	-	-	-	-	-	14		-	-	-	-	-	-	-	-	-	-	-	-
Barium	ug/L	255	3300		-	-	-	-	3,300		1,680		208				-	-	-	-	-	-	-	-	-	-	-	-
Calcium	ug/L	NE	547000		402,000		212,000		381,000		270,000		140,000	J			547,000		529,000		402,000		313,000		386,000		306,000	
Chromium	ug/L	11	15		-	-	-	-	13.4		-	-	-	-	-	-	15		-	-	-	-	-	-	-	-	-	-
Cobalt	ug/L	73	112		-	-	-	-	-	-	-	-	-	-			112		-	-	-	-	-	-	-	-	-	-
Iron	ug/L	1095	1570		282	B	-	-	-	-	116	B	-	-			-	-	132	B	-	-	188		403	B	-	-
Lead	ug/L	15	36.1		-	-	4.1		-	-	-	-	-	-	-	-	36.1		-	-	-	-	20.9		11		-	-
Magnesium	ug/L	NE	277000		246,000		133,000		277,000		200,000		14,600	J			216,000	J	204,000		171,000		168,000	J	181,000		140,000	
Manganese	ug/L	88	5300		372		36.4		16		-	-	43.8		-	-	5,300	J	2,900		617		998	J	1,120		582	
Nickel	ug/L	73	170		-	-	-	-	-	-	-	-	-	-	-	-	170		77.1		-	-	-	-	56.8		-	-
Potassium	ug/L	NE	110000		26,500		12,300		71,100		110,000		-	-			23,700		25,800		12,000		30,600		34,500		21,100	
Selenium	ug/L	18	11.4		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11.4		-	-
Sodium	ug/L	NE	1510000		144,000		78,300		1,010,000	J	1,510,000		53,500				78,900		79,400		74,000		92,300		94,900		60,200	
Vanadium	ug/L	3.7	68.6		-	-	-	-	55.3		-	-	-	-			68.6		-	-	-	-	52.5		-	-	-	-
Zinc	ug/L	1,095	73.3		73.3	J	24.2	B	40.2		30.1		-	-	-	-	41.9		28.5	J	45.5	B	32		52	J	-	-
Water Quality Parameters																												
Alkalinity	ug/L	NE	610000		340,000		410,000				430,000		300,000						270,000		350,000				330,000		250,000	
Chloride	ug/L	NE	2500000		28,000						2,500,000		-	-					17,000		14,000				23,000		27,000	
Hardness	ug/L	NE	13000000		2,200,000						1,600,000		450,000						13,000,000		1,800,000				9,200,000		720,000	
Nitrate	ug/L	1000	400				100						-	-	-	-					-	-					400	
Nitrate-Nitrite	ug/L	100	91000		17,000	J					-	-							-	-					91,000	J		
Sulfate	ug/L	NE	2000000		1,500,000		790,000				13,000		5,000						2,000,000		1,300,000				1,100,000		990,000	
Total dissolved solids	ug/L	NE	4800000		3,100,000		1,600,000				4,800,000		510,000						3,000,000		2,900,000				2,100,000		1,600,000	
Total organic carbon	ug/L	NE	10000		2,900		2,000				9,600		2,000						2,400		3,000				2,600		3,000	
Total suspended solids	ug/L	NE	280000		15,000		-	-			16,000		-	-					-	-	150,000				5,000		280,000	

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Sandusky, Ohio

				Location Code:		PB-TNTC-MW5						PB-TNTC-MW6							
				Sample No:		5090		5650		5655		PB-TNTC-DM-MW5		5100		5660		5665/5665R		PB-TNTC-DM-MW6	
				Sample Date:		30-Sep-96		21-Nov-97		18-May-98		12-Dec-94		2-Oct-96		20-Nov-97		16-May-98/18-May-98		12-Dec-94	
Parameter	Units	RBSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives - Unfiltered																					
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	4.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrobenzene, 1,3-	ug/L	0.37	0.22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	ug/L	0.099	0.1	-	-	-	-	-	-	0.1		-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	ug/L	0.099	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrobenzene	ug/L	0.34	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	ug/L	0.049	1.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 3-	ug/L	12.2	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tetryl	ug/L	37	NA	-	-	-	-	-	-					-	-	-	-	-	-		
Trinitrobenzene, 1,3,5-	ug/L	110	2.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Explosives - Filtered																					
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	3.9																		
Dinitrobenzene, 1,3-	ug/L	0.37	0.2																		
Volatiles																					
Acetone	ug/L	548	NA	-	-	-	-	-	-					-	-	-	-	1.7	B		
Benzene	ug/L	0.35	190	-	-	-	-	-	-					-	-	-	-	-	-		
Carbon disulfide	ug/L	104	5.8	-	-	0.51	B	-	-					-	-	-	-	-	-		
Chlorobenzene	ug/L	10.6	0.17	-	-	-	-	-	-					-	-	-	-	-	-		
Ethylbenzene	ug/L	134	86	-	-	-	-	-	-					-	-	-	-	-	-		
Methylene chloride	ug/L	4.3	NA	5.7	U	0.43	B	0.51	B					-	-	0.32	B	-	-		
Toluene	ug/L	72	190	-	-	-	-	-	-					-	-	-	-	22			
Xylenes, total	ug/L	21	860	-	-	-	-	-	-					-	-	-	-	-	-		
Semivolatiles																					
Bis(2-ethylhexyl)phthalate	ug/L	4.8	55	-	-	-	-	-	-					-	-	7.3	J	-	-		
Dimethylphenol, 2,4-	ug/L	73	16	-	-	-	-	-	-					-	-	-	-	-	-		
Isophorone	ug/L	71	2.7	-	-	-	-	-	-					-	-	-	-	-	-		
Methylnaphthalene, 2-	ug/L	12	34	-	-	-	-	-	-					-	-	-	-	-	-		
Methylphenol, 2-	ug/L	182	4.1	-	-	-	-	-	-					-	-	-	-	-	-		
Methylphenol, 4-	ug/L	18	4.7	-	-	-	-	-	-					-	-	-	-	-	-		
Naphthalene	ug/L	0.62	36	-	-	-	-	-	-					-	-	-	-	-	-		
Phenol	ug/L	1,095	69	-	-	-	-	-	-					-	-	-	-	-	-		
Metals - Unfiltered																					
Aluminum	ug/L	3,650	9540	1,960		3,490	J	5,230						2,660	J	496	J	-	-		
Arsenic	ug/L	0.045	51.6	-	-	10.1		21.3		-	-			-	-	-	-	-	-	-	-
Barium	ug/L	255	3700	-	-	-	-	-	-					-	-	-	-	-	-		
Calcium	ug/L	NE	566000	135,000		146,000	J	132,000						255,000		223,000		194,000			
Chromium	ug/L	11	57.5	17.4		18.4		28		-	-			50.7		-	-	-	-	-	-
Cobalt	ug/L	73	131	-	-	-	-	-	-					-	-	-	-	-	-		
Copper	ug/L	146	48.6	-	-	-	-	31		-	-			-	-	-	-	-	-	-	-
Iron	ug/L	1,095	41100	6,540		13,900		22,700	J					9,940		2,460		2,080	J		
Lead	ug/L	15	47.7	23.6		13.8		20.1		13				18	U	-	-	-	-	5	
Magnesium	ug/L	NE	308000	53,100		55,900		46,400						17,800		15,600		12,700			
Manganese	ug/L	88	5100	717		713		616		570				2,580		3,700		3,830		1,400	
Nickel	ug/L	73	198	-	-	-	-	-	-	-	-			-	-	-	-	-	-	29	
Potassium	ug/L	NE	101000	16,400		15,400		11,700						14,100		12,200		9,830			
Selenium	ug/L	18	7.2	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Sodium	ug/L	NE	1330000	178,000	J	161,000	J	113,000						17,200		17,600		9,450			
Vanadium	ug/L	3.7	87.7	-	-	-	-	-	-					-	-	-	-	-	-		
Zinc	ug/L	1,095	133	48.9		53		56.3	B	52				83.1	U	-	-	66.7	B	34	

TNTC - Historical Groundwater Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	PB-TNTC-MW5								PB-TNTC-MW6							
				Sample No:	5090		5650		5655		PB-TNTC-DM-MW5		5100		5660		5665/5665R		PB-TNTC-DM-MW6	
				Sample Date:	30-Sep-96		21-Nov-97		18-May-98		12-Dec-94		2-Oct-96		20-Nov-97		16-May-98/18-May-98		12-Dec-94	
Parameter	Units	RBSC	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Filtered																				
Aluminum	ug/L	3,650	432		-	-	-	-	-	-			-	-	-	-	-	-		
Antimony	ug/L	1.5	14		-	-	-	-	-	-	8		-	-	-	-	-	-	-	-
Barium	ug/L	255	3300		-	-	-	-	-	-			-	-	-	-	-	-		
Calcium	ug/L	NE	547000		126,000		138,000		130,000				253,000		243,000		213,000			
Chromium	ug/L	11	15		-	-	-	-	-	-	-	-	14.9		-	-	-	-	-	-
Cobalt	ug/L	73	112		-	-	-	-	-	-			-	-	-	-	-	-		
Iron	ug/L	1095	1570		-	-	-	-	-	-			146		1,570		684			
Lead	ug/L	15	36.1		-	-	4.2		-	-	-	-	3.6		-	-	-	-	-	-
Magnesium	ug/L	NE	277000		51,700	J	54,600		47,700				16,800		17,500		14,100			
Manganese	ug/L	88	5300		503	J	522		452		460		2,540		4,020		3,970		1,300	
Nickel	ug/L	73	170		-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	
Potassium	ug/L	NE	110000		15,900		14,700		12,300				14,500		14,300		12,200			
Selenium	ug/L	18	11.4		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	ug/L	NE	1510000		178,000		163,000		127,000				17,300		21,300		15,400			
Vanadium	ug/L	3.7	68.6		-	-	-	-	-	-			-	-	-	-	-	-		
Zinc	ug/L	1,095	73.3		45		-	-	27	B	-	-	32.9	U	-	-	-	-	-	-
Water Quality Parameters																				
Alkalinity	ug/L	NE	610000				320,000		380,000						610,000		610,000			
Chloride	ug/L	NE	2500000				50,000		26,000						3,000		180,000			
Hardness	ug/L	NE	13000000				500,000		850,000						920,000		790,000			
Nitrate	ug/L	1000	400						200		200						-	-	1.4	
Nitrate-Nitrite	ug/L	100	91000				-	-							-	-				
Sulfate	ug/L	NE	2000000				430,000		240,000						-	-	-	-		
Total dissolved solids	ug/L	NE	4800000				1,000,000		1,200,000						640,000		620,000			
Total organic carbon	ug/L	NE	10000				3,000		3,000						10,000		9,000			
Total suspended solids	ug/L	NE	280000				7,000		240,000						130,000		4,000			

Shaded cell indicates value is greater than the RBSC.
RBSC - Values reflect an incremental lifetime cancer risk (ILCR) of 1E-6 or a noncancer hazard quotient (HQ) of 0.1. For chemicals that exhibit both cancer and noncancer effects, whichever type of effect results in a lower concentration (using an ILCR of 1E-6 and an HQ of 0.1), that concentration is selected as the RBSC.
MDC - Maximum detected concentration for the AOC ("B" qualified data not included).
BSC - Background screening concentration.
"-" - Not detected.
µg/L - Micrograms per liter.
NA - Not applicable; detection is the result of blank contamination.
NE - Not established (RBSCs), not evaluated (BSCs).

Validation Qualifiers (VQ)
J - The analyte was positively identified; the reported value is estimated.
B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.
D - Dilution
U - Nondetect due to blank contamination

Table 3-13

WARWP - Historical Surface Water Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

	Location Code:		MK-PMU1-SW-SD02		MK-PMU1-SW-SD03		PB-WA-SW1		PB-WA-SW2		PB-WA-SW3		PB-WA-SW4		PB-WA-SW5		PB-WA-SW7		WARP-SW01	
	Sample No:		MK01SW02		MK01SW03		PB-WA-SW1		PB-WA-SW2		PB-WA-SW3		PB-WA-SW4		PB-WA-SW5		PB-WA-SW7		12100	
	Sample Date:		29-Jun-93		29-Jun-93		25-Oct-94		25-Oct-94		25-Oct-94		25-Oct-94		27-Oct-94		25-Oct-94		5-Nov-98	
	Sample Purpose:		REG		REG		REG		REG		REG		REG		REG		REG		REG	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2-nitrotoluene, 4-	ug/L	0.6					-	-	-	-	0.6		-	-	-	-	-	-		
Dinitrobenzene, 1,3-	ug/L	0.3	-	-	-	-	0.3		-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	ug/L	0.5	-	-	-	-	0.5		-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	ug/L	0.8	-	-	-	-	-	-	-	-	-	-	-	-	0.8		-	-	-	-
Dinitrotoluene, 3,4-	ug/L	0.6					0.5		0.6		0.6		0.6		-	-	-	-		
Nitrotoluene, 3-	ug/L	54	-	-	-	-	-	-	2.3		2.4		2.5		54		2.2		-	-
Volatiles																				
Acetone	ug/L	3.1	-	-	-	-													1.4	B
Bromomethane	ug/L	0.22	-	-	-	-													0.22	J
Butanone, 2-	ug/L	7	7	J	-	-													-	-
Semivolatiles																				
Bis(2-ethylhexyl)phthalate	ug/L	2.7	-	-	-	-													-	-
Di-n-octyl phthalate	ug/L	7.8	-	-	-	-													-	-
Phenol	ug/L	6.9	-	-	-	-													6.9	B
Metals - Unfiltered																				
Aluminum	ug/L	13800	790		720														631	J
Arsenic	ug/L	21.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Barium	ug/L	131	35.9		36														-	-
Calcium	ug/L	115000	84100		85800														107000	
Chromium	ug/L	23.3	-	-	-	-	-	-	-	-	-	-	-	-	10		-	-	-	-
Cobalt	ug/L	18.7	-	-	-	-													-	-
Copper	ug/L	20.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iron	ug/L	26000	954		1000														1300	
Lead	ug/L	77	-	-	-	-	-	-	-	-	77		-	-	-	-	54		-	-
Magnesium	ug/L	50700	20400		20700														26000	
Manganese	ug/L	2960	31.2		37.7		190		260		230		260		1600		240		890	
Nickel	ug/L	32.7	-	-	-	-	-	-	-	-	-	-	-	-	20		-	-	-	-
Potassium	ug/L	12800	3860		4030														9400	
Sodium	ug/L	107000	21700		22200														38200	
Vanadium	ug/L	52.2	-	-	-	-													-	-
Zinc	ug/L	191	16.6		191		-	-	-	-	43		46		70		26		27	

Table 3-13

WARWP - Historical Surface Water Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

	Location Code:		MK-PMU1-SW-SD02		MK-PMU1-SW-SD03		PB-WA-SW1		PB-WA-SW2		PB-WA-SW3		PB-WA-SW4		PB-WA-SW5		PB-WA-SW7		WARP-SW01	
	Sample No:		MK01SW02		MK01SW03		PB-WA-SW1		PB-WA-SW2		PB-WA-SW3		PB-WA-SW4		PB-WA-SW5		PB-WA-SW7		12100	
	Sample Date:		29-Jun-93		29-Jun-93		25-Oct-94		25-Oct-94		25-Oct-94		25-Oct-94		27-Oct-94		25-Oct-94		5-Nov-98	
	Sample Purpose:		REG		REG		REG		REG		REG		REG		REG		REG		REG	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Filtered																				
Aluminum	ug/L	11400																	-	-
Arsenic	ug/L	17.2					-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	ug/L	106000																	104000	
Chromium	ug/L	21.2					-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iron	ug/L	15500																	153	
Lead	ug/L	20.4					-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magnesium	ug/L	49100																	25600	
Manganese	ug/L	1300					150		210		210		200		1300		230		218	
Potassium	ug/L	9370																	8870	
Sodium	ug/L	112000																	37400	
Zinc	ug/L	68					20		23		-	-	-	-	-	-	-	-	-	-
Water Quality Parameters																				
Hardness	ppm	592																	380	
Phosphorous	ug/L	370																		
Total suspended solids	ppm	220					17		21		21		24		220		20			

Table 3-13

WARWP - Historical Surface Water Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

	Location Code:		WARP-SW02		WARP-SW03		WARP-SW04		WARP-SW05		WARP-SW06				WRWP-SW007		WRWP-SW008		WRWP-SW009		WRWP-SW010	
	Sample No:		12110		12120		12130		12140		12150		AD2006		AD2007		AD2008		AD2009		AD2010	
	Sample Date:		5-Nov-98		5-Nov-98		5-Nov-98		5-Nov-98		5-Nov-98		13-Sep-00		13-Sep-00		13-Sep-00		13-Sep-00		13-Sep-00	
	Sample Purpose:		REG		REG		REG		REG		REG		REG		REG		REG		REG		REG	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																						
Amino-2-nitrotoluene, 4-	ug/L	0.6																				
Dinitrobenzene, 1,3-	ug/L	0.3	-	-	-	-	-	-	-	-	-	-										
Dinitrotoluene, 2,4-	ug/L	0.5	-	-	-	-	-	-	-	-	-	-										
Dinitrotoluene, 2,6-	ug/L	0.8	-	-	-	-	-	-	-	-	-	-										
Dinitrotoluene, 3,4-	ug/L	0.6																				
Nitrotoluene, 3-	ug/L	54	-	-	-	-	-	-	-	-	-	-										
Volatiles																						
Acetone	ug/L	3.1	2.6	B	2.4	B	3.1	B	1.6	B	2.7	B										
Bromomethane	ug/L	0.22	-	-	0.16	J	0.21	J	0.21	J	0.16	J										
Butanone, 2-	ug/L	7	-	-	-	-	-	-	-	-	-	-										
Semivolatiles																						
Bis(2-ethylhexyl)phthalate	ug/L	2.7	2.7	B	-	-	-	-	-	-	1.7	B										
Di-n-octyl phthalate	ug/L	7.8	-	-	-	-	-	-	7.8	J	-	-										
Phenol	ug/L	6.9	4	B	4.5	B	1.4	B	1.7	B	2.2	B										
Metals - Unfiltered																						
Aluminum	ug/L	13800	-	-	300	J	-	-	13800	J	12400	J	286		888		313		13500		2610	
Arsenic	ug/L	21.8	-	-	-	-	-	-	20.2		21.8		9.6		7.2		7.1		10.7		-	-
Barium	ug/L	131	-	-	-	-	-	-	-	-	-	-	18.3		22		20.4		131		57.1	
Calcium	ug/L	115000	106000		106000		105000		31100		115000		15400		18800		16000		21800		69600	
Chromium	ug/L	23.3	-	-	-	-	-	-	17.4		23.3	J	-	-	2.5	B	1.2	B	19.8		3.3	B
Cobalt	ug/L	18.7	-	-	-	-	-	-	-	-	-	-	-	-	1.6		-	-	18.7		2.1	
Copper	ug/L	20.5	-	-	-	-	-	-	-	-	-	-	3		2.9		1.4		20.5		7.2	
Iron	ug/L	26000	126		747		646		21100		19000		331		1060		284		26000		2980	
Lead	ug/L	77	-	-	-	-	-	-	25		32.9		-	-	-	-	-	-	16.8		2.8	
Magnesium	ug/L	50700	26500		26200		25800		46500		50700		29700		43600		34000		9040		15500	
Manganese	ug/L	2960	30.6		261		126		1150		1550		91.3		265		130		2960		104	
Nickel	ug/L	32.7	-	-	-	-	-	-	-	-	-	-	2.1		3.2		2.1		32.7		8.9	
Potassium	ug/L	12800	9730		9750		9910		5590		5180		878	B	1810		726	B	12800		5060	
Sodium	ug/L	107000	39300		38300		39000		104000		107000		56000		63200		58400		27100		20100	
Vanadium	ug/L	52.2	-	-	-	-	-	-	-	-	52.2		7.5	B	9.7	B	7.9	B	32.7	B	7.6	B
Zinc	ug/L	191	-	-	-	-	-	-	84.8		92.5		14		11.3		31.9		145		19.9	

Table 3-13

WARWP - Historical Surface Water Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

	Location Code:		WARP-SW02		WARP-SW03		WARP-SW04		WARP-SW05		WARP-SW06				WRWP-SW007		WRWP-SW008		WRWP-SW009		WRWP-SW010	
	Sample No:		12110		12120		12130		12140		12150		AD2006		AD2007		AD2008		AD2009		AD2010	
	Sample Date:		5-Nov-98		5-Nov-98		5-Nov-98		5-Nov-98		5-Nov-98		13-Sep-00		13-Sep-00		13-Sep-00		13-Sep-00		13-Sep-00	
	Sample Purpose:		REG		REG		REG		REG		REG		REG		REG		REG		REG		REG	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Filtered																						
Aluminum	ug/L	11400	-	-	233		-	-	6340		11400											
Arsenic	ug/L	17.2	-	-	-	-	-	-	10.9		17.2											
Calcium	ug/L	106000	106000		104000		103000		27600		71500											
Chromium	ug/L	21.2	-	-	-	-	-	-	-	-	21.2	J										
Iron	ug/L	15500	-	-	484		589		8630		15500											
Lead	ug/L	20.4	-	-	-	-	-	-	7.2		20.4	J										
Magnesium	ug/L	49100	26500		25700		25400		44300		49100											
Manganese	ug/L	1300	-	-	97.2		107		669		907											
Potassium	ug/L	9370	9340		9080		9370		-	-	5900											
Sodium	ug/L	112000	38800		37200		37900		103000		112000											
Zinc	ug/L	68	-	-	-	-	-	-	42.3		68											
Water Quality Parameters																						
Hardness	ppm	592	408		400		420		372		592											
Phosphorous	ug/L	370											260		370		260		-	-	210	
Total suspended solids	ppm	220																				

MDC - Maximum detected concentration for the AOC ("B" qualified data excluded).
"-" - Not detected.
ug/L - Micrograms per liter.
REG - Regular.

Validation Qualifiers (VQ)
B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.
J - The analyte was positively identified; the reported value is estimated.

WARWP - Historical Sediment Analytical Results
2004 Groundwater Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

Location Code:			MK-PMU1-SW-SD02		MK-PMU1-SW-SD03		PB-WA-SED1				PB-WA-SED2				PB-WA-SED3				PB-WA-SED4				PB-WA-SED5			
Sample No:			MK01SD02		MK01SD03		PB-WA-SED1-0_2-1_7		PB-WA-SED1-1_7-2_5		PB-WA-SED2-0_2-1_0		PB-WA-SED2-1-2		PB-WA-SED3-0_2-1_0		PB-WA-SED3-1_0-2_0		PB-WA-SED4-0_2-0_5		PB-WA-SED4-0_5-1_5		PB-WA-SED5-0_2-0_5		PB-WA-SED5-0_5-1_5	
Sample Date:			29-Jun-92		29-Jun-92		27-Oct-94		27-Oct-94		27-Oct-94		27-Oct-94		27-Oct-94		27-Oct-94		28-Oct-94		28-Oct-94		28-Oct-94		28-Oct-94	
Sample Depth:			0 - 1 Ft		0 - 1 Ft		.2 - 1.7 Ft		1.7 - 2.5 Ft		.2 - 1 Ft		1 - 2 Ft		.2 - 1 Ft		1 - 2 Ft		.2 - .5 Ft		.5 - 1.5 Ft		.2 - .5 Ft		.5 - 1.5 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																										
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.3					-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrobenzene, 1,3-	mg/kg	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.7		-	-	0.3		-	-	0.7	
Dinitrotoluene, 2,4-	mg/kg	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5		0.3		0.4		-	-	0.7	
Dinitrotoluene, 2,6-	mg/kg	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	mg/kg	0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.6		-	-	0.8		-	-	0.6	
Volatiles																										
Acetone	mg/kg	0.11	-	-	-	-																				
Butanone, 2-	mg/kg	0.029	-	-	-	-																				
Methylene chloride	mg/kg	0.02	-	-	-	-																				
Semivolatiles																										
Benzo(a)anthracene	mg/kg	0.051	-	-	-	-																				
Benzo(a)pyrene	mg/kg	0.053	-	-	-	-																				
Benzo(k)fluoranthene	mg/kg	0.052	-	-	-	-																				
Chrysene	mg/kg	0.06	-	-	-	-																				
Fluoranthene	mg/kg	0.11	-	-	-	-																				
Phenanthrene	mg/kg	0.055	-	-	-	-																				
Pyrene	mg/kg	0.079	-	-	-	-																				
Pesticides																										
DDD, 4,4'-	mg/kg	0.0027	0.0027	J																						
DDE, 4,4'-	mg/kg	0.0027	0.0027	J																						
DDT, 4,4'-	mg/kg	0.0048	0.0048	J																						
Dieldrin	mg/kg	0.0051	0.0051	J																						
Metals																										
Aluminum	mg/kg	17600	3570		4080																					
Antimony	mg/kg	0.83	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	mg/kg	11.3	-	-	-	-	-	-	-	-	-	-	11.3		-	-	5.2		-	-	4		4.2		7.2	
Barium	mg/kg	154	28.5		34																					
Cadmium	mg/kg	0.16	0.13		0.16		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	mg/kg	74700	48000		7230																					
Chromium	mg/kg	28.7	-	-	-	-	11		17		22		17		16		22		9.9		13		11.5		17	
Cobalt	mg/kg	15.2	10		6.8																					
Copper	mg/kg	24.5	15.1		8.8		-	-	-	-	-	-	3.2		-	-	-	-	3.9		3.9		-	-	-	-
Iron	mg/kg	29300	16800		10300																					
Lead	mg/kg	68.5	8.2		6.2		19		15		17		12		16		12		19		10.7		21		13	
Magnesium	mg/kg	6770	3960		2070																					
Manganese	mg/kg	726	489		350		180		220		190		159		180		220		149		262		169		329	
Mercury	mg/kg	0.02	0.02		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	mg/kg	36.5	-	-	-	-	12		23		19		20		16		23		8.8		18		10.7		20	
Potassium	mg/kg	3230	952		782		1500																			
Sodium	mg/kg	1890	179		268																					
Vanadium	mg/kg	36.5	9.8		9.8																					
Zinc	mg/kg	117	-	-	-	-	46		74		94		70		57		73		36		50		44		62	
General Chemistry																										
Alkalinity	mg/kg	680					680																			
Cation exchange capacity	mg/kg	5.4					5.4																			
Kjeldahl Nitrogen	mg/kg	3240					3240																			
Nitrate	mg/kg	3.4					3.4																			
pH	pH_units	7.73					7.73																			
Phosphorous	mg/kg	236					3.1																			
Total organic carbon	mg/kg	93400					46																			

WARWP - Historical Sediment Analytical Results
2004 Groundwater Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

	Location Code:		PB-WA-SED6				PB-WA-SED7				WARP-SD01		WARP-SD02		WARP-SD03		WARP-SD04		WARP-SD05		WARP-SD06	
	Sample No:		PB-WA-SED6-0_2-1_3		PB-WA-SED6-1_3-1_7		PB-WA-SED7-0_2-1_0		PB-WA-SED8-0_2-1_7		11100		11110		11120		11130		11140		11150	
	Sample Date:		28-Oct-94		28-Oct-94		27-Oct-94		27-Oct-94		5-Nov-98		5-Nov-98		5-Nov-98		5-Nov-98		5-Nov-98		5-Nov-98	
	Sample Depth:		.2 - 1.3 Ft		1.3 - 1.7 Ft		.2 - 1 Ft		.2 - 1.7 Ft		0 - .5 Ft		0 - .5 Ft		0 - .5 Ft		0 - .5 Ft		0 - .5 Ft		0 - .5 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																						
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.3	-	-	0.3		-	-			-	-	-	-	-	-	-	-	-	-	-	-
Dinitrobenzene, 1,3-	mg/kg	0.7	-	-	0.7		-	-			-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	0.7	0.4		0.7		-	-			-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	0.4	0.4		-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	mg/kg	0.8	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-
Volatiles																						
Acetone	mg/kg	0.11									0.017	B	-	-	0.019	B	0.0078	B	0.11	J	0.071	J
Butanone, 2-	mg/kg	0.029									-	-	-	-	0.029	J	-	-	0.021	J	-	-
Methylene chloride	mg/kg	0.02									0.0056	B	0.0057	B	0.0066	B	0.0059	B	0.011	B	0.02	B
Semivolatiles																						
Benzo(a)anthracene	mg/kg	0.051									0.051	J	-	-	-	-	-	-	-	-	-	-
Benzo(a)pyrene	mg/kg	0.053									0.053	J	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	mg/kg	0.052									0.052	J	-	-	-	-	-	-	-	-	-	-
Chrysene	mg/kg	0.06									0.06	J	-	-	-	-	-	-	-	-	-	-
Fluoranthene	mg/kg	0.11									0.11	J	-	-	-	-	0.047	J	-	-	-	-
Phenanthrene	mg/kg	0.055									0.055	J	-	-	-	-	-	-	-	-	-	-
Pyrene	mg/kg	0.079									0.079	J	-	-	-	-	-	-	-	-	-	-
Pesticides																						
DDD, 4,4'-	mg/kg	0.0027																				
DDE, 4,4'-	mg/kg	0.0027																				
DDT, 4,4'-	mg/kg	0.0048																				
Dieldrin	mg/kg	0.0051																				
Metals																						
Aluminum	mg/kg	17600									3170		2450		4260		3230		6880		9600	
Antimony	mg/kg	0.83	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	mg/kg	11.3	-	-	-	-	-	-			5.4		3.5		7.3		8.6		4.6		8.7	
Barium	mg/kg	154									26.6		-	-	36		34.8		65		-	-
Cadmium	mg/kg	0.16	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-
Calcium	mg/kg	74700									10800		13900		12300		16000		6710		74700	
Chromium	mg/kg	28.7	14		19		10				6.7		5.3		8.1		7.4		12.6		28.7	
Cobalt	mg/kg	15.2									10.9		6.4		10.6		10.8		-	-	-	-
Copper	mg/kg	24.5	-	-	-	-	-	-			13.7		8.8		15		9.8		15.2		24.5	
Iron	mg/kg	29300									14900		9900		16500		24300		16000		18000	
Lead	mg/kg	68.5	16		13		16				9.7		6.5		9.4		8.1		22.6		32.1	
Magnesium	mg/kg	6770									2110		2720		2520		2950		3130		6770	
Manganese	mg/kg	726	164		250		160				305		231		290		255		338		726	
Mercury	mg/kg	0.02	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-
Nickel	mg/kg	36.5	14		21		13				23		13.7		24.4		18.3		15.2		24.5	
Potassium	mg/kg	3230									-	-	-	-	821		-	-	-	-	-	-
Sodium	mg/kg	1890									-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	mg/kg	36.5									-	-	-	-	-	-	-	-	-	-	25	
Zinc	mg/kg	117	59		73		63				48		35.1		58.4		45.3		54.4		77	
General Chemistry																						
Alkalinity	mg/kg	680																				
Cation exchange capacity	mg/kg	5.4																				
Kjeldahl Nitrogen	mg/kg	3240																				
Nitrate	mg/kg	3.4																				
pH	pH_units	7.73																				
Phosphorous	mg/kg	236																				
Total organic carbon	mg/kg	93400							44		5430		3960		9650		5520		40200		93400	

WARWP - Historical Sediment Analytical Results
2004 Groundwater Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

			Location Code:	WRWP-SD001		WRWP-SD002		WRWP-SD003		WRWP-SD004		WRWP-SD005		WRWP-SD006		WRWP-SD007		WRWP-SD008		WRWP-SD009		WRWP-SD010	
			Sample No:	AD1001		AD1002		AD1003		AD1004		AD1005		AD1006		AD1007		AD1008		AD1009		AD1010	
			Sample Date:	14-Sep-00		14-Sep-00		14-Sep-00		14-Sep-00		14-Sep-00		13-Sep-00		14-Sep-00		14-Sep-00		13-Sep-00		13-Sep-00	
			Sample Depth:	0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft	
Parameter	Units	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																							
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.3		-	-	-	-	-	-	-	-	-	-										
Dinitrobenzene, 1,3-	mg/kg	0.7		-	-	-	-	-	-	-	-	-	-										
Dinitrotoluene, 2,4-	mg/kg	0.7		-	-	-	-	-	-	-	-	-	-										
Dinitrotoluene, 2,6-	mg/kg	0.4		-	-	-	-	-	-	-	-	-	-										
Trinitrobenzene, 1,3,5-	mg/kg	0.8		-	-	-	-	-	-	-	-	-	-										
Volatiles																							
Acetone	mg/kg	0.11																					
Butanone, 2-	mg/kg	0.029																					
Methylene chloride	mg/kg	0.02																					
Semivolatiles																							
Benzo(a)anthracene	mg/kg	0.051																					
Benzo(a)pyrene	mg/kg	0.053																					
Benzo(k)fluoranthene	mg/kg	0.052																					
Chrysene	mg/kg	0.06																					
Fluoranthene	mg/kg	0.11																					
Phenanthrene	mg/kg	0.055																					
Pyrene	mg/kg	0.079																					
Pesticides																							
DDD, 4,4'-	mg/kg	0.0027																					
DDE, 4,4'-	mg/kg	0.0027																					
DDT, 4,4'-	mg/kg	0.0048																					
Dieldrin	mg/kg	0.0051																					
Metals																							
Aluminum	mg/kg	17600		9150		8690		17600		10600		12300		6930		9270		16400		2170		3630	
Antimony	mg/kg	0.83		-	-	-	-	-	-	-	-	-	-	0.83	J	-	-	-	-	-	-	-	-
Arsenic	mg/kg	11.3		5.1		3.6		7.7		4.3		4.9		4.9		3.5		5.5		2.9		3.1	
Barium	mg/kg	154		83.9		46		126		94.4		102		62.5		92.2		154		19.2		26.9	
Cadmium	mg/kg	0.16																					
Calcium	mg/kg	74700		3220		2710		2890		2880		3570		11000		3400		6470		8810		7990	
Chromium	mg/kg	28.7		12.9		11.7		22.3		13.9		16.5		12		12.7		22		3.7	B	5.8	
Cobalt	mg/kg	15.2		8.9		6.4		11.3		13.1		15.2		10.5		7.7		15		4.9		6.4	
Copper	mg/kg	24.5		12.5		9.2		18.3		15.5		17.6		13.2		19.7		23.4		5.6		9.8	
Iron	mg/kg	29300		18000		14100		29300		17600		20900		13800		16300		24200		7490		8790	
Lead	mg/kg	68.5		25	J	14.1	J	23.4	J	14.7	J	19.8	J	27.3	J	18	J	68.5	J	5	J	7.5	J
Magnesium	mg/kg	6770		2630		2390		3880		2900		3460		2780		2780		5170		1750		1900	
Manganese	mg/kg	726		301		142		371		321		347		283		230		637		178		183	
Mercury	mg/kg	0.02																					
Nickel	mg/kg	36.5		16.7	J	12.3	J	29	J	23.6	J	23.6	J	14.3	J	20.8	J	36.5	J	10.6	J	14.8	J
Potassium	mg/kg	3230		1070	B	937	B	2420	J	1490	B	1880	J	838	B	1040	B	3230	J	596	B	804	B
Sodium	mg/kg	1890		549		268		488		420		426		553		860		1890		63.5		93.7	
Vanadium	mg/kg	36.5		20.2	B	18	B	36.5	B	20.5	B	24.8	B	15.7	B	18.7	B	30.1	B	6.4	B	9.4	B
Zinc	mg/kg	117		56.8		47.2		94.8		77.6		77.2		45.7		60.2		117		24.7		36.7	
General Chemistry																							
Alkalinity	mg/kg	680																					
Cation exchange capacity	mg/kg	5.4																					
Kjeldahl Nitrogen	mg/kg	3240																					
Nitrate	mg/kg	3.4																					
pH	pH_units	7.73																					
Phosphorous	mg/kg	236		17.5		-	-	29.9		-	-	35.2		-	-	236		221		208		-	-
Total organic carbon	mg/kg	93400		17300		17300		17100		36600		38000											

MDC - Maximum detected concentration for the AOC ("B" qualified data not included).
mg/kg - Milligrams per kilogram.
"-" - Not detected.
Ft - Feet.

Validation Qualifiers (VQ)
B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.
J - The analyte was positively identified; the reported value is estimated.

WARWP - Historical Soil Analytical Results
2004 Groundwater Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

			Location Code:	MK-MW09		MK-MW10		MK-MW11		MK-MW12		PB-BG-S1				PB-BG-S2				PB-BG-S3				PB-BG-S4		PB-BG-S5			
			Sample No:	MK01SB01		MK01SB02		MK01SB03		MK01SB04		PB-BG-S1-0_5-3_0		PB-BG-S1-3_0-5_0		PB-BG-S2-0_5-3_0		PB-BG-S2-3_0-5_0		PB-BG-S3-0_5-3_0		PB-BG-S3-3_0-4_0		PB-BG-S4-0_5-3_0		PB-BG-S5-0_5-3_0		PB-BG-S5-3_0-5_0	
			Sample Date:	29-Jun-93		29-Jun-93		29-Jun-93		29-Jun-93		30-Oct-94		30-Oct-94		30-Oct-94		30-Oct-94		1-Nov-94		1-Nov-94		30-Oct-94		30-Oct-94		30-Oct-94	
			Sample Depth:	0 - 2 Ft		0 - 2 Ft		0 - 2 Ft		0 - 2 Ft		.5 - 3 Ft		3 - 5 Ft		.5 - 3 Ft		3 - 5 Ft		.5 - 3 Ft		3 - 4 Ft		.5 - 3 Ft		.5 - 3 Ft		3 - 5 Ft	
Parameter	Units	MDC		VQ		VQ		VQ		VQ		VQ		VQ		VQ		VQ		VQ		VQ		VQ		VQ		VQ
Explosives																													
Amino-2,6-dinitrotoluene, 4-	mg/kg	9.5										-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-2-nitrotoluene, 4-	mg/kg	0.9										-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.5										-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrobenzene, 1,3-	mg/kg	6.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	3.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 3,4-	mg/kg	4.5										-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrobenzene	mg/kg	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	mg/kg	58	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	mg/kg	12000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Volatiles																													
Acetone	mg/kg	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dichloroethene, cis-1,2-	mg/kg	0.0013										-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ethylbenzene	mg/kg	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methylene chloride	mg/kg	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Toluene	mg/kg	0.005	-	-	-	-	0.005	J	0.002	J	-	-	0.0022		-	-	0.0013		0.0017		0.0019		0.0035		-	-	-	-	-	-
Trichloroethene	mg/kg	0.0046	-	-	-	-	-	-	-	-	0.0014		-	-	-	-	0.0045		-	-	-	-	-	-	0.0012		-	-	-
Xylenes, total	mg/kg	0.0035	-	-	-	-	-	-	-	-	-	-	-	-	0.0012		-	-	-	-	-	-	0.0035		-	-	-	-	-
Semivolatiles																													
Acenaphthylene	mg/kg	0.041	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Anthracene	mg/kg	0.23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(a)anthracene	mg/kg	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(a)pyrene	mg/kg	0.39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	mg/kg	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(ghi)perylene	mg/kg	0.22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	mg/kg	0.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bis(2-ethylhexyl)phthalate	mg/kg	1.07	-	-	-	-	-	-	-	-	-	-	0.41		-	-	-	-	-	-	-	-	1.07		0.98		-	-	-
Chrysene	mg/kg	0.42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	mg/kg	0.022	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Di-n-butyl phthalate	mg/kg	0.13	-	-	-	-	0.13	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	0.043	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fluoranthene	mg/kg	0.089	-	-	-	-	0.089	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fluorene	mg/kg	0.0074	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-cd)pyrene	mg/kg	0.23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phenanthrene	mg/kg	0.36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyrene	mg/kg	0.55	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Metals																													
Aluminum	mg/kg	21000	10500		8130		10100		4770																				
Antimony	mg/kg	7.7	-	-	-	-	-	-	-	-	-	-	-	-	6.3		-	-	-	-	-	-	7.6		6.7		5.9		
Arsenic	mg/kg	23.6	-	-	-	-	-	-	-	-	6.8		10		8.4		12		3.5		15		17		17		6.1		
Barium	mg/kg	165	85		53.5		61.6		23.4																				
Beryllium	mg/kg	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	mg/kg	1.6	0.17	BN	0.11	BN	0.22	BN	0.14	BN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	mg/kg	83900	3390		1830		3210		4710																				
Chromium	mg/kg	35	-	-	-	-	-	-	-	-	11		14		17		17		6.2		13		13		17		29		
Cobalt	mg/kg	21	6.6		6.2		11.5		5.1	B																			
Copper	mg/kg	35	14.9		15.3		23.6		6		3.6		5.2		2.3		4		-	-	35		34		10		6.7		
Iron	mg/kg	36000	20000		18300		27200		9970																				
Lead	mg/kg	27	7.9	N*	8	N*	11.6	N*	4.6	N*	8.5		9.5		11		9.9		5.3		24		27		11		13		
Magnesium	mg/kg	23400	2630		1980		3450		1540																				
Manganese	mg/kg	3300	259	N*	337	N*	515	N*	322	N*	270		400		340		314		152		154		24		220		330		
Mercury	mg/kg	0.12	0.04		0.12		0.03		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	mg/kg	52	-	-	-	-	-	-	-	-	13		16		16		17		9		33		11		28		33		
Potassium	mg/kg	5630	749		718		1110		543	B																			
Selenium	mg/kg	0.65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/kg	1270	144	B	140	B	142	B	137	B																			
Thallium	mg/kg	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	mg/kg	40.5	29.2		25.3		27	B	13.5																				
Zinc	mg/kg	187	-	-	-	-	-	-	-	-	41		39		51		45		43		187		13		54		64		
General Chemistry																													
Alkalinity	mg/kg	830																											
Cation exchange capacity	mg/kg	5.2																											
Kjeldahl Nitrogen	mg/kg	2130																											
Nitrate-Nitrite	mg/kg	150																											
pH	pH_units	8																											
Phosphorous	mg/kg	31																											
Sulfate	mg/kg	3330																											
Total organic carbon	mg/kg	1990																											

WARWP - Historical Soil Analytical Results
2004 Groundwater Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

Location Code:			PB-BG-S6				PB-BG-S7		PB-BG-S8		PB-BG-S9				PB-PR-S1				PB-PR-S10						PB-PR-S11					
Sample No:			PB-BG-S6-0_5-3_0		PB-BG-S6-3_0-4_5		PB-BG-S7-0_5-3_0		PB-BG-S8-0_5-3_0		PB-BG-S9-0_5-3_0		PB-BG-S9-3_0-5_0		PB-PR-S1-0_0-2_0		PB-PR-S1-2_0-5_0		PB-PR-S10-0_0-3_0		PB-PR-S10-3_0-5_0		PB-PR-S10-5_0-10_0		PB-PR-S11-0_0-3_0		PB-PR-S11-3_0-5_0		PB-PR-S11-5_0-10_0	
Sample Date:			1-Nov-94		1-Nov-94		1-Nov-94		30-Oct-94		1-Nov-94		1-Nov-94		31-Oct-94		31-Oct-94		29-Oct-94		29-Oct-94		29-Oct-94		29-Oct-94		29-Oct-94		29-Oct-94	
Sample Depth:			.5 - 3 Ft		3 - 4.5 Ft		.5 - 3 Ft		.5 - 3 Ft		.5 - 3 Ft		3 - 5 Ft		0 - 2 Ft		2 - 5 Ft		0 - 3 Ft		3 - 5 Ft		5 - 10 Ft		0 - 3 Ft		3 - 5 Ft		5 - 10 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																														
Amino-2,6-dinitrotoluene, 4-	mg/kg	9.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-2-nitrotoluene, 4-	mg/kg	0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrobenzene, 1,3-	mg/kg	6.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.6		2.5		-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.4		-	-	2.6		2.2		-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	3.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 3,4-	mg/kg	4.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrobenzene	mg/kg	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	mg/kg	58	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.8		5.2		-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	mg/kg	12000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3		-	-	-	-	-	-	-	-	-	-	-	-
Volatiles																														
Acetone	mg/kg	0	-	-	-	-	-	-	-	-	-	-	-	-																
Dichloroethene, cis-1,2-	mg/kg	0.0013	-	-	-	-	-	-	0.0013		-	-	-	-																
Ethylbenzene	mg/kg	0	-	-	-	-	-	-	-	-	-	-	-	-																
Methylene chloride	mg/kg	0	-	-	-	-	-	-	-	-	-	-	-	-																
Toluene	mg/kg	0.005	-	-	-	-	-	-	-	-	-	-	-	-																
Trichloroethene	mg/kg	0.0046	-	-	-	-	-	-	0.0046		-	-	0.0022																	
Xylenes, total	mg/kg	0.0035	-	-	-	-	-	-	-	-	-	-	-	-																
Semivolatiles																														
Acenaphthylene	mg/kg	0.041	-	-	-	-	-	-	-	-	-	-	-	-																
Anthracene	mg/kg	0.23	-	-	-	-	-	-	-	-	-	-	-	-																
Benzo(a)anthracene	mg/kg	0.4	-	-	-	-	-	-	-	-	-	-	-	-																
Benzo(a)pyrene	mg/kg	0.39	-	-	-	-	-	-	-	-	-	-	-	-																
Benzo(b)fluoranthene	mg/kg	0.3	-	-	-	-	-	-	-	-	-	-	-	-																
Benzo(ghi)perylene	mg/kg	0.22	-	-	-	-	-	-	-	-	-	-	-	-																
Benzo(k)fluoranthene	mg/kg	0.35	-	-	-	-	-	-	-	-	-	-	-	-																
Bis(2-ethylhexyl)phthalate	mg/kg	1.07	-	-	-	-	-	-	-	-	-	-	-	-																
Chrysene	mg/kg	0.42	-	-	-	-	-	-	-	-	-	-	-	-																
Dibenz(a,h)anthracene	mg/kg	0.022	-	-	-	-	-	-	-	-	-	-	-	-																
Di-n-butyl phthalate	mg/kg	0.13	-	-	-	-	-	-	-	-	-	-	-	-																
Dinitrotoluene, 2,4-	mg/kg	0.043	-	-	-	-	-	-	-	-	-	-	-	-																
Fluoranthene	mg/kg	0.089	-	-	-	-	-	-	-	-	-	-	-	-																
Fluorene	mg/kg	0.0074	-	-	-	-	-	-	-	-	-	-	-	-																
Indeno(1,2,3-cd)pyrene	mg/kg	0.23	-	-	-	-	-	-	-	-	-	-	-	-																
Phenanthrene	mg/kg	0.36	-	-	-	-	-	-	-	-	-	-	-	-																
Pyrene	mg/kg	0.55	-	-	-	-	-	-	-	-	-	-	-	-																
Metals																														
Aluminum	mg/kg	21000																												
Antimony	mg/kg	7.7	6.4		-	-	7.5		6.4		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.3		-	-
Arsenic	mg/kg	23.6	23		8.3		14		19		-	-	-	-	-	-	4.1		22		9.6		12		-	-	8		-	-
Barium	mg/kg	165																												
Beryllium	mg/kg	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	mg/kg	1.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	mg/kg	83900																												
Chromium	mg/kg	35	6		9.1		14		10		9.2		15		8.7		11		15		17		18		11		15		15	
Cobalt	mg/kg	21																												
Copper	mg/kg	35	14		7.5		34		27		-	-	17		-	-	3.3		-	-	14		9.4		-	-	13		16	
Iron	mg/kg	36000																												
Lead	mg/kg	27	15		11		22		23		6.6		15		5.9		8.4		12		18		11		5.9		8.9		11	
Magnesium	mg/kg	23400																												
Manganese	mg/kg	3300	78		21		63		8.7		133		695		150		260		820		1040		490		150		800		720	
Mercury	mg/kg	0.12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	mg/kg	52	15		20		24		9.4		7.6		30		6.7		10		15		35		25		6.4		24		30	
Potassium	mg/kg	5630																												
Selenium	mg/kg	0.65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/kg	1270																												
Thallium	mg/kg	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	mg/kg	40.5																												
Zinc	mg/kg	187	56		34		32		10		24		61		23		31		38		65		56		24		52		58	
General Chemistry																														
Alkalinity	mg/kg	830																												
Cation exchange capacity	mg/kg	5.2																												
Kjeldahl Nitrogen	mg/kg	2130																												
Nitrate-Nitrite	mg/kg	150																												
pH	pH_units	8																												
Phosphorous	mg/kg	31																												
Sulfate	mg/kg	3330																												
Total organic carbon	mg/kg	1990																												

			PB-PR-S12						PB-PR-S13										PB-PR-S14							
Location Code:																										
Sample No:			PB-PR-S12-0_0-3_0		PB-PR-S12-3_0-5_0		PB-PR-S12-5_0-10_0		PB-PR-S13-0_0-0_5		PB-PR-S13-0_0-3_0		PB-PR-S13-3_0-10_0		PB-PR-S13-3_0-5_0		PB-PR-S13-5_0-10_0		PB-PR-S14-0_0-0_5		PB-PR-S14-0_0-3_0		PB-PR-S14-3_0-5_0		PB-PR-S14-5_0-10_0	
Sample Date:			30-Oct-94		30-Oct-94		30-Oct-94		11-Dec-94		31-Oct-94		31-Oct-94		31-Oct-94		31-Oct-94		11-Dec-94		7-Nov-94		7-Nov-94		7-Nov-94	
Sample Depth:			0 - 3 Ft		3 - 5 Ft		5 - 10 Ft		0 - .5 Ft		0 - 3 Ft		3 - 10 Ft		3 - 5 Ft		5 - 10 Ft		0 - .5 Ft		0 - 3 Ft		3 - 5 Ft		5 - 10 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																										
Amino-2,6-dinitrotoluene, 4-	mg/kg	9.5	-	-	-	-	-	-	-	-	-	-			-	-	0.7		-	-	-	-	9.5		2	
Amino-2-nitrotoluene, 4-	mg/kg	0.9	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.5	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-
Dinitrobenzene, 1,3-	mg/kg	6.7	-	-	1.1		1.5		-	-	-	-			-	-	3.2		-	-	-	-	6.4		6.7	
Dinitrotoluene, 2,4-	mg/kg	19	-	-	1.2		1.6		-	-	-	-			0.4		5.2		-	-	-	-	-	-	19	
Dinitrotoluene, 2,6-	mg/kg	3.6	-	-	0.3		0.3		-	-	-	-			-	-	0.5		-	-	-	-	-	-	2.9	
Dinitrotoluene, 3,4-	mg/kg	4.5	-	-	-	-	-	-	-	-	-	-			-	-	0.5		-	-	-	-	4.5		1.7	
Nitrobenzene	mg/kg	1.1	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	0.9	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	0.9	
Trinitrobenzene, 1,3,5-	mg/kg	58	-	-	2.7		2.8		-	-	-	-			-	-	9.4		-	-	-	-	58		18	
Trinitrotoluene, 2,4,6-	mg/kg	12000	-	-	-	-	-	-	-	-	-	-			-	-	0.5		-	-	-	-	12000		340	
Volatiles																										
Acetone	mg/kg	0																								
Dichloroethene, cis-1,2-	mg/kg	0.0013																								
Ethylbenzene	mg/kg	0																								
Methylene chloride	mg/kg	0																								
Toluene	mg/kg	0.005																								
Trichloroethene	mg/kg	0.0046																								
Xylenes, total	mg/kg	0.0035																								
Semivolatiles																										
Acenaphthylene	mg/kg	0.041																								
Anthracene	mg/kg	0.23																								
Benzo(a)anthracene	mg/kg	0.4																								
Benzo(a)pyrene	mg/kg	0.39																								
Benzo(b)fluoranthene	mg/kg	0.3																								
Benzo(ghi)perylene	mg/kg	0.22																								
Benzo(k)fluoranthene	mg/kg	0.35																								
Bis(2-ethylhexyl)phthalate	mg/kg	1.07																								
Chrysene	mg/kg	0.42																								
Dibenz(a,h)anthracene	mg/kg	0.022																								
Di-n-butyl phthalate	mg/kg	0.13																								
Dinitrotoluene, 2,4-	mg/kg	0.043																								
Fluoranthene	mg/kg	0.089																								
Fluorene	mg/kg	0.0074																								
Indeno(1,2,3-cd)pyrene	mg/kg	0.23																								
Phenanthrene	mg/kg	0.36																								
Pyrene	mg/kg	0.55																								
Metals																										
Aluminum	mg/kg	21000																								
Antimony	mg/kg	7.7	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	mg/kg	23.6	6.7		11		9.3		10		4.4				3.6		15		-	-	3.4		6.6		4.3	
Barium	mg/kg	165																								
Beryllium	mg/kg	1.2	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	mg/kg	1.6	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-
Calcium	mg/kg	83900																								
Chromium	mg/kg	35	8.7		16		14		21		13				17		17		9.3		8.2		11		15	
Cobalt	mg/kg	21																								
Copper	mg/kg	35	12		12		14		5.9		3.8				11		12		-	-	-	-	-	-	7	
Iron	mg/kg	36000																								
Lead	mg/kg	27	18		8.9		9.2		19		9.8				13		15		6.9		7.1		16		11	
Magnesium	mg/kg	23400																								
Manganese	mg/kg	3300	810		520		410		390		330				530		580		190		170		225		260	
Mercury	mg/kg	0.12	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-
Nickel	mg/kg	52	8.3		23		20		20		9.7				20		22		6.7		6.6		9.4		21	
Potassium	mg/kg	5630											1500													
Selenium	mg/kg	0.65	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/kg	1270																								
Thallium	mg/kg	1.1	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	mg/kg	40.5																								
Zinc	mg/kg	187	28		49		47		64		33				53		58		24		33		47		85	
General Chemistry																										
Alkalinity	mg/kg	830											830													
Cation exchange capacity	mg/kg	5.2											5.2													
Kjeldahl Nitrogen	mg/kg	2130											2130													
Nitrate-Nitrite	mg/kg	150											150													
pH	pH_units	8											8													
Phosphorous	mg/kg	31											31													
Sulfate	mg/kg	3330											3330													
Total organic carbon	mg/kg	1990											1990													

			PB-PR-S15						PB-PR-S16						PB-PR-S17						PB-PR-S18			
Location Code:			PB-PR-S15						PB-PR-S16						PB-PR-S17						PB-PR-S18			
Sample No:			PB-PR-S15-0_0-3_0		PB-PR-S15-3_0-5_0		PB-PR-S15-5_0-10_0		PB-PR-S16-0_0-3_0		PB-PR-S16-3_0-5_0		PB-PR-S16-5_0-10_0		PB-PR-S17-0_0-0_5		PB-PR-S17-0_0-2_0		PB-PR-S17-2_0-5_0		PB-PR-S18-0_0-2_0		PB-PR-S18-2_0-5_0	
Sample Date:			30-Oct-94		30-Oct-94		30-Oct-94		30-Oct-94		30-Oct-94		30-Oct-94		15-Dec-94		31-Oct-94		31-Oct-94		30-Oct-94		30-Oct-94	
Sample Depth:			0 - 3 Ft		3 - 5 Ft		5 - 10 Ft		0 - 3 Ft		3 - 5 Ft		5 - 10 Ft		0 - .5 Ft		0 - 2 Ft		2 - 5 Ft		0 - 2 Ft		2 - 5 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																								
Amino-2,6-dinitrotoluene, 4-	mg/kg	9.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-2-nitrotoluene, 4-	mg/kg	0.9	-	-	-	-	0.9		-	-	-	-	0.6		-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrobenzene, 1,3-	mg/kg	6.7	-	-	-	-	6.6		-	-	-	-	4.3		-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	19	0.6		0.3		14		-	-	-	-	8.9		-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	3.6	-	-	-	-	2		-	-	-	-	1		-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 3,4-	mg/kg	4.5	-	-	-	-	1.1		-	-	-	-	0.8		-	-	-	-	-	-	-	-	-	-
Nitrobenzene	mg/kg	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	mg/kg	58	-	-	-	-	23		-	-	-	-	14		-	-	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	mg/kg	12000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Volatiles																								
Acetone	mg/kg	0																						
Dichloroethene, cis-1,2-	mg/kg	0.0013																						
Ethylbenzene	mg/kg	0																						
Methylene chloride	mg/kg	0																						
Toluene	mg/kg	0.005																						
Trichloroethene	mg/kg	0.0046																						
Xylenes, total	mg/kg	0.0035																						
Semivolatiles																								
Acenaphthylene	mg/kg	0.041																						
Anthracene	mg/kg	0.23																						
Benzo(a)anthracene	mg/kg	0.4																						
Benzo(a)pyrene	mg/kg	0.39																						
Benzo(b)fluoranthene	mg/kg	0.3																						
Benzo(ghi)perylene	mg/kg	0.22																						
Benzo(k)fluoranthene	mg/kg	0.35																						
Bis(2-ethylhexyl)phthalate	mg/kg	1.07																						
Chrysene	mg/kg	0.42																						
Dibenz(a,h)anthracene	mg/kg	0.022																						
Di-n-butyl phthalate	mg/kg	0.13																						
Dinitrotoluene, 2,4-	mg/kg	0.043																						
Fluoranthene	mg/kg	0.089																						
Fluorene	mg/kg	0.0074																						
Indeno(1,2,3-cd)pyrene	mg/kg	0.23																						
Phenanthrene	mg/kg	0.36																						
Pyrene	mg/kg	0.55																						
Metals																								
Aluminum	mg/kg	21000																						
Antimony	mg/kg	7.7	-	-	-	-	-	-	-	-	5.6		-	-	-	-	-	-	6.1		-	-	-	-
Arsenic	mg/kg	23.6	4.6		6.3		11		-	-	19		9.5		5.8		3.3		7.1		3.6		6.4	
Barium	mg/kg	165																						
Beryllium	mg/kg	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	mg/kg	1.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	mg/kg	83900																						
Chromium	mg/kg	35	9.9		12		21		10		16		17		12		11		18		9.1		14	
Cobalt	mg/kg	21																						
Copper	mg/kg	35	4.1		3		3.2		-	-	-	-	9.8		-	-	-	-	11		2.7		8.6	
Iron	mg/kg	36000																						
Lead	mg/kg	27	7.8		6.9		11		4.6		8		13		9		7		11		9		12	
Magnesium	mg/kg	23400																						
Manganese	mg/kg	3300	320		340		780		250		210		480		185		165		1500		160		390	
Mercury	mg/kg	0.12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	mg/kg	52	9.3		11		20		7.2		9.6		23		9.1		7.8		28		8.6		17	
Potassium	mg/kg	5630																						
Selenium	mg/kg	0.65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/kg	1270																						
Thallium	mg/kg	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	mg/kg	40.5																						
Zinc	mg/kg	187	29		33		59		22		28		60		28		26		51		28		43	
General Chemistry																								
Alkalinity	mg/kg	830																						
Cation exchange capacity	mg/kg	5.2																						
Kjeldahl Nitrogen	mg/kg	2130																						
Nitrate-Nitrite	mg/kg	150																						
pH	pH_units	8																						
Phosphorous	mg/kg	31																						
Sulfate	mg/kg	3330																						
Total organic carbon	mg/kg	1990																						

WARWP - Historical Soil Analytical Results
2004 Groundwater Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

	Location Code:		PB-PR-S19								PB-PR-S2						PB-PR-S20				PB-PR-S21		PB-PR-S22		PB-PR-S23		PB-PR-S24	
	Sample No:		PB-PR-S19-0_0-0_5		PB-PR-S19-0_0-3_0		PB-PR-S19-3_0-5_0		PB-PR-S19-5_0-10_0		PB-PR-S2-0_0-3_0		PB-PR-S2-3_0-5_0		PB-PR-S2-5_0-10_0		PB-PR-S20-0_0-2_0		PB-PR-S20-2_0-5_0		PB-PR-S21-0_0-0_5		PB-PR-S22-0_0-0_5		PB-PR-S23-0_0-0_5		PB-PR-S24-0_0-0_5	
	Sample Date:		11-Dec-94		30-Oct-94		30-Oct-94		30-Oct-94		28-Oct-94		28-Oct-94		28-Oct-94		30-Oct-94		30-Oct-94		30-Oct-94		30-Oct-94		30-Oct-94		30-Oct-94	
	Sample Depth:		0 - .5 Ft		0 - 3 Ft		3 - 5 Ft		5 - 10 Ft		0 - 3 Ft		3 - 5 Ft		5 - 10 Ft		0 - 2 Ft		2 - 5 Ft		0 - .5 Ft		0 - .5 Ft		0 - .5 Ft		0 - .5 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																												
Amino-2,6-dinitrotoluene, 4-	mg/kg	9.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-2-nitrotoluene, 4-	mg/kg	0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrobenzene, 1,3-	mg/kg	6.7	-	-	-	-	-	-	1.4		-	-	-	-	0.3		-	-	-	-	-	-	-	-	0.4		-	-
Dinitrotoluene, 2,4-	mg/kg	19	-	-	-	-	-	-	1		-	-	-	-	-	-	-	-	-	-	0.3		0.4		1		1.1	
Dinitrotoluene, 2,6-	mg/kg	3.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 3,4-	mg/kg	4.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3	
Nitrobenzene	mg/kg	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	mg/kg	58	-	-	-	-	-	-	1.5		-	-	0.5		2.4		-	-	-	-	-	-	0.4		-	-	-	-
Trinitrotoluene, 2,4,6-	mg/kg	12000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Volatiles																												
Acetone	mg/kg	0																										
Dichloroethene, cis-1,2-	mg/kg	0.0013																										
Ethylbenzene	mg/kg	0																										
Methylene chloride	mg/kg	0																										
Toluene	mg/kg	0.005																										
Trichloroethene	mg/kg	0.0046																										
Xylenes, total	mg/kg	0.0035																										
Semivolatiles																												
Acenaphthylene	mg/kg	0.041																										
Anthracene	mg/kg	0.23																										
Benzo(a)anthracene	mg/kg	0.4																										
Benzo(a)pyrene	mg/kg	0.39																										
Benzo(b)fluoranthene	mg/kg	0.3																										
Benzo(ghi)perylene	mg/kg	0.22																										
Benzo(k)fluoranthene	mg/kg	0.35																										
Bis(2-ethylhexyl)phthalate	mg/kg	1.07																										
Chrysene	mg/kg	0.42																										
Dibenz(a,h)anthracene	mg/kg	0.022																										
Di-n-butyl phthalate	mg/kg	0.13																										
Dinitrotoluene, 2,4-	mg/kg	0.043																										
Fluoranthene	mg/kg	0.089																										
Fluorene	mg/kg	0.0074																										
Indeno(1,2,3-cd)pyrene	mg/kg	0.23																										
Phenanthrene	mg/kg	0.36																										
Pyrene	mg/kg	0.55																										
Metals																												
Aluminum	mg/kg	21000																										
Antimony	mg/kg	7.7	-	-	-	-	6		6.8		-	-	6.8		-	-	-	-	5.7		-	-	-	-	-	-	-	-
Arsenic	mg/kg	23.6	6.1		4.6		14		7.9		-	-	6.5		6		3.8		-	-	-	-	-	-	-	-	-	-
Barium	mg/kg	165																										
Beryllium	mg/kg	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	mg/kg	1.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	mg/kg	83900																										
Chromium	mg/kg	35	10		11		13		15		11		14		19		11		16		10		7		7.1		5.6	
Cobalt	mg/kg	21																										
Copper	mg/kg	35	-	-	-	-	7.5		8.8		2.5		7.4		8.4		4.4		-	-	-	-	-	-	-	-	-	-
Iron	mg/kg	36000																										
Lead	mg/kg	27	8		7.5		11		12		6.9		8.5		9.5		12		10		9.8		7.2		8.7		14	
Magnesium	mg/kg	23400																										
Manganese	mg/kg	3300	300		370		380		570		110		280		400		340		140		460		130		180		180	
Mercury	mg/kg	0.12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	mg/kg	52	7.1		9.9		18		24		6.7		13		19		13		14		8.8		8.4		6		4.7	
Potassium	mg/kg	5630																										
Selenium	mg/kg	0.65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/kg	1270																										
Thallium	mg/kg	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	mg/kg	40.5																										
Zinc	mg/kg	187	24		37		43		48		22		36		49		35		38		20		19		26		17	
General Chemistry																												
Alkalinity	mg/kg	830																										
Cation exchange capacity	mg/kg	5.2																										
Kjeldahl Nitrogen	mg/kg	2130																										
Nitrate-Nitrite	mg/kg	150																										
pH	pH_units	8																										
Phosphorous	mg/kg	31																										
Sulfate	mg/kg	3330																										
Total organic carbon	mg/kg	1990																										

			Location Code:	PB-PR-S25		PB-PR-S26		PB-PR-S27		PB-PR-S28		PB-PR-S29		PB-PR-S3				PB-PR-S30		PB-PR-S4					
			Sample No:	PB-PR-S25-5_0-10_0		PB-PR-S26-5_0-10_0		PB-PR-S27-5_0-10_0		PB-PR-S28-5_0-10_0		PB-PR-S29-2_0-5_0		PB-PR-S3-0_0-2_0		PB-PR-S3-2_0-5_0		PB-PR-S30-0_0-0_5		PB-PR-S4-0_0-3_0		PB-PR-S4-3_0-5_0		PB-PR-S4-5_0-10_0	
			Sample Date:	29-Oct-94		29-Oct-94		30-Oct-94		7-Nov-94		31-Oct-94		30-Oct-94		30-Oct-94		30-Oct-94		30-Oct-94		30-Oct-94		30-Oct-94	
			Sample Depth:	5 - 10 Ft		5 - 10 Ft		5 - 10 Ft		5 - 10 Ft		2 - 5 Ft		0 - 2 Ft		2 - 5 Ft		0 - .5 Ft		0 - 3 Ft		3 - 5 Ft		5 - 10 Ft	
Parameter	Units	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																									
Amino-2,6-dinitrotoluene, 4-	mg/kg	9.5		-	-	-	-	-	-	0.8		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-2-nitrotoluene, 4-	mg/kg	0.9		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.5		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrobenzene, 1,3-	mg/kg	6.7		-	-	2.1		0.9		3.9		-	-	-	-	-	-	0.4		0.8		3.2		2.1	
Dinitrotoluene, 2,4-	mg/kg	19		-	-	1.1		0.8		10		-	-	-	-	-	-	0.9		1.1		5.7		2.8	
Dinitrotoluene, 2,6-	mg/kg	3.6		-	-	-	-	-	-	1.8		-	-	-	-	-	-	-	-	-	-	0.5		-	-
Dinitrotoluene, 3,4-	mg/kg	4.5		-	-	-	-	-	-	1.1		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrobenzene	mg/kg	1.1		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	0.9		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	mg/kg	58		-	-	3.9		2.8		8.5		-	-	-	-	-	-	-	-	1.7		12		6.8	
Trinitrotoluene, 2,4,6-	mg/kg	12000		-	-	-	-	-	-	280		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Volatiles																									
Acetone	mg/kg	0																							
Dichloroethene, cis-1,2-	mg/kg	0.0013																							
Ethylbenzene	mg/kg	0																							
Methylene chloride	mg/kg	0																							
Toluene	mg/kg	0.005																							
Trichloroethene	mg/kg	0.0046																							
Xylenes, total	mg/kg	0.0035																							
Semivolatiles																									
Acenaphthylene	mg/kg	0.041																							
Anthracene	mg/kg	0.23																							
Benzo(a)anthracene	mg/kg	0.4																							
Benzo(a)pyrene	mg/kg	0.39																							
Benzo(b)fluoranthene	mg/kg	0.3																							
Benzo(ghi)perylene	mg/kg	0.22																							
Benzo(k)fluoranthene	mg/kg	0.35																							
Bis(2-ethylhexyl)phthalate	mg/kg	1.07																							
Chrysene	mg/kg	0.42																							
Dibenz(a,h)anthracene	mg/kg	0.022																							
Di-n-butyl phthalate	mg/kg	0.13																							
Dinitrotoluene, 2,4-	mg/kg	0.043																							
Fluoranthene	mg/kg	0.089																							
Fluorene	mg/kg	0.0074																							
Indeno(1,2,3-cd)pyrene	mg/kg	0.23																							
Phenanthrene	mg/kg	0.36																							
Pyrene	mg/kg	0.55																							
Metals																									
Aluminum	mg/kg	21000																							
Antimony	mg/kg	7.7		-	-	6.7		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	mg/kg	23.6		9.8		13		12		5.6		6.2		-	-	3.9		-	-	-	-	8		-	-
Barium	mg/kg	165																							
Beryllium	mg/kg	1.2		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	mg/kg	1.6		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	mg/kg	83900																							
Chromium	mg/kg	35		15		19		16		20		13		9		11		8.3		9.5		15		20	
Cobalt	mg/kg	21																							
Copper	mg/kg	35		13		7.7		11		3.6		13		-	-	6.2		-	-	4.3		6.9		6.3	
Iron	mg/kg	36000																							
Lead	mg/kg	27		13		10		12		9.5		10		6.4		9		8.5		12		7.3		11	
Magnesium	mg/kg	23400																							
Manganese	mg/kg	3300		1100		420		530		570		380		88		310		150		210		560		470	
Mercury	mg/kg	0.12		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	mg/kg	52		40		29		26		20		15		5.5		13		5.9		9.3		16		20	
Potassium	mg/kg	5630																							
Selenium	mg/kg	0.65		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/kg	1270																							
Thallium	mg/kg	1.1		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	mg/kg	40.5																							
Zinc	mg/kg	187		52		62		59		54		44		23		38		24		34		46		51	
General Chemistry																									
Alkalinity	mg/kg	830																							
Cation exchange capacity	mg/kg	5.2																							
Kjeldahl Nitrogen	mg/kg	2130																							
Nitrate-Nitrite	mg/kg	150																							
pH	pH_units	8																							
Phosphorous	mg/kg	31																							
Sulfate	mg/kg	3330																							
Total organic carbon	mg/kg	1990																							

			PB-PR-S5						PB-PR-S6						PB-PR-S7						PB-PR-S8					
Location Code:																										
Sample No:			PB-PR-S5-0_0-3_0		PB-PR-S5-3_0-5_0		PB-PR-S5-5_0-10_0		PB-PR-S6-0_0-3_0		PB-PR-S6-3_0-5_0		PB-PR-S6-5_0-10_0		PB-PR-S7-0_0-3_0		PB-PR-S7-3_0-5_0		PB-PR-S7-5_0-10_0		PB-PR-S8-0_0-0_5		PB-PR-S8-0_0-2_0		PB-PR-S8-2_0-5_0	
Sample Date:			28-Oct-94		28-Oct-94		28-Oct-94		29-Oct-94		29-Oct-94		29-Oct-94		28-Oct-94		28-Oct-94		28-Oct-94		15-Dec-94		31-Oct-94		31-Oct-94	
Sample Depth:			0 - 3 Ft		3 - 5 Ft		5 - 10 Ft		0 - 3 Ft		3 - 5 Ft		5 - 10 Ft		0 - 3 Ft		3 - 5 Ft		5 - 10 Ft		0 - .5 Ft		0 - 2 Ft		2 - 5 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																										
Amino-2,6-dinitrotoluene, 4-	mg/kg	9.5	-	-	-	-	-	-	-	-	0.3		1		-	-	0.3		-	-	-	-	-	-	-	-
Amino-2-nitrotoluene, 4-	mg/kg	0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrobenzene, 1,3-	mg/kg	6.7	-	-	-	-	-	-	0.9		3.4		3.8		0.3		2.1		0.5		-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	19	-	-	-	-	-	-	2.1		8.7		7.6		0.4		3.4		0.3		-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	3.6	-	-	-	-	-	-	0.4		3.6		0.5		-	-	0.4		-	-	-	-	-	-	-	-
Dinitrotoluene, 3,4-	mg/kg	4.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrobenzene	mg/kg	1.1	-	-	-	-	-	-	-	-	1.1		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	mg/kg	58	-	-	0.7		0.4		0.7		13		18		0.5		6.6		1.3		-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	mg/kg	12000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Volatiles																										
Acetone	mg/kg	0																								
Dichloroethene, cis-1,2-	mg/kg	0.0013																								
Ethylbenzene	mg/kg	0																								
Methylene chloride	mg/kg	0																								
Toluene	mg/kg	0.005																								
Trichloroethene	mg/kg	0.0046																								
Xylenes, total	mg/kg	0.0035																								
Semivolatiles																										
Acenaphthylene	mg/kg	0.041																								
Anthracene	mg/kg	0.23																								
Benzo(a)anthracene	mg/kg	0.4																								
Benzo(a)pyrene	mg/kg	0.39																								
Benzo(b)fluoranthene	mg/kg	0.3																								
Benzo(ghi)perylene	mg/kg	0.22																								
Benzo(k)fluoranthene	mg/kg	0.35																								
Bis(2-ethylhexyl)phthalate	mg/kg	1.07																								
Chrysene	mg/kg	0.42																								
Dibenz(a,h)anthracene	mg/kg	0.022																								
Di-n-butyl phthalate	mg/kg	0.13																								
Dinitrotoluene, 2,4-	mg/kg	0.043																								
Fluoranthene	mg/kg	0.089																								
Fluorene	mg/kg	0.0074																								
Indeno(1,2,3-cd)pyrene	mg/kg	0.23																								
Phenanthrene	mg/kg	0.36																								
Pyrene	mg/kg	0.55																								
Metals																										
Aluminum	mg/kg	21000																								
Antimony	mg/kg	7.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	mg/kg	23.6	15		9.3		4.8		3.9		6.3		9.4		3.7		14		8.3		-	-	-	-	-	-
Barium	mg/kg	165																								
Beryllium	mg/kg	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	mg/kg	1.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	mg/kg	83900																								
Chromium	mg/kg	35	9.8		21		27		13		16		15		11		15		19		7.9		8		8	
Cobalt	mg/kg	21																								
Copper	mg/kg	35	3.5		6.8		3.2		-	-	-	-	7.9		-	-	7.8		4.2		-	-	-	-	-	-
Iron	mg/kg	36000																								
Lead	mg/kg	27	7.2		12		11		12		9.5		12		6.4		11		10		8.6		3.9		3.9	
Magnesium	mg/kg	23400																								
Manganese	mg/kg	3300	200		270		490		150		280		490		230		650		500		90		86		230	
Mercury	mg/kg	0.12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	mg/kg	52	8.8		19		27		8.9		12		16		8.6		20		20		6		5.4		6.4	
Potassium	mg/kg	5630																								
Selenium	mg/kg	0.65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/kg	1270																								
Thallium	mg/kg	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	mg/kg	40.5																								
Zinc	mg/kg	187	28		62		62		35		41		45		25		48		54		31		33		23	
General Chemistry																										
Alkalinity	mg/kg	830																								
Cation exchange capacity	mg/kg	5.2																								
Kjeldahl Nitrogen	mg/kg	2130																								
Nitrate-Nitrite	mg/kg	150																								
pH	pH_units	8																								
Phosphorous	mg/kg	31																								
Sulfate	mg/kg	3330																								
Total organic carbon	mg/kg	1990																								

WARWP - Historical Soil Analytical Results
2004 Groundwater Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

			PB-PR-S9						PB-WA-S1		PB-WA-S10				PB-WA-S11				PB-WA-S12				PB-WA-S13							
Location Code:																														
Sample No:			PB-PR-S9-3_0-5_0		PB-PR-S9-5_0-10_0		PR-PR-S9-0_0-3_0		PB-WA-S1-0_0-0_5		PB-WA-S10-3_0-5_0		PB-WA-S10-5_0-10_0		PB-WA-S11-0_0-2_0		PB-WA-S11-2_0-5_0		PB-WA-S12-0_0-2_0		PB-WA-S12-2_0-5_0		PB-WA-S13-0_0-0_5		PB-WA-S13-0_0-3_0		PB-WA-S13-3_0-5_0		PB-WA-S13-5_0-10_0	
Sample Date:			29-Oct-94		29-Oct-94		29-Oct-94		27-Oct-94		27-Oct-94		27-Oct-94		25-Oct-94		25-Oct-94		25-Oct-94		25-Oct-94		13-Dec-94		18-Oct-94		18-Oct-94		18-Oct-94	
Sample Depth:			3 - 5 Ft		5 - 10 Ft		0 - 3 Ft		0 - .5 Ft		3 - 5 Ft		5 - 10 Ft		0 - 2 Ft		2 - 5 Ft		0 - 2 Ft		2 - 5 Ft		0 - .5 Ft		0 - 3 Ft		3 - 5 Ft		5 - 10 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																														
Amino-2,6-dinitrotoluene, 4-	mg/kg	9.5	-	-	-	-	-	-	-	-	0.7		-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3		-	-
Amino-2-nitrotoluene, 4-	mg/kg	0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrobenzene, 1,3-	mg/kg	6.7	1.5		2.2		1.6		-	-	2.3		0.5		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	19	3.8		2		2.4		-	-	5.1		-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.6		-	-
Dinitrotoluene, 2,6-	mg/kg	3.6	-	-	-	-	0.8		-	-	0.3		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 3,4-	mg/kg	4.5	-	-	-	-	-	-	-	-	-	-	0.3		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrobenzene	mg/kg	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	mg/kg	58	6.6		4.9		1.1		-	-	5.5		1.1		-	-	-	-	-	-	0.6		-	-	-	-	1.6		0.5	
Trinitrotoluene, 2,4,6-	mg/kg	12000	-	-	-	-	-	-	-	-	0.4		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Volatiles																														
Acetone	mg/kg	0																												
Dichloroethene, cis-1,2-	mg/kg	0.0013																												
Ethylbenzene	mg/kg	0																												
Methylene chloride	mg/kg	0																												
Toluene	mg/kg	0.005																												
Trichloroethene	mg/kg	0.0046																												
Xylenes, total	mg/kg	0.0035																												
Semivolatiles																														
Acenaphthylene	mg/kg	0.041																												
Anthracene	mg/kg	0.23																												
Benzo(a)anthracene	mg/kg	0.4																												
Benzo(a)pyrene	mg/kg	0.39																												
Benzo(b)fluoranthene	mg/kg	0.3																												
Benzo(ghi)perylene	mg/kg	0.22																												
Benzo(k)fluoranthene	mg/kg	0.35																												
Bis(2-ethylhexyl)phthalate	mg/kg	1.07																												
Chrysene	mg/kg	0.42																												
Dibenz(a,h)anthracene	mg/kg	0.022																												
Di-n-butyl phthalate	mg/kg	0.13																												
Dinitrotoluene, 2,4-	mg/kg	0.043																												
Fluoranthene	mg/kg	0.089																												
Fluorene	mg/kg	0.0074																												
Indeno(1,2,3-cd)pyrene	mg/kg	0.23																												
Phenanthrene	mg/kg	0.36																												
Pyrene	mg/kg	0.55																												
Metals																														
Aluminum	mg/kg	21000																												
Antimony	mg/kg	7.7	-	-	6.7		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	mg/kg	23.6	6		11		4.6		6		5.8		14		5.1		4.3		4.8		7.2		6.4		-	-	-	-	-	-
Barium	mg/kg	165																												
Beryllium	mg/kg	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	mg/kg	1.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	mg/kg	83900																												
Chromium	mg/kg	35	16		15		10		23		26		25		16		10.6		15		29		14		16		11		23	
Cobalt	mg/kg	21																												
Copper	mg/kg	35	6.5		7.3		-	-	-	-	3.4		-	-	6.8		6.4		-	-	3.5		3.2		7.4		8.8		12	
Iron	mg/kg	36000																												
Lead	mg/kg	27	11		10		7.8		16		10		10.9		18		13		10.6		16		17		15		11.1		18	
Magnesium	mg/kg	23400																												
Manganese	mg/kg	3300	320		415		130		366		455		392		466		267		216		373		200		184		220		434	
Mercury	mg/kg	0.12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	mg/kg	52	17		18		7.3		23		23		25		27		19		16		29		17		20		22		35	
Potassium	mg/kg	5630																												
Selenium	mg/kg	0.65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/kg	1270																												
Thallium	mg/kg	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	mg/kg	40.5																												
Zinc	mg/kg	187	47		48		28		73		60		68		76		51		41		58		57		55		54		59	
General Chemistry																														
Alkalinity	mg/kg	830																												
Cation exchange capacity	mg/kg	5.2																												
Kjeldahl Nitrogen	mg/kg	2130																												
Nitrate-Nitrite	mg/kg	150																												
pH	pH_units	8																												
Phosphorous	mg/kg	31																												
Sulfate	mg/kg	3330																												
Total organic carbon	mg/kg	1990																												

			PB-WA-S14				PB-WA-S15				PB-WA-S16				PB-WA-S17								PB-WA-S18					
Location Code:																												
Sample No:			PB-WA-S14-0_0-2_0		PB-WA-S14-2_0-5_0		PB-WA-S15-0_0-2_0		PB-WA-S15-2_0-5_0		PB-WA-S16-0_0-2_0		PB-WA-S16-2_0-4_0		PB-WA-S17-0_0-0_5		PB-WA-S17-0_0-3_0		PB-WA-S17-3_0-5_0		PB-WA-S17-5_0-10_0		PB-WA-S18-0_0-3_0		PB-WA-S18-3_0-5_0		PB-WA-S18-5_0-10_0	
Sample Date:			25-Oct-94		25-Oct-94		24-Oct-94		24-Oct-94		18-Oct-94		18-Oct-94		13-Dec-94		19-Oct-94		19-Oct-94		19-Oct-94		18-Oct-94		18-Oct-94		18-Oct-94	
Sample Depth:			0 - 2 Ft		2 - 5 Ft		0 - 2 Ft		2 - 5 Ft		0 - 2 Ft		2 - 4 Ft		0 - .5 Ft		0 - 3 Ft		3 - 5 Ft		5 - 10 Ft		0 - 3 Ft		3 - 5 Ft		5 - 10 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																												
Amino-2,6-dinitrotoluene, 4-	mg/kg	9.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3		-	-	-	-	-	-	-	-	-	-
Amino-2-nitrotoluene, 4-	mg/kg	0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5		-	-	-	-	-	-
Dinitrobenzene, 1,3-	mg/kg	6.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.9		-	-	0.3		-	-
Dinitrotoluene, 2,4-	mg/kg	19	0.4		0.3		-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.3		-	-	0.7		0.3	
Dinitrotoluene, 2,6-	mg/kg	3.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3		-	-	-	-	-	-
Dinitrotoluene, 3,4-	mg/kg	4.5	-	-	0.5		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrobenzene	mg/kg	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	mg/kg	58	-	-	0.4		-	-	-	-	-	-	-	-	-	-	-	-	0.5		4.2		-	-	0.9		0.9	
Trinitrotoluene, 2,4,6-	mg/kg	12000	-	-	0.3		-	-	-	-	-	-	-	-	-	-	0.3		-	-	2.1		-	-	-	-	-	-
Volatiles																												
Acetone	mg/kg	0																										
Dichloroethene, cis-1,2-	mg/kg	0.0013																										
Ethylbenzene	mg/kg	0																										
Methylene chloride	mg/kg	0																										
Toluene	mg/kg	0.005																										
Trichloroethene	mg/kg	0.0046																										
Xylenes, total	mg/kg	0.0035																										
Semivolatiles																												
Acenaphthylene	mg/kg	0.041																										
Anthracene	mg/kg	0.23																										
Benzo(a)anthracene	mg/kg	0.4																										
Benzo(a)pyrene	mg/kg	0.39																										
Benzo(b)fluoranthene	mg/kg	0.3																										
Benzo(ghi)perylene	mg/kg	0.22																										
Benzo(k)fluoranthene	mg/kg	0.35																										
Bis(2-ethylhexyl)phthalate	mg/kg	1.07																										
Chrysene	mg/kg	0.42																										
Dibenz(a,h)anthracene	mg/kg	0.022																										
Di-n-butyl phthalate	mg/kg	0.13																										
Dinitrotoluene, 2,4-	mg/kg	0.043																										
Fluoranthene	mg/kg	0.089																										
Fluorene	mg/kg	0.0074																										
Indeno(1,2,3-cd)pyrene	mg/kg	0.23																										
Phenanthrene	mg/kg	0.36																										
Pyrene	mg/kg	0.55																										
Metals																												
Aluminum	mg/kg	21000																										
Antimony	mg/kg	7.7	-	-	-	-	-	-	-	-	-	-	-	-	7.4		-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	mg/kg	23.6	5.6		5.5		6.1		4.8		4.4		6.9		8.5		-	-	8.5		5.4		3.9		-	-	-	-
Barium	mg/kg	165																										
Beryllium	mg/kg	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	mg/kg	1.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	mg/kg	83900																										
Chromium	mg/kg	35	9.2		9.9		16		13		21		19		19		17		16		11.2		20		11		19	
Cobalt	mg/kg	21																										
Copper	mg/kg	35	5.1		7.4		7.1		7.1		2.8		5.3		3.7		8.5		8.2		11.3		16		9.3		5.9	
Iron	mg/kg	36000																										
Lead	mg/kg	27	10.3		8.4		17		12		8.4		8.9		22		23		16		11.4		19		12		15	
Magnesium	mg/kg	23400																										
Manganese	mg/kg	3300	398		198		433		413		165		185		270		1023		398		274		1000		325		333	
Mercury	mg/kg	0.12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	mg/kg	52	17		19		21		23		10.1		9.5		18		31		22		18		34		18		24	
Potassium	mg/kg	5630																										
Selenium	mg/kg	0.65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/kg	1270																										
Thallium	mg/kg	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	mg/kg	40.5																										
Zinc	mg/kg	187	45		46		64		62		32		33		69		80		64		50		87		54		57	
General Chemistry																												
Alkalinity	mg/kg	830																										
Cation exchange capacity	mg/kg	5.2																										
Kjeldahl Nitrogen	mg/kg	2130																										
Nitrate-Nitrite	mg/kg	150																										
pH	pH_units	8																										
Phosphorous	mg/kg	31																										
Sulfate	mg/kg	3330																										
Total organic carbon	mg/kg	1990																										

			Location Code:	PB-WA-S19			PB-WA-S2		PB-WA-S20		PB-WA-S21		PB-WA-S22		PB-WA-S23		PB-WA-S24		PB-WA-S3		PB-WA-S4		PB-WA-S5				PB-WA-S6			
			Sample No:	PB-WA-S19-0_0-2_0		PB-WA-S19-2_0-5_0																	PB-WA-S5-0_0-2_0		PB-WA-S5-2_0-5_0		PB-WA-S6-0_0-2_0		PB-WA-S6-2_0-5_0	
			Sample Date:	24-Oct-94		24-Oct-94		27-Oct-94		29-Oct-94		17-Oct-94		18-Oct-94		29-Oct-94		19-Oct-94		27-Oct-94		29-Oct-94		17-Oct-94		17-Oct-94		17-Oct-94		17-Oct-94	
			Sample Depth:	0 - 2 Ft		2 - 5 Ft		0 - .5 Ft		0 - .5 Ft		0 - 2 Ft		2 - 5 Ft		0 - .5 Ft		5 - 10 Ft		0 - .5 Ft		0 - .5 Ft		0 - 2 Ft		2 - 5 Ft		0 - 2 Ft		2 - 5 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																														
Amino-2,6-dinitrotoluene, 4-	mg/kg	9.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3		-	-	-	-	-	-	0.4		-	-	0.6	
Amino-2-nitrotoluene, 4-	mg/kg	0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrobenzene, 1,3-	mg/kg	6.7	-	-	-	-	-	-	0.3		-	-	-	-	-	-	1.5		-	-	-	-	-	-	0.7		-	-	2.4	
Dinitrotoluene, 2,4-	mg/kg	19	-	-	-	-	-	-	0.4		-	-	-	-	0.4		3.8		-	-	-	-	0.3		1.3		-	-	3	
Dinitrotoluene, 2,6-	mg/kg	3.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3		-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 3,4-	mg/kg	4.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrobenzene	mg/kg	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	mg/kg	58	-	-	-	-	-	-	0.7		0.5		-	-	0.5		3.1		-	-	-	-	0.6		3		0.3		4.2	
Trinitrotoluene, 2,4,6-	mg/kg	12000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3		-	-	-	-	-	-	0.3		-	-	-	-
Volatiles																														
Acetone	mg/kg	0.53																												
Dichloroethene, cis-1,2-	mg/kg	0																												
Ethylbenzene	mg/kg	0.0013																												
Methylene chloride	mg/kg	0.0088																												
Toluene	mg/kg	0.0038																												
Trichloroethene	mg/kg	0																												
Xylenes, total	mg/kg	0																												
Semivolatiles																														
Acenaphthylene	mg/kg	0.041																												
Anthracene	mg/kg	0.23																												
Benzo(a)anthracene	mg/kg	0.4																												
Benzo(a)pyrene	mg/kg	0.39																												
Benzo(b)fluoranthene	mg/kg	0.3																												
Benzo(ghi)perylene	mg/kg	0.22																												
Benzo(k)fluoranthene	mg/kg	0.35																												
Bis(2-ethylhexyl)phthalate	mg/kg	1.07																												
Chrysene	mg/kg	0.42																												
Dibenz(a,h)anthracene	mg/kg	0.022																												
Di-n-butyl phthalate	mg/kg	0.13																												
Dinitrotoluene, 2,4-	mg/kg	0.043																												
Fluoranthene	mg/kg	0.76																												
Fluorene	mg/kg	0.0074																												
Indeno(1,2,3-cd)pyrene	mg/kg	0.23																												
Phenanthrene	mg/kg	0.36																												
Pyrene	mg/kg	0.55																												
Metals																														
Aluminum	mg/kg	21000																												
Antimony	mg/kg	7.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	mg/kg	23.6	5.7		7.7		5.7		4.6		5.2		5		5		-	-	6.5		-	-	4.7		4.8		-	-	5.6	
Barium	mg/kg	165																												
Beryllium	mg/kg	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	mg/kg	1.6	-	-	-	-	-	-	-	-	-	-	1.6		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	mg/kg	83900																												
Chromium	mg/kg	35	22		22		10.8		16		16		12		18		11.2		16		12		35		17		16		12.7	
Cobalt	mg/kg	21																												
Copper	mg/kg	35	6.2		11		7.6		2.9		6		14		3.1		5.3		11.3		2.4		-	-	7.1		3.3		7.8	
Iron	mg/kg	36000																												
Lead	mg/kg	27	20		15		10		12		15		8.5		13		11		16		12		19		11.7		15		11.5	
Magnesium	mg/kg	23400																												
Manganese	mg/kg	3300	442		494		329		190		695		3300		290		198		841		350		1012		305		268		282	
Mercury	mg/kg	0.12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	mg/kg	52	27		31		20		16		29		52		18		15		29		15		35		26		21		22	
Potassium	mg/kg	5630																												
Selenium	mg/kg	0.65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/kg	1270																												
Thallium	mg/kg	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	mg/kg	40.5																												
Zinc	mg/kg	187	79		66		-	-	45		72		37		51		43		78		49		91		62		66		56	
General Chemistry																														
Alkalinity	mg/kg	830																												
Cation exchange capacity	mg/kg	5.2																												
Kjeldahl Nitrogen	mg/kg	2130																												
Nitrate-Nitrite	mg/kg	150																												
pH	pH_units	8																												
Phosphorous	mg/kg	31																												
Sulfate	mg/kg	3330																												
Total organic carbon	mg/kg	1990																												

			Location Code:	PB-WA-S7				PB-WA-S8				PB-WA-S9				WARP-DP01						WARP-DP02						WARP-DP03					
			Sample No:	PB-WA-S7-0_0-2_0		PB-WA-S7-2_0-5_0		PB-WA-S8-0_0-2_0		PB-WA-S8-2_0-5_0		PB-WA-S9-0_0-2_0		PB-WA-S9-2_0-5_0		8100		8110		8120		8140		8150		8160		8180		8190		8200	
			Sample Date:	18-Oct-94		18-Oct-94		18-Oct-94		18-Oct-94		18-Oct-94		18-Oct-94		23-Jun-98		23-Jun-98		23-Jun-98		23-Jun-98		23-Jun-98		23-Jun-98		23-Jun-98		23-Jun-98		23-Jun-98	
			Sample Depth:	0 - 2 Ft		2 - 5 Ft		0 - 2 Ft		2 - 5 Ft		0 - 2 Ft		2 - 5 Ft		0 - 2 Ft		4 - 6 Ft		8 - 10 Ft		0 - 2 Ft		4 - 6 Ft		8 - 10 Ft		0 - 2 Ft		4 - 6 Ft		8 - 10 Ft	
Parameter	Units	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																																	
Amino-2,6-dinitrotoluene, 4-	mg/kg	9.5		-	-	0.3		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-2-nitrotoluene, 4-	mg/kg	0.9		-	-	-	-	-	-	-	-	-	-	-	-																		
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.5		-	-	-	-	-	-	-	-	-	-	-	-																		
Dinitrobenzene, 1,3-	mg/kg	6.7		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	19		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	3.6		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 3,4-	mg/kg	4.5		-	-	-	-	-	-	-	-	-	-	-	-																		
Nitrobenzene	mg/kg	1.1		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	0.9		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	mg/kg	58		-	-	0.4		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.28	
Trinitrotoluene, 2,4,6-	mg/kg	12000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Volatiles																																	
Acetone	mg/kg	0.53																-	-			-	-					-	-				
Dichloroethene, cis-1,2-	mg/kg	0																															
Ethylbenzene	mg/kg	0.0013																-	-			-	-					-	-				
Methylene chloride	mg/kg	0.0088																0.0032	B			0.0023	B					0.0039	B				
Toluene	mg/kg	0.0038																0.0022	J			0.0018	J					-	-				
Trichloroethene	mg/kg	0																-	-			-	-					-	-				
Xylenes, total	mg/kg	0																-	-			-	-					-	-				
Semivolatiles																																	
Acenaphthylene	mg/kg	0.041																-	-			-	-					-	-				
Anthracene	mg/kg	0.23																-	-			-	-					-	-				
Benzo(a)anthracene	mg/kg	0.4																-	-			-	-					-	-				
Benzo(a)pyrene	mg/kg	0.39																-	-			-	-					-	-				
Benzo(b)fluoranthene	mg/kg	0.3																-	-			-	-					-	-				
Benzo(ghi)perylene	mg/kg	0.22																-	-			-	-					-	-				
Benzo(k)fluoranthene	mg/kg	0.35																-	-			-	-					-	-				
Bis(2-ethylhexyl)phthalate	mg/kg	1.07																-	-			-	-					-	-				
Chrysene	mg/kg	0.42																-	-			-	-					-	-				
Dibenz(a,h)anthracene	mg/kg	0.022																-	-			-	-					-	-				
Di-n-butyl phthalate	mg/kg	0.13																-	-			-	-					-	-				
Dinitrotoluene, 2,4-	mg/kg	0.043																-	-			-	-					-	-				
Fluoranthene	mg/kg	0.76																-	-			-	-					-	-				
Fluorene	mg/kg	0.0074																-	-			-	-					-	-				
Indeno(1,2,3-cd)pyrene	mg/kg	0.23																-	-			-	-					-	-				
Phenanthrene	mg/kg	0.36																-	-			-	-					-	-				
Pyrene	mg/kg	0.55																-	-			-	-					-	-				
Metals																																	
Aluminum	mg/kg	21000														6880		9190		6010		17900		7540		14500		16500		7040		9400	
Antimony	mg/kg	7.7		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	mg/kg	23.6		4.4		5.1		4.5		5.3		6.2		3.9		2.8		8.6		4.5		7.2		2.5		11.7		8.1		6.8		5.8	
Barium	mg/kg	165														-	-	40.3		27.9		124		32.1		75.3		112		87.2		58	
Beryllium	mg/kg	1.2		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1		-	-	0.7		0.76	J	-	-	-	-
Cadmium	mg/kg	1.6		-	-	-	-	-	-	1.4		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.59		-	-	-	-
Calcium	mg/kg	83900														1490		35700		67600		5930		3010		56600		2710		2200		40200	
Chromium	mg/kg	35		14		16		14		13		30		23		9.9	J	16.1	J	10.9	J	20.8	J	12.1	J	22.2	J	19.9	J	11.4	J	14.8	J
Cobalt	mg/kg	21														-	-	8.5		6.2		16.2		-	-	10		17.9		21		8.5	
Copper	mg/kg	35		3.6		14		-	-	2.4		2.6		-	-	4		20.1		17.1		20		7		25.6		21.4		15.1		20.3	
Iron	mg/kg	36000														10300		19600		15000		26800		11500		26400		30200		19600		20100	
Lead	mg/kg	27		16		20		13		7.4		7.8		7.9		3.6	J	8.1	J	7.1	J	13.5	J	4.8	J	10.8	J	11.7		9.4		7.6	
Magnesium	mg/kg	23400														1090		14500		20700		4020		2110		15100		3760		2020		10800	
Manganese	mg/kg	3300		300		1011		702		621		163		156		89.6		282		329		1190		92.5		423		1340		495		372	
Mercury	mg/kg	0.12		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.061		-	-	-	-	-	-	-	-	-	-
Nickel	mg/kg	52		16		31		17		16		10.3		9.4		7.6		19.4		14		29.1		13		27.8		44.3		24		23	
Potassium	mg/kg	5630														-	-	2010	J	1480	J	2490	J	1210	J	3370	J	2970	J	941	J	2460	J
Selenium	mg/kg	0.65		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/kg	1270														-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium	mg/kg	1.1		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	mg/kg	40.5														18.9		28		20.5		37.7		17.8		34.6		32.5	J	19.6	J	23.3	J
Zinc	mg/kg	187		64		60		57		34		33		34		21.7		51.2		40		87.4		33.9		68.1		111		64.1		54.7	
General Chemistry																																	
Alkalinity	mg/kg	830																															
Cation exchange capacity	mg/kg	5.2																															
Kjeldahl Nitrogen	mg/kg	2130																															
Nitrate-Nitrite	mg/kg	150																															
pH	pH_units	8																															
Phosphorous	mg/kg	31																															
Sulfate	mg/kg	3330																															
Total organic carbon	mg/kg	1990																															

			WARP-DP04						WARP-DP05						WARP-DP06						WARP-DP07						WARP-DP08					
Location Code:																																
Sample No:			8220		8230		8240		8260		8270		8280		8300		8310		8320		8340		8350		8360		8380		8390		8400	
Sample Date:			23-Jun-98		23-Jun-98		23-Jun-98		16-Jun-98		16-Jun-98		16-Jun-98		23-Jun-98		23-Jun-98		23-Jun-98		25-Jun-98		25-Jun-98		25-Jun-98		15-Jun-98		15-Jun-98		15-Jun-98	
Sample Depth:			0 - 2 Ft		4 - 6 Ft		8 - 10 Ft		0 - 2 Ft		4 - 6 Ft		8 - 10 Ft		0 - 2 Ft		4 - 6 Ft		8 - 10 Ft		0 - 2 Ft		4 - 6 Ft		8 - 10 Ft		0 - 2 Ft		4 - 6 Ft		8 - 10 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																																
Amino-2,6-dinitrotoluene, 4-	mg/kg	9.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-2-nitrotoluene, 4-	mg/kg	0.9																														
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.5																														
Dinitrobenzene, 1,3-	mg/kg	6.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	3.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 3,4-	mg/kg	4.5																														
Nitrobenzene	mg/kg	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	mg/kg	58	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	mg/kg	12000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Volatiles																																
Acetone	mg/kg	0.53					-	-			-	-			-	-							-	-			0.035					
Dichloroethene, cis-1,2-	mg/kg	0																														
Ethylbenzene	mg/kg	0.0013					-	-			-	-			-	-							-	-			-	-				
Methylene chloride	mg/kg	0.0088					0.0027	B			-	-			0.0018	B							0.0032	B			0.002	J				
Toluene	mg/kg	0.0038					0.0025	J			-	-			0.0023	J							-	-			-	-				
Trichloroethene	mg/kg	0					-	-			-	-			-	-							-	-			-	-				
Xylenes, total	mg/kg	0					-	-			-	-			-	-							-	-			-	-				
Semivolatiles																																
Acenaphthylene	mg/kg	0.041					-	-			-	-			-	-							-	-			-	-				
Anthracene	mg/kg	0.23					-	-			-	-			-	-							-	-			-	-				
Benzo(a)anthracene	mg/kg	0.4					-	-			-	-			-	-							-	-			-	-				
Benzo(a)pyrene	mg/kg	0.39					-	-			-	-			-	-							-	-			-	-				
Benzo(b)fluoranthene	mg/kg	0.3					-	-			-	-			-	-							-	-			-	-				
Benzo(ghi)perylene	mg/kg	0.22					-	-			-	-			-	-							-	-			-	-				
Benzo(k)fluoranthene	mg/kg	0.35					-	-			-	-			-	-							-	-			-	-				
Bis(2-ethylhexyl)phthalate	mg/kg	1.07					-	-			-	-			-	-							-	-			-	-				
Chrysene	mg/kg	0.42					-	-			-	-			-	-							-	-			-	-				
Dibenz(a,h)anthracene	mg/kg	0.022					-	-			-	-			-	-							-	-			-	-				
Di-n-butyl phthalate	mg/kg	0.13					-	-			-	-			-	-							-	-			-	-				
Dinitrotoluene, 2,4-	mg/kg	0.043					-	-			-	-			-	-							-	-			-	-				
Fluoranthene	mg/kg	0.76					-	-			-	-			-	-							-	-			-	-				
Fluorene	mg/kg	0.0074					-	-			-	-			-	-							-	-			-	-				
Indeno(1,2,3-cd)pyrene	mg/kg	0.23					-	-			-	-			-	-							-	-			-	-				
Phenanthrene	mg/kg	0.36					-	-			-	-			-	-							-	-			-	-				
Pyrene	mg/kg	0.55					-	-			-	-			-	-							-	-			-	-				
Metals																																
Aluminum	mg/kg	21000	17000		8640		13400		8120		8840		9510		5600		8610		12100		11500		9160		10900		4880		8740		5570	
Antimony	mg/kg	7.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	mg/kg	23.6	6.1		4.5		11.2		4.8		4.6		6.7		2.3		6.8		6.6		3.7		3.1		7.4		2.2		6.9		4	
Barium	mg/kg	165	85.4		45.7		35.3		51.2		62.4		54.3		-	-	31.3		82.3		69.7		43.3		55.4		-	-	43.8		-	-
Beryllium	mg/kg	1.2	0.78	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.7		-	-	0.65		-	-	-	-	-	-
Cadmium	mg/kg	1.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	mg/kg	83900	1900		1860		40300		2390		54500		50400		1620		2530		55700		2700		2410		25000		1480		1810		1460	
Chromium	mg/kg	35	19.2	J	11.9	J	20	J	13.1		15.3		17.4		8.9	J	15.5	J	17.9	J	15.8	J	14.1	J	17.1	J	6.8		17.4		7.5	
Cobalt	mg/kg	21	14.7		9.2		11.6		8.5		9.6		9.2		-	-	7.9		12.8		9		7.3		13.8		-	-	7.4		-	-
Copper	mg/kg	35	21.9		12.7		34.7		11.7		19.3		19		4.5		12.4		23.5		15.9		12.5		21.4		2.9		10.4		6.9	
Iron	mg/kg	36000	23900		14500		27800		17600		17000		18200		10200		17000		21500		16800		13900		20700		8460		22000		10000	
Lead	mg/kg	27	10.3		6.2		12.3		6.1		10.5		8.4		2.8	J	7.1	J	11.6	J	10.1	J	6.9	J	11.6	J	2.2		5.4		4.4	
Magnesium	mg/kg	23400	3220		1990		11000		2150		23400		14800		1060		1860		17700		2720		2340		5620		-	-	1810		832	
Manganese	mg/kg	3300	915		267		363		468		527		362		143		413		768		186		123		472		107		231		215	
Mercury	mg/kg	0.12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	mg/kg	52	29.7		20.9		36		17		23.2		21.7		7.1		14.8		31.4		22.3		18.3		29.7		7.5		17		10.8	
Potassium	mg/kg	5630	2510	J	1370	J	3570	J	813		1740		1730		-	-	924	J	2860	J	1650	J	1650	J	2390	J	-	-	643		-	-
Selenium	mg/kg	0.65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/kg	1270	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium	mg/kg	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	mg/kg	40.5	32.9	J	18.2	J	24.7	J	24.1	J	27.1	J	25.9	J	17.9		25.4		30.8		21.1		20.4		24.2		15.8		30		17.8	
Zinc	mg/kg	187	88.1		53.8		80		40.4		53.6		53.4		21.1		39.3		62.2		70.5		57.5		75.6		15.9		37.8		26.5	
General Chemistry																																
Alkalinity	mg/kg	830																														
Cation exchange capacity	mg/kg	5.2																														
Kjeldahl Nitrogen	mg/kg	2130																														
Nitrate-Nitrite	mg/kg	150																														
pH	pH_units	8																														
Phosphorous	mg/kg	31																														
Sulfate	mg/kg	3330																														
Total organic carbon	mg/kg	1990																														

WARWP - Historical Soil Analytical Results
2004 Groundwater Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

	Location Code:		WARP-DP09										WARP-DP10				WARP-DP11						WARP-DP12						WARP-DP13									
	Sample No:		8420		8430		8440		BD0023		BD0024		8460		8470		8500		8510		8520		8540		8550		8560		8580		8590		8600		BD0025		BD0028	
	Sample Date:		16-Jun-98		16-Jun-98		16-Jun-98		27-Sep-01		27-Sep-01		26-Jun-98		26-Jun-98		25-Jun-98		25-Jun-98		25-Jun-98		15-Jun-98		15-Jun-98		15-Jun-98		15-Jun-98		15-Jun-98		15-Jun-98		27-Sep-01		27-Sep-01	
	Sample Depth:		0 - 2 Ft		4 - 6 Ft		8 - 10 Ft		4 - 4.9 Ft		11 - 12 Ft		0 - 2 Ft		4 - 6 Ft		0 - 2 Ft		4 - 6 Ft		8 - 10 Ft		0 - 2 Ft		4 - 6 Ft		8 - 10 Ft		0 - 2 Ft		4 - 6 Ft		8 - 10 Ft		4.1 - 5.1 Ft		11 - 12 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																																							
Amino-2,6-dinitrotoluene, 4-	mg/kg	9.5	-	-	-	-	-	-	-	-	0.16	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-2-nitrotoluene, 4-	mg/kg	0.9																																				
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.5							-	-	0.11	J																							-	-	-	-
Dinitrobenzene, 1,3-	mg/kg	6.7	-	-	-	-	-	-	-	-	0.31		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.4			
Dinitrotoluene, 2,4-	mg/kg	19	-	-	-	-	0.49		0.71		2.7		-	-	1.4		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.3		0.29		6.5	
Dinitrotoluene, 2,6-	mg/kg	3.6	-	-	-	-	-	-	0.35		0.27		-	-	1.5		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.64	J
Dinitrotoluene, 3,4-	mg/kg	4.5																																				
Nitrobenzene	mg/kg	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	mg/kg	58	-	-	-	-	0.31		-	-	1.7		-	-	4.4		-	-	-	-	0.74		-	-	-	-	-	-	-	-	-	-	4.4		0.16	J	11	
Trinitrotoluene, 2,4,6-	mg/kg	12000	-	-	-	-	-	-	1		-	-	-	-	0.38		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Volatiles																																						
Acetone	mg/kg	0.53			-	-			0.53	J	0.017	B	-	-			-	-							-	-			-	-					0.33	J	-	-
Dichloroethene, cis-1,2-	mg/kg	0																																				
Ethylbenzene	mg/kg	0.0013			-	-			-	-	-	-	-	-			-	-							-	-			-	-					0.0013	J	-	-
Methylene chloride	mg/kg	0.0088			-	-			0.008	B	0.0088	B	0.0027	B			0.0037	B							0.002	J			0.0023	J					0.0081	B	0.0081	B
Toluene	mg/kg	0.0038			-	-			-	-	0.00071	J	-	-			0.0032	J							-	-			-	-					0.0038	J	0.00081	J
Trichloroethene	mg/kg	0			-	-			-	-	-	-	-	-			-	-							-	-			-	-					-	-	-	-
Xylenes, total	mg/kg	0			-	-			-	-	-	-	-	-			-	-							-	-			-	-					-	-	-	-
Semivolatiles																																						
Acenaphthylene	mg/kg	0.041			-	-							-	-			-	-							-	-			0.041	J								
Anthracene	mg/kg	0.23			-	-							-	-			-	-							-	-			0.23	J								
Benzo(a)anthracene	mg/kg	0.4			-	-							-	-			-	-							-	-			0.4									
Benzo(a)pyrene	mg/kg	0.39			-	-							-	-			-	-							-	-			0.39									
Benzo(b)fluoranthene	mg/kg	0.3			-	-							-	-			-	-							-	-			0.3	J								
Benzo(ghi)perylene	mg/kg	0.22			-	-							-	-			-	-							-	-			0.22	J								
Benzo(k)fluoranthene	mg/kg	0.35			-	-							-	-			-	-							-	-			0.35	J								
Bis(2-ethylhexyl)phthalate	mg/kg	1.07			-	-							-	-			-	-							-	-			-	-								
Chrysene	mg/kg	0.42			-	-							-	-			-	-							-	-			0.42									
Dibenz(a,h)anthracene	mg/kg	0.022			-	-							-	-			-	-							-	-			-	-								
Di-n-butyl phthalate	mg/kg	0.13			-	-							-	-			-	-							-	-			-	-								
Dinitrotoluene, 2,4-	mg/kg	0.043			-	-							-	-			0.043	J							-	-			-	-								
Fluoranthene	mg/kg	0.76			0.058	J							-	-			-	-							-	-			0.76									
Fluorene	mg/kg	0.0074			-	-							-	-			-	-							-	-			-	-								
Indeno(1,2,3-cd)pyrene	mg/kg	0.23			-	-							-	-			-	-							-	-			0.23	J								
Phenanthrene	mg/kg	0.36			-	-							-	-			-	-							-	-			0.36	J								
Pyrene	mg/kg	0.55			0.043	J							-	-			-	-							-	-			0.55									
Metals																																						
Aluminum	mg/kg	21000	7610		6470		11100		6980		9320		12300		12000		11300		5980		11400		4720		5080		9320		11900		5910		13700		4340		11400	
Antimony	mg/kg	7.7	-	-	-	-	7.7		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.64	J
Arsenic	mg/kg	23.6	6.8		2.2		14		6.1		12.7		5.2		7.9		3.7		6.5		7.9		2		23.6		8.3		11.5		3.1		15.3		2.6		20.3	
Barium	mg/kg	165	53.9		41.3		78.2		49.8		65.4		77.4		80.3		72.9		35.5		51.5		24.8		39.3		54.5		82		27.9		76.3		32.6		73.5	
Beryllium	mg/kg	1.2	-	-	-	-	0.65		0.45	B	0.64	J	0.73		0.86		0.64		-	-	0.59		-	-	-	-	-	-	0.67		-	-	0.83		0.34	B	0.79	
Cadmium	mg/kg	1.6	-	-	-	-	-	-	0.22	J	0.23	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.68		0.11	J	0.27	J
Calcium	mg/kg	83900	58600		1220		7860		83900		2560		3260		2130		2600		1570		51000		757		18800		57200		16600		4680		3580		974		23100	
Chromium	mg/kg	35	22.2		8.2		20.9		23.2		16.3		15.7	J	17.9	J	15.8	J	9.4	J	16.8	J	5.4		10.6		16.2		20.3		10.3		22.2		6.4		18.7	
Cobalt	mg/kg	21	-	-	-	-	11.9		3.8	J	14.2		15.7		11.2		11.5		6.9		10.1		-	-	8.2		8.9		11.1		6		18.4		5.5	J	13.8	
Copper	mg/kg	35	18.5		4.9		24.2		10.1		23.8		16.5		20.4		12.3		10.4		24.3		3.5		19.3		22.6		26.8		14		29.1		4.9		23.5	
Iron	mg/kg	36000	14200		8490		29000		12000		24300		20000		27000		18700		16800		22500		7190		23200		19500		27400		10900		34000		8370		30300	
Lead	mg/kg	27	11.7		5.8		10.6		12		10.7		11	J	11.5	J	9.1	J	6.2	J	8.2	J	2.9		6.4		9.8		11.3		4.9		14		5.7		10.6	
Magnesium	mg/kg	23400	4510		2010		4980		6410		4020		2930		2850		3030		1580		11300		684		6810		17400		8890		2050		4310		901		9230	
Manganese	mg/kg	3300	213		83.4		405		236	J	748	J	681		243		375		114		392		172		551		433		391		231		780		184	J	592	J
Mercury	mg/kg	0.12	0.1		-	-	-	-	0.044		0.027	J	0.045		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.017	J	-	-
Nickel	mg/kg	52	10.6		7.4		36.6		10.7		37.7		29		33.5		22.6		16.6		30.2		8.6		24.9		23.9		29.1		10.3		45		7.4		36.9	
Potassium	mg/kg	5630	-	-	-	-	1160		407	J	1250		1600	J	1340	J	1660	J	903	J	3140	J	-	-	803		1860		1830		-	-	1630		328	J	1790	
Selenium	mg/kg	0.65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/kg	1270	-	-	-	-	-	-	-	-	91.3	J	-	-	1270		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1030		387	J	244	J
Thallium	mg/kg	1.1	-	-	-	-	-	-	1.1	B	0.91	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.94	B
Vanadium	mg/kg	40.5	21.1	J	14.2	J	27.5	J	16		22		22.4		24.6		21.1		13.9		24.2		10.1		22.3		25.9		31		17		36.7		12.1		26.1	
Zinc	mg/kg	187	36.9		30.6		72.5		33.3		63.5		74.6		94.6		75.4		42.4		58.9		22.9		55		60.6		69.9		27.2		82.9		23.3		75.7	
General Chemistry																																						
Alkalinity	mg/kg	830																																				
Cation exchange capacity	mg/kg	5.2																																				
Kjeldahl Nitrogen	mg/kg	2130																																				
Nitrate-Nitrite	mg/kg	150																																				
pH	pH_units	8																																				
Phosphorous	mg/kg	31																																				
Sulfate	mg/kg	3330																																				
Total organic carbon	mg/kg	1990																																				

	Location Code:		WARP-DP15						WARP-DP16										WARP-DP17						WARP-DP18						WARP-DP19					
	Sample No:		8660		8670		8680		8700		8710		8720		BD0029R		BD0030R		8740		8750		8760		8780		8790		8800		8820		8830		8840	
	Sample Date:		24-Jun-98		24-Jun-98		24-Jun-98		24-Jun-98		24-Jun-98		24-Jun-98		2-Oct-01		2-Oct-01		25-Jun-98		25-Jun-98		25-Jun-98		25-Jun-98		25-Jun-98		25-Jun-98		24-Jun-98		24-Jun-98		24-Jun-98	
	Sample Depth:		0 - 2 Ft		4 - 6 Ft		8 - 10 Ft		0 - 2 Ft		4 - 6 Ft		8 - 10 Ft		3.5 - 4 Ft		11 - 12 Ft		0 - 2 Ft		4 - 6 Ft		8 - 10 Ft		0 - 2 Ft		4 - 6 Ft		8 - 10 Ft		0 - 2 Ft		4 - 6 Ft		8 - 10 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	9.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-2-nitrotoluene, 4-	mg/kg	0.9																																		
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.5													-	-	-	-																		
Dinitrobenzene, 1,3-	mg/kg	6.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.033	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	19	-	-	-	-	-	-	-	-	-	-	-	-	0.052	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	3.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 3,4-	mg/kg	4.5																																		
Nitrobenzene	mg/kg	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	mg/kg	58	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.6		-	-	-	-	-	-	-	-	-	-	0.98		-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	mg/kg	12000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Volatiles																																				
Acetone	mg/kg	0.53			-	-			-	-					-	-	0.18				-	-			-	-					-	-				
Dichloroethene, cis-1,2-	mg/kg	0																																		
Ethylbenzene	mg/kg	0.0013			-	-			-	-					-	-	-	-			-	-			-	-					-	-				
Methylene chloride	mg/kg	0.0088			0.0025	B			0.0026	B					0.0034	B	0.0052	B			-	-			0.0019	B					0.0024	B				
Toluene	mg/kg	0.0038			0.0021	J			-	-					-	-	-	-			0.0022	J			-	-					-	-				
Trichloroethene	mg/kg	0			-	-			-	-					-	-	-	-			-	-			-	-					-	-				
Xylenes, total	mg/kg	0			-	-			-	-					-	-	-	-			-	-			-	-					-	-				
Semivolatiles																																				
Acenaphthylene	mg/kg	0.041			-	-			-	-											-	-			-	-					-	-				
Anthracene	mg/kg	0.23			-	-			-	-											-	-			-	-					-	-				
Benzo(a)anthracene	mg/kg	0.4			-	-			-	-											-	-			-	-					-	-				
Benzo(a)pyrene	mg/kg	0.39			-	-			-	-											-	-			-	-					-	-				
Benzo(b)fluoranthene	mg/kg	0.3			-	-			-	-											-	-			-	-					-	-				
Benzo(ghi)perylene	mg/kg	0.22			-	-			-	-											-	-			-	-					-	-				
Benzo(k)fluoranthene	mg/kg	0.35			-	-			-	-											-	-			-	-					-	-				
Bis(2-ethylhexyl)phthalate	mg/kg	1.07			-	-			-	-											-	-			-	-					-	-				
Chrysene	mg/kg	0.42			-	-			-	-											-	-			-	-					-	-				
Dibenz(a,h)anthracene	mg/kg	0.022			-	-			-	-											-	-			-	-					-	-				
Di-n-butyl phthalate	mg/kg	0.13			-	-			-	-											-	-			-	-					-	-				
Dinitrotoluene, 2,4-	mg/kg	0.043			-	-			-	-											-	-			-	-					-	-				
Fluoranthene	mg/kg	0.76			-	-			-	-											-	-			-	-					-	-				
Fluorene	mg/kg	0.0074			-	-			-	-											-	-			-	-					-	-				
Indeno(1,2,3-cd)pyrene	mg/kg	0.23			-	-			-	-											-	-			-	-					-	-				
Phenanthrene	mg/kg	0.36			-	-			-	-											-	-			-	-					-	-				
Pyrene	mg/kg	0.55			-	-			-	-											-	-			-	-					-	-				
Metals																																				
Aluminum	mg/kg	21000	14300		11100		13800		20600		12400		18400		10700	J	12500	J	11200		9420		12500		10700		8670		21000		6680		18000		17000	
Antimony	mg/kg	7.7	-	-	-	-	-	-	7.4	J	-	-	-	-	0.56	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	mg/kg	23.6	9.3		3.7		7.6		11.4		11		9.5		10.3	J	6.8	J	5.1		11.6		10		5.3		4.1		4.9		2.1		9.4		9.8	
Barium	mg/kg	165	91.4		53.8		165		130		117		118		102	J	94.9	J	61.9		67.7		74.8		61.9		58.8		92.7		26.4		70		83.3	
Beryllium	mg/kg	1.2	0.63	J	-	-	0.64	J	1.2	J	-	-	0.82	J	0.75	B	0.83	B	-	-	-	-	0.74		0.59		-	-	1		-	-	0.83	J	0.75	J
Cadmium	mg/kg	1.6	-	-	-	-	-	-	-	-	-	-	-	-	0.17	B	0.16	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	mg/kg	83900	31400		2480		3480		3760		31700		13300		6430	J	34300	J	1460		2240		2460		7330		4890		39100		1620		2600		34600	
Chromium	mg/kg	35	19.7	J	13	J	12.9	J	25.4	J	15.8	J	22.7	J	16.7	J	19.8	J	14.8	J	15.5	J	19.6	J	15.3	J	13	J	28.6	J	9.1	J	23.3	J	25.1	J
Cobalt	mg/kg	21	13		6.2		16.2		17.1		13		15		14.2	J	11.7	J	11.5		15.5		13.8		11.1		8.1		11.5		-	-	19		14.5	
Copper	mg/kg	35	22.7		9.6		18		30.9		26.2		26.4		22.3		18.8		15.4		19.2		21.7		17.3		14		25.2		5.8		30.6		30.9	
Iron	mg/kg	36000	24700		13400		24500		36000		29200		31100		26100	J	25600	J	19800		26100		26600		18400		15400		26000		10600		32000		30000	
Lead	mg/kg	27	10.7		5.9		13.2		11.4		9.1		10.1		13	J	9.6	J	10.6		9		8.7		9.6		7.6		11		3.4		13.2		11.2	
Magnesium	mg/kg	23400	12200		2010		4220		4870		10100		6970		5590	J	10400	J	2500	J	2530	J	2920	J	4680	J	2860	J	10300	J	1290		4480		14700	
Manganese	mg/kg	3300	781		269		1900		982		1280		1170		1500	J	377	J	207		326		362		453		261		374		184		898		568	
Mercury	mg/kg	0.12	-	-	-	-	-	-	0.04		-	-	-	-	0.021	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	mg/kg	52	32.1		13.6		40.8		46.9		33.9		39.3		37.9	J	30	J	20.5		31.6		31.1		23.5		20.4		35.9		9.8		42.3		37.9	
Potassium	mg/kg	5630	2640	J	1370	J	2070	J	2590	J	1830	J	3240	J	755		2850		898	J	1030	J	1580	J	1270	J	1080	J	5630	J	742	J	2430	J	3960	J
Selenium	mg/kg	0.65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.65		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/kg	1270	-	-	-	-	-	-	681		-	-	726		683		630	J	-	-	858		952		-	-	-	-	-	-	-	-	-	-	-	-
Thallium	mg/kg	1.1	-	-	-	-	-	-	-	-	-	-	-	-	0.71	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	mg/kg	40.5	36.3	J	23.2	J	27.7	J	40.5	J	31	J	40.3	J	23.3	J	23.9	J	19.2		22.1		27.5		23		17.8		37.2		19.8	J	38.9	J	37.3	J
Zinc	mg/kg	187	63.4		45.3		75.7		103		70.9		81.2		74.9	J	57.7	J	65.4		66.1		74.3		60.3		55.2		64.9		28.7		85.1		81.6	
General Chemistry																																				
Alkalinity	mg/kg	830																																		
Cation exchange capacity	mg/kg	5.2																																		
Kjeldahl Nitrogen	mg/kg	2130																																		
Nitrate-Nitrite	mg/kg	150																																		
pH	pH_units	8																																		
Phosphorous	mg/kg	31																																		
Sulfate	mg/kg	3330																																		
Total organic carbon	mg/kg	1990																																		

			Location Code:		WARP-DP20				WRWP-SO001		WRWP-SO002		WRWP-SO003		WRWP-SO004		WRWP-SO005	
			Sample No:		8860		8870		8880		AD0001		AD0002		AD0003		AD0004		AD0005	
			Sample Date:		24-Jun-98		24-Jun-98		24-Jun-98		15-Sep-00		15-Sep-00		15-Sep-00		15-Sep-00		15-Sep-00	
			Sample Depth:		0 - 2 Ft		4 - 6 Ft		8 - 10 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 1.5 Ft	
Parameter	Units	MDC		VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	9.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-2-nitrotoluene, 4-	mg/kg	0.9																		
Amino-4,6-dinitrotoluene, 2-	mg/kg	0.5									-	-	-	-	-	-	-	-	-	-
Dinitrobenzene, 1,3-	mg/kg	6.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	3.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 3,4-	mg/kg	4.5																		
Nitrobenzene	mg/kg	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	mg/kg	0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	mg/kg	58	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	mg/kg	12000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Volatiles																				
Acetone	mg/kg	0.53			-	-														
Dichloroethene, cis-1,2-	mg/kg	0																		
Ethylbenzene	mg/kg	0.0013			-	-														
Methylene chloride	mg/kg	0.0088			0.0024	B														
Toluene	mg/kg	0.0038			0.0015	J														
Trichloroethene	mg/kg	0			-	-														
Xylenes, total	mg/kg	0			-	-														
Semivolatiles																				
Acenaphthylene	mg/kg	0.041			0.04	J			-	-	-	-	-	-	-	-	-	-		
Anthracene	mg/kg	0.23			0.12	J			0.0036		-	-	-	-	-	-	0.001	J		
Benzo(a)anthracene	mg/kg	0.4			0.17	J			0.025		0.049	J	0.0059		0.0036	J	0.0066			
Benzo(a)pyrene	mg/kg	0.39			0.14	J			0.039		0.0074		0.0099		0.0055		0.012			
Benzo(b)fluoranthene	mg/kg	0.3			0.14	J			0.033		0.006		0.0095		0.0048		0.0099			
Benzo(ghi)perylene	mg/kg	0.22			0.076	J			0.016		-	-	-	-	-	-	-	-		
Benzo(k)fluoranthene	mg/kg	0.35			0.11	J			0.019		0.0033		0.0039		0.0026		0.0029			
Bis(2-ethylhexyl)phthalate	mg/kg	1.07			-	-														
Chrysene	mg/kg	0.42			0.17	J			0.026		0.0067		0.0082		0.0047	J	0.0092			
Dibenz(a,h)anthracene	mg/kg	0.022			-	-			0.022		-	-	0.0095	J	-	-	-	-		
Di-n-butyl phthalate	mg/kg	0.13			-	-														
Dinitrotoluene, 2,4-	mg/kg	0.043			-	-														
Fluoranthene	mg/kg	0.76			0.38				0.076		0.017		0.021		0.013		0.026			
Fluorene	mg/kg	0.0074			-	-			-	-	0.006	J	0.0074	J	0.0069	J	-	-		
Indeno(1,2,3-cd)pyrene	mg/kg	0.23			0.076	J			0.029		0.0068		0.0083		0.0046	J	0.0086			
Phenanthrene	mg/kg	0.36			0.25	J			0.032		0.033		0.04		0.04		0.032			
Pyrene	mg/kg	0.55			0.28	J			0.055		0.12		0.015		0.009	J	0.02			
Metals																				
Aluminum	mg/kg	21000	13000		10900		12000													
Antimony	mg/kg	7.7	-	-	-	-	-	-												
Arsenic	mg/kg	23.6	8.5		7		4.6													
Barium	mg/kg	165	66		56.1		80.3													
Beryllium	mg/kg	1.2	-	-	-	-	-	-												
Cadmium	mg/kg	1.6	-	-	-	-	-	-												
Calcium	mg/kg	83900	35600		23500		5120													
Chromium	mg/kg	35	16.7	J	16.1	J	16.9	J												
Cobalt	mg/kg	21	11.9		7.8		10.1													
Copper	mg/kg	35	15.1	B	15.1	B	15.7	B												
Iron	mg/kg	36000	20900		19100		18800													
Lead	mg/kg	27	9.4		7.4		7.4													
Magnesium	mg/kg	23400	9970		8670		3690													
Manganese	mg/kg	3300	551		320		484													
Mercury	mg/kg	0.12	-	-	-	-	-	-												
Nickel	mg/kg	52	19.3		18.6		28.7													
Potassium	mg/kg	5630	2040	J	1350	J	1710	J												
Selenium	mg/kg	0.65	-	-	-	-	-	-												
Sodium	mg/kg	1270	-	-	-	-	619													
Thallium	mg/kg	1.1	-	-	-	-	-	-												
Vanadium	mg/kg	40.5	35	J	29.1	J	24.1	J												
Zinc	mg/kg	187	49.8		48.2		77.5													
General Chemistry																				
Alkalinity	mg/kg	830																		
Cation exchange capacity	mg/kg	5.2																		
Kjeldahl Nitrogen	mg/kg	2130																		
Nitrate-Nitrite	mg/kg	150																		
pH	pH_units	8																		
Phosphorous	mg/kg	31																		
Sulfate	mg/kg	3330																		
Total organic carbon	mg/kg	1990																		

MDC - Maximum detected concentration ("B" qualified data excluded).
mg/kg - Milligrams per kilogram.

Validation Qualifiers (VQ)
B - The analyte was not detected significantly above the levels in the associated method blank or field blanks.
J - The analyte was positively identified; the value is estimated.
N - Compound was tentatively identified; consider present.
* - Duplicate analysis not within control limits.

WARWP - Historical Groundwater Analytical Results
2004 Groundwater Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	IT-MW02							MK-MW09						MK-MW10								MK-MW11									
				Sample No:	5310		5540		5545		PB-WA-IT-MW2		5720		5725		MK01MW09		5240		5730		5735		MK01MW10		5250		5740		5745		MK01MW11		PB-WA-MK-MW11	
				Sample Date:	30-Sep-96		21-Nov-97		15-May-98		13-Dec-94		16-Nov-97		13-May-98		29-Jun-93		27-Sep-96		13-Nov-97		12-May-98		29-Jun-93		27-Sep-96		18-Nov-97		13-May-98		30-Jun-93		9-Dec-94	
Parameter	Units	RBSC	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives - Unfiltered																																				
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	5.1		-	-	-	-	-	-	5.1		-	-	-	-			-	-	-	-	-	-			-	-	-	-	-	-			-	-
Amino-2-nitrotoluene, 4-	ug/L	NE	14								14																								-	-
Amino-4,6-dinitrotoluene, 2-	ug/L	0.73	5.7								0.6																								-	-
Amino-4-nitrotoluene, 2-	ug/L	NE	11								1.7																								-	-
Dinitrobenzene, 1,3-	ug/L	0.37	470		12		17		19		340		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	ug/L	0.099	340		20		47		47		340		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	
Dinitrotoluene, 2,6-	ug/L	0.099	24		2.3		7.8		8.9		24		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 3,4-	ug/L	NE	75								0.5																								-	-
Nitrobenzene	ug/L	0.34	2.5		-	-	-	-	2.5		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 3-	ug/L	12.2	36		-	-	-	-	36		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 4-	ug/L	0.66	2.8								2.8						-	-						-											-	-
RDX	ug/L	0.61	11		11		-	-	6.2				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Trinitrobenzene, 1,3,5-	ug/L	110	570		9.7		14		15		390		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	ug/L	1.83	34		-	-	-	-	-	-	1.4		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Volatiles																																				
Acetone	ug/L	548	5.4		-	-	-	-	2	B			-	-	-	-	-	-	5.4	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Benzene	ug/L	0.35	1.1		-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Carbon disulfide	ug/L	104	1.3		-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.31	J	-	-	-	-		
Chlorobenzene	ug/L	10.6	1.1		-	-	-	-	-	-			-	-	-	-	-	-	1.1	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Chloroform	ug/L	0.17	0.45		-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	0.45	J	-	-	-	-	-	-	-	-	-	-		
Ethylbenzene	ug/L	134	1.6		-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Hexanone, 2-	ug/L	150	NA		-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Methylene chloride	ug/L	4.3	NA		6.1	U	0.41	B	-	-			0.3	B	0.34	B	-	-	5.7	U	-	-	0.69	B	-	-	6.9	U	0.27	B	0.34	B	-	-		
Toluene	ug/L	72	3		-	-	-	-	0.14	B			0.13	B	-	-	-	-	1.1	J	-	-	0.34	B	-	-	-	-	-	-	-	-	-	-		
Trichloroethene	ug/L	0.028	NA		-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Xylenes, total	ug/L	21	14		-	-	-	-	-	-			0.13	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Semivolatiles																																				
Bis(2-ethylhexyl)phthalate	ug/L	4.8	28		-	-	-	-	7.9	B			-	-	-	-	-	-	-	-	11		-	-	-	-	-	-	-	-	-	-	-	-		
Dinitro-2-methylphenol, 4,6-	ug/L	0.37	60		60	J	12	J	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Dinitrophenol, 2,4-	ug/L	7.3	14		-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Dinitrotoluene, 2,4-	ug/L	0.099	110		110	J	43		43				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Dinitrotoluene, 2,6-	ug/L	0.099	16		16	J	7.1	J	6.7	J			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Di-n-octyl phthalate	ug/L	146	2.7		-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Nitroaniline, 2-	ug/L	11	1.5		-	-	1.5	J	1.3	J			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Nitroaniline, 3-	ug/L	3.2	330		4.1	J	-	-	3.3	J			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Nitrobenzene	ug/L	0.34	5.8		-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Nitrophenol, 4-	ug/L	4.9	1.6		-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Pesticides																																				
Endosulfan sulfate	ug/L	NE	0.023		-	-													-	-							-	-								

WARWP - Historical Groundwater Analytical Results
2004 Groundwater Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	IT-MW02								MK-MW09						MK-MW10								MK-MW11							
				Sample No:	5310		5540		5545		PB-WA-IT-MW2		5720		5725		MK01MW09		5240		5730		5735		MK01MW10		5250		5740		5745		MK01MW11		PB-WA-MK-MW11	
				Sample Date:	30-Sep-96		21-Nov-97		15-May-98		13-Dec-94		16-Nov-97		13-May-98		29-Jun-93		27-Sep-96		13-Nov-97		12-May-98		29-Jun-93		27-Sep-96		18-Nov-97		13-May-98		30-Jun-93		9-Dec-94	
Parameter	Units	RBSC	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Unfiltered																																		
Aluminum	ug/L	3,650	16600		431		-	-	-	-			282	B	-	-	2,880		11,100		1,140		-	-	16,600		1,970		5,080		6,810		480			
Arsenic	ug/L	0.045	14		-	-	-	-	-	-	-	-	-	-	-	-	-	-	10		-	-	-	-	14		-	-	-	-	-	-	3		-	-
Barium	ug/L	255	190		-	-	-	-	-	-			-	-	-	-	73.1		-	-	-	-	-	-	155		-	-	-	-	-	-	190			
Cadmium	ug/L	1.8	0.5		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5		-	-	-	-	-	-	-	-	-	-
Calcium	ug/L	NE	497000		151,000		150,000	J	109,000				103,000		78,500		81,000		108,000		99,200	J	74,300		13,900		185,000		161,000		140,000		14,900			
Chromium	ug/L	11	30.7		-	-	-	-	-	-	-	-	-	-	-	-	-	-	24.7		-	-	-	-	22.7		12.1		12.6		15.4		-	-	-	-
Cobalt	ug/L	73	142		68.8		-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Copper	ug/L	146	140		45.1		62.6		30.7		140		-	-	-	-	-	-	31.8		-	-	-	-	48.5		-	-	-	-	-	-	-	-	-	-
Iron	ug/L	1,095	41800		1,120		-	-	595	J			493	B	-	-	4,930		26,500		2,080		-	-	41,800		8,020		12,300		17,000		1,100			
Lead	ug/L	15	43.9		27.7		-	-	-	-	-	-	8.5		-	-	2		43.9		3.5		-	-	23		37.6		9.4		9.1		-	-	-	-
Magnesium	ug/L	NE	181000		65,400		70,500		53,000				27,600		21,100		29,200		34,100		27,600		20,700		44,500		47,100		39,400		35,500		44,300			
Manganese	ug/L	88	2300		1,230		896		754		2,300		-	-	-	-	-	-	412		90.9		-	-	-	-	978		344		477		-	-	160	
Nickel	ug/L	73	228		49.8		-	-	-	-	120		-	-	-	-	-	-	-	-	-	-	-	-	55.6		-	-	-	-	-	-	-	-	-	-
Potassium	ug/L	NE	49000		-	-	-	-	-	-			-	-	-	-	1,640		-	-	-	-	-	-	4,320		-	-	-	-	-	-	2,360			
Selenium	ug/L	18	16.7		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	ug/L	NE	1010000		286,000	J	250,000	J	175,000				6,290		-	-	7,860		-	-	-	-	-	-	5,670		10,600	J	8,430		7,030		11,100			
Thallium	ug/L	0.24	0.5		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	ug/L	3.7	70.5		-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	35.8		-	-	-	-	-	-	-	-		
Zinc	ug/L	1,095	166		32.2		-	-	40.2	B	34		-	-	29	B	30.3		97.4		25.5		25	B	166		45.4		43.5		163		-	-	30	
Metals - Filtered																																		
Aluminum	ug/L	3,650	246		-	-	-	-	-	-			-	-	-	-			-	-	-	-	-	-			-	-	-	-	-	-				
Calcium	ug/L	NE	472000		157,000		147,000		130,000				106,000	J	92,700				82,300		96,700		84,200				159,000		142,000	J	117,000					
Chromium	ug/L	11	12.4		-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-			-	-	-	-	-	-			-	-
Cobalt	ug/L	73	126		72.6		-	-	-	-			-	-	-	-			-	-	-	-	-	-			-	-	-	-	-	-				
Copper	ug/L	146	130		50.2		41.6		-	-	130		-	-	50.7				-	-	-	-	-	-			-	-	-	-	-	-			-	-
Iron	ug/L	1,095	509		-	-	-	-	509				329	B	-	-			-	-	-	-	121				-	-	-	-	-	-				
Lead	ug/L	15	28.4		28.4		-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-			9.7		-	-	-	-			-	-
Magnesium	ug/L	NE	170000		67,500	J	68,000		61,900				28,100		25,500				22,300	J	26,200		22,800				41,400	J	33,300		27,700					
Manganese	ug/L	88	2500		1,190	J	877		969		2,500		-	-	-	-			23.5	J	65.4		-	-			-	-	-	-	-	-			180	
Mercury	ug/L	1.1	0.25		-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-			-	-	-	-	-	-			-	-
Nickel	ug/L	73	199		50.3		-	-	-	-	130		-	-	-	-			-	-	-	-	-	-			-	-	-	-	-	-			-	-
Potassium	ug/L	NE	64500		-	-	-	-	-	-			-	-	-	-			-	-	-	-	-	-			-	-	-	-	-	-				
Selenium	ug/L	18	6		-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-			-	-	-	-	-	-			-	-
Sodium	ug/L	NE	1140000		291,000		244,000		206,000				6,470		5,760				-	-	-	-	-	-			11,300		7,950		7,170					
Zinc	ug/L	1,095	136		71		27.2	J	41.4	B	-	-	-	-	-	-			32		-	-	21.5	B			44.1		-	-	27.3	B			-	-
Water Quality Parameters																																		
Alkalinity	ug/L	NE	650000				550,000		650,000				300,000		270,000						450,000		240,000						590,000		320,000					
Chloride	ug/L	NE	97000				97,000		23,000				5,000		2,000	J					14,000		4,000	J					21,000		18,000	J				
Cyanide, total	ug/L	73	89		26		-	-	16				-	-	-	-			-	-	-	-	-	-			-	-	-	-	38					
Hardness	ug/L	NE	4900000				1,500,000		660,000				370,000		320,000						370,000		290,000						860,000		580,000					
Nitrate	ug/L	1000	62000						-	-	12				200								3,200								4,700				0.2	
Nitrate-Nitrite	ug/L	100	80000				-	-					200								-	-							600							
Sulfate	ug/L	NE	2300000				270,000		260,000				32,000		31,000	J					270,000		21,000	J					54,000		53,000	J				
Total dissolved solids	ug/L	NE	7700000				1,300,000		1,100,000				350,000		370,000						350,000		2,700,000						500,000		430,000					
Total organic carbon	ug/L	NE	970000				41,000		28,000				1,500		1,000	J					1,400		1,000	J					3,100		2,000	J				
Total suspended solids	ug/L	NE	370000				-	-	370,000				5,000		-	-					35,000		74,000						-	-	58,000					

WARWP - Historical Groundwater Analytical Results
2004 Groundwater Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	MK-MW12					PB-BED-MW14								PB-WA-MW1						PB-WA-MW2									
				Sample No:	5750		5755		MK01MW12		5170		5900		5905/5905R		PB-BED-MW14		5110		5670		5675		5120		5680		5685		PB-WA-DM-MW2		PB-WA-DM-MW22	
				Sample Date:	17-Nov-97		14-May-98		30-Jun-93		17-Oct-96		18-Nov-97		16-May-98/18-May-98		14-Dec-94		30-Sep-96		21-Nov-97		18-May-98		30-Sep-96		23-Nov-97		15-May-98		12-Dec-94		12-Dec-94	
Parameter	Units	RBSC	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives - Unfiltered																																		
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	5.1		-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.1		-	-	-	-	4.2		2.6	
Amino-2-nitrotoluene, 4-	ug/L	NE	14														-	-													-	-	-	-
Amino-4,6-dinitrotoluene, 2-	ug/L	0.73	5.7														-	-													5.7		5.2	
Amino-4-nitrotoluene, 2-	ug/L	NE	11														11														4.1		4.4	
Dinitrobenzene, 1,3-	ug/L	0.37	470		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	18		-	-	23		470		400	
Dinitrotoluene, 2,4-	ug/L	0.099	340		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12		-	-	21		320		250	
Dinitrotoluene, 2,6-	ug/L	0.099	24		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.1		12		10	
Dinitrotoluene, 3,4-	ug/L	NE	75														-	-													75		2.6	
Nitrobenzene	ug/L	0.34	2.5		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 3-	ug/L	12.2	36		-	-	-	-	-	-	-	-	-	-	-	-	2.8		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 4-	ug/L	0.66	2.8						-	-							-	-													-	-	-	-
RDX	ug/L	0.61	11		-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-				
Trinitrobenzene, 1,3,5-	ug/L	110	570		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11		-	-	23		550		570	
Trinitrotoluene, 2,4,6-	ug/L	1.83	34		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.4		-	-	-	-	34		26	
Volatiles																																		
Acetone	ug/L	548	5.4		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.9	B				
Benzene	ug/L	0.35	1.1		-	-	-	-	-	-	-	-	1.1		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
Carbon disulfide	ug/L	104	1.3		-	-	-	-	-	-	-	-	1.3		0.25	J	-	-	-	-	0.33	B	-	-	-	-	-	-	-	-				
Chlorobenzene	ug/L	10.6	1.1		-	-	-	-	-	-	1.1	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
Chloroform	ug/L	0.17	0.45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
Ethylbenzene	ug/L	134	1.6		-	-	-	-	-	-	-	-	0.59	J	-	-	1.6		-	-	-	-	-	-	-	-	-	-	-	-				
Hexanone, 2-	ug/L	150	NA		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.9	B				
Methylene chloride	ug/L	4.3	NA		-	-	0.62	B	-	-	-	-	-	-	-	-	-	-	5.3	U	0.33	B	0.52	B	-	-	-	-	0.64	B				
Toluene	ug/L	72	3		-	-	-	-	-	-	1.5	J	1.7	B	-	-	3		-	-	-	-	-	-	-	-	-	-	-	-				
Trichloroethene	ug/L	0.028	NA		-	-	0.32	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
Xylenes, total	ug/L	21	14		-	-	-	-	-	-	2.7	J	3.9		-	-	14		-	-	-	-	-	-	-	-	0.17	B	-	-				
Semivolatiles																																		
Bis(2-ethylhexyl)phthalate	ug/L	4.8	28		28		3.4	B	-	-	1	J	-	-	-	-	-	-	-	-	-	-	3.4	B	-	-	-	-	-	-				
Dinitro-2-methylphenol, 4,6-	ug/L	0.37	60		-	-	-	-	-	-	-	-	-	-	28	NJ	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
Dinitrophenol, 2,4-	ug/L	7.3	14		-	-	-	-	-	-	-	-	-	-	14	J	-	-	-	-	-	-	-	-	-	-	-	-	7.6	J				
Dinitrotoluene, 2,4-	ug/L	0.099	110		-	-	-	-	-	-	1.7	J	-	-	16		-	-	-	-	-	-	-	-	30		-	-	55					
Dinitrotoluene, 2,6-	ug/L	0.099	16		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.8	J	-	-	1.8	J				
Di-n-octyl phthalate	ug/L	146	2.7		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.7	J	-	-	-	-	-	-	-	-				
Nitroaniline, 2-	ug/L	11	1.5		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
Nitroaniline, 3-	ug/L	3.2	330		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	110	J	-	-	330	J				
Nitrobenzene	ug/L	0.34	5.8		-	-	-	-	-	-	-	-	-	-	5.8	J	-	-	-	-	-	-	-	-	-	-	-	-	3.7	J				
Nitrophenol, 4-	ug/L	4.9	1.6		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.6	J				
Pesticides																																		
Endosulfan sulfate	ug/L	NE	0.023						0.023	J	-	-							-	-					-	-								

WARWP - Historical Groundwater Analytical Results
2004 Groundwater Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	MK-MW12				PB-BED-MW14								PB-WA-MW1						PB-WA-MW2									
				Sample No:	5750		5755		MK01MW12		5170		5900		5905/5905R		PB-BED-MW14		5110		5670		5675		5120		5680		5685		PB-WA-DM-MW2		PB-WA-DM-MW22	
				Sample Date:	17-Nov-97		14-May-98		30-Jun-93		17-Oct-96		18-Nov-97		16-May-98/18-May-98		14-Dec-94		30-Sep-96		21-Nov-97		18-May-98		30-Sep-96		23-Nov-97		15-May-98		12-Dec-94		12-Dec-94	
Parameter	Units	RBSC	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Unfiltered																																		
Aluminum	ug/L	3,650	16600		310		-	-	8,280		-	-	374	J	-	-			1,600		2,710	J	-	-	13,400		3,720	J	4,220					
Arsenic	ug/L	0.045	14		-	-	-	-	4		-	-	-	-	-	-	-	-	-	-	-	-	-	-	11		-	-	-	-	-	-	-	-
Barium	ug/L	255	190		-	-	-	-	91.5		-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-					
Cadmium	ug/L	1.8	0.5		-	-	-	-	0.3		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	ug/L	NE	497000		133,000		98,900		14,200		210,000		152,000		99,000				156,000		150,000	J	166,000		394,000		497,000	J	371,000					
Chromium	ug/L	11	30.7		-	-	-	-	18.6		12.3		10.2		-	-	-	-	11.4		-	-	-	-	30.7		12.8		11.4		14		-	-
Cobalt	ug/L	73	142		-	-	-	-	-	-	69.1		-	-	-	-			-	-	-	-	-	-	114		142		118					
Copper	ug/L	146	140		-	-	-	-	9.8		-	-	-	-	-	-	-	-	-	-	-	-	-	-	63.3		70.2		61.9		38		32	
Iron	ug/L	1,095	41800		830		396		28,000		450		923		427	J			4,300		5,600		319	J	26,800		7,930		9,390	J				
Lead	ug/L	15	43.9		-	-	-	-	13		-	-	-	-	-	-	-	-	5.2		4.7	B	-	-	13.2		9.7	B	-	-	10		4	
Magnesium	ug/L	NE	181000		21,900		17,000		29,200		125,000	J	70,700		59,700				65,200		58,100		52,500		143,000		181,000		138,000					
Manganese	ug/L	88	2300		1,130		1,000		-	-	47.5		54		32		-	-	342		235		303		1,540		1,660		1,510		1,600		1,800	
Nickel	ug/L	73	228		-	-	-	-	73.8		68.1		42.3		45.5		-	-	-	-	-	-	-	-	207		228		190		63		47	
Potassium	ug/L	NE	49000		-	-	-	-	6,840		38,300		44,700		49,000				-	-	-	-	-	-	23,700		28,000		20,900					
Selenium	ug/L	18	16.7		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.9		16.7		-	-	-	-	-	-
Sodium	ug/L	NE	1010000		-	-	-	-	6,470		471,000	J	311,000		269,000				15,200	J	14,300	J	12,100		731,000	J	1,010,000	J	914,000					
Thallium	ug/L	0.24	0.5		-	-	-	-	-	-	-	-	-	-	-	-	0.5		-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5	
Vanadium	ug/L	3.7	70.5		-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	70.5		-	-	-	-				
Zinc	ug/L	1,095	166		25.8		25.8	B	79.9		36	UJ	39.8		42.2	B	28		66.3		32.5	B	21.3	B	107		36.7		57.7	B	88		63	
Metals - Filtered																																		
Aluminum	ug/L	3,650	246		-	-	-	-			246		-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-				
Calcium	ug/L	NE	472000		131,000	J	113,000				132,000		120,000		149,000				158,000		136,000		168,000		244,000		472,000		400,000					
Chromium	ug/L	11	12.4		-	-	-	-			11.6		-	-	-	-	-	-	-	-	-	-	-	-	11.9		-	-	12.4		-	-	-	-
Cobalt	ug/L	73	126		-	-	-	-			53.8		-	-	65.4				-	-	-	-	-	-	66.2		-	-	126					
Copper	ug/L	146	130		-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	31.2		-	-	66.9		20		20	
Iron	ug/L	1,095	509		173	B	-	-			-	-	-	-	269				-	-	150	B	-	-	138		-	-	422					
Lead	ug/L	15	28.4		-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.6		-	-	-	-	-	-	-	-
Magnesium	ug/L	NE	170000		21,600		19,400				97,700		82,500		99,900				62,100	J	54,600		55,100		89,300	J	170,000		150,000					
Manganese	ug/L	88	2500		1,060		1,050				25		29.1		32.6		-	-	364	J	163		253		913	J	1,620		2,260		1,000		970	
Mercury	ug/L	1.1	0.25		-	-	-	-			0.25		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	ug/L	73	199		-	-	-	-			53.5		40.7		71.3		-	-	-	-	-	-	-	-	123		-	-	199		60		60	
Potassium	ug/L	NE	64500		-	-	-	-			64,500		40,500		32,400				-	-	-	-	-	-	13,800		-	-	22,900					
Selenium	ug/L	18	6		-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	6		-	-	-	-	-	-	-	-
Sodium	ug/L	NE	1140000		-	-	-	-			346,000	J	360,000		365,000				14,300		13,800		13,500		528,000		1,030,000		1,140,000					
Zinc	ug/L	1,095	136		-	-	26	B			26		32.4		53.9	B	-	-	44.6		-	-	39.9	B	24.5		-	-	136	B	-	-	-	-
Water Quality Parameters																																		
Alkalinity	ug/L	NE	650000		340,000		270,000						210,000		500,000						380,000		470,000				520,000		640,000					
Chloride	ug/L	NE	97000		6,000		1,000	J					79,000		3,000						7,000		7,000				2,000		-	-				
Cyanide, total	ug/L	73	89		-	-	-	-			20		16		44				-	-	-	-	-	-	57		79		89					
Hardness	ug/L	NE	4900000		540,000		450,000						640,000		730,000						4,900,000		940,000				3,300,000		1,500,000					
Nitrate	ug/L	1000	62000				-	-							24,000		3.3						-	-					62,000		15		16	
Nitrate-Nitrite	ug/L	100	80000		-	-							300								-	-					80,000	J						
Sulfate	ug/L	NE	2300000		54,000		51,000	J					610,000		630,000						170,000		200,000				2,300,000		2,000,000					
Total dissolved solids	ug/L	NE	7700000		410,000		400,000						2,500,000		2,300,000						650,000		630,000				7,700,000		6,400,000					
Total organic carbon	ug/L	NE	970000		2,000		2,000	J					190,000		160,000						2,100		3,000				970,000		780,000					
Total suspended solids	ug/L	NE	370000		5,000		-	-					37,000		23,000						-	-	8,000				40,000		160,000					

Shaded cell indicates value is greater than the RBSC.

RBSC - Values reflect an incremental lifetime cancer risk (ILCR) of 1E-6 or a noncancer hazard quotient (HQ) of 0.1. For chemicals that exhibit both cancer and noncancer effects, whichever type of effect results in a lower concentration (using an ILCR of 1E-6 and an HQ of 0.1), that concentration is selected as the RBSC.

MDC - Maximum detected concentration for the AOC ("B" qualified data not included).

"-" - Not detected.

µg/L - Micrograms per liter.

NA - Not applicable; detection is the result of blank contamination.

NE - Not established (RBSCs), not evaluated (BSCs).

Validation Qualifiers (VQ)

J - The analyte was positively identified; the reported value is estimated.

B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.

U - Nondetect due to blank contamination

Table 3-17

PRRWP - Historical Surface Water Analytical Results
2004 Groundwater Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

	Location Code:		MK-PMU3-SW-SD14		MK-PMU3-SW-SD15		MK-PMU3-SW-SD22		PRRP-SW01		PRRP-SW02		PRRP-SW03		PRRP-SW04			
	Sample No:		MK03SW14		MK03SW15		MK03SW22		12160		12170		12180		12190		AC2004	
	Sample Date:		12-Jul-93		12-Jul-93		12-Jul-93		5-Nov-98		5-Nov-98		5-Nov-98		5-Nov-98		14-Sep-00	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Volatiles																		
Acetone	ug/L	NA	-	-	-	-	-	-	2.5	B	1.7	B	2.5	B	1.2	B		
Bromodichloromethane	ug/L	0.72	-	-	-	-	-	-	0.72	J	-	-	-	-	-	-		
Bromomethane	ug/L	0.17	-	-	-	-	-	-	0.17	J	0.11	J	-	-	-	-		
Chloroform	ug/L	NA	-	-	-	-	-	-	3.5	B	0.55	B	-	-	-	-		
Dibromochloromethane	ug/L	0.21	-	-	-	-	-	-	0.21	J	-	-	-	-	-	-		
Semivolatiles																		
Bis(2-ethylhexyl)phthalate	ug/L	NA	-	-	-	-	-	-	-	-	2.1	B	-	-	-	-		
Phenol	ug/L	NA	-	-	-	-	-	-	2.2	B	1.9	B	2.3	B	-	-		
Metals - Unfiltered																		
Aluminum	ug/L	3040	363		363		-	-	778	J	530	J	3040	J	-	-	712	
Barium	ug/L	89.7	68.9		68.9		51.9		-	-	-	-	-	-	-	-	88.6	
Calcium	ug/L	118000	40400		40400		-	-	74200		71700		118000		97900		109000	
Chromium	ug/L	1.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.2	
Cobalt	ug/L	1.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.8	
Copper	ug/L	7.4	-	-	-	-	5.8		-	-	-	-	-	-	-	-	2.4	
Iron	ug/L	5790	1680		1680		-	-	1420		972		5790		948		1220	
Magnesium	ug/L	37300	15600		15600		-	-	16000		15800		37300		36800		26000	
Manganese	ug/L	718	718		718		-	-	245		261		404		67.1		149	
Nickel	ug/L	1.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.7	
Potassium	ug/L	4880	2200		2200		4880		-	-	-	-	-	-	-	-	2330	
Sodium	ug/L	24900	8950		8950		17300		24900		24700		13700		14800		9510	
Vanadium	ug/L	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.2	B
Zinc	ug/L	58	16		16		10.5		-	-	-	-	58		20.2		54.3	J
Metals - Filtered																		
Aluminum	ug/L	10200	-	-	-	-	252		463		874		10200		-	-		
Barium	ug/L	215	59.4		44.1		52.2		-	-	-	-	215		-	-		
Calcium	ug/L	179000	35500		44200		55600		74000		71400		179000		98100			
Chromium	ug/L	17.2	-	-	-	-	-	-	-	-	-	-	17.2		-	-		
Iron	ug/L	16800	250		986		233		809		1260		16800		550			
Lead	ug/L	8.7	-	-	-	-	-	-	-	-	-	-	8.7		-	-		
Magnesium	ug/L	46700	15600		15500		21400		15700		15800		46700		36900			
Manganese	ug/L	720	617		720		217		144		249		649		34.4			
Potassium	ug/L	7130	2100		3850		4880		-	-	-	-	7130		-	-		
Sodium	ug/L	25700	8360		15600		16600		25700		24500		15000		15300			
Vanadium	ug/L	53.9	-	-	-	-	-	-	-	-	-	-	53.9		-	-		
Zinc	ug/L	145	-	-	34.5		-	-	-	-	-	-	145		-	-		
General Chemistry																		
Hardness	ppm	488							328		284		488		432			
Phosphorous	ug/L	120															-	-

Table 3-17

PRRWP - Historical Surface Water Analytical Results
2004 Groundwater Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

			Location Code:	PRWP-SW006		PRWP-SW007		PRWP-SW008		PRWP-SW009		PRWP-SW010	
			Sample No:	AC2006		AC2007		AC2008		AC2009		AC2010	
			Sample Date:	14-Sep-00		14-Sep-00		14-Sep-00		14-Sep-00		14-Sep-00	
Parameter	Units	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Volatiles													
Acetone	ug/L	NA											
Bromodichloromethane	ug/L	0.72											
Bromomethane	ug/L	0.17											
Chloroform	ug/L	NA											
Dibromochloromethane	ug/L	0.21											
Semivolatiles													
Bis(2-ethylhexyl)phthalate	ug/L	NA											
Phenol	ug/L	NA											
Metals - Unfiltered													
Aluminum	ug/L	3040		-	-	137		237		-	-	494	
Barium	ug/L	89.7		74.1		82.5		86.9		83.1		89.7	
Calcium	ug/L	118000		107000		118000		117000		118000		113000	
Chromium	ug/L	1.9		1.1		0.8		0.9		1.9		0.9	
Cobalt	ug/L	1.8		-	-	-	-	-	-	-	-	-	-
Copper	ug/L	7.4		1.8		1.8		1.8		-	-	7.4	
Iron	ug/L	5790		388		364		608		314		1010	
Magnesium	ug/L	37300		24400		27100		27100		27300		26400	
Manganese	ug/L	718		104		106		148		101		147	
Nickel	ug/L	1.7		-	-	-	-	-	-	-	-	-	-
Potassium	ug/L	4880		1870		2100		2190		2110		2090	
Sodium	ug/L	24900		8950		9910		9790		9920		9620	
Vanadium	ug/L	NA		3.6	B	4.1	B	5	B	4.4	B	4.3	B
Zinc	ug/L	58		14	J	13	J	15.2	J	12.1	J	14	J
Metals - Filtered													
Aluminum	ug/L	10200											
Barium	ug/L	215											
Calcium	ug/L	179000											
Chromium	ug/L	17.2											
Iron	ug/L	16800											
Lead	ug/L	8.7											
Magnesium	ug/L	46700											
Manganese	ug/L	720											
Potassium	ug/L	7130											
Sodium	ug/L	25700											
Vanadium	ug/L	53.9											
Zinc	ug/L	145											
General Chemistry													
Hardness	ppm	488											
Phosphorous	ug/L	120		50		66		120		51		86	

MDC - Maximum detected concentration for the AOC ("B" qualified data not included).
NA - Not applicable; detection is the result of blank contamination.
"-" - Not detected.
µg/L - Micrograms per liter.

Validation Qualifiers (VQ)
B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.
J - The analyte was positively identified; the reported value is estimated.

Table 3-18

PRRWP - Historical Sediment Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

			Location Code:		MK-PMU3-SW-SD15		MK-PMU3-SW-SD22		PRRP-SD01		PRRP-SD02		PRRP-SD03		PRRP-SD04	
			Sample No:		MK03SD15		MK03SD22		11160		11170		11180		11190	
			Sample Date:		12-Jul-93		12-Jul-93		5-Nov-98		5-Nov-98		5-Nov-98		5-Nov-98	
			Sample Depth:		0 - 1 Ft		0 - 1 Ft		0 - 0.5 Ft		0 - 0.5 Ft		0 - 0.5 Ft		0 - 0.5 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Volatiles																
Acetone	mg/kg	0.066	0.017		0.066		-	-	0.051	J	-	-	0.049	J	0.017	B
Bromomethane	mg/kg	NA	-	-	-	-	-	-	0.0052	B	-	-	-	-	-	-
Butanone, 2-	mg/kg	0.011	0.002	J	-	-	-	-	0.011	J	-	-	0.01	J	-	-
Chloroform	mg/kg	0.002	-	-	0.002	J	-	-	-	-	-	-	-	-	-	-
Methylene chloride	mg/kg	NA	-	-	-	-	-	-	0.013	B	0.0056	B	0.0069	B	0.0059	B
Toluene	mg/kg	0.002	0.002	J	-	-	-	-	-	-	-	-	-	-	-	-
Semivolatiles																
Acenaphthene	mg/kg	0.11	-	-	-	-	-	-	-	-	0.11	J	-	-	-	-
Anthracene	mg/kg	0.077	-	-	-	-	0.017	J	-	-	0.077	J	-	-	0.029	J
Benzo(a)anthracene	mg/kg	0.084	-	-	-	-	0.067	J	-	-	-	-	-	-	0.084	J
Benzo(a)pyrene	mg/kg	0.096	-	-	-	-	0.054	J	-	-	-	-	-	-	0.096	J
Benzo(b)fluoranthene	mg/kg	0.1	-	-	-	-	0.065	J	-	-	-	-	-	-	0.1	J
Benzo(ghi)perylene	mg/kg	0.053	-	-	-	-	0.037	J	-	-	-	-	-	-	0.053	J
Benzo(k)fluoranthene	mg/kg	0.084	-	-	-	-	0.026	J	-	-	-	-	-	-	0.084	J
Bis(2-ethylhexyl)phthalate	mg/kg	0.57	0.57		-	-	0.18	J	-	-	-	-	-	-	-	-
Carbazole	mg/kg	0.18							-	-	0.18	J	-	-	-	-
Chrysene	mg/kg	0.11	-	-	-	-	0.07	J	-	-	-	-	-	-	0.11	J
Dibenzofuran	mg/kg	0.06	-	-	-	-	-	-	-	-	0.06	J	-	-	-	-
Fluoranthene	mg/kg	0.23	-	-	-	-	0.082	J	-	-	0.14	J	-	-	0.23	J
Fluorene	mg/kg	0.11	-	-	-	-	-	-	-	-	0.11	J	-	-	-	-
Indeno(1,2,3-cd)pyrene	mg/kg	0.054	-	-	-	-	-	-	-	-	-	-	-	-	0.054	J
Phenanthrene	mg/kg	0.32	-	-	-	-	0.064	J	-	-	0.32	J	-	-	0.12	J
Pyrene	mg/kg	0.19	-	-	-	-	0.098	J	-	-	0.11	J	-	-	0.16	J

Table 3-18

PRRWP - Historical Sediment Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

			Location Code:		MK-PMU3-SW-SD14		MK-PMU3-SW-SD15		MK-PMU3-SW-SD22		PRRP-SD01		PRRP-SD02		PRRP-SD03		PRRP-SD04	
			Sample No:		MK03SD14		MK03SD15		MK03SD22		11160		11170		11180		11190	
			Sample Date:		12-Jul-93		12-Jul-93		12-Jul-93		5-Nov-98		5-Nov-98		5-Nov-98		5-Nov-98	
			Sample Depth:		0 - 1 Ft		0 - 1 Ft		0 - 1 Ft		0 - 0.5 Ft		0 - 0.5 Ft		0 - 0.5 Ft		0 - 0.5 Ft	
Parameter	Units	MDC		VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals																		
Aluminum	mg/kg	8420			2160		6510		-	-	6020		2830		5130		3400	
Arsenic	mg/kg	10			2.5		4.7		10		4.5		5.1		4.3		4.4	
Barium	mg/kg	100			17.3		83.3		-	-	53.4		-	-	48.1		30.9	
Cadmium	mg/kg	0.39			0.07		0.39		0.26		-	-	-	-	-	-	-	-
Calcium	mg/kg	96000			19900		7910		-	-	96000		46300		62000		8110	
Chromium	mg/kg	13.8			3.7		10.9		-	-	11.5		6.3		10.4		6.8	
Cobalt	mg/kg	10.8			3.8		10.8		-	-	-	-	-	-	-	-	-	-
Copper	mg/kg	19.6		-	-	-	-		11.2		17.9		7.6		14.5		7.4	
Iron	mg/kg	19800			5420		15900		-	-	16200		9620		13700		9330	
Lead	mg/kg	12.8			3.2		10.5		-	-	12.8		4.8		7.8		5.6	
Magnesium	mg/kg	19300			7090		2330		-	-	10700		19300		13500		2710	
Manganese	mg/kg	1050			288		379		-	-	865		421		404		104	
Nickel	mg/kg	46.3			9.5		25		46.3		18.6		9.5		17.9		10.4	
Potassium	mg/kg	2480			372		629		-	-	-	-	-	-	1040		-	-
Selenium	mg/kg	0.98		-	-		0.98		-	-	-	-	-	-	-	-	-	-
Sodium	mg/kg	312			206		312		168		-	-	-	-	-	-	-	-
Vanadium	mg/kg	23.5			6.9		17.4		-	-	17.4		12.9		14.2		7.9	
Zinc	mg/kg	135			36.3		101		76.5		73.3		23.2		58.4		42.1	
General Chemistry																		
Phosphorous	mg/kg	138																
Total organic carbon	mg/kg	33000									33000		5450		17000		12000	J

Table 3-18

PRRWP - Historical Sediment Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

	Location Code:		PRWP-SD001		PRWP-SD002		PRWP-SD003		PRWP-SD004		PRWP-SD005	
	Sample No:		AC1001		AC1002		AC1003		AC1004		AC1005	
	Sample Date:		15-Sep-00		15-Sep-00		15-Sep-00		15-Sep-00		15-Sep-00	
	Sample Depth:		0 - 0 Ft		0 - 0.5 Ft		0 - 0.5 Ft		0 - 0.5 Ft		0 - 0.5 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Volatiles												
Acetone	mg/kg	0.066										
Bromomethane	mg/kg	NA										
Butanone, 2-	mg/kg	0.011										
Chloroform	mg/kg	0.002										
Methylene chloride	mg/kg	NA										
Toluene	mg/kg	0.002										
Semivolatiles												
Acenaphthene	mg/kg	0.11	-	-	-	-	-	-	-	-	-	-
Anthracene	mg/kg	0.077	-	-	-	-	-	-	-	-	-	-
Benzo(a)anthracene	mg/kg	0.084	0.067	J	-	-	-	-	-	-	-	-
Benzo(a)pyrene	mg/kg	0.096	0.082	J	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	mg/kg	0.1	0.1	J	-	-	-	-	-	-	-	-
Benzo(ghi)perylene	mg/kg	0.053	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	mg/kg	0.084	0.068	J	-	-	-	-	-	-	-	-
Bis(2-ethylhexyl)phthalate	mg/kg	0.57	-	-	-	-	-	-	-	-	-	-
Carbazole	mg/kg	0.18	-	-	-	-	-	-	-	-	-	-
Chrysene	mg/kg	0.11	0.1	J	-	-	-	-	-	-	-	-
Dibenzofuran	mg/kg	0.06	-	-	-	-	-	-	-	-	-	-
Fluoranthene	mg/kg	0.23	0.14	J	-	-	-	-	-	-	-	-
Fluorene	mg/kg	0.11	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-cd)pyrene	mg/kg	0.054	-	-	-	-	-	-	-	-	-	-
Phenanthrene	mg/kg	0.32	0.096	J	-	-	-	-	-	-	-	-
Pyrene	mg/kg	0.19	0.19	J	-	-	-	-	-	-	-	-

Table 3-18

PRRWP - Historical Sediment Analytical Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

			Location Code:		PRWP-SD001		PRWP-SD002		PRWP-SD003		PRWP-SD004		PRWP-SD005	
			Sample No:		AC1001		AC1002		AC1003		AC1004		AC1005	
			Sample Date:		15-Sep-00		15-Sep-00		15-Sep-00		15-Sep-00		15-Sep-00	
			Sample Depth:		0 - 0 Ft		0 - 0.5 Ft		0 - 0.5 Ft		0 - 0.5 Ft		0 - 0.5 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals												
Aluminum	mg/kg	8420	6520		5570		8420		5840		6880	
Arsenic	mg/kg	10	5.7		5.6		5		6.3		7.7	
Barium	mg/kg	100	100		63.3		62.5		55.1		49	
Cadmium	mg/kg	0.39										
Calcium	mg/kg	96000	93400		44500		48700		39400		27500	
Chromium	mg/kg	13.8	12.6		10.1		13.8		10.3		12.2	
Cobalt	mg/kg	10.8	6.7		6.2		8.8		7		6.7	
Copper	mg/kg	19.6	17.2		14.8		19.6		13.9		13.7	
Iron	mg/kg	19800	15500		13700		19800		15800		18100	
Lead	mg/kg	12.8	9.8	J	9.4	J	9.5	J	7.2	J	9	J
Magnesium	mg/kg	19300	11200		9140		15900		12400		6920	
Manganese	mg/kg	1050	491		310		461		361		1050	
Nickel	mg/kg	46.3	16.2	J	15.1	J	22.9	J	17.1	J	16.6	J
Potassium	mg/kg	2480	1530	B	1170	B	2480	J	1650	J	1520	B
Selenium	mg/kg	0.98										
Sodium	mg/kg	312	158		113		174		138		118	
Vanadium	mg/kg	23.5	19.3	B	16.5	B	23.5	B	19.9	B	22.3	B
Zinc	mg/kg	135	130		135		47.8		36.2		50.5	
General Chemistry												
Phosphorous	mg/kg	138	138		-	-	-	-	-	-	87.4	
Total organic carbon	mg/kg	33000	24800		25900		9040		5190		10400	

MDC - Maximum detected concentration for the AOC ("B" qualified data excluded).
"-" - Not detected.
Ft - Feet.
mg/kg - Milligrams per kilogram.
PCB - Polychlorinated biphenyl

Validation Qualifiers (VQ)
B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.
J - The analyte was positively identified; the reported value is estimated.

Table 3-19

PRRWP - Historical Soil Analytical Results
2004 Groundwater Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

	Location Code:		PRRP-DP01						PRRP-DP02						PRRP-DP03							
	Sample No:		7200		7210		7220		7240R		7250		7260		7280		7290		BD0001		BD0002	
	Sample Date:		11-Jun-98		11-Jun-98		11-Jun-98		22-Jun-98		14-Jun-98		14-Jun-98		8-Jun-98		8-Jun-98		27-Sep-01		27-Sep-01	
	Sample Depth:		0 - 2 Ft		4 - 6 Ft		8 - 10 Ft		0 - 2 Ft		4 - 6 Ft		8 - 10 Ft		0 - 2 Ft		4 - 5 Ft		4.3 - 4.8 Ft		11 - 12 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																						
Amino-2,6-dinitrotoluene, 4-	mg/kg	2.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	1.1																	-	-	-	-
Dinitrobenzene, 1,3-	mg/kg	9.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9.3		4.6		0.064	J
Dinitrotoluene, 2,4-	mg/kg	26	-	-	0.96		0.29		-	-	-	-	0.28		1.2		25		14		0.48	
Dinitrotoluene, 2,6-	mg/kg	2.9	-	-	0.35		-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.48	
Trinitrobenzene, 1,3,5-	mg/kg	43	-	-	0.56		2.7		-	-	-	-	-	-	-	-	43		31		1	
Trinitrotoluene, 2,4,6-	mg/kg	1.4	-	-	-	-	-	-	-	-	-	-	0.38		-	-	-	-	-	-	-	-
Volatiles																						
Acetone	mg/kg	0.34	-	-									-	-			-	-	0.34	J	0.014	B
Carbon disulfide	mg/kg	0.0029	-	-									-	-			-	-	-	-	0.0029	J
Methylene chloride	mg/kg	0.002	-	-									-	-			-	-	0.0083	B	0.0079	B
Toluene	mg/kg	0.0017	-	-									-	-			-	-	0.00077	J	0.00078	J
Semivolatiles																						
Dinitrotoluene, 2,4-	mg/kg	8.8	-	-									0.081	J			8.8					
Dinitrotoluene, 2,6-	mg/kg	0.58	-	-									-	-			0.58	J				
Nitroaniline, 3-	mg/kg	0.053	-	-									-	-			-	-				
Metals																						
Aluminum	mg/kg	13500	9370		11500		10100		9210		11200		11500		6330		9580		8820		9820	
Antimony	mg/kg	9.3	-	-	7.9	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.55	J
Arsenic	mg/kg	42.8	4.5	J	27.9	J	9.1	J	5		6.1		12.5		5.4		9.7		5.4		9	
Barium	mg/kg	239	84.3		239		88.5		45.1		61.5		91.9		65.7		67.9		63.6		76.5	
Beryllium	mg/kg	0.83	0.69		0.71		-	-	-	-	0.68		-	-	-	-	-	-	0.62		0.67	
Cadmium	mg/kg	0.63	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.13	J	0.38	J
Calcium	mg/kg	70400	5740		35300		35600		10300		3670		7720		2560		2600		2090		58200	
Chromium	mg/kg	21.8	14.7		9		17.7		13.3	J	20.4		20.8		8.7		15.7		13.7		16.2	
Cobalt	mg/kg	30.3	11.1		21.2		11.6		6.6		11.2		13.6		-	-	6.3		5.2	J	12.7	
Copper	mg/kg	34.5	22.6		34.5		23.3		12.6		14.5		25.8		8.4		18.7		10.2		25.3	
Iron	mg/kg	43700	18000		34500		22500		14300		21900		23800		14100		23700		16600		24900	
Lead	mg/kg	14.7	8.6		13.2		10.4		12.3	J	7.8		12.2		9.3	J	11.6	J	9.1		12.7	
Magnesium	mg/kg	25300	2480		12500		13900		5150		2590		5650		1160		2810		2030		18100	
Manganese	mg/kg	2270	321		2230		706		234		315		521		320		338		270	J	587	J
Mercury	mg/kg	0.045	-	-	-	-	-	-	0.04		0.045		-	-	-	-	-	-	0.023	B	-	-
Nickel	mg/kg	57.2	27.2		57.2		32.5		14.6		25.6		32.2		9.3		22.9		15.6		30.4	
Potassium	mg/kg	2730	777		2330		1790		1460	J	916		1630		-	-	968		591	J	2170	
Selenium	mg/kg	1.1	0.84		-	-	-	-	-	-	0.69		0.82		0.59		-	-	-	-	-	-
Sodium	mg/kg	5170	1240		1080		1050		-	-	-	-	-	-	-	-	3760		2930		2660	
Thallium	mg/kg	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.62	B
Vanadium	mg/kg	38.4	19.1		30		26.6		23.1		27.3	J	26.2	J	17.3	J	23.9	J	22.3		23.3	
Zinc	mg/kg	104	78.5		83.1		65.9		45.5		64.6		70.3		34.2		61.3		43.2		65.8	

Table 3-19

PRRWP - Historical Soil Analytical Results
2004 Groundwater Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

	Location Code:		PRRP-DP04						PRRP-DP05						PRRP-DP06					
	Sample No:		7320		7330		7340		7360R		7370		7380R		7400		7410		7420	
	Sample Date:		9-Jun-98		9-Jun-98		9-Jun-98		25-Jun-98		14-Jun-98		25-Jun-98		8-Jun-98		8-Jun-98		8-Jun-98	
	Sample Depth:		0 - 2 Ft		4 - 6 Ft		8 - 10 Ft		0 - 2 Ft		4 - 6 Ft		8 - 10 Ft		0 - 2 Ft		4 - 5 Ft		9 - 10 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	2.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	1.1																		
Dinitrobenzene, 1,3-	mg/kg	9.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.1	
Dinitrotoluene, 2,6-	mg/kg	2.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	mg/kg	43	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.8	
Trinitrotoluene, 2,4,6-	mg/kg	1.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Volatiles																				
Acetone	mg/kg	0.34	-	-											-	-				
Carbon disulfide	mg/kg	0.0029	-	-											-	-				
Methylene chloride	mg/kg	0.002	-	-											-	-				
Toluene	mg/kg	0.0017	-	-											-	-				
Semivolatiles																				
Dinitrotoluene, 2,4-	mg/kg	8.8	-	-											-	-				
Dinitrotoluene, 2,6-	mg/kg	0.58	-	-											-	-				
Nitroaniline, 3-	mg/kg	0.053	-	-											-	-				
Metals																				
Aluminum	mg/kg	13500	7030		6990		8040		6820		11300		9040		6110		8710		7260	
Antimony	mg/kg	9.3	-	-	-	-	-	-	-	-	9.3		-	-	-	-	-	-	-	-
Arsenic	mg/kg	42.8	6.6		5.4		5.2		2.9		42.8		17.6		3.6		9.1		5.3	
Barium	mg/kg	239	37.2		39.4		50.5		27.6		128		115		-	-	57.3		44.9	
Beryllium	mg/kg	0.83	-	-	-	-	-	-	-	-	0.67		-	-	-	-	-	-	-	-
Cadmium	mg/kg	0.63	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	mg/kg	70400	2680		19800		61200		1490		58500		57800		945		62300		43700	
Chromium	mg/kg	21.8	15.5		12.4		14.1		9.3		18.4		14.4		10.9		15.9		14.4	
Cobalt	mg/kg	30.3	-	-	7.4		9.8		-	-	19		10.2		-	-	-	-	-	-
Copper	mg/kg	34.5	7		13.3		23.6		4.9		24.6		19.7		5.9		26.2		15.2	
Iron	mg/kg	43700	16700		13900		18200		9170		43700		22700		13700		24200		15300	
Lead	mg/kg	14.7	4.3	J	9.8	J	10.3	J	5.5		10.6		8		3.5	J	11.3	J	7.6	J
Magnesium	mg/kg	25300	1290		10700		19500		1010		17400		17100		885		16000		12600	
Manganese	mg/kg	2270	144		292		327		127	J	797		731	J	166		430		321	
Mercury	mg/kg	0.045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	mg/kg	57.2	12.2		16.6		25.9		7.4		40.1		23.8		9.4		22.9		17.6	
Potassium	mg/kg	2730	-	-	864		1580		-	-	2250		2190		-	-	1380		1190	
Selenium	mg/kg	1.1	-	-	0.64		1.1		-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/kg	5170	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium	mg/kg	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	mg/kg	38.4	28.5	J	19.7	J	23.7	J	16.3	J	38.4	J	25.4	J	23.1	J	27.1	J	21.8	J
Zinc	mg/kg	104	30.6		43.7		56.9		24.9		104		52.1		22.6		68.9		45.5	

Table 3-19

PRRWP - Historical Soil Analytical Results
2004 Groundwater Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

	Location Code:		PRRP-DP07						PRRP-DP08						PRRP-DP09					
	Sample No:		7440		7450		7460		7480		7490		7500		7520R		7530R		7540R	
	Sample Date:		9-Jun-98		9-Jun-98		9-Jun-98		10-Jun-98		10-Jun-98		10-Jun-98		25-Jun-98		25-Jun-98		25-Jun-98	
	Sample Depth:		0 - 2 Ft		4 - 6 Ft		8 - 10 Ft		0 - 2 Ft		4 - 6 Ft		8 - 10 Ft		0 - 2 Ft		4 - 6 Ft		8 - 10 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	2.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	1.1																		
Dinitrobenzene, 1,3-	mg/kg	9.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	mg/kg	43	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.3	
Trinitrotoluene, 2,4,6-	mg/kg	1.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Volatiles																				
Acetone	mg/kg	0.34			0.0082	J			-	-							-	-		
Carbon disulfide	mg/kg	0.0029			-	-			-	-							-	-		
Methylene chloride	mg/kg	0.002			-	-			-	-							-	-		
Toluene	mg/kg	0.0017			-	-			-	-							0.0017	J		
Semivolatiles																				
Dinitrotoluene, 2,4-	mg/kg	8.8			-	-			-	-							0.056	J		
Dinitrotoluene, 2,6-	mg/kg	0.58			-	-			-	-							-	-		
Nitroaniline, 3-	mg/kg	0.053			-	-			-	-							-	-		
Metals																				
Aluminum	mg/kg	13500	4120		8560		7960		4450		8700		7140		7220		4410		4630	
Antimony	mg/kg	9.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	mg/kg	42.8	2.5		6.3		6.5		4.2		12.9		4.2		2.4		2.6		6.3	
Barium	mg/kg	239	-	-	55.3		54.5		-	-	42.5		47.4		24.3		-	-	26.5	
Beryllium	mg/kg	0.83	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	mg/kg	0.63	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	mg/kg	70400	1420		62800		62000		1820		57000		52200		1750		63200		58500	
Chromium	mg/kg	21.8	6.1		14.3		13		10.6		14.6		12.6		8.8		9.2		8.7	
Cobalt	mg/kg	30.3	-	-	13.1		9.8		6		9.8		7.9		-	-	-	-	-	-
Copper	mg/kg	34.5	4.3		20.3		23.9		6.5		21.7		16.5		4.9		11.2		15.1	
Iron	mg/kg	43700	8330		17500		20000		13400		19400		16000		8430		9480		10600	
Lead	mg/kg	14.7	3.2	J	10.3	J	10.9	J	3.1	J	9.2	J	7.6	J	5.1		4.9		6.3	
Magnesium	mg/kg	25300	830		19100		19200		894		16800		15700		1110		16800		16900	
Manganese	mg/kg	2270	116		536		520		207		283		393		102	J	184	J	273	J
Mercury	mg/kg	0.045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	mg/kg	57.2	7		29.7		26.1		7.9		25.7		19.6		6.3		8.4		15.5	
Potassium	mg/kg	2730	-	-	1720		1660		-	-	1820		1580		-	-	1050		1200	
Selenium	mg/kg	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.87	
Sodium	mg/kg	5170	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium	mg/kg	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	mg/kg	38.4	12.9	J	24.4	J	22.9	J	24.4	J	24.1	J	21.3	J	15.8	J	20.9	J	17.5	J
Zinc	mg/kg	104	17.9		54.7		61.9		21.7		64.8		46.6		22.5		24.8		35.5	

Table 3-19

PRRWP - Historical Soil Analytical Results
2004 Groundwater Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

			PRRP-DP10										PRRP-DP11									
Location Code:			PRRP-DP10										PRRP-DP11									
Sample No:			7560		7570		7580		BD0003		BD0004		7600		7610		7620		BD0005		BD0006	
Sample Date:			10-Jun-98		10-Jun-98		10-Jun-98		26-Sep-01		26-Sep-01		13-Jun-98		13-Jun-98		13-Jun-98		26-Sep-01		26-Sep-01	
Sample Depth:			0		4 - 5 Ft		9 - 10 Ft		8.4 - 8.9 Ft		10.5 - 12 Ft		0 - 2 Ft		4 - 6 Ft		8 - 10 Ft		2.6 - 3.1 Ft		11 - 12 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																						
Amino-2,6-dinitrotoluene, 4-	mg/kg	2.7	-	-	-	-	-	-	-	-	-	-	2.7		-	-	-	-	1.1		0.27	
Amino-4,6-dinitrotoluene, 2-	mg/kg	1.1							-	-	-	-							1.1		0.16	J
Dinitrobenzene, 1,3-	mg/kg	9.3	-	-	-	-	5.2		3.3		9.3		-	-	0.43		5.8		0.062	J	1.1	
Dinitrotoluene, 2,4-	mg/kg	26	-	-	-	-	15		12		26		0.32		1.6		1.2		1.3		0.91	
Dinitrotoluene, 2,6-	mg/kg	2.9	-	-	-	-	1.7		1.3		2.9		-	-	0.29		0.3		0.57		0.25	
Trinitrobenzene, 1,3,5-	mg/kg	43	-	-	-	-	18		18		25		-	-	0.43		7		0.2	J	5.2	
Trinitrotoluene, 2,4,6-	mg/kg	1.4	-	-	-	-	-	-	-	-	-	-	0.27		-	-	-	-	1.4		0.23	J
Volatiles																						
Acetone	mg/kg	0.34	-	-					0.016	B	0.01	B	-	-					0.015	B	0.018	B
Carbon disulfide	mg/kg	0.0029	-	-					-	-	-	-	-	-					-	-	-	-
Methylene chloride	mg/kg	0.002	-	-					0.0051	B	0.0061	B	-	-					0.0057	B	0.007	B
Toluene	mg/kg	0.0017	-	-					0.00089	J	0.0011	J	-	-					0.00081	J	0.00098	J
Semivolatiles																						
Dinitrotoluene, 2,4-	mg/kg	8.8	-	-									0.16	J								
Dinitrotoluene, 2,6-	mg/kg	0.58	-	-									0.05	J								
Nitroaniline, 3-	mg/kg	0.053	-	-									-	-								
Metals																						
Aluminum	mg/kg	13500	4620		9510		11600		10700	J	13500	J	6200		8950		11200		8410	J	7960	J
Antimony	mg/kg	9.3	-	-	-	-	-	-	0.6	J	0.71	J	-	-	-	-	-	-	-	-	-	-
Arsenic	mg/kg	42.8	3.4		5.6		14.9		11.6	J	18.3	J	7		25.3		5.3		4.7	J	6.7	J
Barium	mg/kg	239	-	-	81.5		90.9		112		103		39.4		209		51.5		51.4		54	
Beryllium	mg/kg	0.83	-	-	0.83		0.77		0.76	B	0.9	B	-	-	0.66		-	-	0.55	B	0.57	B
Cadmium	mg/kg	0.63	-	-	-	-	-	-	0.16	J	0.45	J	-	-	-	-	-	-	0.18	B	0.34	B
Calcium	mg/kg	70400	2440		4620		4510		5700	J	14200	J	17300		3380		61600		8830	J	38600	J
Chromium	mg/kg	21.8	10.9		12.6		20.1		17.4	J	21.8	J	11.2		11		19		13	J	13.5	J
Cobalt	mg/kg	30.3	-	-	-	-	10.2		7.6	J	10.9	J	7.4		30.3		10.8		5.5	J	9.4	J
Copper	mg/kg	34.5	5.9		17.5		22.1		19.5		27.8		10.1		13.1		23.3		9.9		20.7	
Iron	mg/kg	43700	13700		16100		28700		25200	J	32700	J	14700		36200		20800		14300	J	18700	J
Lead	mg/kg	14.7	3.2	J	11.3	J	14.3	J	14.7	J	14.3	J	7.9		9.8		9.9		9.2	J	10.2	J
Magnesium	mg/kg	25300	920		2090		3970		3220	J	8860	J	6390		2500		20500		3790	J	13800	J
Manganese	mg/kg	2270	273		230		484		474	J	710	J	365		1640		457		309	J	413	J
Mercury	mg/kg	0.045	-	-	-	-	-	-	0.014	B	0.025	B	-	-	-	-	-	-	0.015	B	0.013	B
Nickel	mg/kg	57.2	9.6		11.4		30		24.9	J	35.7	J	14.4		26.8		30.1		14.1	J	25.2	J
Potassium	mg/kg	2730	-	-	-	-	1080		739		1800		849		1060		2580		759		1540	
Selenium	mg/kg	1.1	-	-	0.71		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/kg	5170	-	-	4130		4280		3500	J	5170	J	741		1200		1520		1250	J	1480	J
Thallium	mg/kg	1.1	-	-	-	-	-	-	0.78	B	1.1	J	-	-	-	-	-	-	-	-	0.8	J
Vanadium	mg/kg	38.4	23.6	J	22.1	J	31.6	J	29.1	J	31.5	J	20.1	J	34.2	J	31	J	16.7	J	19.8	J
Zinc	mg/kg	104	24.4		49.7		72.7		56.2	J	84.4	J	39.1		68.5		62.2		48.2	J	64.2	J

Table 3-19

PRRWP - Historical Soil Analytical Results
2004 Groundwater Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

Location Code:			PRRP-DP12						PRRP-DP13						PRRP-DP14					
Sample No:			7640		7650		7660		7680		7690		7700		7720		7730		7740	
Sample Date:			11-Jun-98		11-Jun-98		11-Jun-98		12-Jun-98		12-Jun-98		12-Jun-98		11-Jun-98		11-Jun-98		11-Jun-98	
Sample Depth:			0 - 2 Ft		4 - 6 Ft		8 - 10 Ft		0 - 2 Ft		4 - 6 Ft		8 - 10 Ft		0 - 2 Ft		4 - 6 Ft		8 - 10 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	2.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	1.1																		
Dinitrobenzene, 1,3-	mg/kg	9.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	mg/kg	43	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	mg/kg	1.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Volatiles																				
Acetone	mg/kg	0.34			-	-							-	-	-	-				
Carbon disulfide	mg/kg	0.0029			-	-							-	-	-	-				
Methylene chloride	mg/kg	0.002			-	-							-	-	-	-				
Toluene	mg/kg	0.0017			-	-							-	-	-	-				
Semivolatiles																				
Dinitrotoluene, 2,4-	mg/kg	8.8			-	-							-	-	-	-				
Dinitrotoluene, 2,6-	mg/kg	0.58			-	-							-	-	-	-				
Nitroaniline, 3-	mg/kg	0.053			-	-							-	-	-	-				
Metals																				
Aluminum	mg/kg	13500	9560		12000		12300		7760		6380		5930		12700		9640		8710	
Antimony	mg/kg	9.3	-	-	-	-	7.8	J	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	mg/kg	42.8	7.3	J	5.7	J	7.4	J	3.4		5.3		4.1		7.4		8.2		8.1	
Barium	mg/kg	239	71.5		60.3		69.5		-	-	29.2		42.4		49.6		39		64.8	
Beryllium	mg/kg	0.83	0.68		-	-	-	-	-	-	-	-	-	-	0.69		-	-	-	-
Cadmium	mg/kg	0.63	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	mg/kg	70400	4310		37100		55600		-	-	2100		67100		3010		4340		53400	
Chromium	mg/kg	21.8	14		19.7		20		9.4		11.3		10.7		20.2		17.4		15.9	
Cobalt	mg/kg	30.3	6.4		10.8		12		-	-	7		7.2		8.3		8.4		10.3	
Copper	mg/kg	34.5	10.4		26.7		25.4		6.5		13.7		16.2		14.7		14.3		21.1	
Iron	mg/kg	43700	16000		22300		23200		11200		15400		13000		22900		20100		18700	
Lead	mg/kg	14.7	9.6		10.7		10.6		4.1		5.1		7.7		6.8		6.5		9.6	
Magnesium	mg/kg	25300	1900		16600		19100		938		1560		25300		2310		2940		21100	
Manganese	mg/kg	2270	337		306		521		74.5		313		472		173		275		506	
Mercury	mg/kg	0.045	-	-	-	-	-	-	-	-	-	-	-	-	0.043		-	-	-	-
Nickel	mg/kg	57.2	12.1		31.6		30.9		8.4		20.2		19.4		20.5		19.4		26.5	
Potassium	mg/kg	2730	684		2430		2730		-	-	-	-	1330		771		713		1850	
Selenium	mg/kg	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/kg	5170	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium	mg/kg	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	mg/kg	38.4	23.7		26.8		29.9		19.8		19.1		21		35.2		27		25.2	
Zinc	mg/kg	104	38.5		71.9		65.3		23.1		40.6		43.7		46.1		41.2		57.3	

Table 3-19

PRRWP - Historical Soil Analytical Results
2004 Groundwater Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

	Location Code:		PRRP-DP15						PRRP-DP16						PRRP-DP17					
	Sample No:		7760		7770		7780		7800		7810		7820		7840		7850		7860	
	Sample Date:		12-Jun-98		12-Jun-98		12-Jun-98		12-Jun-98		12-Jun-98		12-Jun-98		10-Jun-98		10-Jun-98		10-Jun-98	
	Sample Depth:		0 - 2 Ft		4 - 6 Ft		8 - 10 Ft		0 - 2 Ft		4 - 6 Ft		8 - 10 Ft		0 - 2 Ft		4 - 6 Ft		8 - 10 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	mg/kg	2.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	1.1																		
Dinitrobenzene, 1,3-	mg/kg	9.3	-	-	-	-	-	-	-	-	-	-	0.25		-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	26	-	-	-	-	-	-	-	-	-	-	0.5		-	-	-	-	-	-
Dinitrotoluene, 2,6-	mg/kg	2.9	-	-	-	-	-	-	-	-	-	-	0.5		-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	mg/kg	43	-	-	-	-	-	-	-	-	-	-	1.9		-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	mg/kg	1.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Volatiles																				
Acetone	mg/kg	0.34					-	-					-	-	-	-				
Carbon disulfide	mg/kg	0.0029					-	-					-	-	-	-				
Methylene chloride	mg/kg	0.002					-	-					0.0021	J	-	-				
Toluene	mg/kg	0.0017					-	-					-	-	-	-				
Semivolatiles																				
Dinitrotoluene, 2,4-	mg/kg	8.8					0.19	J					0.0004	J	-	-				
Dinitrotoluene, 2,6-	mg/kg	0.58					-	-					0.049	J	-	-				
Nitroaniline, 3-	mg/kg	0.053					0.053	J					-	-	-	-				
Metals																				
Aluminum	mg/kg	13500	6680		8870		6010		7300		9850		9430		7140		5570		3320	
Antimony	mg/kg	9.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	mg/kg	42.8	5.8		15.9		6.9		5.4		9.7		4.8		2.3	J	3.1	J	4.5	J
Barium	mg/kg	239	34.9		176		41.5		30.4		59.5		47.5		-	-	-	-	-	-
Beryllium	mg/kg	0.83	-	-	-	-	-	-	-	-	0.55		-	-	-	-	-	-	-	-
Cadmium	mg/kg	0.63	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	mg/kg	70400	2880		53300		67400		7980		3080		57600		817		1850		61500	
Chromium	mg/kg	21.8	12.1		5.2		11.6		11		17.5		16.8		10.8		15.5		7.3	
Cobalt	mg/kg	30.3	5.8		26.7		9		-	-	14.4		9.1		-	-	7.3		-	-
Copper	mg/kg	34.5	7		24.6		19.3		11.2		21.7		24.3		3.8		5.3		10.6	
Iron	mg/kg	43700	14700		20500		18300		13300		22000		19300		13100		16400		8940	
Lead	mg/kg	14.7	5.5		13.4		8.1		7.7	J	10.7	J	10.5	J	3.3		2.9		4.3	
Magnesium	mg/kg	25300	1660		17200		20300		3100		4020		18100		791		917		16200	
Manganese	mg/kg	2270	93.2		2270		467		147		437		303		104		323		252	
Mercury	mg/kg	0.045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	mg/kg	57.2	13.9		56.1		22.2		12		31.1		27		6.4		8.1		11	
Potassium	mg/kg	2730	-	-	1380		1370		-	-	1210		1750		-	-	-	-	726	
Selenium	mg/kg	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	mg/kg	5170	-	-	-	-	1030		-	-	1160		1090		-	-	-	-	-	-
Thallium	mg/kg	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	mg/kg	38.4	23		26.7		19.3		21.4	J	23.3	J	26.1	J	23.4		29.3		15	
Zinc	mg/kg	104	30.4		59.7		52		37.4		67.2		64.2		21.3		22.7		31.6	

Table 3-19

PRRWP - Historical Soil Analytical Results
2004 Groundwater Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

	Location Code:		PRRP-DP18						PRRP-DP19						PRRP-DP20						PRWP-SO001	
	Sample No:		7880		7890		7900		7920		7930		7940		7960		7970		7980		AC0001	
	Sample Date:		11-Jun-98		11-Jun-98		11-Jun-98		12-Jun-98		12-Jun-98		12-Jun-98		13-Jun-98		13-Jun-98		13-Jun-98		15-Sep-00	
	Sample Depth:		0 - 2 Ft		4 - 6 Ft		8 - 10 Ft		0 - 2 Ft		4 - 6 Ft		8 - 10 Ft		0 - 2 Ft		4 - 6 Ft		8 - 10 Ft		0 - 1 Ft	
Parameter	Units	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																						
Amino-2,6-dinitrotoluene, 4-	mg/kg	2.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	mg/kg	1.1																			-	-
Dinitrobenzene, 1,3-	mg/kg	9.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	mg/kg	26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.2	
Dinitrotoluene, 2,6-	mg/kg	2.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	mg/kg	43	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	mg/kg	1.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Volatiles																						
Acetone	mg/kg	0.34	-	-					-	-									-	-		
Carbon disulfide	mg/kg	0.0029	-	-					-	-									-	-		
Methylene chloride	mg/kg	0.002	-	-					0.0018	J									-	-		
Toluene	mg/kg	0.0017	-	-					-	-									-	-		
Semivolatiles																						
Dinitrotoluene, 2,4-	mg/kg	8.8	-	-					-	-									-	-		
Dinitrotoluene, 2,6-	mg/kg	0.58	-	-					-	-									-	-		
Nitroaniline, 3-	mg/kg	0.053	-	-					-	-									-	-		
Metals																						
Aluminum	mg/kg	13500	10700		7340		9140		2370		7060		9590		5360		7580		10800			
Antimony	mg/kg	9.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.7			
Arsenic	mg/kg	42.8	4	J	27.3	J	5.8	J	14.1		4.7		4.9		3.6		4.7		5.5			
Barium	mg/kg	239	32.3		41.8		66.2		33.6		51.2		61		-	-	58.2		69.3			
Beryllium	mg/kg	0.83	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Cadmium	mg/kg	0.63	-	-	-	-	0.63		-	-	-	-	-	-	-	-	-	-	-	-		
Calcium	mg/kg	70400	1040		38400		61600		54000		56900		68000		2160		61900		70400			
Chromium	mg/kg	21.8	14.6		13.6		15.7		4.2		12.5		15.7		11.4		13.1		17			
Cobalt	mg/kg	30.3	6.2		8.7		10.6		-	-	8.7		9.4		5.8		9.3		11.3			
Copper	mg/kg	34.5	7.5		19		24.3		10.6		19.1		22.4		7.2		18.3		20.1			
Iron	mg/kg	43700	17800		20000		20600		15900		16200		19900		16000		18000		22500			
Lead	mg/kg	14.7	5.6		7.6		9.6		3.2		8.5		9.4		3.2		9		9.7			
Magnesium	mg/kg	25300	1120		12800		19200		11500		22500		21300		999		24600		20200			
Manganese	mg/kg	2270	158		300		534		658		495		512		262		527		513			
Mercury	mg/kg	0.045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Nickel	mg/kg	57.2	9.8		21.5		29		11.6		22.8		26.1		9.3		24		29.6			
Potassium	mg/kg	2730	-	-	1310		1990		-	-	1490		2330		-	-	1610		2640			
Selenium	mg/kg	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Sodium	mg/kg	5170	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Thallium	mg/kg	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Vanadium	mg/kg	38.4	30.3		25.7		24.6		13.2		21.4		26.2		27.6	J	23.8	J	28.6	J		
Zinc	mg/kg	104	27.9		56.2		64.5		26.8		52.8		60.5		26		50.6		69.5			

MDC - Maximum detected concentration for the AOC ("B" qualified data excluded).
"-" - Not detected.
Ft - Feet.
mg/kg - Milligrams per kilogram.
PCB - Polychlorinated biphenyl

Validation Qualifiers (VQ)
B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.
J - The analyte was positively identified; the reported value is estimated.

PRRWP - Historical Groundwater Analytical Results
2004 Groundwater Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	IT-MW05								PB-BED-MW15								PB-PR-MW7							
				Sample No:	5320		5550		5555		PB-PR-IT-MW5		5180		5910		5915		PB-BED-MW15		5130		5690		5695		PB-PR-DM-MW7	
				Sample Date:	20-Oct-96		19-Nov-97		28-May-98		8-Dec-94		21-Oct-96		18-Nov-97		28-May-98		13-Dec-94		21-Oct-96		17-Nov-97		20-May-98		8-Dec-94	
Parameter	Units	RBSC	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives - Unfiltered																												
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	10		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amino-2-nitrotoluene, 4-	ug/L	NE	66								-	-							-	-							66	
Amino-4,6-dinitrotoluene, 2-	ug/L	0.73	11								-	-							-	-							-	-
Dinitrobenzene, 1,3-	ug/L	0.37	3000		-	-	-	-	-	-	-	-	0.44		-	-	-	-	-	-	1,400		1,500		2,000		3,000	
Dinitrotoluene, 2,4-	ug/L	0.099	2400		-	-	-	-	-	-	-	-	-	-	-	-	0.89		0.7		1,100		1,200		1,600		980	
Dinitrotoluene, 2,6-	ug/L	0.099	310		-	-	-	-	-	-	-	-	-	-	-	-	0.89		0.6		310		-	-	-	-	17	
Dinitrotoluene, 3,4-	ug/L	NE	41								-	-							-	-							11	
Nitrotoluene, 3-	ug/L	12.2	2.7		-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.7		-	-	-	-	-	-	-	-
Nitrotoluene, 4-	ug/L	0.66	1.9								-	-							-	-							1.9	
RDX	ug/L	0.61	3.7		-	-	-	-	-	-			3.7		-	-	-	-			-	-	-	-	-	-		
Tetryl	ug/L	37	1.7		-	-	-	-	-	-			1.7		-	-	-	-			-	-	-	-	-	-		
Trinitrobenzene, 1,3,5-	ug/L	110	5700		-	-	-	-	-	-	-	-	0.52		-	-	-	-	2.1		2,000		2,000		2,800		5,700	
Trinitrotoluene, 2,4,6-	ug/L	1.83	64		-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.2		-	-	-	-	-	-	30	
Explosives - Filtered																												
Dinitrobenzene, 1,3-	ug/L	0.37	1700		-	-							0.66								1,600							
Dinitrotoluene, 2,4-	ug/L	0.099	1400		-	-							-	-							1,400							
Dinitrotoluene, 2,6-	ug/L	0.099	300		-	-							-	-							300							
RDX	ug/L	0.61	630		-	-							6.3								310							
Tetryl	ug/L	37	2.3		-	-							2.3								-	-						
Trinitrobenzene, 1,3,5-	ug/L	110	2400		-	-							0.8								2,400							
Trinitrotoluene, 2,4,6-	ug/L	1.83	160		-	-							-	-							-	-						
Volatiles																												
Acetone	ug/L	548	660		-	-	22	J	45	J			-	-	-	-	-	-	660	J	-	-	-	-	-	-		
Benzene	ug/L	0.35	1300		-	-	-	-	0.21	J			1,300		570		780		830	J	-	-	-	-	-	-		
Bromodichloromethane	ug/L	0.17	0.23		-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Butanone, 2-	ug/L	697	14		-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Carbon disulfide	ug/L	104	1500		-	-	0.21	J	-	-			-	-	-	-	-	-	1,500	J	-	-	-	-	-	-		
Chlorobenzene	ug/L	10.6	5.5		1.3	J	-	-	-	-			-	-	-	-	5.5	J	-	-	-	-	-	-	-	-		
Chloroform	ug/L	0.17	8.6		-	-	-	-	-	-			8.6	J	8.4	B	-	-	-	-	-	-	-	-	-	-		
Ethylbenzene	ug/L	134	180		-	-	-	-	-	-			180		130		140		180	J	-	-	-	-	0.17	J		
Hexanone, 2-	ug/L	150	2		-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Methylene chloride	ug/L	4.3	NA		-	-	0.27	B	2.4	B			-	-	31	B	83	B	-	-	-	-	3	B	0.37	B		
Toluene	ug/L	72	800		1.1	J	-	-	0.36	B			800		490		550		540	J	-	-	-	-	0.31	B		
Trichloroethane, 1,1,2-	ug/L	0.2	4.9		-	-	-	-	-	-			-	-	-	-	4.9	J			-	-	-	-	-	-		
Xylenes, total	ug/L	21	1300		-	-	-	-	-	-			1,100		920		880		1,300	J	-	-	-	-	0.82	J		
Semivolatiles																												
Bis(2-ethylhexyl)phthalate	ug/L	4.8	37		-	-	-	-	-	-			14	J	37		28	B	-	-	-	-	-	-	20	B		
Dibenzofuran	ug/L	1.2	620		-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Dimethylphenol, 2,4-	ug/L	73	16		-	-	-	-	-	-			16	J	6.7	J	10		-	-	-	-	-	-	-	-		
Dinitro-2-methylphenol, 4,6-	ug/L	0.37	20000		-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	660	J	12,000	NJ		
Dinitrophenol, 2,4-	ug/L	7.3	6000		-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Dinitrotoluene, 2,4-	ug/L	0.098	1800		-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	1,800		1,800	NJ		
Dinitrotoluene, 2,6-	ug/L	0.098	190		-	-	-	-	-	-			-	-	-	-	-	-	-	-	70		140	J	-	-		
Fluorene	ug/L	24.3	44		-	-	-	-	-	-			-	-	1.7	J	-	-	-	-	-	-	-	-	-	-		
Isophorone	ug/L	71	4.2		-	-	-	-	-	-			-	-	4.2	J	3.8	J	-	-	-	-	-	-	-	-		
Methylnaphthalene, 2-	ug/L	12	72		-	-	-	-	-	-			72	J	31		37		70	J	-	-	-	-	-	-		
Methylphenol, 2-	ug/L	182	6.7		-	-	-	-	-	-			-	-	3	J	6.7	J	-	-	-	-	-	-	-	-		
Methylphenol, 4-	ug/L	18	7.7		-	-	-	-	-	-			-	-	3.9	J	7.7	J	-	-	-	-	-	-	-	-		
Naphthalene	ug/L	0.62	60		-	-	-	-	-	-			52	J	22		31		60	J	-	-	-	-	-	-		
Nitroaniline, 2-	ug/L	11	2		-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Nitroaniline, 3-	ug/L	3.2	450		-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Nitrobenzene	ug/L	0.34	14		-	-	-	-	-	-			-	-	-	-	-	-	-	-	6.9	J	-	-	13	NJ		
Nitrophenol, 2-	ug/L	4.9	15		-	-	-	-	-	-			-	-	-	-	-	-	-	-	5.2	J	-	-	6.6	NJ		
Nitrophenol, 4-	ug/L	4.9	42		-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Phenanthrene	ug/L	18	2.2		-	-	-	-	-	-			-	-	2.2	J	2	J	-	-	-	-	-	-	-	-		
Phenol	ug/L	1,095	40		-	-	-	-	-	-			40	J	18		32		-	-	-	-	-	-	-	-		

				Location Code:	IT-MW05								PB-BED-MW15								PB-PR-MW7							
				Sample No:	5320		5550		5555		PB-PR-IT-MW5		5180		5910		5915		PB-BED-MW15		5130		5690		5695		PB-PR-DM-MW7	
				Sample Date:	20-Oct-96		19-Nov-97		28-May-98		8-Dec-94		21-Oct-96		18-Nov-97		28-May-98		13-Dec-94		21-Oct-96		17-Nov-97		20-May-98		8-Dec-94	
Parameter	Units	RBSC	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Unfiltered																												
Aluminum	ug/L	3,650	15800		1,520	J	3,970	J	15,800	J			-	-	-	-	513	J			2,550	J	8,960	J	10,500	J		
Antimony	ug/L	1.5	78.3		-	-	-	-	-	-	-	-	77.6		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	ug/L	0.045	14.3		13.6		11.5		14.3		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Barium	ug/L	255	1850		277		-	-	312				1,850		605		1,710				-	-	-	-	-	-		
Calcium	ug/L	NE	998000		156,000		116,000		145,000	J			459,000		280,000		662,000	J			540,000		625,000		526,000			
Chromium	ug/L	11	149		11.6		10.6		22.7		-	-	-	-	-	-	20.6		-	-	35.5		-	-	-	-	36	
Cobalt	ug/L	73	7270		-	-	-	-	-	-			-	-	-	-	-	-			2,250		2,320		2,350			
Copper	ug/L	146	4680		-	-	-	-	43.7		-	-	-	-	-	-	39.5		40		964		887		1,060		1,400	
Iron	ug/L	1,095	32600		7,840		14,700		26,500				-	-	930		4,810				6,010		21,700		32,600			
Lead	ug/L	15	9.4		5.7	U	6.6		9.4		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magnesium	ug/L	NE	574000		48,500	J	38,400		47,200				358,000		177,000		259,000				180,000	J	189,000		184,000			
Manganese	ug/L	88	43900		459		302		592		100		16.9		26.3		139		-	-	13,600		17,000		13,700		12,000	
Mercury	ug/L	1.1	0.3		-	-	0.3		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	ug/L	73	7600		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,690		1,710		1,790		2,000	
Potassium	ug/L	NE	78000		-	-	-	-	7,710				78,000		58,800		62,500				11,800		-	-	-	-		
Sodium	ug/L	NE	11900000		23,600		18,100		22,100				945,000	R	559,000		811,000				3,200,000		3,540,000		3,680,000			
Thallium	ug/L	0.24	50.8		-	-	-	-	-	-	-	-	-	-	-	-	50.8		0.6		-	-	-	-	-	-	0.9	
Vanadium	ug/L	3.7	65.2		-	-	-	-	-	-			-	-	-	-	-	-			62.8		-	-	-	-		
Zinc	ug/L	1,095	201		36.2	U	47.6		103	B	27		22.8		30.6		105	B	22		119		-	-	-	-	94	
Metals - Filtered																												
Aluminum	ug/L	3,650	859		248		-	-	-	-			-	-	-	-	-	-			-	-	-	-	-	-		
Antimony	ug/L	1.5	69.6		-	-	-	-	-	-	-	-	69.6		-	-	-	-	18		-	-	-	-	-	-	-	-
Arsenic	ug/L	0.045	12.5		-	-	12.5		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Barium	ug/L	255	2390		236		-	-	-	-			2,390		555		1,390				-	-	-	-	-	-		
Cadmium	ug/L	1.8	7.2		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	ug/L	NE	998000		132,000		99,500		113,000	J			556,000		245,000	J	390,000	J			562,000		582,000		597,000			
Chromium	ug/L	11	150		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	33.1		-	-	-	-	21	
Cobalt	ug/L	73	7450		-	-	-	-	-	-			-	-	-	-	-	-			2,240		2,330		2,610			
Copper	ug/L	146	4710		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	931	J	911		1,050		1,100	
Iron	ug/L	1,095	13200		-	-	3,050		185				-	-	-	-	-	-			1,150		1,360		2,110			
Lead	ug/L	15	5.2		5.2		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magnesium	ug/L	NE	584000		45,600		36,500		38,300	J			443,000		182,000		299,000	J			165,000		184,000		180,000			
Manganese	ug/L	88	45500		195		114		223		100		27.2		-	-	-	-	-	-	15,200		17,000		17,600		10,000	
Nickel	ug/L	73	7310		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,630	J	1,710		1,900		1,800	
Potassium	ug/L	NE	104000		-	-	-	-	-	-			104,000		61,100		74,800				8,310		-	-	-	-		
Sodium	ug/L	NE	11900000		23,600		19,100		22,800				1,320,000	R	582,000		1,010,000				3,380,000		3,850,000		3,970,000			
Thallium	ug/L	0.24	62.2		-	-	-	-	-	-	-	-	-	-	-	-	62.2		-	-	-	-	-	-	-	-	0.7	
Vanadium	ug/L	3.7	68.3		-	-	-	-	-	-			-	-	-	-	-	-			68.3		-	-	-	-		
Zinc	ug/L	1,095	674		-	-	-	-	-	-	-	-	22.8		30.9		47.3	B	-	-	85.9		-	-	-	-	44	
Water Quality Parameters																												
Alkalinity	ug/L	NE	1500000				350,000		680,000						85,000		500,000						820,000		840,000			
Chloride	ug/L	NE	9500000				3,000		11,000						1,400,000		2,200,000						-	-	9,500,000			
Cyanide, total	ug/L	73	1700		-	-	-	-	-	-			-	-	-	-	-	-			190		120		200			
Hardness	ug/L	NE	13000000				760,000		570,000						1,500,000		1,800,000						5,000,000		2,300,000			
Nitrate	ug/L	1000	1500000						-	-	0.1						-	-	0.5						190,000		80	
Nitrate-Nitrite	ug/L	100	1600000				-	-							-	-							400	J				
Sulfate	ug/L	NE	12000000				48,000		61,000						-	-	82,000						8,000,000		5,400,000			
Total dissolved solids	ug/L	NE	50000000				420,000		650,000						3,200,000		3,800,000						17,000,000		18,000,000			
Total organic carbon	ug/L	NE	14000000				4,700		6,000						11,000		13,000						2,700,000		2,900,000			
Total suspended solids	ug/L	NE	79000				6,000		15,000						7,000		13,000						25,000		17,000			

				Location Code:	PB-PR-MW8								PB-PR-MW9							
				Sample No:	5140		5700		5705		PB-PR-DM-MW8		5150		5710		5715		PB-PR-DM-MW9	
				Sample Date:	20-Oct-96		17-Nov-97		20-May-98		8-Dec-94		20-Oct-96		17-Nov-97		20-May-98		8-Dec-94	
Parameter	Units	RBSC	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives - Unfiltered																				
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	10		-	-	-	-	-	-	10		-	-	-	-	-	-	-	-
Amino-2-nitrotoluene, 4-	ug/L	NE	66								37								1.4	
Amino-4,6-dinitrotoluene, 2-	ug/L	0.73	11								11								0.2	
Dinitrobenzene, 1,3-	ug/L	0.37	3000		1,400		1,500		2,100		790		57		35		170		49	
Dinitrotoluene, 2,4-	ug/L	0.099	2400		1,400		1,300		2,400		440		36		28		110		9.5	
Dinitrotoluene, 2,6-	ug/L	0.099	310		-	-	-	-	-	-	33		-	-	-	-	-	-	1	
Dinitrotoluene, 3,4-	ug/L	NE	41								41								0.6	
Nitrotoluene, 3-	ug/L	12.2	2.7		-	-	-	-	-	-	2.2		-	-	-	-	-	-	-	-
Nitrotoluene, 4-	ug/L	0.66	1.9								-	-							-	-
RDX	ug/L	0.61	3.7		-	-	-	-	-	-			-	-	-	-	-	-		
Tetryl	ug/L	37	1.7		-	-	-	-	-	-			-	-	-	-	-	-		
Trinitrobenzene, 1,3,5-	ug/L	110	5700		1,700		1,500		2,400		1,300		27		-	-	71		4	
Trinitrotoluene, 2,4,6-	ug/L	1.83	64		-	-	-	-	-	-	64		-	-	-	-	-	-	1.1	
Explosives - Filtered																				
Dinitrobenzene, 1,3-	ug/L	0.37	1700		1,700	J														
Dinitrotoluene, 2,4-	ug/L	0.099	1400		1,400	J														
Dinitrotoluene, 2,6-	ug/L	0.099	300		-	-														
RDX	ug/L	0.61	630		630	J														
Tetryl	ug/L	37	2.3		-	-														
Trinitrobenzene, 1,3,5-	ug/L	110	2400		2,100	J														
Trinitrotoluene, 2,4,6-	ug/L	1.83	160		160	J														
Volatiles																				
Acetone	ug/L	548	660		-	-	-	-	15	B			-	-	-	-	-	-		
Benzene	ug/L	0.35	1300		-	-	-	-	-	-			-	-	-	-	0.47	J		
Bromodichloromethane	ug/L	0.17	0.23		-	-	-	-	0.23	J			-	-	-	-	-	-		
Butanone, 2-	ug/L	697	14		-	-	-	-	14	J			-	-	-	-	-	-		
Carbon disulfide	ug/L	104	1500		-	-	-	-	-	-			-	-	-	-	-	-		
Chlorobenzene	ug/L	10.6	5.5		-	-	-	-	-	-			-	-	-	-	-	-		
Chloroform	ug/L	0.17	8.6		-	-	-	-	0.74	B			-	-	-	-	-	-		
Ethylbenzene	ug/L	134	180		-	-	-	-	-	-			-	-	-	-	1.5			
Hexanone, 2-	ug/L	150	2		-	-	-	-	2	J			-	-	-	-	-	-		
Methylene chloride	ug/L	4.3	NA		-	-	5.7	B	0.31	B			-	-	0.54	B	0.35	B		
Toluene	ug/L	72	800		-	-	-	-	0.38	B			-	-	-	-	1.5			
Trichloroethane, 1,1,2-	ug/L	0.2	4.9		-	-	-	-	-	-			-	-	-	-	-	-		
Xylenes, total	ug/L	21	1300		-	-	-	-	0.44	J			-	-	-	-	8			
Semivolatiles																				
Bis(2-ethylhexyl)phthalate	ug/L	4.8	37		-	-	-	-	-	-			-	-	-	-	-	-		
Dibenzofuran	ug/L	1.2	620		-	-	-	-	620	NJ			-	-	-	-	-	-		
Dimethylphenol, 2,4-	ug/L	73	16		-	-	-	-	-	-			-	-	-	-	-	-		
Dinitro-2-methylphenol, 4,6-	ug/L	0.37	20000		870	J	2,300	J	20,000	NJ			-	-	-	-	280	NJ		
Dinitrophenol, 2,4-	ug/L	7.3	6000		690	J	6,000		3,800	NJ			-	-	48	J	-	-		
Dinitrotoluene, 2,4-	ug/L	0.098	1800		530		1,500		1,700	NJ			30		110		120			
Dinitrotoluene, 2,6-	ug/L	0.098	190		52	J	190	J	-	-			6.8	J	-	-	-	-		
Fluorene	ug/L	24.3	44		-	-	-	-	44	NJ			-	-	-	-	-	-		
Isophorone	ug/L	71	4.2		-	-	-	-	-	-			-	-	-	-	-	-		
Methylnaphthalene, 2-	ug/L	12	72		-	-	-	-	-	-			-	-	-	-	-	-		
Methylphenol, 2-	ug/L	182	6.7		-	-	-	-	-	-			-	-	-	-	-	-		
Methylphenol, 4-	ug/L	18	7.7		-	-	-	-	-	-			-	-	-	-	-	-		
Naphthalene	ug/L	0.62	60		-	-	-	-	-	-			-	-	-	-	-	-		
Nitroaniline, 2-	ug/L	11	2		-	-	-	-	-	-			2	J	-	-	-	-		
Nitroaniline, 3-	ug/L	3.2	450		-	-	160	J	-	-			-	-	450	J	-	-		
Nitrobenzene	ug/L	0.34	14		-	-	-	-	14				-	-	-	-	-	-		
Nitrophenol, 2-	ug/L	4.9	15		-	-	-	-	15				-	-	-	-	-	-		
Nitrophenol, 4-	ug/L	4.9	42		-	-	-	-	42	NJ			-	-	-	-	-	-		
Phenanthrene	ug/L	18	2.2		-	-	-	-	-	-			-	-	-	-	-	-		
Phenol	ug/L	1,095	40		-	-	-	-	-	-			-	-	-	-	-	-		

PRRWP - Historical Groundwater Analytical Results
2004 Groundwater Summary and Evaluation Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

				Location Code:	PB-PR-MW8								PB-PR-MW9							
				Sample No:	5140		5700		5705		PB-PR-DM-MW8		5150		5710		5715		PB-PR-DM-MW9	
				Sample Date:	20-Oct-96		17-Nov-97		20-May-98		8-Dec-94		20-Oct-96		17-Nov-97		20-May-98		8-Dec-94	
Parameter	Units	RBSC	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Unfiltered																				
Aluminum	ug/L	3,650	15800		965	J	-	-	-	-			-	-	-	-	-	-		
Antimony	ug/L	1.5	78.3		76		-	-	-	-	-	-	78.3		-	-	-	-	-	-
Arsenic	ug/L	0.045	14.3		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Barium	ug/L	255	1850		-	-	-	-	-	-			-	-	-	-	-	-		
Calcium	ug/L	NE	998000		994,000		749,000		998,000				428,000		-	-	171,000			
Chromium	ug/L	11	149		149		-	-	-	-	52		27.9		-	-	-	-	-	-
Cobalt	ug/L	73	7270		6,340		7,270		7,150				762		-	-	480			
Copper	ug/L	146	4680		4,680		3,790		3,740		1,600		445		-	-	430		770	
Iron	ug/L	1,095	32600		13,300		22,000		12,100				1,750		-	-	2,070			
Lead	ug/L	15	9.4		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magnesium	ug/L	NE	574000		424,000	J	541,000		574,000				178,000	J	-	-	62,900			
Manganese	ug/L	88	43900		30,700		34,100		43,900		8,000		2,280		1,900		2,300		1,800	
Mercury	ug/L	1.1	0.3		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	ug/L	73	7600		6,080		7,600		6,950		2,500		1,060		-	-	466		1,500	
Potassium	ug/L	NE	78000		35,400		-	-	-	-			17,100		-	-	-	-		
Sodium	ug/L	NE	11900000		11,200,000		10,800,000		11,900,000				1,960,000		1,360,000		1,210,000			
Thallium	ug/L	0.24	50.8		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	ug/L	3.7	65.2		65.2		-	-	-	-			58.9		-	-	-	-		
Zinc	ug/L	1,095	201		155	U	-	-	-	-	52		201	U	-	-	-	-	60	
Metals - Filtered																				
Aluminum	ug/L	3,650	859		859		-	-	-	-			-	-	-	-	-	-		
Antimony	ug/L	1.5	69.6		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	ug/L	0.045	12.5		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Barium	ug/L	255	2390		-	-	-	-	-	-			-	-	-	-	-	-		
Cadmium	ug/L	1.8	7.2		7.2		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	ug/L	NE	998000		967,000		753,000	J	998,000				410,000		-	-	198,000			
Chromium	ug/L	11	150		150		-	-	-	-	38		26.6		-	-	-	-	-	-
Cobalt	ug/L	73	7450		6,480		6,770		7,450				692		-	-	522			
Copper	ug/L	146	4710		4,710	J	3,390		3,900		1,400		414	J	-	-	294		760	
Iron	ug/L	1,095	13200		13,200		12,200		9,560				1,190		-	-	-	-		
Lead	ug/L	15	5.2		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magnesium	ug/L	NE	584000		422,000		-	-	584,000				171,000		-	-	70,100			
Manganese	ug/L	88	45500		30,900		29,700		45,500		7,000		2,140		1,890		2,500		1,800	
Nickel	ug/L	73	7310		6,230	J	6,820		7,310		2,100		963	J	-	-	460		1,600	
Potassium	ug/L	NE	104000		35,100		-	-	-	-			16,700		-	-	-	-		
Sodium	ug/L	NE	11900000		11,500,000		9,230,000		11,900,000				1,710,000		1,450,000		1,270,000			
Thallium	ug/L	0.24	62.2		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	ug/L	3.7	68.3		67.3		-	-	-	-			56.6		-	-	-	-		
Zinc	ug/L	1,095	674		183		-	-	-	-	50		674		-	-	-	-	70	
Water Quality Parameters																				
Alkalinity	ug/L	NE	1500000				990,000		1,500,000						860,000		810,000			
Chloride	ug/L	NE	9500000				6,500,000		4,700,000						7,200,000		3,600,000			
Cyanide, total	ug/L	73	1700		430		240		1,700				62		36		72			
Hardness	ug/L	NE	13000000				13,000,000		3,100,000						2,200,000		1,200,000			
Nitrate	ug/L	1000	1500000						1,500,000		650						110,000		50	
Nitrate-Nitrite	ug/L	100	1600000				1,600,000	J							200	J				
Sulfate	ug/L	NE	12000000				12,000,000		12,000,000						3,000,000		1,600,000			
Total dissolved solids	ug/L	NE	50000000				50,000,000		49,000,000						8,700,000		6,400,000			
Total organic carbon	ug/L	NE	14000000				14,000,000		11,000,000						1,300,000		930,000			
Total suspended solids	ug/L	NE	79000				73,000		79,000						8,000		7,000			

Shaded cell indicates value is greater than the RBSC.
RBSC - Values reflect an incremental lifetime cancer risk (ILCR) of 1E-6 or a noncancer hazard quotient (HQ) of 0.1. For chemicals that exhibit both cancer and noncancer effects, whichever type of effect results in a lower concentration (using an ILCR of 1E-6 and an HQ of 0.1), that concentration is selected as the RBSC.
MDC - Maximum detected concentration for the AOC ("B" qualified data not included).
"-" - Not detected.
µg/L - Micrograms per liter.
NA - Not applicable; detection is the result of blank contamination.
NE - Not established.

Validation Qualifiers (VQ)
J - The analyte was positively identified; the reported value is estimated.
B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.
N - Tentatively identified
U - Nondetect due to blank contamination

TABLES

Table 4-1

Summary of Background Investigations
2004 Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Investigation Conducted By	Date of Activity	Seasonal Period	Designation	Report of Analytical Results and Field Activities	Activity
IT	August 2001	Dry	Groundwater RI	IT Corporation (IT), 2002a, *2001 Groundwater Remedial Investigation, Former Plum Brook Ordnance Works, Sandusky, Ohio,* March	Included installation of 3 background bedrock wells.
IT	September-October 2001	Dry	1st Quarterly Background	IT Corporation (IT), 2002a, *2001 Groundwater Remedial Investigation, Former Plum Brook Ordnance Works, Sandusky, Ohio,* March.	Low-flow groundwater sample collection from background wells and selected non-background wells.
IT	January 2002	Wet	2nd Quarterly Background	IT Corporation (IT), 2002b, *Second Quarterly Background Report, Former Plum Brook Ordnance Works, Sandusky, Ohio,* May	Low-flow groundwater sample collection from background wells.
IT	April 2002	Wet	3rd Quarterly Background	IT Corporation (IT), 2002c, *Third Quarterly Background Report, Former Plum Brook Ordnance Works, Sandusky, Ohio,* July	Low-flow groundwater sample collection from background wells and selected non-background wells.
Shaw[a]	July 2002	Dry	4th Quarterly Background	Shaw Environmental, Inc. (Shaw), 2003a, *2002 Groundwater Data Summary and Evaluation Report, Former Plum Brook Ordnance Works, Sandusky, Ohio,* June	Low-flow groundwater sample collection from background wells.
Shaw	October 2002	Dry	5th Quarterly Background	IT Corporation (IT), 2003a, *Fifth Quarterly Background Report, Former Plum Brook Ordnance Works, Sandusky, Ohio,* February	Low-flow groundwater sample collection from background wells.
Shaw	April 2003	Wet	6th Quarterly Background	Shaw Environmental, Inc. (Shaw), 2003b, *Sixth Quarterly Background Report, Former Plum Brook Ordnance Works, Sandusky, Ohio,* July	Low-flow groundwater sample collection from background wells.
Shaw	September 2003	Dry	7th Quarterly Background	Shaw Environmental, Inc. (Shaw), 2003c, *Seventh Quarterly Background Report, Former Plum Brook Ordnance Works, Sandusky, Ohio,* December	Low-flow groundwater sample collection from background wells, including new background wells PB-BED-MW28 and PB-BED-MW29.
Shaw	December 2003	Dry	8th Quarterly Background	Shaw Environmental, Inc. (Shaw), 2004a, *Eighth Quarterly Background Report, Former Plum Brook Ordnance Works, Sandusky, Ohio*, March	Low-flow groundwater sample collection from background wells.

Table 4-1

Summary of Background Investigations
2004 Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Investigation Conducted By	Date of Activity	Seasonal Period	Designation	Report of Analytical Results and Field Activities	Activity
Shaw	March 2004	Wet	9th Quarterly Background	Shaw Environmental, Inc. (Shaw), 2004b, *Ninth Quarterly Background Report, Former Plum Brook Ordnance Works, Sandusky, Ohio*, June	Low-flow groundwater sample collection from background wells.
Shaw	August 2004	Dry	10th Quarterly Background	Shaw Environmental, Inc. (Shaw), *2004 Groundwater Data Summary and Evaluation Report, Former Plum Brook Ordnance Works, Sandusky, Ohio*, November	Low-flow groundwater sample collection from background wells.

RI - Remedial Investigation.
IT - IT Corporation.
[a]Shaw - IT Corporation was purchased by Shaw Environmental and Infrastructure, Inc. June 6, 2002, and given the name Shaw Environmental, Inc.

Table 4-2

Monitoring Well Construction Details
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Well ID	Coordinates (Ohio Plane) Northings (y)	Coordinates (Ohio Plane) Eastings (x)	Well Depth (feet bgs)	Date Installed	Installed By	Casing Type	Casing Diameter (inches)	Borehole Diameter (inches)	Screen Interval (feet bgs)	Geologic Unit Screened	Top of Filter Pack (feet bgs)	TOC Elevation (feet msl)	Ground Elevation (feet msl)	Bedrock Elevation (feet msl)	Well Bottom Elevation (feet msl)
Monitoring Wells Screened in Overburden															
AA1-GW-002	623068.000	1917728.000	22.00	9/19/1997	IT	PVC (40)	2	8.25	6.75-21.75	Overburden	6	640.85	638.60	615.60	616.60
AA2-GW-002	623589.000	1909481.000	18.50	9/22/1997	IT	PVC (40)	2	8.25	8.25-18.25	Overburden	5.5	643.95	641.50	622.00	623.00
AA3-GW-002	625028.000	1914956.000	16.00	9/18/1997	IT	PVC (40)	2	8.25	5.75-15.75	Overburden	3.0	636.11	634.10	<617.1	618.10
ABG-GW-002	621579.000	1921516.000	6.75	9/11/1997	IT	PVC (40)	2	8.25	2.50-6.50	Overburden	2.0	661.06	658.20	652.20	651.45
PS-02	624343.951	1920061.236	18.00	1990	EBASCO	NA	NA	NA	NA	Overburden	NA	638.53	635.70	NA	617.70
PS-03	624323.698	1920186.918	18.00	1990	EBASCO	NA	NA	NA	NA	Overburden	NA	637.15	634.40	NA	616.40
PS-04	624298.302	1920259.217	16.00	1990	EBASCO	NA	NA	NA	NA	Overburden	NA	637.87	635.30	NA	619.30
SP-01	613598.448	1927549.988	9.50	1990	EBASCO	NA	NA	8	NA	Overburden	NA	655.07	652.30	NA	642.80
SP-03	613397.744	1926835.797	9.50	1990	EBASCO	NA	NA	8	NA	Overburden	NA	657.73	655.10	NA	645.60
SP-04	613161.741	1926936.786	9.50	1990	EBASCO	NA	NA	8	NA	Overburden	NA	658.02	655.25	NA	645.75
SP-05	613050.710	1926896.790	9.50	1990	EBASCO	NA	NA	8	NA	Overburden	NA	657.00	654.50	NA	645.00
SP-06	613055.655	1927073.522	9.00	1990	EBASCO	NA	NA	8	NA	Overburden	NA	658.25	655.40	NA	646.40
GCL-MW01	617559.743	1921255.401	11.03	3/12/1992	H+GLC	Stainless	1	8	5.99 - 10.97	Overburden	4	674.81	671.40	663.40	660.37
GCL-MW02A	617937.096	1920960.532	22.15	3/11/1992	H+GLC	Stainless	1	8	12.09 - 22.09	Overburden	9.9	672.96	669.70	663.70	647.55
GCL-MW02B	617940.838	1920983.807	9.83	3/12/1992	H+GLC	Stainless	1	8	4.82 - 9.82	Overburden	3.75	673.42	669.60	663.60	659.77
GCL-MW03	617640.608	1920776.792	10.60	3/12/1992	H+GLC	Stainless	1	8	4.56 - 9.45	Overburden	3	672.57	669.55	663.65	658.95
IT-MW01	616900.738	1915525.461	9.00	1989	IT	PVC	2	8	4.0 - 9.0	Overburden	2	678.19	674.50	671.00	665.50
IT-MW02	622512.00	1910265.00	18.30	1989	IT	PVC	2	8	6.0 - 16.0	Overburden	3.8	639.28	636.37	618.07	618.07
IT-MW05	625346.00	1919475.00	21.00	1989	IT	PVC	2	8	8.5 - 18.5	Overburden	6.5	634.67	631.59	<610.59	610.59
IT-MW06	628642.323	1918767.674	18.50	1989	IT	PVC	2	8	6.0 - 16.0	Overburden	4.4	631.70	628.50	610.00	610.00
IT-MW07 (abandoned)	622076.00	1909862.00	5.50	1996	IT	PVC	2	4.25	0.5 - 5.5	Overburden	none	635.03	632.30	NA	626.80
IT-MW08	622498.00	1911132.00	13.40	1996	IT	PVC	2	8.25	3.1 - 13.1	Overburden	3.6	633.16	630.60	620.20	617.20
IT-MW09	620956.00	1910699.00	14.50	1996	IT	PVC	2	8.25	4.1 - 14.1	Overburden	2	647.45	645.40	636.40	630.90
IT-MW10	623027.00	1919485.00	19.80	1996	IT	PVC	2	8.25	9.3 - 19.3	Overburden	8.6	644.80	642.20	622.70	622.40
MK-MW09	623900.555	1908872.118	15.00	1993	MK	PVC	2	10	5.0 - 15.0	Overburden	3	645.61	642.95	<627.95	627.95
MK-MW10	623860.78	1910563.73	14.00	1993	MK	PVC	2	10	4.0 - 14.0	Overburden	2	640.57	637.74	<623.74	623.74
MK-MW11	623828.58	1911843.40	13.00	1993	MK	PVC	2	10	3.0 - 13.0	Overburden	2	637.36	634.39	<621.39	621.39
MK-MW12	621233.056	1908763.800	13.00	1993	MK	PVC	2	10	3.0 - 13.0	Overburden	2	640.93	638.10	<625.10	625.10
MK-MW14	618310.640	1913325.155	11.50	1993	MK	PVC	2	10	4.0 - 9.0	Overburden	2	681.26	678.50	667.00	667.00
MK-MW15	618487.557	1913304.311	9.00	1993	MK	PVC	2	10	4.0 - 9.0	Overburden	2	680.63	677.80	668.80	668.80
MK-MW16	616834.00	1918011.00	8.00	1993	MK	PVC	2	10	2.0 - 7.0	Overburden	1	674.00	671.01	667.01	663.01
MK-MW17	618572.39	1917812.81	6.00	1993	MK	PVC	2	10	2.0 - 6.0	Overburden	1	664.32	660.65	655.65	654.65
MK-MW19	623870.997	1917534.913	13.00	1993	MK	PVC	2	10	3.0 - 13.0	Overburden	2	639.13	636.20	<623.20	623.20
MK-MW20	622911.715	1920539.143	23.00	1993	MK	PVC	2	10	5.0 - 20.0	Overburden	3	637.51	634.30	<611.30	611.30
MK-MW22	624339.00	1923776.00	9.50	1993	MK	PVC	2	10	2.5 - 7.5	Overburden	1.5	637.73	635.24	<625.74	625.74
MK-MW23	624657.00	1925354.00	16.00	1993	MK	PVC	2	10	6.0 - 16.0	Overburden	4	639.11	636.63	620.63	620.63
MK-MW24	622264.00	1923302.00	9.50	1993	MK	PVC	2	10	4.5 - 9.5	Overburden	2.5	656.80	654.12	<644.62	644.62
PB-MW01	NA	NA	NA	NA	NA	NA	NA	NA	NA	Overburden	NA	NA	NA	NA	NA
PB-MW02	NA	NA	NA	NA	NA	NA	NA	NA	NA	Overburden	NA	NA	NA	NA	NA

Table 4-2

Monitoring Well Construction Details
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Well ID	Coordinates (Ohio Plane) Northings (y)	Coordinates (Ohio Plane) Eastings (x)	Well Depth (feet bgs)	Date Installed	Installed By	Casing Type	Casing Diameter (inches)	Borehole Diameter (inches)	Screen Interval (feet bgs)	Geologic Unit Screened	Top of Filter Pack (feet bgs)	TOC Elevation (feet msl)	Ground Elevation (feet msl)	Bedrock Elevation (feet msl)	Well Bottom Elevation (feet msl)
PB-MW03	NA	NA	NA	NA	NA	NA	NA	NA	NA	Overburden	NA	NA	NA	NA	NA
PB-MW04	NA	NA	NA	NA	NA	NA	NA	NA	NA	Overburden	NA	NA	NA	NA	NA
PR-MW07	624996.230	1919021.590	22.30	1994	D&M	PVC	2	8	4.3 - 22.3	Overburden	3	633.67	631.18	609.18	608.88
PR-MW08 (abandoned)	624889.320	1919309.120	27.50	1994	D&M	PVC	2	8	5.0 - 27.5	Overburden	4	634.70	632.18	614.18	604.68
PR-MW09	625089.480	1919513.960	19.00	1994	D&M	PVC	2	8	4.0 - 19.0	Overburden	3	633.38	630.38	611.38	611.38
TNTA-MW10	623864.00	1923399.00	11.00	1994	D&M	PVC	2	8	3.0 - 11.0	Overburden	2.5	639.86	637.18	631.18	626.18
TNTA-MW11	623518.00	1922744.00	11.40	1994	D&M	PVC	2	8	3.4 - 11.4	Overburden	2.5	640.18	637.54	631.54	626.14
TNTC-MW03	621465.00	1911391.00	14.00	1994	D&M	PVC	2	8	5.0 - 14.0	Overburden	3.2	645.09	642.25	629.25	628.25
TNTC-MW04	620413.00	1910470.00	18.80	1994	D&M	PVC	2	8	8.8 - 18.8	Overburden	6	654.11	651.57	633.57	632.77
TNTC-MW05	620692.00	1911811.00	29.70	1994	D&M	PVC	2	8	4.7 - 29.7	Overburden	3.7	651.49	648.75	619.05	619.05
TNTC-MW06	620429.00	1913006.00	12.20	1994	D&M	PVC	2	8	3.2 - 12.2	Overburden	2.5	659.08	656.50	646.90	644.30
WA-MW01	622641.00	1909948.00	22.30	1994	D&M	PVC	2	8	4.3 - 22.3	Overburden	3.7	644.11	642.00	619.70	619.70
WA-MW02	622124.00	1910176.00	13.00	1994	D&M	PVC	2	8	3.0 - 12.0	Overburden	2.5	633.33	630.84	620.14	617.84
GM-01	623563.215	1918338.625	27.00	1990	EBASCO	NA	NA	NA	NA	Overburden	NA	640.45	637.70	NA	610.70
GM-02	624435.112	1917822.470	29.00	1990	EBASCO	NA	NA	NA	NA	Overburden	NA	637.52	634.90	NA	605.90
GM-03	624130.765	1917775.154	18.00	1990	EBASCO	NA	NA	NA	NA	Overburden	NA	638.90	636.20	NA	618.20
GM-04	624052.048	1917441.495	16.00	1990	EBASCO	NA	NA	NA	NA	Overburden	NA	636.34	633.60	NA	617.60
GM-05	623871.542	1917802.134	18.00	1990	EBASCO	NA	NA	NA	NA	Overburden	NA	639.70	637.00	NA	619.00
GM-06	623723.314	1917799.169	18.00	1990	EBASCO	NA	NA	NA	NA	Overburden	NA	639.61	637.00	NA	619.00
GM-MW-5	~623799.10	~1917899.28	27.00	10/1/1998	URS	Stainless	2	8	22-27	Overburden	20				
GM-MW-6	~623950.37	~1917700.20	26.00	9/17/1998	URS	Stainless	2	8	21-26	Overburden	19				
GM-MW-7	~624044.93	~1917790.04	27.00	9/17/1998	URS	Stainless	2	8	22-27	Overburden	19				
GM-MW-8	~624132.30	~1917780.18	27.00	10/1/1998	URS	Stainless	2	8	22-27	Overburden	20				
GM-MW-9	~624158.26	~1917622.54	27.00	9/30/1998	URS	Stainless	2	8	22-27	Overburden	20				
GM-MW-10	~624154.29	~1917501.26	28.00	9/14/1998	URS	Stainless	2	8	23-28	Overburden	21				
GM-MW-11	~624209.52	~1917730.58	24.00	9/17/1998	URS	Stainless	2	8	19-24	Overburden	17				
GM-MW-12	~624282.66	~1917411.21	32.00	9/15/1998	URS	Stainless	2	8	27-32	Overburden	25				
RA-01	625963.641	1917783.365	16.00	12/4/1990	EBASCO	Stainless	2	8	5.5 - 15.5	Overburden	4	633.97	631.40	<615.40	615.40
RA-02	626944.348	1918281.944	20.00	12/13/1990	EBASCO	Stainless	2	8	7.75 - 17.75	Overburden	6	633.95	631.30	<611.30	611.30
RA-03	626788.304	1918346.186	22.00	12/13/1990	EBASCO	Stainless	2	8	6.75 - 21.75	Overburden	5	633.63	630.90	<608.90	608.90
RA-04	626730.526	1918389.466	10.00	12/1/1990	EBASCO	Stainless	2	8	4.75 - 9.75	Overburden	2.75	633.54	630.70	<620.70	620.70
RA-05	626717.470	1918491.581	10.00	12/1/1990	EBASCO	Stainless	2	8	4.75 - 9.75	Overburden	2.75	633.34	630.60	<620.20	620.60
RA-06	626748.047	1918749.548	10.00	12/1/1990	EBASCO	Stainless	2	8	3.7 - 8.7	Overburden	3.4	632.64	630.10	612.00	620.10
RA-MW-02[a]	~626663.75	~1918540.54	24	9/9/1998	URS	Stainless	2	8	19-24	Overburden	17	628.07	628.50	604.50	604.50
RA-MW-03[a]	~626685.23	~1918263.33	20.5	9//9/1998	URS	Stainless	2	8	15.5-20.5	Overburden	13.5	627.82	628.00	606.00	607.50
RA-MW-04[a]	~626898.77	~1918380.42	25	9/9/1998	URS	Stainless	2	8	20-25	Overburden	18	628.36	628.50	602.50	603.50
RA-MW-06[a]	~626836.31	~1918528.92	23	9/8/1998	URS	Stainless	2	8	18-23	Overburden	16	627.64	628.00	606.00	605.00
RA-07S[a]	~626990.73	~1918083.00	23.5	10/15/2003	CATI	PVC	2	7" to 23.5', 5" to 23.5'	18.5-23.5	Overburden	15	[b]634.84	[b]632.65	609.65	609.15
RA-08S[a]	~626999.79	~1918440.79	22	10/15/2003	CATI	PVC	2	7" to 22', 5" to 22'	17-22	Overburden	17	[b]633.02	[b]630.71	610.71	608.71

Table 4-2

Monitoring Well Construction Details
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Well ID	Coordinates (Ohio Plane) Northings (y)	Coordinates (Ohio Plane) Eastings (x)	Well Depth (feet bgs)	Date Installed	Installed By	Casing Type	Casing Diameter (inches)	Borehole Diameter (inches)	Screen Interval (feet bgs)	Geologic Unit Screened	Top of Filter Pack (feet bgs)	TOC Elevation (feet msl)	Ground Elevation (feet msl)	Bedrock Elevation (feet msl)	Well Bottom Elevation (feet msl)
Monitoring Wells Screened in Shale															
ABG-BEDGW-001	621580.00	1921506.00	21.00	9/10/1997	IT	Steel to 7', PVC (40) to 21'	10" to 7', 2" to 21'	14.25" to 7', 6" to 22'	10.75-20.75	Ohio SH	9.0	660.59	658.20	652.20	637.20
BG8-BEDGW-001	618635.00	1909857.00	20.00	9/20/1997	IT	Steel to 4', PVC (40) to 20'	10" to 4', 2" to 20'	14.25" to 4', 6" to 21'	4.75-19.75	Olentangy SH	4	676.56	673.70	670.70	653.70
BED-MW20	612423.00	1922952.00	48.50	11/13/1994	D&M	PVC	4" to 35', 2" to 48.5'	3	28.5-48.5	Ohio SH	none ?	676.01	673.25	666.65	624.75
BED-MW25	617820.942	1914457.628	38.00	9/12/2001	IT	PVC	2	6	27.5-37.5	Olentangy SH	25.5	684.59	681.99	673.19	643.99
BED-MW26	613878.45	1920274.33	57.75	9/10/2001	IT	PVC	2	6	42.25-57.25	Olentangy SH	40	677.21	674.61	668.11	616.86
BED-MW28	610536.42	1923306.40	41.90	8/8/2003	Shaw	6" Steel to 23.65'	6	10" to 14, 6" to 46.5	26.65-41.65	Ohio SH	23.65	670.83	670.99	668.69	629.09
BED-MW29	616832.04	1913519.80	37.90	8/9/2003	Shaw	6" Steel to 25'	6"	10" to 24, 6" to 40	27.65-37.65	Olentangy SH	25	678.30	678.50	674.70	640.60
TNTB-BEDGW-001	618738.00	1917218.00	24.00	9/31/97	IT	Steel to 9', PVC (40) to 24'	10" to 9', 2" to 24'	14.25" to 9', 6" to 25'	8.75-23.75	Olentangy SH	7.5	662.43	659.80	658.80	635.80
TNTB-BEDGW-002	616835.00	1918021.00	24.20	9/24/1997	IT	Steel to 8', PVC (40) to 24.2'	10" to 8', 2" to 24.2'	14.25" to 8', 6" to 25.2'	13.95-23.95	Ohio SH	11.2	673.35	670.10	667.30	645.90
TNTB-BEDGW-003	618102.551	1918710.111	43.00	9/8/2001	IT	PVC	2	6	32.5-42.5	Ohio SH	30.5	683.11	681.34	666.54	638.34
TNTB-BEDGW-004	618468.655	1918572.329	25.50	9/7/2001	IT	PVC	2	6	15-25	Ohio SH	13	668.63	666.78	661.88	641.28
Monitoring Wells Screened in Delaware Limestone															
AA1-BEDGW-001	623069.00	1917718.00	65.00	9/24/1997	IT	Steel to 27', PVC (40) to 65'	10" to 27', 2" to 65'	14.25" to 27', 6" to 66'	49.75-64.75	Delaware LM	45	641.04	638.80	615.70	573.80
AA2-BEDGW-001	623600.00	1909552.00	43.00	10/2/1997	IT	Steel to 20', PVC (40) to 43'	10" to 20', 2" to 43'	14.25" to 20', 6" to 44'	27.75-42.75	Delaware LM	23	644.06	641.60	622.80	598.60
AA3-BEDGW-001	625037.00	1914957.00	53.00	10/5/1997	IT	Steel to 28', PVC (40) to 53'	10" to 28', 2" to 53'	14.25" to 28', 6" to 54'	37.75-52.75	Delaware LM	33.0	636.43	634.10	608.20	581.10
MNTA-BEDGW-001	623808.00	1918699.00	64.00	9/22/1997	IT	Steel to 31', PVC (40) to 64'	10" to 31', 2" to 64'	14.25" to 31', 6" to 65'	48.75-63.75	Delaware LM	44	638.40	636.05	611.25	572.05
BED-MW13	621044.00	1912175.00	75.50	1994	D&M	PVC	4	3" 46.0-75.5'	46.0-75.5 (A)	Delaware LM	none	647.95	645.49	635.49	569.99
BED-MW14	622720.00	1910457.00	52.20	1994	D&M	PVC	4	3" 24.4-49.4'	24.4-49.4	Delaware LM	none	645.72	642.73	622.73	590.53
BED-MW15	626179.00	1919283.00	74.40	1994	D&M	PVC	4	3" 31.5-74.4'	31.5-74.4 (A)	Delaware LM	none	631.31	628.76	612.00	554.36
BED-MW16	623299.00	1920594.00	74.00	1994	D&M	PVC	4	3" 49.2-74.0'	49.2-74.0 (A)	Delaware LM	none	635.70	633.36	621.36	559.36
BED-MW17	625417.00	1924121.00	64.40	1994	D&M	PVC	4	3" 45.9-64.4'	45.0-64.4 (A)	Delaware LM	none	629.65	627.02	616.02	562.62
BED-MW18	623849.00	1925483.00	75.40	1994	D&M	PVC	4	3" 45.4-75.4'	45.4-75.4	Olentangy SH /Delaware LM	none	651.18	648.51	638.51	573.11
BED-MW19	623869.00	1910174.00	49.50	1994	D&M	PVC	4	3" 24.5-49.5'	24.5-49.5	Delaware LM	none	642.75	640.19	621.69	590.69
BED-MW22	629778.465	1918366.518	42.00	9/10/2001	IT	PVC	2	6	27-42	Delaware LM	25	629.67	627.22	607.72	585.22
BED-MW23	625837.856	1918150.334	73.00	9/8/2001	IT	PVC	2	6	53-73	Delaware LM	49	633.71	631.11	604.81	558.11
BED-MW24	622916.444	1908168.033	41.00	9/13/2001	IT	PVC	2	6	25.5-40.5	Delaware LM	23.5	645.98	644.20	626.90	603.20
BED-MW27 (abandoned)	627896.268	1920791.393	105.00	9/8/2001	IT	6" Steel to 26.50'	6	12" to 18.8', 8" to 26.5", 6" to 105'	26.5-105(A)	Delaware LM	none	627.14	625.24	606.44	520.24
BED-MW30	623091.78	1907134.63	57.30	3/19/2004	Shaw	6" Steel to 29.5'	6"	10" to 29.5', 6" to 58.3'	42.3-57.3	Delaware LM	39	646.87	647.25	623.25	589.95
BED-MW31 (abandoned)	626721.75	1910435.87	SB	3/2004	Shaw	NA	NA	NA	NA	Delaware LM	NA	NA	632.90	619.90	NA
BED-MW32 (abandoned)	630607.25	1920393.20	SB	3/2004	Shaw	NA	NA	NA	NA	Delaware LM	NA	NA	627.76	610.26	NA
BED-MW33	631564.04	1921870.27	88.50	4/3/2004	Shaw	6" Steel to 19.5'	6"	10" to 19.5', 6" to 89.5	68.5-88.5	Delaware LM	65.5	619.74	619.87	604.87	531.37
BED-MW34 (abandoned)	628322.03	1924720.88	SB	3/2004	Shaw	NA	NA	NA	NA	Delaware LM	NA	NA	621.00	602.00	NA
TNTA-BEDGW-001	623446.555	1922580.21	85.00	9/13/2001	IT	PVC	2	6	70-85	Delaware LM	67	638.79	636.99	628.49	551.99
TNTC-BEDGW-001	620253.524	1912852.629	85.00	9/12/2001	IT	PVC	2	6	70-85	Delaware LM	67	667.04	664.04	651.04	579.04

Table 4-2

Monitoring Well Construction Details
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Well ID	Coordinates (Ohio Plane)		Well Depth (feet bgs)	Date Installed	Installed By	Casing Type	Casing Diameter (inches)	Borehole Diameter (inches)	Screen Interval (feet bgs)	Geologic Unit Screened	Top of Filter Pack (feet bgs)	TOC Elevation (feet msl)	Ground Elevation (feet msl)	Bedrock Elevation (feet msl)	Well Bottom Elevation (feet msl)
	Northings (y)	Eastings (x)													
2BG-BEDMW-001	622295.9447	1913066.307	48.00	6/21/2004	Jacobs	Steel? to 22', PVC (40) to 48	2	8.25	38-48	Delaware LM	33	626.82	639.37	615.87	591.37
2BG-BEDMW-002	622163.5934	1913149.975	72.00	6/18/2004	Jacobs	Steel? to 24.5',PVC (40) to 72'	2	8.25	42-72	Delaware LM	39	670.51	640.58	618.08	568.58
2BG-BEDMW-003	622002.7403	1913246.237	61.00	6/23/2004	Jacobs	Steel? to 22.5',PVC (40) to 61'	2	8.25	41-61	Delaware LM	36	677.98	640.54	621.04	579.54
GM-MW-13[a]	~623806.35	~1917819.51	59.00	9/25/1998	URS	Steel to 31', Stainless Steel to 54'	2	12" to 31', 8" to 32", 6" to 60'	54-59	Delaware LM	38	637.09	637.00	~612	578.00
RA-MW-05[a]	~626707.19	~1918533.01	49	6/20/1998	URS	Steel to 28', Stainless steel to 49'	2	12" to 26', 8" to 28', 6" to 50'	44-49	Delaware LM	38	627.67	628.00	604.00	580.00
RA-07D[a]	~626992.96	~1918050.72	55	10/15/2003	CATI	PVC	2	7" to 25.5', 5" to 55'	45-55	Delaware LM	42.5	[b]634.35	[b]632.46	606.96	577.46
RA-08D[a]	~626999.79	~1918392.84	55	10/15/2003	CATI	PVC	2	7" to 23.5', 5" to 55'	45-55	Delaware LM	41.5	[b]632.96	[b]630.56	607.56	575.56
REACTOR1	626773.262	1917983.440	80.00	6/3/1960	NASA	NA	NA	8" 34.5-80.0'	34.5-80.0 (A)	Delaware LM	none	630.51	630.45	604.45	550.45
REACTOR2	626660.608	1918003.172	40.00	5/24/1960	NASA	NA	NA	8" 33-44'	33-40 (A)	Delaware LM	none	631.05	631.00	606.00	591.00
REACTOR3	626684.798	1918148.199	40.00	5/16/1960	NASA	NA	NA	8" 32-40'	32-40 (A)	Delaware LM	none	631.21	631.10	607.10	591.10
REACTOR4	626630.259	1918146.510	50.00	5/19/1960	NASA	NA	NA	8" 32.5-50.0'	32.5-50.0 (A)	Delaware LM	none	630.83	630.44	605.44	580.44
BVR-1	NA	NA	65.00	9/22/1958	Robertson's	Steel	5 5/8	5.6" 35.5-65.0'	35.5-65.0 (A)	Delaware LM	none	NA	NA	NA	NA
PT-5912	~626011.995	~1907641.202	89.00	2/17/1982	Jones Drilling	Steel	6"	5" 25-89.0'	25-89.0 (A)	Delaware LM	none	636.22	634.81	611.81	545.81

Survey coordinates scaled to the Ohio State Plane coordinate system, North Zone, NAD 1983. Vertical datum is NAVD 1929.

[a]Survey coordinates for monitoring wells GM-MW5 through GM-MW13 and RA-MW-02 through RA-MW-06 were obtained from NASA. Horizontal coordinates are estimated. Vertical coordinates used the Ohio State Plane system, but the NAD and NAVD year are not known.

[b] Surveyed August 2004 using Reactor Area benchmark. Benchmark was not certified.

(A) - Indicated interval is an open borehole (no screen) in bedrock.
ID - Identification.
BG - Background location
bgs - Below ground surface.
msl - Mean sea level.
NA - Information not available
PBS - Plum Brook Station
PRA - Pentolite Road Area
RWP - Red Water Ponds
SB - Soil boring not converted to a well because groundwater was not encountered.
- PB-BED-MW27 was abanonded in January 2003 at the public's request due to obnoxious hydrogen sulfide odors.
- PR-MW08 was abandoned in January 2003 for TNT soil removal interim actions (Red Water Ponds FS, Dec. 2002).
TOC - Top of casing.

Table 4-3

Summary of Groundwater Samples Collected
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Well Identification	Sample Identification	Sample Date	Number
October 2002 Monitoring Well BED-MW27 Sampling (Prior to Abandonment)			
PB-BED-MW27	PBOW-02-GW-PB-BED-MW27-CD3009	18-OCT-02	CD3009
May 2004 Downgradient Well Sampling			
PB-BED-MW17	PBOW-04-PB-BED-MW17-DF3000	06-MAY-04	DF3000
PB-BED-MW19	PBOW-04-PB-BED-MW19-DF3001	05-MAY-04	DF3001
PB-BED-MW22	PBOW-04-PB-BED-MW22-DF3002	05-MAY-04	DF3002
PB-BED-MW30	PBOW-04-PB-BED-MW30-DF3003	07-MAY-04	DF3003
PB-BED-MW33	PBOW-04-PB-BED-MW33-DF3004	07-MAY-04	DF3004
PB-BED-MW22	PBOW-04-PB-BED-MW22-DF3005	05-MAY-04	DF3005[a]
PB-BED-MW22	PBOW-04-PB-BED-MW22-DF3007	05-MAY-04	DF3006[b]
June 2004 Background Well Sampling (10th Quarterly)			
IT-BG8-BEDGW-001	PBOW-04-IT-BG8-BEDGW-001-DG3000	16-JUN-04	DG3000
PB-BED-MW20	PBOW-04-PB-BED-MW20-DG3001	17-JUN-04	DG3001
PB-BED-MW24	PBOW-04-PB-BED-MW24-DG3002	16-JUN-04	DG3002
PB-BED-MW25	PBOW-04-PB-BED-MW25-DG3003	17-JUN-04	DG3003
PB-BED-MW28	PBOW-04-PB-BED-MW28-DG3004	15-JUN-04	DG3004
PB-BED-MW29	PBOW-04-PB-BED-MW29-DG3005	16-JUN-04	DG3005
PB-BED-MW25	PBOW-04-PB-BED-MW25-DG3006	17-JUN-04	DG3006[a]
PB-BED-MW25	PBOW-04-PB-BED-MW25-DG3007	17-JUN-04	DG3007[b]
August 2004 Downgradient Well Sampling			
PB-BED-MW17	PBOW-04-PB-BED-MW17-DH3000	26-AUG-04	DH3000
PB-BED-MW19	PBOW-04-PB-BED-MW19-DH3001	25-AUG-04	DH3001
PB-BED-MW22	PBOW-04-PB-BED-MW22-DH3002	26-AUG-04	DH3002
PB-BED-MW30	PBOW-04-PB-BED-MW30-DH3003	25-AUG-04	DH3003
PB-BED-MW33	PBOW-04-PB-BED-MW33-DH3004	27-AUG-04	DH3004
PB-BED-MW22	PBOW-04-PB-BED-MW22-DH3005	26-AUG-04	DH3005[a]
PB-BED-MW22	PBOW-04-PB-BED-MW22-DH3006	26-AUG-04	DH3006[b]
PT-5912	PBOW-04-PT-5912-DH3007	27-AUG-04	DH3007

[a] Field duplicate.
[b] Field split.

Table 4-4

Final Field Measurements of Groundwater Samples
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Well Identification	Date	Time	Low-Flow Sampled	PID (ppm)	H_2S (ppm)	Eh (mV)	pH	Conductivity (mmhos/cm)	Turbidity (NTU)	Dissolved O_2 (ppm)	Temperature (°C)	Volume Purged (gal)
Background Overburden Well (1997 through March 2004)												
IT-MW01	11/19/1997	NA	No	0	NM	-58.2	6.7	0.512	1.0	10.57	9.6	6.5
	5/16/1998	NA	No	0	NM	57.3	6.23	0.447	0.0	13.13	14.2	8
	9/27/2001	1040	NA	NM	NM	Not sampled. Riser section dented and prohibited bailer from entering well.						
	1/16/2002	NA	NA	NM	NM	Not sampled. Riser section dented and prohibited bailer from entering well.						
	4/2/2002	NA	NA	NM	NM	Not sampled. Riser section dented and prohibited bailer from entering well.						
	7/10/2002	0900	No	0	0	-8	6.28	0.590	3.7	5.08	17.76	4
	10/16/2002	0925	No	0.0	0.0	-28	6.22	0.765	3.6	3.41	14.4	3.09
	4/9/2003	1040	No	0.0	0.0	134.16	5.22	0.572	45.0	8.08	5.45	6
	9/3/2003	NA	NA	NM	NM	Not sampled.						
	12/10/2003	NA	NA	NA	NA	Not sampled.						
	3/10/2004	NA	NA	NA	NA	Not sampled.						
	6/15/2004	NA	NA	NA	NA	Not sampled.						
Background Bedrock Wells (1997 through March 2004)												
BG8-BEDGW-001	11/17/1997	NA	No	0	NM	-245.3	7.21	3.31	321	6.83	10.5	30
	5/15/1998	NA	No	0.1	NM	-36.2	7.80	0.151	10	8.00	13.0	27.73
	9/27/2001	1220	Yes	0.0	NM	-339	13.03	3.75	0.0	0.00	12.65	2.97
	1/16/2002	1450	Yes	0.0	0.0	-79	7.38	0.856	2.8	0.00	10.69	2.22
	4/3/2002	1127	Yes	0.0	0.0	220	7.25	0.43	4.7	NM	6.7	3
	7/12/2002	0920	Yes	0	0	-258	7.21	3.68	10.3	0.41	13.45	5
	10/18/2002	1050	Yes	0.0	0.0	-307	5.97	3.88	16.5	1.73	14.2	4.0
	4/10/2003	1545	Yes	1.1	0.0	-64.5	7.79	0.656	2.3	NM	8.61	3
	9/18/2003	1550	Yes	0.0	0	-307.9	6.84	3.429	0.0	1.92	15.72	2
	12/10/2003	1620	Yes	0.0	0	-50.8	7.23	0.988	0.0	0.31	11.11	3
	3/11/2004	1405	Yes	0.0	0	42.8	7.16	0.983	0.0	5.51	9.21	2.7
	6/16/2004	1600	Yes	0.0	0.0	-102.8	7.18	0.648	0.0	1.90	15.82	1.8
PB-BED-MW20	11/17/1997	NA	No	0	NM	-24.7	6.74	48.5	563	4.14	9.4	27
	5/28/1998	NA	No	0.1	NM	NM	6.65	38.1	999	12.80	13.0	58
	9/26/2001	1415	No	0.0	NM	-73	8.95	53.60	53.5	0.00	10.54	10.33
	1/15/2002	1415	Yes	1.6	0.0	-55	6.83	52.60	15.0	0.00	7.22	1
	4/4/2002	1013	Yes	0.0	NM	51	7.07	53	0.0	0.00	10.37	1.9
	7/10/2002	1600	Yes	0	0	-57	6.73	52.9	NR	0.00	13.85	3.5
	10/17/2002	1510	No	0.0	0.0	-32	5.69	56.3	10.8	3.38	11.60	24
	4/11/2003	1050	Yes	0.9	0.0	64.3	6.96	49.75	3.7	9.23	10.17	2.8
	9/18/2003	0845	Yes	0.0	0	-9.6	6.43	49.71	0.0	0.38	11.97	1.8
	12/10/2003	1200	Yes	0.0	0	-30.2	6.68	51.46	0.1	0.46	8.86	1.5
	3/10/2004	1525	Yes	0.0	0	-55.7	6.70	48.57	0.0	0.00	10.91	0.75
	6/17/2004	1515	Yes	0	0.0	-53.5	6.68	48.96	0.0	0.54	25.98	1.5

Table 4-4

Final Field Measurements of Groundwater Samples
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Well Identification	Date	Time	Low-Flow Sampled	PID (ppm)	H_2S (ppm)	Eh (mV)	pH	Conductivity (mmhos/cm)	Turbidity (NTU)	Dissolved O_2 (ppm)	Temperature (°C)	Volume Purged (gal)
Background Bedrock Wells (1997 through March 2004), continued												
PB-BED-MW24	10/9/2001	0935	Yes	NM	NM	-144	9.38	1.81	73.3	5.32	11.20	2.99
	1/17/2002	1005	Yes	114	0.0	-333	6.82	1.99	2.5	0.00	9.69	2.11
	4/3/2002	1730	Yes	76.0	0.0	-318	7.06	1.98	0.0	NM	10.71	1.8
	7/12/2002	1405	Yes	84.1	>500	-358	6.66	1.88	350	0.00	12.93	4.5
	10/19/2002	1110	No	58.2	>50	-297	6.30	1.85	22.3	5.52	12.20	4.5
	4/9/2003	1530	Yes	5.6	>200	-337.7	6.64	1.753	0.0	0.00	9.98	3.3
	9/17/2003	1320	Yes	62.9	>500	-323.0	6.14	1.637	0.0	4.88	13.00	3.25
	12/10/2003	1035	Yes	58.3	>50	-331.7	6.61	1.408	0.0	-1.99	10.06	3.2
	3/10/2004	1305	Yes	56.8	156	-310.3	6.54	1.700	3.4	0.00	10.84	2.1
	6/16/2004	1330	Yes	47.5	>200	-321.9	6.63	1.334	0.0	0.00	14.65	3.3
PB-BED-MW25	10/5/2001	0920	Yes	0.0	0.01	-237	10.58	1.89	5.7	2.41	11.90	3.67
	1/16/2002	1030	Yes	0.0	0.0	-291	7.23	2.42	5.8	0.00	10.54	4.44
	4/3/2002	1120	Yes	NM	NM	-333	8.46	2.62	2.7	0.01	10.90	8
	7/11/2002	1115	Yes	0	0	-302	7.19	1.86	1.9	0.00	12.92	8
	10/17/2002	1035	Yes	0.0	0.0	-290	6.56	2.96	2.1	1.69	12.00	6.0
	4/10/2003	1035	Yes	0.0	0.0	-333.8	7.22	2.817	3.7	NM	10.93	5.5
	9/18/2003	1220	Yes	0.3	0.0	-296.2	6.98	1.707	0.0	0.22	13.91	5.5
	12/11/2003	1355	Yes	0.0	0	-325.6	7.11	1.509	0.0	0.10	10.82	3.6
	3/11/2004	0915	Yes	0.0	0.0	-303.4	7.01	1.605	0.0	0.00	10.85	5.2
	6/17/2004	0945	Yes	0.0	0.0	-275.5	7.09	1.672	0.0	0.26	13.59	4.8
PB-BED-MW26	10/10/2001	NA	NA	3.6	NM	No sample collected due to insufficient water volume.						
	1/15/02[a]	1030	No	2.2	0.21	-59	6.87	31.0	999	8.04	8.69	0.5
	4/9/2002	NA	NA	NM	NM	No sample collected due to insufficient water volume.						
	7/12/2002	NA	NA	3.1	0	No sample collected due to insufficient water volume.						
	10/16/2002	NA	NA	6.0	0.0	No sample collected due to insufficient water volume.						
	4/8/2003	NA	NA	NM	NM	No sample collected due to insufficient water volume.						
	9/3/2003	NA	NA	NM	NM	No sample collected due to insufficient water volume.						
	12/10/2003	NA	NA	NM	NM	No sample collected due to insufficient water volume.						
	3/10/2004	NA	NA	15.6	0.00	No sample collected due to insufficient water volume.						
	6/17/2004	NA	NA	14.6	20	No sample collected due to insufficient water volume.						
PB-BED-MW28	9/17/2003	0915	Yes	0.0	0	-95.2	7.50	1.408	0.0	0.21	13.88	1.50
	12/9/2003	1320	Yes	0.0	0	7.5	7.54	1.391	0.0	0.45	10.28	1.5
	3/9/2004	1410	Yes	0.0	0	75.3	8.50	1.739	0.0	0.00	10.01	2.5
	6/15/2004	1330	Yes	0.0	0	-131.9	7.89	1.228	0.4	0.33	15.01	4
PB-BED-MW29	9/16/2003	1520	Yes	0.0	0	6.5	6.66	10.30	25.0	0.22	15.80	3.9
	12/9/2003	1535	Yes	8.0	0	3.0	6.82	8.490	1.9	0.39	10.00	1.37
	3/10/2004	1015	Yes	0.0	0	34.4	6.73	9.207	10.2	0.0	9.13	1.8
	6/16/2004	0955	Yes	0.0	0	-52.9	6.78	9.125	0.3	0.19	13.65	3

Table 4-4

Final Field Measurements of Groundwater Samples
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Well Identification	Date	Time	Low-Flow Sampled	PID (ppm)	H_2S (ppm)	Eh (mV)	pH	Conductivity (mmhos/cm)	Turbidity (NTU)	Dissolved O_2 (ppm)	Temperature (°C)	Volume Purged (gal)
Abandoned Downgradient Well												
PB-BED-MW27	10/9/2001	1115	No	197	NM	Water quality readings not recorded due to oily film on groundwater						1.75
	10/18/2001	0820	No	162	>50	Water quality readings not recorded due to 0.5 ft of product on groundwater						60
	4/9/2002	0900	No	137	NM	Water quality readings not recorded due to oily film on groundwater						62
Downgradient Wells												
BED-MW17	11/20/1997	NA	No	2	0	322.2	7.00	4.70	318	7.46	8.9	23
	5/29/1998	NA	No	3	NM	NM	6.70	4.21	213	1.30	15.3	60
	10/3/2001	1500	Yes	>2000	NM	-386	15.18	5.79	134	0.00	16.5	2
	4/11/2002	1100	Yes	84	>50	-411	8.51	5.78	412	0.00	11.2	3.5
	5/6/2004	1525	Yes	157.4	>200	-358.4	6.88	7.146	20.8	13.45	13.48	2.2
	8/26/2004	1715	Yes	130.0	>500	-315.4	6.40	6.412	11.2	15.70	17.94	2.7
BED-MW19	11/14/1997	NA	No	0	NM	-318.1	6.91	1.30	108	5.58	9.4	14
	5/16/1998	NA	No	0.1	NM	17.8	6.70	1.80	17	6.00	16.0	82.5
	10/4/2001	1315	Yes	873	NM	-1416	14.29	1.43	307	0.00	18.4	2.85
	4/4/2002	1520	Yes	11.6	NM	-367	7.48	1.43	0	0.00	11.15	5
	5/4/2004	0930	Yes	1.2	0	-366.2	6.76	1.566	14.9	9.57	12.42	1.3
	8/25/2004	1700	Yes	0.0	0	-242.0	6.29	0.988	21.1	0.00	14.35	1.2
PB-BED-MW22	10/8/2001	1020	Yes	18.3	NM	-263	10.25	0.777	5.2	0.00	11.4	3
	4/4/2002	1025	Yes	35.6	>50	-347	7.74	0.94	15.3	0.00	9.8	3.5
	5/4/2004	1530	Yes	16.4	>200	-327.7	6.67	0.935	68.0	5.37	13.86	2.8
	8/26/2004	1110	Yes	10.7	>500	-192.7	6.64	0.838	50.0	6.48	15.24	2.3
PB-BED-MW30	5/7/2004	1010	Yes	14.7	0	-300.1	7.09	1.371	23.2	0.29	11.63	1.5
	8/25/2004	1355	Yes	0.0	0	-221.1	6.36	1.334	2.1	0.00	19.81	1.3
PB-BED-MW33	5/6/2004[b]	1115	No	15.3	0	-166.8	7.10	3.284	19.5	0.28	16.64	2.8
	8/25/2004[b]	1130	No	23.4	0	-227.0	6.41	2.124	34.7	1.37	13.75	3.8
PT-5912[c]	8/27/2004	1030	Yes	0.1	0	-188.0	6.64	0.680	19.3	0.65	21.74	2

Notes:

Water quality measurements recorded at time of sample collection. PID and H_2S readings taken as monitoring well lid removed.

[a]Water quality reading collected from last purged groundwater due to a limited water volume. Reading was not recorded in a flow through cell. Well was purged on 1/15/02 and sample was collected on 1/17/02 at 0820.

[b]Water quality reading collected from last purged groundwater due to a limited water volume. Reading was not recorded in a flow through cell. The groundwater sample was collected 1 or 2 days following well purging.

[c]PT-5912 is a water well located at 5912 Patten Tract Road on private property.

°C - Degrees Celsius.
Eh - Oxidation-reduction potential.
gal - Gallons.
H_2S - Hydrogen sulfide.
mmhos/cm - Millimhos per centimeter.
mV - Millivolts.
NA - Not applicable.
NM - Not measured.
NR - Not recorded.
NTU - Nephelometric turbidity unit.
O_2 - Oxygen.
PID - Photoionization detector.
ppm - Parts per million.

Table 5-1

Summary of Analytical Parameters and Methods
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Sample Matrix	Analytical Parameters[a]	Analytical Method[b]
Groundwater (Monitoring Well)	TCL Volatile Organic Compounds	SW-846 5030/8260B
	TCL Semivolatile Organic Compounds	SW-846 3510C/8270C
	Nitroaromatic Compounds	SW-846 8330M
	TAL Metals (T/D)	SW-846 3005A/6010B/7470A
	Turbidity	EPA 180.1
	Alkalinity	EPA 310.1
	Hardness	EPA 130.2
	Total Organic Carbon	SW-846 9060
	Total Dissolved Solids	EPA 160.1
	Total Suspended Solids	EPA 160.2
	Chloride	EPA 325.2
	Cyanide, total	SW-846 9012A
	Nitrate	EPA 353.2
	Sulfate	EPA 375.4
Groundwater IDW	2,4-Dinitrotoluene	SW-846 8330M
Soil IDW	TCLP Volatile Organic Compounds	SW-846 1311/8260B
	TCLP Semivolatile Organic Compounds	SW-846 1311/8270C
	TCLP Metals	SW-846 1311/6010B/7471A
	Ignitability	SW-846 1010
	Corrosivity	SW-846 1110
	Reactivity	7.3.3.2/7.3.4.2

[a]Target analyte list (TAL) and target compound list (TCL) are used to designate parameter lists with no requirements for Contract Laboratory Program (CLP) method quality control or data reporting packages

[b] Analyses found in *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods,* Third Edition and *Methods for Chemical Analysis of Water and Wastes* , March 1983 and their subsequent revisions.
ID W - Investigation-derived waste.

Table 6-1

Summary of Groundwater Elevation Measurements
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Well Identification	Coordinates (Ohio St. Plane)[a] Northing (y)	Easting (x)	Top of Casing Elevation[a] (ft msl)	Ground Elevation[a] (ft msl)	Groundwater Elevation Measurements (feet above mean sea level [ft msl]) 12/94	12/1994[b]	3/19	03/19/95[c]	10/96	10/1996[d]	8/27	8/27/1997[e]	11/12	11/12/1997[f]	2/24	02/24/1998[g]
Monitoring Wells Screened in Overburden																
AA1-GW002	623068	1917728	640.85	638.60	--[J]	--	--	--	--	--	--	--	6.22	634.63	3.05	637.80
AA2-GW002	623589	1909481	643.95	641.50	--	--	--	--	--	--	--	--	--	dry	--	dry
AA3-GW002	625028	1914956	636.11	634.10	--	--	--	--	--	--	--	--	6.30	629.81	3.88	632.23
ABG-GW002	621579	1921516	661.06	658.20	--	--	--	--	--	--	--	--	6.55	654.51	3.95	657.11
PS-02	624344	1920061	638.53	635.70	--	--	--	--	--	--	5.97	632.56	5.87	632.66	4.81	633.72
PS-03	624324	1920187	637.15	634.40	--	--	--	--	--	--	5.65	631.50	6.35	630.80	5.62	631.53
PS-04	624298	1920259	637.87	635.30	--	--	--	--	--	--	8.87	629.00	9.00	628.87	7.30	630.57
SP-01	613598	1927550	655.07	652.30	--	--	--	--	--	--	6.43	648.64	7.55	647.52	5.54	649.53
SP-03	613398	1926836	657.73	655.10	--	--	--	--	--	--	5.26	652.47	6.94	650.79	4.26	653.47
SP-04	613162	1926937	658.02	655.25	--	--	--	--	--	--	7.20	650.82	8.18	649.84	4.21	653.81
SP-05	613051	1926897	657.00	654.50	--	--	--	--	--	--	5.08	651.92	6.17	650.83	4.92	652.08
SP-06	613056	1927074	658.25	655.40	--	--	--	--	--	--	6.80	651.45	8.10	650.15	7.04	651.21
GCL-MW01	617560	1921255	674.81	671.40	--	--	--	--	--	--	8.32	666.49	8.81	666.00	4.57	670.24
GCL-MW02A	617937	1920961	672.96	669.70	--	--	--	--	--	--	7.57	665.39	7.79	665.17	4.65	668.31
GCL-MW02B	617941	1920984	673.42	669.60	--	--	--	--	--	--	8.32	665.10	8.41	665.01	4.59	668.83
GCL-MW03	617641	1920777	672.57	669.55	--	--	--	--	--	--	6.00	666.57	6.61	665.96	4.20	668.37
IT-MW01	616901	1915525	678.19	674.50	--	--	--	--	--	--	5.45	672.74	7.00	671.19	4.66	673.53
IT-MW02	622512	1910265	639.28	636.37	11.96	627.32	5.53	633.75	9.95	629.33	8.09	631.19	9.78	629.50	5.68	633.60
IT-MW05	625346	1919475	634.67	631.59	14.48	620.19	5.05	629.62	11.31	623.36	9.88	624.79	10.45	624.22	4.42	630.25
IT-MW06	628642	1918768	631.70	628.50	--	--	--	--	--	--	8.34	623.36	9.21	622.49	4.01	627.69
IT-MW07 (abandoned)	622076	1909862	635.03	632.30	--	--	--	--	--	--	--	dry	--	dry	--	dry
IT-MW08	622498	1911132	633.16	630.60	--[J]	--	--	--	13.20	619.96	8.22	624.94	10.72	622.44	2.91	630.25
IT-MW09	620956	1910699	647.45	645.40	--	--	--	--	dry	--	6.00	641.45	7.24	640.21	4.72	642.73
IT-MW10	623027	1909485	644.80	642.20	--	--	--	--	18.39	626.41	11.25	633.55	12.12	632.68	8.20	636.60
MK-MW09	623901	1908872	645.61	642.95	--	--	--	--	--	--	6.09	639.52	6.49	639.12	5.00	640.61
MK-MW10	623861	1910564	640.57	637.74	13.91	626.66	--	--	8.34	632.23	7.13	633.44	8.49	632.08	7.15	633.42
MK-MW11	623829	1911843	637.36	634.39	12.14	625.22	6.00	631.36	8.47	628.89	7.13	630.23	8.14	629.22	5.92	631.44
MK-MW12	621233	1908764	640.93	638.10	--	--	--	--	--	--	9.86	631.07	10.78	630.15	7.45	633.48
MK-MW14	618311	1913325	681.26	678.50	--	--	--	--	--	--	8.17	673.09	8.72	672.54	4.62	676.64
MK-MW15	618488	1913304	680.63	677.80	--	--	--	--	--	--	8.22	672.41	8.80	671.83	4.92	675.71
MK-MW16	616834	1918011	674.00	671.01	6.86	667.14	4.64	669.36	5.58	668.42	5.97	668.03	7.75	666.25	5.14	668.86
MK-MW17[k]	618572	1917813	664.51	661.15	4.74	659.58	3.22	661.10	3.76	660.56	4.32	660.00	4.75	659.57	3.68	660.64
MK-MW19	623871	1917535	639.13	636.20	--	--	--	--	--	--	7.99	631.14	6.83	632.30	3.67	635.46
MK-MW20	622912	1920539	637.51	634.30	--	--	--	--	--	--	4.97	632.54	4.78	632.73	6.61	630.90
MK-MW22	624339	1923776	637.73	635.24	8.88	628.85	6.18	631.55	7.66	630.07	8.20	629.53	8.24	629.49	6.94	630.79
MK-MW23	624657	1925354	639.11	636.63	18.23	620.88	10.99	628.12	6.97	632.14	8.49	630.62	8.02	631.09	5.61	633.50
MK-MW24	622264	1923302	656.80	654.12	8.49	648.31	6.03	650.77	7.19	649.61	7.08	649.72	7.22	649.58	6.25	650.55

Table 6-1

Summary of Groundwater Elevation Measurements
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Well Identification	Groundwater Elevation Measurements (feet above mean sea level [ft msl])																	
	5/5	05/05/1998[h]	9/20[i]	09/20/00	1/17[i]	01/17/01	8/15[i]	08/15/01	11/15[i]	11/15/01	2/2728[i]	02/27/02	5/4[i]	05/04/02	8/6[i]	08/06/02	11/21[i]	11/21/02
Monitoring Wells Screened in Overburden																		
AA1-GW002	3.42	637.43	4.20	636.65	3.60	637.25	7.32	633.53	4.38	636.47	3.39	637.46	3.32	637.53	7.85	633.00	5.99	634.86
AA2-GW002	--	dry	13.20	630.75	7.50	636.45	16.57	627.38	20.58	623.37	10.63	633.32	4.85	639.10	15.28	628.67	20.80	623.15
AA3-GW002	3.97	632.14	5.10	631.01	4.00	632.11	8.80	627.31	6.82	629.29	4.50	631.61	4.22	631.89	9.42	626.69	9.13	626.98
ABG-GW002	4.92	656.14	5.80	655.26	4.60	656.46	8.51	652.55	6.46	654.60	4.18	656.88	4.06	657.00	8.70	652.36	7.12	653.94
PS-02	4.90	633.63	5.70	632.83	4.50	634.03	7.27	631.26	5.96	632.57	4.70	633.83	5.19	633.34	7.90	630.63	6.13	632.40
PS-03	5.52	631.63	5.70	631.45	6.30	630.85	6.27	630.88	6.35	630.80	5.96	631.19	5.98	631.17	6.93	630.22	5.94	631.21
PS-04	5.26	632.61	8.40	629.47	8.60	629.27	9.43	628.45	8.60	629.27	8.00	629.87	8.16	629.71	9.40	628.47	9.40	628.47
SP-01	5.78	649.29	7.40	647.67	6.50	648.57	9.34	645.73	7.89	647.18	6.10	648.97	6.20	648.87	9.61	645.46	9.86	645.21
SP-03	4.21	653.52	4.80	652.93	--	--	7.07	650.66	5.94	651.79	4.19	653.54	4.76	652.97	8.51	649.22	4.52	653.21
SP-04	7.20	650.82	7.40	650.62	--	--	7.76	650.26	7.80	650.22	7.30	650.72	7.44	650.58	7.36	650.66	7.30	650.72
SP-05	4.96	652.04	5.40	651.60	--	--	7.03	649.97	5.95	651.05	4.96	652.04	5.27	651.73	8.14	648.86	6.36	650.64
SP-06	7.24	651.01	6.40	651.85	--	--	7.63	650.63	7.63	650.62	4.18	654.07	7.25	651.00	9.15	649.10	7.13	651.12
GCL-MW01	4.98	669.83	6.80	668.01	6.90	667.91	10.12	664.69	8.94	665.87	5.10	669.71	5.22	669.59	10.17	664.64	11.56	663.25
GCL-MW02A	4.85	668.11	5.60	667.36	4.90	668.06	9.20	663.76	6.34	666.62	4.75	668.21	5.25	667.71	9.55	663.41	10.39	662.57
GCL-MW02B	5.00	668.42	6.10	667.32	5.20	668.22	9.67	663.75	6.88	666.54	4.84	668.58	5.02	668.40	9.98	663.44	11.18	662.24
GCL-MW03	4.50	668.07	5.30	667.27	4.60	667.97	8.25	664.32	5.60	666.97	4.30	668.27	4.52	668.05	8.53	664.04	9.10	663.47
IT-MW01	4.60	673.59	5.30	672.89	4.80	673.39	8.12	670.07	5.60	672.59	4.66	673.53	4.85	673.34	8.42	669.77	6.63	671.56
IT-MW02	5.79	633.49	6.95	632.33	5.80	633.48	11.66	627.62	9.88	629.40	5.82	633.46	6.03	633.25	11.86	627.42	13.37	625.91
IT-MW05	4.76	629.91	8.80	625.87	6.40	628.27	12.35	622.32	14.15	620.52	5.17	629.50	4.80	629.87	12.10	622.57	18.50	616.17
IT-MW06	4.02	627.68	--	--	--	--	10.48	621.22	10.08	621.62	5.84	625.86	4.11	627.59	10.35	621.35	11.86	619.84
IT-MW07 (abandoned)	--	dry	3.90	631.13	2.70	632.33	6.81	628.22	NM	--	NM	--	AB	--	AB	--	AB	--
IT-MW08	3.12	630.04	6.60	626.56	5.20	627.96	12.18	620.98	14.38	618.78	4.19	628.97	5.30	627.86	11.45	621.71	15.84	617.32
IT-MW09	5.02	642.43	8.30	639.15	6.80	640.65	9.50	637.95	7.06	640.39	6.42	641.03	7.18	640.27	10.61	636.84	9.75	637.70
IT-MW10	8.19	636.61	10.30	634.50	9.50	635.30	16.06	628.74	14.09	630.71	8.77	636.03	8.25	636.55	15.35	629.45	21.80	623.00
MK-MW09	4.99	640.62	5.80	639.81	5.60	640.01	9.21	636.40	6.35	639.26	5.51	640.10	5.41	640.20	9.35	636.26	13.24	632.37
MK-MW10	5.22	635.35	5.60	634.97	5.20	635.37	9.33	631.24	6.98	633.59	5.02	635.55	5.56	635.01	9.31	631.26	13.86	626.71
MK-MW11	6.51	630.85	6.80	630.56	6.50	630.86	12.07	625.29	7.99	629.37	3.92	633.44	6.91	630.45	12.20	625.16	9.01	628.35
MK-MW12	8.38	632.55	--	--	9.40	631.53	11.50	629.43	10.39	630.54	8.30	632.63	8.50	632.43	11.59	629.34	11.01	629.92
MK-MW14	4.81	676.45	7.50	673.76	6.00	675.26	9.58	671.68	9.50	671.76	5.88	675.38	5.12	676.14	9.65	671.61	10.80	670.46
MK-MW15	4.86	675.77	7.40	673.23	6.80	673.83	9.13	671.50	8.75	671.88	5.29	675.34	5.27	675.36	9.04	671.59	10.23	670.40
MK-MW16	5.10	668.90	5.90	668.10	6.10	667.90	8.49	665.51	6.77	667.23	5.36	668.64	5.34	668.66	8.34	665.66	6.19	667.81
MK-MW17[k]	3.90	660.42	5.10	659.22	4.90	659.42	5.78	658.55	5.10	659.22	4.46	659.86	4.40	659.92	6.18	658.14	5.35	658.97
MK-MW19	4.56	634.57	4.90	634.23	4.80	634.33	8.30	630.83	5.68	633.45	4.27	634.86	4.80	634.33	8.69	630.44	6.60	632.53
MK-MW20	5.85	631.66	5.50	632.01	--	--	5.57	631.94	6.12	631.39	NM[l]	--	NM[l]	--	NM[l]	--	NM[l]	--
MK-MW22	7.42	630.31	7.80	629.93	6.90	630.83	9.60	628.13	7.28	630.45	6.69	631.04	7.35	630.38	9.77	627.96	9.22	628.51
MK-MW23	6.54	632.57	7.40	631.71	7.30	631.81	10.35	628.76	7.11	632.00	5.96	633.15	6.43	632.68	10.23	628.88	9.60	629.51
MK-MW24	6.18	650.62	7.50	649.30	6.10	650.70	9.39	647.41	8.24	648.56	6.15	650.65	6.18	650.62	9.47	647.33	10.00	646.80

Table 6-1

Summary of Groundwater Elevation Measurements
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Well Identification	Groundwater Elevation Measurements (feet above mean sea level [ft msl])															
	3/03[i]	03/18,19/03	5/03[i]	5/19-21/03	8/03[i]	8/5-7/03	9/03	9/14/03	11/03[i]	11/4-5/03	3/04[i]	03/1-2/04	5/04[i]	05/11-12/04	8/04[i]	08/10-11/04
Monitoring Wells Screened in Overburden																
AA1-GW002	2.48	638.37	3.66	637.19	4.10	636.75	6.95	633.90	4.72	636.13	3.15	637.70	3.35	637.50	6.99	633.86
AA2-GW002	20.81	623.14	4.95	639.00	13.28	630.67	16.65	627.30	18.69	625.26	5.20	638.75	4.51	639.44	13.12	630.83
AA3-GW002	3.99	632.12	4.25	631.86	4.90	631.21	7.70	628.41	5.48	630.63	3.82	632.29	3.92	632.19	6.98	629.13
ABG-GW002	4.02	657.04	3.75	657.31	5.08	655.98	7.50	653.56	5.02	656.04	3.81	657.25	4.08	656.98	7.53	653.53
PS-02	4.58	633.95	5.55	632.98	5.61	632.92	7.10	631.43	5.46	633.07	8.31	630.22	5.23	633.30	7.10	631.43
PS-03	6.00	631.15	6.00	631.15	5.34	631.81	6.38	630.77	5.95	631.20	5.99	631.16	5.83	631.32	6.20	630.95
PS-04	8.65	629.22	8.33	629.54	8.65	629.22	9.10	628.77	8.61	629.26	4.42	633.45	8.15	629.72	8.92	628.95
SP-01	5.64	649.43	6.50	648.57	6.49	648.58	8.39	646.68	7.08	647.99	5.59	649.48	6.18	648.89	7.60	647.47
SP-03	4.20	653.53	5.06	652.67	3.76	653.97	6.56	651.17	4.43	653.30	4.05	653.68	4.95	652.78	5.76	651.97
SP-04	7.41	650.61	7.50	650.52	6.94	651.08	7.60	650.42	7.44	650.58	7.72	650.30	7.40	650.62	7.59	650.43
SP-05	4.57	652.43	5.50	651.50	4.71	652.29	6.33	650.67	5.10	651.90	5.10	651.90	5.21	651.79	6.06	650.94
SP-06	8.65	649.60	7.78	650.47	6.78	651.47	7.82	650.43	7.10	651.15	8.90	649.35	7.41	650.84	7.21	651.04
GCL-MW01	5.62	669.19	4.58	670.23	7.10	667.71	9.22	665.59	6.30	668.51	5.05	669.76	5.34	669.47	8.63	666.18
GCL-MW02A	4.75	668.21	4.52	668.44	5.78	667.18	8.44	664.52	5.15	667.81	4.70	668.26	5.39	667.57	8.18	664.78
GCL-MW02B	5.02	668.40	4.60	668.82	6.21	667.21	8.98	664.44	5.56	667.86	4.70	668.72	5.92	667.50	8.89	664.53
GCL-MW03	4.37	668.20	4.03	668.54	5.30	667.27	7.35	665.22	4.68	667.89	4.08	668.49	4.64	667.93	7.11	665.46
IT-MW01	4.94	673.25	4.60	673.59	4.75	673.44	7.49	670.70	4.91	673.28	4.48	673.71	4.92	673.27	7.25	670.94
IT-MW02	5.75	633.53	5.58	633.70	7.40	631.88	10.17	629.11	7.94	631.34	5.57	633.71	5.80	633.48	10.10	629.18
IT-MW05	10.48	624.19	5.62	629.05	8.77	625.90	11.06	623.61	10.80	623.87	4.51	630.16	5.12	629.55	9.65	625.02
IT-MW06	7.48	624.22	4.25	627.45	6.45	625.25	9.31	622.39	8.00	623.70	3.91	627.79	4.17	627.53	8.64	623.06
IT-MW07 (abandoned)	AB	--	AB	--	AB	--	AB	--	AB	--	AB	--	AB	--	AB	--
IT-MW08	5.65	627.51	3.81	629.35	6.20	626.96	10.24	622.92	10.82	622.34	2.84	630.32	2.95	630.21	8.45	624.71
IT-MW09	7.45	640.00	8.38	639.07	8.16	639.29	8.52	638.93	7.10	640.35	8.68	638.77	9.78	637.67	10.29	637.16
IT-MW10	9.82	634.98	8.91	635.89	11.85	632.95	14.54	630.26	10.25	634.55	8.32	636.48	8.19	636.61	4.23	640.57
MK-MW09	4.83	640.78	5.63	639.98	5.70	639.91	7.79	637.82	5.80	639.81	4.90	640.71	5.15	640.46	6.95	638.66
MK-MW10	4.50	636.07	5.49	635.08	5.61	634.96	8.50	632.07	5.59	634.98	4.78	635.79	5.45	635.12	7.75	632.82
MK-MW11	6.00	631.36	7.08	630.28	6.99	630.37	8.73	628.63	7.17	630.19	5.95	631.41	6.54	630.82	8.03	629.33
MK-MW12	7.13	633.80	8.44	632.49	9.37	631.56	11.24	629.69	9.70	631.23	8.10	632.83	8.68	632.25	11.20	629.73
MK-MW14	5.57	675.69	4.82	676.44	7.25	674.01	8.98	672.28	8.21	673.05	5.10	676.16	5.12	676.14	8.43	672.83
MK-MW15	6.87	673.76	5.08	675.55	7.00	673.63	8.64	671.99	8.28	672.35	5.51	675.12	5.17	675.46	8.01	672.62
MK-MW16	4.87	669.13	5.35	668.65	5.80	668.20	7.73	666.27	5.80	668.20	5.20	668.80	5.34	668.66	7.75	666.25
MK-MW17[k]	4.29	660.03	4.35	659.97	4.86	659.65	5.14	659.37	4.75	659.76	4.16	660.35	4.67	659.84	5.36	659.15
MK-MW19	3.70	635.43	4.75	634.38	4.45	634.68	7.38	631.75	5.41	633.72	4.52	634.61	5.19	633.94	7.40	631.73
MK-MW20	9.46	628.05	8.52	628.99	5.90	631.61	5.50	632.01	5.42	632.09	7.10	630.41	6.62	630.89	4.35	633.16
MK-MW22	dry	--	7.37	630.36	7.05	630.68	8.20	629.53	7.35	630.38	7.40	630.33	7.37	630.36	8.99	628.74
MK-MW23	5.51	633.60	6.30	632.81	8.54	630.57	9.78	629.33	7.43	631.68	5.92	633.19	6.10	633.01	9.68	629.43
MK-MW24	6.19	650.61	6.20	650.60	6.85	649.95	9.33	647.47	6.80	650.00	5.85	650.95	6.08	650.72	9.14	647.66

Table 6-1

Summary of Groundwater Elevation Measurements
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Well Identification	Coordinates (Ohio St. Plane)[a] Northing (y)	Easting (x)	Top of Casing Elevation[a] (ft msl)	Ground Elevation[a] (ft msl)	Groundwater Elevation Measurements (feet above mean sea level [ft msl]) 12/94	12/1994[b]	3/19	03/19/95[c]	10/96	10/1996[d]	8/27	8/27/1997[e]	11/12	11/12/1997[f]	2/24	02/24/1998[g]
Monitoring Wells Screened in Overburden																
PR-MW07	624996	1919021	633.67	631.18	7.35	626.32	2.02	631.65	4.03	629.64	5.35	628.32	5.06	628.61	2.21	631.46
PR-MW08 (abandoned)	624889	1919309	634.70	632.18	10.15	624.55	4.72	629.98	7.14	627.56	6.66	628.04	7.72	626.98	4.90	629.80
PR-MW09	625092	1919510	633.38	630.38	10.46	622.92	3.26	630.12	6.81	626.57	6.50	626.88	7.85	625.53	3.36	630.02
TNTA-MW10	623864	1923399	639.86	637.18	6.15	633.71	2.82	637.04	4.24	635.62	4.16	635.70	4.67	635.19	3.10	636.76
TNTA-MW11	623518	1922744	640.18	637.54	9.68	630.50	7.36	632.82	6.62	633.56	5.49	634.69	5.16	635.02	4.78	635.40
TNTC-MW03	621465	1911391	645.09	642.25	dry	--	5.89	639.20	10.08	635.01	8.07	637.02	9.27	635.82	3.80	641.29
TNTC-MW04	620413	1910470	654.11	651.57	19.24	634.87	3.04	651.07	5.60	648.51	6.15	647.96	7.62	646.49	3.32	650.79
TNTC-MW05	620692	1911811	651.49	648.75	23.48	628.01	3.87	647.62	8.21	643.28	5.62	645.87	5.60	645.89	3.02	648.47
TNTC-MW06	620429	1913006	659.08	656.50	7.15	651.93	3.88	655.20	4.52	654.56	4.46	654.62	5.71	653.37	3.72	655.36
WA-MW01	622641	1909948	644.11	642.00	--	--	--	--	--	--	14.00	630.11	16.15	627.96	4.09	640.02
WA-MW02	622124	1910176	633.33	630.84	--	--	--	--	--	--	3.89	629.44	4.46	628.87	1.53	631.80
GM-01	623563	1918339	640.45	637.70	--	--	--	--	--	--	8.77	631.68	9.29	631.16	7.35	633.10
GM-02	624435	1917822	637.52	634.90	--	--	--	--	--	--	10.76	626.76	9.46	628.06	4.91	632.61
GM-03	624131	1917775	638.90	636.20	--	--	--	--	--	--	6.28	632.62	7.38	631.52	5.81	633.09
GM-04	624052	1917442	636.34	633.60	--	--	--	--	--	--	5.56	630.78	5.55	630.79	3.27	633.07
GM-05	623872	1917802	639.70	637.00	--	--	--	--	--	--	6.24	633.46	7.57	632.13	5.80	633.90
GM-06	623723	1917799	639.61	637.00	--	--	--	--	--	--	6.08	633.53	7.36	632.25	5.92	633.69
RA-01	625964	1917783	633.97	631.40	--	--	--	--	--	--	6.61	627.36	7.88	626.09	5.63	628.34
RA-02	626944	1918282	633.95	631.30	--	--	--	--	--	--	8.10	625.85	8.72	625.43	6.52	627.43
RA-03	626788	1918346	633.63	630.90	--	--	--	--	--	--	--	dry	--	dry	9.09	624.54
RA-04	626731	1918389	633.54	630.70	--	--	--	--	--	--	8.07	625.47	10.36	623.18	7.12	626.42
RA-05	626717	1918492	633.34	630.60	--	--	--	--	--	--	7.95	625.39	8.87	624.47	6.87	626.47
RA-06	626748	1918750	632.64	630.10	--	--	--	--	--	--	8.65	623.99	7.86	624.78	5.20	627.44
RA-MW-02[aa]	~626663`	~1918540	628.07	628.50	--	--	--	--	--	--	--	--	--	--	--	--
RA-MW-03[aa]	~626685	~1918263	627.82	628.00	--	--	--	--	--	--	--	--	--	--	--	--
RA-MW-04[aa]	~626898	~1918380	628.36	628.50	--	--	--	--	--	--	--	--	--	--	--	--
RA-MW-06[aa]	~626836	~1918528	627.64	628.00	--	--	--	--	--	--	--	--	--	--	--	--
RA-07S[bb]	~626991	~1918083	634.83	632.65	--	--	--	--	--	--	--	--	--	--	--	--
RA-08S[bb]	~626999	~1918440	633.02	630.71	--	--	--	--	--	--	--	--	--	--	--	--
Monitoring Wells Screened in Shale																
ABG-BEDGW-001	621580	1921506	660.59	658.20	--	--	--	--	--	--	--	--	6.09	654.50	3.55	657.04
BG8-BEDGW-001	618635	1909857	676.56	673.70	--	--	--	--	--	--	--	--	6.38	670.18	8.11	668.45
BED-MW20	612423	1922952	676.01	673.25	14.66	661.35	14.73	661.28	14.03	661.98	14.28	661.73	14.42	661.59	13.98	662.03
BED-MW25	617821	1914458	684.59	681.99	--	--	--	--	--	--	--	--	--	--	--	--
BED-MW26	613878	1920274	677.21	674.61	--	--	--	--	--	--	--	--	--	--	--	--
BED-MW28	610536	1923306	670.83	670.99	--	--	--	--	--	--	--	--	--	--	--	--
BED-MW29	616832	1913520	678.30	678.50	--	--	--	--	--	--	--	--	--	--	--	--
TNTB-BEDGW-001	618738	1917218	662.43	659.80	--	--	--	--	--	--	--	--	4.11	658.32	5.60	656.83
TNTB-BEDGW-002	616835	1918021	673.35	670.10	--	--	--	--	--	--	--	--	6.91	666.44	2.89	670.46
TNTB-BEDGW-003	618103	1918710	683.11	681.34	--	--	--	--	--	--	--	--	--	--	--	--
TNTB-BEDGW-004	618469	1918572	668.63	666.78	--	--	--	--	--	--	--	--	--	--	--	--

Table 6-1

Summary of Groundwater Elevation Measurements
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Well Identification	Groundwater Elevation Measurements (feet above mean sea level [ft msl])																	
	5/5	05/05/1998[h]	9/20[i]	09/20/00	1/17[i]	01/17/01	8/15[i]	08/15/01	11/15[i]	11/15/01	2/2728[i]	02/27/02	5/4[i]	05/04/02	8/6[i]	08/06/02	11/21[i]	11/21/02
	Monitoring Wells Screened in Overburden																	
PR-MW07	2.17	631.50	--	--	--	--	5.63	628.05	5.08	628.59	2.46	631.21	2.28	631.39	5.82	627.85	5.54	628.13
PR-MW08 (abandoned)	4.37	630.33	--	--	--	--	7.19	627.51	6.82	627.88	5.08	629.62	4.46	630.24	7.25	627.45	9.68	625.02
PR-MW09	3.40	629.98	--	--	--	--	8.70	624.68	6.40	626.98	3.49	629.89	3.42	629.96	7.94	625.44	9.88	623.50
TNTA-MW10	3.24	636.62	4.80	635.06	2.90	636.96	8.03	631.83	5.60	634.26	3.20	636.66	3.18	636.68	8.00	631.86	6.69	633.17
TNTA-MW11	4.34	635.84	6.20	633.98	3.10	637.08	7.30	632.88	9.40	630.78	4.30	635.88	4.41	635.77	7.09	633.09	10.30	629.88
TNTC-MW03	4.95	640.14	6.80	638.29	4.20	640.89	11.46	633.63	11.31	633.78	4.55	640.54	5.21	639.88	11.24	633.85	16.14	628.95
TNTC-MW04	3.21	659.90	6.80	647.31	4.00	650.11	7.80	646.31	6.66	647.45	3.85	650.26	4.29	649.82	8.08	646.03	8.88	645.23
TNTC-MW05	3.10	648.39	5.20	646.29	3.60	647.89	7.76	643.73	17.60	633.89	3.07	648.42	3.30	648.19	7.81	643.68	18.78	632.71
TNTC-MW06	3.81	655.27	4.90	654.18	4.10	654.98	6.68	652.40	4.89	654.19	3.74	655.34	4.40	654.68	6.75	652.33	5.80	653.28
WA-MW01	4.70	639.41	14.20	629.91	9.20	634.91	17.65	626.46	21.12	622.99	18.38	625.73	5.29	638.82	16.15	627.96	22.75	621.36
WA-MW02	1.54	631.79	3.90	629.43	1.90	631.43	4.74	628.59	3.39	629.94	1.27	632.06	1.22	632.11	5.16	628.17	5.25	628.08
GM-01	7.97	632.48	8.40	632.05	8.60	631.85	9.71	630.74	8.57	631.88	8.10	632.35	8.15	632.30	10.05	630.40	9.09	631.36
GM-02	5.14	632.38	7.80	629.72	5.10	632.42	14.04	623.48	14.83	622.69	4.72	632.80	5.15	632.37	13.29	624.23	19.97	617.55
GM-03	5.99	632.91	6.00	632.90	6.40	632.50	7.60	631.30	6.81	632.09	5.96	632.94	6.17	632.73	8.30	630.60	6.75	632.15
GM-04	3.91	632.43	4.60	631.74	3.90	632.44	10.28	626.06	4.57	631.77	3.47	632.87	3.94	632.40	10.71	625.63	8.40	627.94
GM-05	dry	dry	6.40	633.30	6.90	632.80	7.48	632.22	7.05	632.65	6.25	633.45	6.40	633.30	8.09	631.61	6.80	632.90
GM-06	6.00	633.61	6.30	633.31	6.80	632.81	7.23	632.38	7.65	631.96	6.28	633.33	6.34	633.27	7.65	631.96	6.68	632.93
RA-01	5.75	628.22	6.40	627.57	5.90	628.07	9.35	624.62	7.42	626.55	5.85	628.12	6.25	627.72	9.74	624.23	8.00	625.97
RA-02	6.72	627.23	7.10	626.85	7.30	626.65	10.45	623.50	9.50	624.45	NM	--	NM	--	NM	--	NM	--
RA-03	9.70	623.93	12.60	621.03	15.70	617.93	16.03	617.61	14.27	619.36	NM	--	NM	--	NM	--	NM	--
RA-04	7.53	626.01	8.60	624.94	9.80	623.74	11.30	622.24	9.18	624.36	NM	--	NM	--	NM	--	NM	--
RA-05	7.07	626.27	7.10	626.24	7.40	625.94	10.10	623.24	8.29	625.05	NM	--	NM	--	NM	--	NM	--
RA-06	4.49	628.15	6.10	626.54	5.20	627.44	9.66	622.98	6.76	625.88	NM	--	NM	--	NM	--	NM	--
RA-MW-02[aa]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
RA-MW-03[aa]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
RA-MW-04[aa]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
RA-MW-06[aa]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
RA-07S[bb]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
RA-08S[bb]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Monitoring Wells Screened in Shale																	
ABG-BEDGW-001	5.60	654.99	5.80	654.79	4.20	656.39	7.80	652.79	5.99	654.60	3.82	656.77	3.81	656.78	7.85	652.74	6.83	653.76
BG8-BEDGW-001	5.86	670.70	5.40	671.16	6.00	670.56	9.04	667.52	5.57	670.99	5.68	670.88	5.82	670.74	5.70	670.86	5.99	670.57
BED-MW20	13.29	662.72	13.80	662.21	13.80	662.21	13.75	662.26	14.48	661.53	13.81	662.20	13.94	662.07	14.29	661.72	14.56	661.45
BED-MW25	--	--	--	--	--	--	--	--	--	--	14.05	670.54	13.90	670.69	16.76	667.83	15.78	668.81
BED-MW26	--	--	--	--	--	--	--	--	--	--	59.63	617.58	59.96	617.25	60.20	617.01	59.82	617.39
BED-MW28	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
BED-MW29	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TNTB-BEDGW-001	2.91	659.52	3.60	658.83	3.60	658.83	4.78	657.65	3.83	658.60	3.16	659.27	3.10	659.33	4.86	657.57	3.58	658.85
TNTB-BEDGW-002	7.67	665.68	6.20	667.15	5.60	667.75	8.20	665.15	6.48	666.87	5.72	667.63	5.80	667.55	8.48	664.87	6.90	666.45
TNTB-BEDGW-003	--	--	--	--	--	--	--	--	--	--	19.38	663.73	25.28	657.83	21.20	661.91	21.71	661.40
TNTB-BEDGW-004	--	--	--	--	--	--	--	--	--	--	7.31	661.32	7.20	661.43	9.85	658.78	9.05	659.58

Table 6-1

Summary of Groundwater Elevation Measurements
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Well Identification	Groundwater Elevation Measurements (feet above mean sea level [ft msl])															
	3/03[i]	03/18,19/03	5/03[i]	5/19-21/03	8/03[i]	8/5-7/03	9/03	9/14/03	11/03[i]	11/4-5/03	3/04[i]	03/1-2/04	5/04[i]	05/11-12/04	8/04[i]	08/10-11/04
Monitoring Wells Screened in Overburden																
PR-MW07	2.61	631.06	2.55	631.12	3.60	630.07	5.47	628.20	3.35	630.32	2.20	631.47	2.26	631.41	4.81	628.86
PR-MW08 (abandoned)	AB	--	AB	--	AB	--	AB	--	AB	--	AB	--	AB	--	AB	--
PR-MW09	3.66	629.72	3.71	629.67	4.64	628.74	7.22	626.16	5.80	627.58	3.30	630.08	3.56	629.82	6.88	626.50
TNTA-MW10	2.90	636.96	3.61	636.25	4.45	635.41	6.25	633.61	4.15	635.71	2.70	637.16	3.56	636.30	6.61	633.25
TNTA-MW11	2.98	637.20	4.27	635.91	6.47	633.71	8.93	631.25	4.34	635.84	2.81	637.37	3.97	636.21	7.35	632.83
TNTC-MW03	4.81	640.28	5.32	639.77	6.00	639.09	9.58	635.51	7.20	637.89	3.74	641.35	4.95	640.14	9.08	636.01
TNTC-MW04	3.25	650.86	4.48	649.63	5.21	648.90	7.10	647.01	6.25	647.86	3.49	650.62	4.04	650.07	7.17	646.94
TNTC-MW05	3.04	648.45	3.10	648.39	4.60	646.89	6.95	644.54	5.15	646.34	2.95	648.54	4.05	647.44	6.85	644.64
TNTC-MW06	3.60	655.48	4.82	654.26	4.15	654.93	5.68	653.40	4.33	654.75	3.60	655.48	4.20	654.88	5.70	653.38
WA-MW01	23.05	621.06	6.88	637.23	13.73	630.38	16.11	628.00	16.72	627.39	5.21	638.90	4.71	639.40	12.58	631.53
WA-MW02	2.24	631.09	1.50	631.83	3.15	630.18	4.60	628.73	3.65	629.68	1.62	631.71	0.51	632.82	4.27	629.06
GM-01	7.50	632.95	8.20	632.25	8.30	632.15	9.31	631.14	8.39	632.06	8.30	632.15	7.97	632.48	9.22	631.23
GM-02	6.67	630.85	4.91	632.61	7.70	629.82	11.37	626.15	6.60	630.92	4.44	633.08	5.72	631.80	6.34	631.18
GM-03	5.86	633.04	5.98	632.92	5.90	633.00	7.04	631.86	6.37	632.53	6.15	632.75	6.31	632.59	7.55	631.35
GM-04	3.04	633.30	3.40	632.94	3.90	632.44	7.21	629.13	4.24	632.10	3.40	632.94	4.27	632.07	6.63	629.71
GM-05	5.80	633.90	6.10	633.60	5.55	634.15	6.98	632.72	6.54	633.16	6.22	633.48	6.67	633.03	8.10	631.60
GM-06	5.99	633.62	5.94	633.67	5.65	633.96	6.80	632.81	6.41	633.20	6.22	633.39	7.38	632.23	8.52	631.09
RA-01	5.62	628.35	6.48	627.49	6.30	627.67	7.84	626.13	6.65	627.32	5.79	628.18	6.15	627.82	8.66	625.31
RA-02	NM	--	NM	--	NM	--	8.33	625.62	NM	--	NM	--	NM	--	8.80	625.15
RA-03	NM	--	NM	--	NM	--	15.20	618.43	NM	--	NM	--	NM	--	NM	--
RA-04	NM	--	NM	--	NM	--	10.11	623.43	NM	--	NM	--	NM	--	NM	--
RA-05	NM	--	NM	--	NM	--	8.79	624.55	NM	--	NM	--	NM	--	NM	--
RA-06	NM	--	NM	--	NM	--	8.13	624.51	NM	--	NM	--	NM	--	NM	--
RA-MW-02[aa]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	9.30	618.77
RA-MW-03[aa]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	NM	--
RA-MW-04[aa]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	NM	--
RA-MW-06[aa]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	NM	--
RA-07S[bb]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	16.90	617.93
RA-08S[bb]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	18.00	615.02
Monitoring Wells Screened in Shale																
ABG-BEDGW-001	3.71	656.88	3.39	657.20	4.82	655.77	6.93	653.66	4.60	655.99	3.48	657.11	3.77	656.82	6.88	653.71
BG8-BEDGW-001	6.45	670.11	5.98	670.58	5.10	671.46	5.24	671.32	5.00	671.56	5.64	670.92	5.42	671.14	4.80	671.76
BED-MW20	14.07	661.94	14.05	661.96	13.93	662.08	14.17	661.84	14.42	661.59	13.98	662.03	14.17	661.84	14.07	661.94
BED-MW25	14.05	670.54	13.83	670.76	14.49	670.10	15.89	668.70	14.62	669.97	13.72	670.87	13.80	670.79	15.58	669.01
BED-MW26	59.44	617.77	58.97	618.24	58.80	618.41	58.75	618.46	58.76	618.45	58.37	618.84	57.72	619.49	57.30	619.91
BED-MW28	--	--	--	--	--	--	8.68	662.15	8.70	662.13	8.32	662.51	6.32	664.51	7.70	663.13
BED-MW29	--	--	--	--	--	--	3.81	674.49	3.65	674.65	2.90	675.40	2.60	675.70	3.24	675.06
TNTB-BEDGW-001	3.87	658.56	3.32	659.11	6.90	655.53	4.52	657.91	3.59	658.84	3.23	659.20	3.39	659.04	4.95	657.48
TNTB-BEDGW-002	5.65	667.70	5.55	667.80	6.14	667.21	7.65	665.70	6.24	667.11	5.45	667.90	5.70	667.65	7.58	665.77
TNTB-BEDGW-003	20.90	662.21	20.47	662.64	20.58	662.53	20.90	662.21	20.75	662.36	20.28	662.83	20.02	663.09	20.31	662.80
TNTB-BEDGW-004	7.28	661.35	7.09	661.54	7.61	661.02	8.66	659.97	7.57	661.06	6.70	661.93	7.10	661.53	8.16	660.47

Table 6-1

Summary of Groundwater Elevation Measurements
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Well Identification	Coordinates (Ohio St. Plane)[a] Northing (y)	Easting (x)	Top of Casing Elevation[a] (ft msl)	Ground Elevation[a] (ft msl)	Groundwater Elevation Measurements (feet above mean sea level [ft msl]) 12/94	12/1994[b]	3/19	03/19/95[c]	10/96	10/1996[d]	8/27	8/27/1997[e]	11/12	11/12/1997[f]	2/24	02/24/1998[g]
Monitoring Wells Screened in Limestone (Delaware)																
AA1-BEDGW-001	623069	1917719	641.04	638.80	--	--	--	--	--	--	--	--	30.52	610.52	30.50	610.54
AA2-BEDGW-001	623600	1909552	644.06	641.60	--	--	--	--	--	--	--	--	13.11	630.95	11.58	632.48
AA3-BEDGW-001	625037	1914957	636.43	634.10	--	--	--	--	--	--	--	--	23.22	613.21	21.53	614.90
MNTA-BEDGW-001	623808	1918699	638.40	636.05	--	--	--	--	--	--	--	--	28.04	610.36	27.05	611.35
BED-MW13	621044	1912175	647.95	645.49	40.10	607.85	28.66	619.29	26.16	621.79	27.80	620.15	27.08	620.87	48.47	599.48
BED-MW14	622720	1910457	645.72	642.73	23.96	621.76	21.33	624.39	20.49	625.23	18.51	627.21	19.72	626.00	16.44	629.28
BED-MW15	626179	1919283	631.31	628.76	27.77	603.54	32.40	598.91	21.09	610.22	29.95	601.36	21.12	610.19	20.34	610.97
BED-MW16	623299	1920594	635.70	633.36	64.32	571.38	2.02	633.68	5.53	630.17	11.80	623.90	7.41	628.29	2.28	633.42
BED-MW17	625417	1924121	629.65	627.02	27.08	602.57	26.75	602.90	26.89	602.76	26.48	603.17	27.75	601.90	26.85	602.80
BED-MW18	623849	1925483	651.18	648.51	26.13	625.05	30.79	620.39	29.50	621.68	30.58	620.60	30.22	620.96	30.55	620.63
BED-MW19	623869	1910174	642.75	640.19	21.68	621.07	19.23	623.52	19.83	622.92	19.85	622.90	20.55	622.20	19.00	623.75
BED-MW22	629778	1918367	629.67	627.22	--	--	--	--	--	--	--	--	--	--	--	--
BED-MW23	625838	1918150	633.71	631.11	--	--	--	--	--	--	--	--	--	--	--	--
BED-MW24	622916	1908168	645.98	644.20	--	--	--	--	--	--	--	--	--	--	--	--
BED-MW27 (abandoned)	627896	1920791	627.14	625.24	--	--	--	--	--	--	--	--	--	--	--	--
BED-MW30	623092	1907135	646.87	647.25	--	--	--	--	--	--	--	--	--	--	--	--
BED-MW33	631564	1921870	619.74	619.87	--	--	--	--	--	--	--	--	--	--	--	--
TNTA-BEDGW-001	623447	1922580	638.79	636.99	--	--	--	--	--	--	--	--	--	--	--	--
TNTC-BEDGW-001	620254	1912853	667.04	664.04	--	--	--	--	--	--	--	--	--	--	--	--
2BG-BEDGW-001	622296	1913066	645.66	643.88	--	--	--	--	--	--	--	--	--	--	--	--
2BG-BEDGW-002	622164	1913150	684.27	681.67	--	--	--	--	--	--	--	--	--	--	--	--
2BG-BEDGW-003	622003	1913246	676.89	674.29	--	--	--	--	--	--	--	--	--	--	--	--
RA-MW-05[aa]	~626707	~1918533	627.67	628.00	--	--	--	--	--	--	--	--	--	--	--	--
RA-07D[bb]	~626993	~1918050	634.34	632.46	--	--	--	--	--	--	--	--	--	--	--	--
RA-08D[bb]	~626999	~1918392	632.96	630.56	--	--	--	--	--	--	--	--	--	--	--	--
REACTOR1[n]	626773	1917983	630.51	630.45	--	--	--	--	--	--	15.32	615.19	22.06	608.45	33.25	597.26
REACTOR2	626661	1918003	631.05	631.00	16.34	614.71	29.16	601.89	--	--	15.40	615.65	4.81	626.24	28.53	602.52
REACTOR3[n]	626685	1918148	631.21	631.10	--	--	--	--	--	--	14.60	616.61	22.17	609.04	37.45	593.76
REACTOR4	626630	1918147	630.83	630.44	--	--	--	--	--	--	--	--	--	--	--	--
PT-5912[o] (private well)	~626012	~1907641	636.22	634.81	--	--	--	--	--	--	--	--	--	--	--	--

Table 6-1

Summary of Groundwater Elevation Measurements
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Well Identification	Groundwater Elevation Measurements (feet above mean sea level [ft msl])																	
	5/5	05/05/1998[h]	9/20[i]	09/20/00	1/17[i]	01/17/01	8/15[i]	08/15/01	11/15[i]	11/15/01	2/2728[i]	02/27/02	5/4[i]	05/04/02	8/6[i]	08/06/02	11/21[i]	11/21/02
	Monitoring Wells Screened in Limestone (Delaware)																	
AA1-BEDGW-001	29.1	611.94	14.30	626.74	--	--	31.00	610.04	32.16	608.88	30.93	610.11	32.50	608.54	31.90	609.14	31.30	609.74
AA2-BEDGW-001	9.89	634.17	14.30	629.76	--	--	13.25	630.81	15.91	628.15	15.08	628.98	13.62	630.44	13.60	630.46	16.47	627.59
AA3-BEDGW-001	21.62	614.81	25.20	611.23	24.90	611.53	25.61	610.82	27.58	608.85	20.66	615.77	25.90	610.53	26.68	609.75	28.70	607.73
MNTA-BEDGW-001	25.60	612.80	--	--	--	--	29.40	609.00	30.99	607.41	30.19	608.21	31.50	606.90	32.78	605.62	32.43	605.97
BED-MW13	41.40	606.55	27.90	620.05	28.40	619.55	30.31	617.64	45.60	602.35	37.50	610.45	56.67	591.28	36.54	611.41	33.32	614.63
BED-MW14	15.99	629.73	18.80	626.92	17.90	627.82	19.63	626.09	21.73	623.99	18.59	627.13	17.30	628.42	19.62	626.10	23.90	621.82
BED-MW15	19.79	611.52	20.40	610.91	18.80	612.51	17.13	614.18	31.18	600.13	23.96	607.35	30.05	601.26	21.47	609.84	22.86	608.45
BED-MW16	2.74	632.96	5.00	630.70	--	--	5.29	630.41	30.14	605.56	NM[k]	--	--	--	--	--	--	--
BED-MW17	26.40	603.25	29.80	599.85	0.00	629.65	29.33	600.32	31.50	598.15	29.65	600.00	31.62	598.03	30.92	598.73	31.55	598.10
BED-MW18	30.72	620.46	30.90	620.28	31.80	619.38	31.79	619.39	33.10	618.08	32.43	618.75	32.59	618.59	32.94	618.24	32.66	618.52
BED-MW19	18.45	624.30	21.20	621.55	21.90	620.85	25.38	617.38	24.91	617.84	23.27	619.48	22.75	620.00	26.38	616.37	27.58	615.17
BED-MW22	--	--	--	--	--	--	--	--	--	--	29.76	599.91	28.50	601.17	33.51	596.16	34.13	595.54
BED-MW23	--	--	--	--	--	--	--	--	--	--	60.80	572.91	73.04	560.67	67.58	566.13	61.80	571.91
BED-MW24	--	--	--	--	--	--	--	--	--	--	25.80	620.18	24.80	621.18	27.88	618.10	36.29	609.69
BED-MW27 (abandoned)	--	--	--	--	--	--	--	--	--	--	44.60	582.54	46.10	581.04	45.60	581.54	53.45	573.69
BED-MW30	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
BED-MW33	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TNTA-BEDGW-001	--	--	--	--	--	--	--	--	--	--	62.56	576.23[m]	64.90	573.89[m]	60.84	577.95[m]	52.44	586.35[m]
TNTC-BEDGW-001	--	--	--	--	--	--	--	--	--	--	57.64	609.40	56.96	610.08	59.81	607.23	59.25	607.79
2BG-BEDGW-001	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2BG-BEDGW-002	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2BG-BEDGW-003	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
RA-MW-05[aa]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
RA-07D[bb]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
RA-08D[bb]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
REACTOR1[n]	32.30	598.21	25.50	605.01	31.80	598.71	30.20	600.31	28.64	601.87	NM	--	--	--	--	--	--	--
REACTOR2	27.50	603.55	27.40	603.65	27.10	603.95	0.13	630.93	0.00	631.05	NM	--	--	--	--	--	--	--
REACTOR3[n]	37.08	594.13	35.60	595.61	35.20	596.01	34.43	596.78	34.43	596.78	NM	--	--	--	--	--	--	--
REACTOR4	--	--	20.40	610.43	20.30	610.53	20.65	610.18	20.40	610.43	NM	--	--	--	--	--	--	--
PT-5912[o] (private well)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 6-1

Summary of Groundwater Elevation Measurements
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Well Identification	Groundwater Elevation Measurements (feet above mean sea level [ft msl])															
	3/03[i]	03/18,19/03	5/03[i]	5/19-21/03	8/03[i]	8/5-7/03	9/03	9/14/03	11/03[i]	11/4-5/03	3/04[i]	03/1-2/04	5/04[i]	05/11-12/04	8/04[i]	08/10-11/04
Monitoring Wells Screened in Limestone (Delaware)																
AA1-BEDGW-001	31.51	609.53	31.40	609.64	31.08	609.96	31.21	609.83[m]	31.02	610.02[m]	31.39	609.65[m]	31.44	609.60[m]	31.00	610.04[m]
AA2-BEDGW-001	15.02	629.04	16.90	627.16	14.00	630.06	14.25	629.81	14.58	629.48	12.54	631.52	11.14	632.92	11.68	632.38
AA3-BEDGW-001	28.78	607.65	27.50	608.93	26.85	609.58	27.18	609.25	27.50	608.93	26.63	609.80	26.15	610.28	26.10	610.33
MNTA-BEDGW-001	31.79	606.61	31.22	607.18	30.68	607.72	31.13	607.27	31.20	607.20	30.95	607.45	30.65	607.75	30.61	607.79
BED-MW13	31.34	616.61	31.22	616.73	30.80	617.15	31.32	616.63	31.71	616.24	30.55	617.40	30.46	617.49	30.74	617.21
BED-MW14	21.08	624.64	18.58	627.14	18.54	627.18	19.20	626.52	19.80	625.92	16.96	628.76	16.50	629.22	17.64	628.08
BED-MW15	22.59	608.72	22.40	608.91	22.10	609.21	22.35	608.96	22.20	609.11	20.76	610.55	20.85	610.46	20.07	611.24
BED-MW16	3.10	632.60	2.65	633.05	3.10	632.60	3.11	632.64[m]	3.50	632.20	2.82	632.88	2.90	632.80	2.97	632.73
BED-MW17	32.43	597.22	31.59	598.06	31.70	597.95	33.71	595.94	33.33	596.32	33.71	595.94	32.86	596.79	32.58	597.07
BED-MW18	33.35	617.83	33.30	617.88	33.05	618.13	32.99	618.19	33.38	617.80	32.95	618.23	33.27	617.91	33.04	618.14
BED-MW19	25.08	617.67	24.80	617.95	24.36	618.39	25.47	617.28	25.29	617.46	23.58	619.17	23.36	619.39	24.68	618.07
BED-MW22	32.90	596.77	31.55	598.12	31.25	598.42	31.36	598.31	38.12	591.55	38.50	591.17	36.73	592.94	37.85	591.82
BED-MW23	56.50	577.21	52.15	581.56	46.70	587.01	44.50	589.21	41.80	591.91	36.91	596.80[m]	34.52	599.19[m]	33.94	599.77[m]
BED-MW24	27.35	618.63	26.00	619.98	26.53	619.45	27.88	618.10	27.48	618.50	25.81	620.17	25.49	620.49	27.00	618.98
BED-MW27 (abandoned)	AB	--	AB	--	AB	--	AB	--	AB	--	AB	--	AB	--	AB	--
BED-MW30	--	--	--	--	--	--	--	--	--	--	--	--	27.05	619.82	27.92	618.95
BED-MW33	--	--	--	--	--	--	--	--	--	--	--	--	81.15	538.59	73.91	545.83
TNTA-BEDGW-001	47.82	590.97[m]	44.65	594.14[m]	41.51	597.28[m]	40.36	598.43[m]	39.30	599.49[m]	37.72	601.07[m]	35.64	603.15[m]	34.32	604.45[m]
TNTC-BEDGW-001	59.11	607.93	58.01	609.03	58.30	608.74	59.32	607.72	59.32	607.72	57.71	609.33	57.50	609.54	58.83	608.21
2BG-BEDGW-001	--	--	--	--	--	--	--	--	--	--	--	--	--	--	49.67	595.99
2BG-BEDGW-002	--	--	--	--	--	--	--	--	--	--	--	--	--	--	71.75	612.52
2BG-BEDGW-003	--	--	--	--	--	--	--	--	--	--	--	--	--	--	61.39	615.50
RA-MW-05[aa]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	24.60	603.07
RA-07D[bb]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	36.50	597.84
RA-08D[bb]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	55.50	577.46
REACTOR1[n]	--	--	--	--	--	--	27.49	603.02	NM	--	NM	--	NM	--	26.60	603.91
REACTOR2	--	--	--	--	--	--	--	--	NM	--	NM	--	NM	--	NM	--
REACTOR3[n]	--	--	--	--	--	--	37.02	594.19	NM	--	NM	--	NM	--	35.40	595.81
REACTOR4	--	--	--	--	--	--	19.86	610.97	NM	--	NM	--	NM	--	NM	--
PT-5912[o] (private well)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7.03	629.19

Table 6-1

Summary of Groundwater Elevation Measurements
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

[a] Northings and Eastings are scaled to the Ohio State Plane Coordinate System (North Zone), NAD 1983. Vertical datum to NGVD 1929.

[b] Data from Dames & Moore, Sitewide Groundwater Investigation Final Report (4/97).

[c] Data from Dames & Moore, Sitewide Groundwater Investigation Final Report (4/97).

[d] Data from IT Corporation, Site-Wide Groundwater Investigation Report (9/97).

[e] Data from IT Corporation, 1st Quarterly Water Level Measurement Event Report (10/97).

[f] Data from IT Corporation, 2nd Quarterly Water Level Measurement and 1st Semi-Annual Groundwater Sampling Event Report (5/98).

[g] Data from IT Corporation, 3rd Quarterly Water Level Measurement Event Report (6/97).

[h] Data from IT Corporation, 4th Quarterly Water Level Measurement and 2nd Semi-Annual Groundwater Sampling Event Report (6/99).

[i] Data received from ICI field measurements.

[j] Symbol denotes data are not available.

[k] Monitoring well MK-MW17 riser cut and resurveyed August 2003. Previous TOC elevation was 664.32. GW elevations prior to August '03 based on previous TOC measurments.

[l] Hydrocarbon product suspected in well. No measurement recorded.

[m] Groundwater elevation corrected for hydrocarbon product in well. TOC elevation - (depth to groundwater - [product thickness x 0.8]).

AB - Abandoned.
Temporary piezometer IT-MW07 abandoned 4/14/02.
Monitoring well PR-MW08 abandoned in January 2003 for soil remediation (IT, September 2002 FFS Report).
Monitoring well PB-BED-MW27 was abandoned at the publics request in January 2003 due to "nuisance" (hydrogen sulfide) odors.

[n] Static depth to groundwater recorded on August 17, 2004. Depth to groundwater in nearby well RA-01 was approximately 0.6 feet higher in the well on August 17 as compared to August 10 or 11, 2004. Therefore, 0.6 feet was added to the depth to water to make the elevation comparable.

[o] Static depth to groundwater recorded on August 24, 2004. Depth to groundwater in nearby wells PB-BED-MW30 and PB-BED-MW19 was approximately 0.9 feet deeper August 24 as compared to August 10 or 11, 2004. Therefore, 0.9 feet was subtracted from the depth to water to make the elevation comparable.

[aa] Survey coordinates and water level measurments for wells RA-MW-02 through RA-MW-06 were obtained from NASA. Horizontal coordinates estimated. Vertical coordinates used the Ohio State Plane system. Groundwater level measured August 17, 2004.

[bb] Surveyed August 2004 using Reactor Area benchmark. Benchmark was not certified. Groundwater levels measured by NASA on August 17, 2004.

Table 6-2

Detected Hydrocarbons in Bedrock Drilling
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Borehole Identification	Date Drilled	Location	Depth to Bedrock (ft)	Depth to Bedrock (refusal - ft)	Depth to Delaware Limestone[a] (ft)	Depth Drilled (ft)	Hydrocarbon/H_2S Odor Detected[b] (ft)	Hydrocarbon Stained Core[c] (ft)	Comments
TPCB-1 (Boring)	6/9/1941	Behind Water Clarification Bldg 416	3	Unknown	85	336.8	Gas 58-60;Oil intermittently	Unknown	
BED-MW22 (Well)	8/24/01-9/10/01	Downgradient Boundary, North of Reactor Area	19.5	19.5	19.5	43	20-24.5	40-43	
BED-MW23 (Well)	8/25/01-9/6/01	South of Reactor Area and Pentolite Road	26.3	26.3	26.3	74	30-74	33-74	Hydrocarbon observed seepng from rock core.
BED-MW24 (Well)	8/26/01-9/13/01	West of West Red Water Ponds, Downgradient	17.3	17.3	17.3	41.5	26.5-40.0	31.5-41.5	Hydrocarbon observed seepng from rock core. Gas discharge (gurgling) heard during water recharge.
BED-MW27 (Well) (Abandoned)	8/23/01-9/8/01	Downgradient Boundary, East-Northeast of Reactor Area	18.8	18.8	20	105	95-105	41-105	Hydrocarbon observed seepng from rock core. Well abandoned due to excessive (nuisance) hydrogen sulfide odors.
TNTA-BEDGW-001 (Well)	9/24/01-9/13/01	TNT Area A, Near Maintenance and Short Cut Rd, At Former Bldg 146	8.5	25	51	86	None	68-85	A thickness of approx. 3.5 feet free-phase hydrocarbon was encountered prior to sampling (10/9/01).
BED-MW30 (Well)	3/15/04-3/19/04	Near Bouy Road and Patten Tract Intersection, Outside (west) PBOW Boundaries	24	24	24	58.3	31-58.3	34.5-35.7; 38.8-39.1; 39.5-49.5;	
BED-MW31 (Boring)	3/16/04-3/20/04	At former RR bed, West of Schenk Rd, Outside (downgradient) of PBOW Boundaries	13	14.5	13.8	90.2	17.5-90.2	20-30; 31.1; 40.1-21; 87.1-90.2	
BED-MW32 (Boring)	3/29/04-4/1/04	East of Columbus Rd, Between east and west bound lanes of Route 2; Outside (downgradient) of PBOW Boundaries	17.5	17.5	17.5	90.1	17.5-55.1	29-29.5; 30-40;	

Table 6-2

Detected Hydrocarbons in Bedrock Drilling
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Borehole Identification	Date Drilled	Location	Depth to Bedrock (ft)	Depth to Bedrock (refusal - ft)	Depth to Delaware Limestone[a] (ft)	Depth Drilled (ft)	Hydrocarbon/H_2S Odor Detected[b] (ft)	Hydrocarbon Stained Core[c] (ft)	Comments
BED-MW33 (Well)	3/30/04-4/2/04	Columbus Park, Northeast of facility; Outside (downgradeint) of PBOW Boundaries	15	15	15	89.5	20-39.5	38-39.5; 85.3-89	
BED-MW34 (Boring)	3/17/04-3/22/04	NASA's Old Sewage Water Treatment Plant Area; Outside (downgradient) of main PBOW facility	19	20	35.5	90.1	20-90.1	41.5-90.1	Core section very heavily stained. Heard gas "burping" in borehole 66.1-71.1'. Free-phase hydrocarbon on water (0.3 to 0.8'), prior to abandonment.

Notes

[a] Limestone unit interpretations from Regional Geologic Map, 2002 Groundwater Data Summary and Evaluation Report (Shaw, 2003).

[b] A hydrocarbon odor was detected by the olfactory senses. PID readings in the breathing air remained below action levels.

[c] Hydrocarbon staining on the rock core is also seen in photographs (Appendix C).

A hydrocarbon thickness of 0.05 feet was measured in well BED-MW16 on 10/3/01.

A hydrocarbon thickness of 0.63 feet was measured in well AA1-BEDGW-001 on 10/4/01.

ft - Feet.

NASA - National Aeronautics and Space Administration.

PBOW - Plum Brook Ordnance Works.

TNT - Trinitrotoluene.

Table 6-3

Summary of Hydraulic Conductivity Testing Results
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Well No.	Date Tested	Aquifer Response	Saturated Aquifer Thickness (Assumed)	Test Type	Transmisivities T (ft^2/day)	Hydraulic Conductivities K (ft/min)	Hydraulic Conductivities K (cm/sec)	Hydraulic Conductivities K (ft/day)
OVERBURDEN								
IT-MW-08	10/96	Unconfined		Rising		3.32E-03	1.69E-03	4.78E+00
		Unconfined		Rising		7.16E-03	3.64E-03	1.03E+01
		Unconfined		Rising		9.57E-03	4.86E-03	1.38E+01
IT-AA1-GW-002	10/10/1997	Unconfined	22.13	Rising	1.63E+01	5.13E-04	2.61E-04	7.39E-01
IT-AA2-GW-002	10/97	----	dry	----	----	----	----	----
IT-AA3-GW-002	10/8/1997	Unconfined	18.02	Rising	7.63E+01	2.94E-03	1.49E-03	4.23E+00
IT-ABG-GW-002	10/8/1997	Unconfined	9.58	Rising	2.03E+03	1.47E-01	7.47E-02	2.12E+02
Maximum					***2.03E+03***	***1.47E-01***	***7.47E-02***	***2.12E+02***
Minimum					***1.63E+01***	***5.13E-04***	***2.61E-04***	***7.39E-01***
Geometric Mean					***1.36E+02***	***6.08E-03***	***3.09E-03***	***8.75E+00***
BEDROCK								
Ohio Shale								
IT-ABG-BEDGW-001	10/8/1997	Unconfined	17.65	Rising	3.91E+02	1.54E-02	7.83E-03	2.22E+01
IT-TNTB-BEDGW-002	10/8/1997	Unconfined	19.68	Rising	3.51E+02	1.24E-02	6.30E-03	1.79E+01
PB-BED-MW26	11/13/2001	slug test not performed due to small water column						
PB-BED-MW28	5/4/04	Unconfined	35.03	Falling	2.61E+01	5.18E-04	2.63E-04	7.46E-01
				Rising	1.77E+01	3.50E-04	1.78E-04	5.04E-01
Olentangy Formation								
IT-TNTB-BEDGW-001	10/8/1997	Unconfined	22.73	Rising	1.33E+00	4.07E-05	2.07E-05	5.86E-02
TNTB-BEDGW-003	11/13/2001	Unconfined	11.68	Falling	insufficient data			
				Rising	2.82E-02	1.68E-06	8.52E-07	2.41E-03
TNTB-BEDGW-004	11/13/2001	Unconfined	18.36	Falling	4.03E+01	1.53E-03	7.75E-04	2.20E+00
				Rising	8.51E+01	3.22E-03	1.64E-03	4.63E+00
PB-BED-MW25	11/14/2001	Unconfined	25.55	Falling	1.40E+02	3.81E-03	1.94E-03	5.48E+00
				Rising	1.23E+02	3.33E-03	1.69E-03	4.80E+00
PB-BED-MW29	5/4/04	Unconfined	35.24	Falling	1.87E+01	3.69E-04	1.88E-04	5.32E-01
				Rising	2.10E+01	4.14E-04	2.11E-04	5.96E-01
IT-BG8-BEDGW-001	10/8/1997	Unconfined	16.64	Rising	5.73E+00	2.39E-04	1.21E-04	3.44E-01
Maximum					***3.91E+02***	***1.54E-02***	***7.83E-03***	***2.22E+01***
Minimum					***2.82E-02***	***1.68E-06***	***8.52E-07***	***2.41E-03***
Geometric Mean					***2.22E+01***	***6.69E-04***	***3.40E-04***	***9.63E-01***
Delaware Limestone								
PB-BED-MW22	11/13/2001	Unconfined	14.21	Rising	3.69E+00	1.80E-04	9.16E-05	2.59E-01
PB-BED-MW23	11/14/2001	Unconfined	8.27	Rising	5.41E-01	4.54E-05	2.31E-05	6.54E-02
PB-BED-MW24	11/13/2001	Unconfined	15.32	Falling	2.35E+01	1.07E-03	5.42E-04	1.54E+00
				Rising	2.81E+01	1.28E-03	6.48E-04	1.84E+00
PB-BED-MW27	11/14/2001	Unconfined	59.26	Rising	1.37E-01	1.61E-06	8.16E-07	2.31E-03
PB-BED-MW30	5/4/04	Unconfined	27.93	Falling	1.09E+01	2.70E-04	1.37E-04	3.89E-01
				Rising	1.10E+01	2.74E-04	1.39E-04	3.94E-01
PB-BED-MW33	5/4/04	Unconfined	9.61	Rising	1.19E+01	8.57E-04	4.36E-04	1.23E+00
IT-AA1-BEDGW-001	10/7/1997	Unconfined	35.82	Rising	2.67E+00	5.17E-05	2.63E-05	7.44E-02
IT-AA2-BEDGW-001	10/7/1997	Unconfined	31.40	Rising	1.02E+00	2.26E-05	1.15E-05	3.25E-02
IT-MNTA-BEDGW-001	10/8/1997	Unconfined	38.14	Rising	1.19E+00	2.17E-05	1.10E-05	3.12E-02
IT-AA3-BEDGW-001	10/8/1997	Unconfined	30.81	Rising	1.14E+01	2.58E-04	1.31E-04	3.72E-01
TNTA-BEDGW-001	11/13/2001	slug test not performed due to small water column						
TNTC-BEDGW-001	11/14/2001	Unconfined	28.59	Falling	8.66E+00	2.10E-04	1.07E-04	3.03E-01
				Rising	5.46E+00	1.33E-04	6.74E-05	1.91E-01
Maximum					***2.81E+01***	***1.28E-03***	***6.48E-04***	***1.84E+00***
Minimum					***1.37E-01***	***1.61E-06***	***8.16E-07***	***2.31E-03***
Geometric Mean					***4.15E+00***	***1.24E-04***	***6.31E-05***	***1.79E-01***

ft^2/day - Square feet per day.

ft/min - Feet per minute.

cm/sec - Centimeters per second.

ft/day - Feet per day.

Table 6-4

Well Pair Vertical Hydraulic Gradients
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

	Well Name	Unit Monitored (ft bgs)	Well TD (ft bgs)	Depth of Monitored Zone (ft bgs)	Elevation of Ground Surface (ft)	Elevation of Center of Monitored Zone (ft)	Groundwater Elevation							Average Vertical Gradient (ft/ft)
							11/12/1997	2/24/1998	5/5/1998	11/15/2001	2/27/2002	5/11/2004	8/10/2004	
Pair 1	AA1-GW002	OB/OS	22	6.8-21.9	638.6	624.25	634.63	637.80	637.43	636.47	637.46	637.50	633.86	
	AA1-BEDGW-001	DL	65.0	49.8-64	638.8	581.90	610.52	610.54	611.94	608.88	610.11	609.60	610.04	
	Distance between Center of Monitored Zones					42.35								
	Vertical Gradient						0.569	0.644	0.602	0.651	0.646	0.659	0.562	0.619
Pair 2	AA2-GW-002	OB/OLS	18.5	8.3-18.3	641.5	628.20	DRY	DRY	643.95	623.37	633.32	639.44	630.83	
	AA2-BEDGW-001	DL	54	27.8-42.8	641.6	606.30	630.95	632.48	634.17	628.15	628.98	632.92	632.38	
	Distance between Center of Monitored Zones					21.90								
	Vertical Gradient						NA	NA	0.447	-0.218	0.198	0.298	-0.071	0.131
Pair 3	AA3-GW002	OB	16	5.8-15.8	634.1	623.30	629.81	632.23	622.14	629.29	631.61	632.19	629.13	
	AA3-BEDGW-001	DL	53	37.8-52.8	634.1	588.80	613.21	614.9	614.81	608.85	615.77	610.28	610.33	
	Distance between Center of Monitored Zones					34.50								
	Vertical Gradient						0.481	0.502	0.212	0.592	0.459	0.635	0.545	0.490
Pair 4	ABG-GW002	OB	6.8	2.5-6.5	658.2	653.70	654.51	657.11	657.06	654.60	656.88	656.98	653.53	
	ABG-BEDGW-001	OS	21	10.8-20.8	658.2	642.40	654.5	657.04	656.99	654.60	656.77	656.82	653.71	
	Distance between Center of Monitored Zones					11.30								
	Vertical Gradient						0.001	0.006	0.006	0.000	0.010	0.014	-0.016	0.003
Pair 5	MK-MW16	OB/OS	8	2-7	671.01	666.51	666.25	669.18	669.22	667.23	668.64	668.66	666.25	
	TNTB-BEDGW-002	OS	24.2	14-24	670.10	651.10	666.44	670.46	665.68	666.87	667.63	667.65	665.77	
	Distance between Center of Monitored Zones					15.41								
	Vertical Gradient						-0.012	-0.083	0.230	0.023	0.066	0.066	0.031	0.046

A negative vertical gradient indicates an upward gradient.
A positive vertical gradient indicates a downward gradient.
bgs - Below ground surface.
DL - Delaware limestone.
ft - Feet.
OB - Overburden.
OLS - Olentangy shale.
OS - Ohio Shale.

Table 7-1

Detected Constituents in Overburden/Shale Temporary Piezometer Sampling Locations
TNT Manufacturing Areas A, B, and C
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:	TNTA-GW01		TNTA-GW02		TNTA-GW03		TNTA-GW04		TNTA-GW05		TNTA-GW06		TNTA-GW07		TNTA-GW08		TNTA-GW10	
					Sample Number:	AA3001		AA3002		AA3003		AA3004		AA3005		AA3006		AA3007		AA3008		AA3010	
					Sample Date:	11-Oct-00		11-Oct-00		12-Oct-00		12-Oct-00		11-Oct-00		27-Sep-00		11-Oct-00		12-Oct-00		26-Sep-00	
					Low-Flow Sampled:	No		No		No		No		No		No		No		No		No	
Parameter	Units	RBSC	BSC	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																							
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	NE	931		-	-	28.9		-	-	201		931		230		0.629		-	-	-	-
Amino-4,6-dinitrotoluene, 2-	ug/L	0.73	NE	1890		-	-	16.1		-	-	139		1,890		217		0.937		-	-	-	-
Dinitrobenzene, 1,3-	ug/L	0.37	NE	0.802		-	-	-	-	0.563		-	-	0.529		0.654		-	-	-	-	-	-
Dinitrotoluene, 2,4-	ug/L	0.099	NE	9.5																			
Dinitrotoluene, 2,6-	ug/L	0.099	NE	4.9																			
Dinitrotoluene, total	ug/L	0.099	NE	21100		14.5		-	-	771		-	-	-	-	24.6		0.526		30.9		13,800	
Nitrobenzene	ug/L	0.34	NE	5.37		-	-	-	-	5.37		-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	ug/L	0.049	NE	2510		129		-	-	2,510		0.599		-	-	-	-	-	-	115		-	-
Nitrotoluene, 3-	ug/L	12.2	NE	190		8.3		-	-	190		-	-	-	-	-	-	-	-	7.62		27.8	
Nitrotoluene, 4-	ug/L	0.66	NE	1880		86.3		-	-	1,880		-	-	-	-	-	-	-	-	28.6		8.35	
Trinitrobenzene, 1,3,5-	ug/L	110	NE	19		-	-	0.279		-	-	-	-	19		7.93		-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	32400		-	-	137		-	-	157		11,500		32,400		0.451		-	-	50.9	
Volatiles																							
Acetone	ug/L	548	NE	13.4		-	-	-	-	-	-	-	-	-	-	6.59	J	-	-	-	-	-	-
Benzene	ug/L	0.35	2.4	4.81		4.81		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbon disulfide	ug/L	104	NE	1.16		1.16		-	-	0.79	J	-	-	-	-	-	-	0.86	J	-	-	-	-
Chloroform	ug/L	0.17	NE	1		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloromethane	ug/L	16	NE	0.53		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.53	J
Dichloroethene, cis-1,2-	ug/L	6.1	NE	2.11		-	-	-	-	-	-	-	-	2.11		-	-	-	-	-	-	-	-
Ethylbenzene	ug/L	134	0.87	2.33		2.33		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methylene chloride	ug/L	4.3	NE	NA		0.99	B	1.23	B	0.94	B	0.86	B	1.21	B	0.82	B	0.75	B	0.59	B	0.89	B
Toluene	ug/L	72	1.7	1350		1,350		-	-	5.24		-	-	-	-	-	-	-	-	1.11		-	-
Xylene, o-	ug/L	21	NE	5.29		5.29		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Xylenes, m,p-	ug/L	21	NE	6.9		6.9		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Semivolatiles																							
Di-n-butyl phthalate	ug/L	370	NE	NA		-	-	-	-	10.1	B	11.6	B	-	-	-	-	1.79	B	1.8	B	-	-
Dinitrotoluene, 2,4-	ug/L	0.099	NE	37600		957	J	3.29	J	218	J	-	-	4.74	J	3.92	J	-	-	15.6		5,750	
Dinitrotoluene, 2,6-	ug/L	0.099	NE	5610		377	J	-	-	50.8	J	-	-	-	-	-	-	-	-	11.8		5,610	

Table 7-1

Detected Constituents in Overburden/Shale Temporary Piezometer Sampling Locations
TNT Manufacturing Areas A, B, and C
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:	TNTA-GW01		TNTA-GW02		TNTA-GW03		TNTA-GW04		TNTA-GW05		TNTA-GW06		TNTA-GW07		TNTA-GW08		TNTA-GW10	
					Sample Number:	AA3001		AA3002		AA3003		AA3004		AA3005		AA3006		AA3007		AA3008		AA3010	
					Sample Date:	11-Oct-00		11-Oct-00		12-Oct-00		12-Oct-00		11-Oct-00		27-Sep-00		11-Oct-00		12-Oct-00		26-Sep-00	
					Low-Flow Sampled:	No		No		No		No		No		No		No		No		No	
Parameter	Units	RBSC	BSC	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Unfiltered																							
Aluminum	ug/L	3,650	309	221000		**48,600**		**26,300**		**9,150**		**24,100**		**34,500**		**15,600**		144	J	**19,600**		**465**	
Antimony	ug/L	1.5	NE	12.5		-	-	-	-	12.5		-	-	6.25		-	-	-	-	-	-	-	-
Arsenic	ug/L	0.045	7.4	432		**52.7**		**30.6**	J	**16**		**8.04**		**21**	J	**8.88**		-	-	**19**		-	-
Barium	ug/L	255	11,800	3540		669		140		236		229		253		174		59.2		198		23.4	
Beryllium	ug/L	7.3	NE	17.2		4.23		1.98		0.433	J	2.03		2.26		0.854	J	0.175	J	2.99		-	-
Cadmium	ug/L	1.8	NE	6.39		5.96		-	-	0.793	J	2.01	J	6.39		1.26	J	-	-	3.54		0.751	J
Calcium	ug/L	NE	316,000	2664000		229,000		**557,000**		212,000		264,000		229,000		237,000		**525,000**		144,000		237,000	
Chromium	ug/L	11	NE	450		66.3		62.1		11.9		26.8		65.3		27.2		1.11	J	28.1		1.24	J
Cobalt	ug/L	73	12.1	471		**37.7**		**25.8**		10		**17.8**		**24.4**		**13.3**		**48.7**		**49**		5.73	
Copper	ug/L	146	19.8	1110		**54.9**		**57.3**		**24.4**		**23.1**		253		**41.1**		1.62	B	**117**		4.53	B
Iron	ug/L	1,095	1,550	979000		**78,700**		**67,100**		**22,500**		**22,800**		**63,800**		**28,700**		**15,400**		**32,000**		906	
Lead	ug/L	15	NE	2050		566		63.7		1,010		50.5		694		320		2.13	J	451		1.6	B
Magnesium	ug/L	NE	217,000	726000		29,200		103,000		24,700		34,300		34,600		68,000		130,000		20,600		20,300	
Manganese	ug/L	88	636	38100		**7,050**		**1,910**		**1,480**		**1,430**		**2,080**		**1,540**		**2,560**		**1,460**		**1,900**	
Mercury	ug/L	1.1	NE	9.3		0.22		-	-	-	-	0.126	J	1.86		1.74		-	-	0.23		-	-
Nickel	ug/L	73	8.6	1540		**65.1**		**66.7**		**16.7**		**30.5**		**68.6**		**44**		**98.9**		**103**		**11**	
Potassium	ug/L	NE	116,000	32500		13,400		7,150		8,650		6,800		15,500		13,600		2,930		5,220		2,210	
Selenium	ug/L	18	NE	202		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Silver	ug/L	18	NE	0.987		-	-	-	-	1.26	B	-	-	-	-	0.987	J	-	-	-	-	-	-
Sodium	ug/L	NE	1,390,000	113000		6,300		9,680		20,400		97,700		67,800		113,000		8,550		6,350		6,700	
Vanadium	ug/L	3.7	NE	647		106		86.8		19.7		32.9		98.1		29.9		-	-	44		1.59	J
Zinc	ug/L	1,095	507	3960		**923**		237		92.5		219		**1,830**		280		53.6		**706**		37.2	
Metals - Filtered																							
Aluminum	ug/L	3,650	309	334				29.3	J							281						38.4	B
Barium	ug/L	255	11,800	76.1				25.3								52.6						22.2	
Beryllium	ug/L	7.3	NE	NA				-	-							-	-					-	-
Cadmium	ug/L	1.8	NE	0.702				-	-							-	-					0.702	J
Calcium	ug/L	NE	316,000	240000				204,000								173,000						240,000	
Chromium	ug/L	11	NE	1.54				1.15	J							-	-					-	-
Cobalt	ug/L	73	12.1	5.42				-	-							2.01	J					5.42	
Copper	ug/L	146	19.8	2.59				2.59	J							2.38	B					3.52	B
Iron	ug/L	1,095	1,550	771				94.6	J							417						39.1	B
Lead	ug/L	15	NE	4.61				-	-							4.61						2.03	B
Magnesium	ug/L	NE	217,000	59300				25,700								59,300						19,300	
Manganese	ug/L	88	636	2060				187								1,540						2,060	
Mercury	ug/L	1.1	NE	0.11				-	-							-	-					-	-
Nickel	ug/L	73	8.6	8.84				-	-							-	-					**8.84**	
Potassium	ug/L	NE	116,000	9110				2,350								9,110						2,210	
Selenium	ug/L	18	NE	2.73				-	-							-	-					-	-
Silver	ug/L	18	NE	0.975				-	-							0.975	J					-	-
Sodium	ug/L	NE	1,390,000	117000				7,480								117,000						7,390	
Vanadium	ug/L	3.7	NE	1.27				-	-							-	-					-	-
Zinc	ug/L	1,095	507	25				-	-							16.4						25	
PCBs																							
Aroclor 1260	ug/L	0.034	NE	0.239		-	-	-	-	0.239	J	-	-	-	-	-	-	-	-	-	-	-	-

Table 7-1

Detected Constituents in Overburden/Shale Temporary Piezometer Sampling Locations
TNT Manufacturing Areas A, B, and C
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:	TNTC-GW02		TNTC-GW03		TNTC-GW04		TNTC-GW05		TNTC-GW06		TNTC-GW07		TNTC-GW08		TNTC-GW09		TNTC-GW10	
					Sample Number:	AB3002		AB3003		AB3004		AB3005		AB3006		AB3007		AB3008		AB3009		AB3010	
					Sample Date:	10-Oct-00		28-Sep-00		28-Sep-00		10-Oct-00		28-Sep-00		28-Sep-00		10-Oct-00		29-Sep-00		27-Sep-00	
					Low-Flow Sampled:	No		No		No		No		No		No		No		No		No	
Parameter	Units	RBSC	BSC	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																							
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	NE	931		436		0.715		59.4		48		2.27		2.74		419		17.4		21.1	
Amino-4,6-dinitrotoluene, 2-	ug/L	0.73	NE	1890		-	-	0.181	J	147		34.9		2.88		3.2		-	-	40.3		15.1	
Dinitrobenzene, 1,3-	ug/L	0.37	NE	0.802		0.802		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	ug/L	0.099	NE	9.5																			
Dinitrotoluene, 2,6-	ug/L	0.099	NE	4.9																			
Dinitrotoluene, total	ug/L	0.099	NE	21100		1,260		-	-	338		9.64		0.754		1.8		21,100		453		7.9	
Nitrobenzene	ug/L	0.34	NE	5.37		-	-	-	-	-	-	0.488		-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	ug/L	0.049	NE	2510		258		-	-	4.73		-	-	-	-	0.791		236		2,310		2.61	
Nitrotoluene, 3-	ug/L	12.2	NE	190		16.1		-	-	0.88		-	-	-	-	-	-	18.4		182		0.481	J
Nitrotoluene, 4-	ug/L	0.66	NE	1880		94.7		-	-	-	-	-	-	-	-	-	-	189		1,290		0.396	J
Trinitrobenzene, 1,3,5-	ug/L	110	NE	19		-	-	-	-	-	-	10.3		-	-	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	32400		1,880		2.13		620		9,720		0.547		0.208	J	20,100		3.9		9.7	
Volatiles																							
Acetone	ug/L	548	NE	13.4		6.92	B	13.4	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzene	ug/L	0.35	2.4	4.81		-	-	0.51	J	-	-	-	-	-	-	-	-	-	-	0.59	J	-	-
Carbon disulfide	ug/L	104	NE	1.16		0.76	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloroform	ug/L	0.17	NE	1		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloromethane	ug/L	16	NE	0.53		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dichloroethene, cis-1,2-	ug/L	6.1	NE	2.11		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ethylbenzene	ug/L	134	0.87	2.33		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methylene chloride	ug/L	4.3	NE	NA		1.18	B	0.68	B	1.2	B	1.15	B	0.91	B	1.34	B	0.94	B	0.96	B	0.71	B
Toluene	ug/L	72	1.7	1350		1	J	0.83	J	-	-	-	-	-	-	-	-	-	-	**7.88**		-	-
Xylene, o-	ug/L	21	NE	5.29		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Xylenes, m,p-	ug/L	21	NE	6.9		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Semivolatiles																							
Di-n-butyl phthalate	ug/L	370	NE	NA		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	ug/L	0.099	NE	37600		4,610		-	-	215		3.64	J	-	-	6.91	J	37,600		442		4.05	J
Dinitrotoluene, 2,6-	ug/L	0.099	NE	5610		1,330		-	-	45.5	J	-	-	-	-	-	-	1,060	J	122		2.4	J

Table 7-1

Detected Constituents in Overburden/Shale Temporary Piezometer Sampling Locations
TNT Manufacturing Areas A, B, and C
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:	TNTC-GW02		TNTC-GW03		TNTC-GW04		TNTC-GW05		TNTC-GW06		TNTC-GW07		TNTC-GW08		TNTC-GW09		TNTC-GW10	
					Sample Number:	AB3002		AB3003		AB3004		AB3005		AB3006		AB3007		AB3008		AB3009		AB3010	
					Sample Date:	10-Oct-00		28-Sep-00		28-Sep-00		10-Oct-00		28-Sep-00		28-Sep-00		10-Oct-00		29-Sep-00		27-Sep-00	
					Low-Flow Sampled:	No		No		No		No		No		No		No		No		No	
Parameter	Units	RBSC	BSC	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Unfiltered																							
Aluminum	ug/L	3,650	309	221000		**15,400**		**9,370**		**12,300**		**26,400**		**7,310**		**19,500**		**4,470**		**221,000**		**426**	
Antimony	ug/L	1.5	NE	12.5		4.02	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	ug/L	0.045	7.4	432		**9.86**	J	**11**	J	**8.22**	J	**21.6**	J	**9.23**	J	**39.1**	J	5.15	J	**432**	J	-	-
Barium	ug/L	255	11,800	3540		264		178		143		207		155		579		140		3,540		21.5	
Beryllium	ug/L	7.3	NE	17.2		1.18		0.766	J	1.07		2.35		0.608	J	1.6		0.343	B	17.2	J	-	-
Cadmium	ug/L	1.8	NE	6.39		-	-	-	-	-	-	0.962	J	-	-	-	-	-	-	-	-	-	-
Calcium	ug/L	NE	316,000	2664000		214,000		223,000		**338,000**		224,000		214,000		**514,000**		154,000		**2,664,000**		147,000	
Chromium	ug/L	11	NE	450		48.6		32.2		24.4		64		19.3		47.2		10		450		-	-
Cobalt	ug/L	73	12.1	471		**15.6**		**13.5**		**16.2**		**28.2**		7.23		**21.1**		5.93		471		-	-
Copper	ug/L	146	19.8	1110		**41.4**		**29.7**		**26.5**		516		14		**45.5**		15.2		1,110		4.13	J
Iron	ug/L	1,095	1,550	979000		**32,200**		**47,100**		**29,100**		**72,900**		**21,800**		**68,500**		**7,450**		**979,000**		810	
Lead	ug/L	15	NE	2050		46.1		241		23.6		2,050		15.5		54.6		20.8		1,460		-	-
Magnesium	ug/L	NE	217,000	726000		37,000		43,600		34,700		50,100		49,100		90,000		20,700		**726,000**		12,500	
Manganese	ug/L	88	636	38100		**1,170**		**1,070**		**1,890**		**1,040**		**958**		**1,300**		317		**38,100**		109	
Mercury	ug/L	1.1	NE	9.3		-	-	-	-	0.146	J	9.3		-	-	0.15	J	-	-	-	-	0.105	J
Nickel	ug/L	73	8.6	1540		**38.6**		**52.5**		**40.8**		86.4		**18.5**		**56.3**		**16.6**		1,540		2.5	J
Potassium	ug/L	NE	116,000	32500		4,560		5,080		6,490		13,600		2,220		5,820		1,650		32,500		6,020	
Selenium	ug/L	18	NE	202		-	-	-	-	-	-	-	-	-	-	2.31	J	-	-	202	J	-	-
Silver	ug/L	18	NE	0.987		-	-	-	-	-	-	0.703	J	-	-	-	-	-	-	-	-	-	-
Sodium	ug/L	NE	1,390,000	113000		2,640		2,730		2,520		23,600		3,630		7,360		1,810		28,100	J	3,400	
Vanadium	ug/L	3.7	NE	647		70.4		49.3		24		111		32.6		93.9		17.7		647		1.02	J
Zinc	ug/L	1,095	507	3960		137		162		99.6		**993**		53.2		175		42.5		3,960		24.9	
Metals - Filtered																							
Aluminum	ug/L	3,650	309	334						107	B			**334**								-	-
Barium	ug/L	255	11,800	76.1						42.4				76.1								16.4	
Beryllium	ug/L	7.3	NE	NA						0.104	B			-	-							-	-
Cadmium	ug/L	1.8	NE	0.702						-	-			-	-							-	-
Calcium	ug/L	NE	316,000	240000						132,000				197,000								135,000	
Chromium	ug/L	11	NE	1.54						-	-			1.54	J							-	-
Cobalt	ug/L	73	12.1	5.42						1.8	J			-	-							-	-
Copper	ug/L	146	19.8	2.59						2.58	J			2.07	J							3.23	B
Iron	ug/L	1,095	1,550	771						240				771								-	-
Lead	ug/L	15	NE	4.61						-	-			-	-							-	-
Magnesium	ug/L	NE	217,000	59300						29,100				46,500								12,100	
Manganese	ug/L	88	636	2060						236				226								115	
Mercury	ug/L	1.1	NE	0.11						0.11	J											-	-
Nickel	ug/L	73	8.6	8.84						2.04	J			-	-							-	-
Potassium	ug/L	NE	116,000	9110						1,110				848								4,770	
Selenium	ug/L	18	NE	2.73						-	-			2.73	J							-	-
Silver	ug/L	18	NE	0.975						-	-			-	-							-	-
Sodium	ug/L	NE	1,390,000	117000						2,030				3,190								2,900	
Vanadium	ug/L	3.7	NE	1.27						-	-			1.27	J							-	-
Zinc	ug/L	1,095	507	25						5.89	J			5.74	J							16.5	
PCBs																							
Aroclor 1260	ug/L	0.034	NE	0.239		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 7-1

Detected Constituents in Overburden/Shale Temporary Piezometer Sampling Locations
TNT Manufacturing Areas A, B, and C
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:	TNTA-DP21		TNTB-DP02		TNTB-DP03		TNTC-DP13		TNTC-DP19	
					Sample Number:	BA3021		BB3002		BB3003		BC3013		BC3019	
					Sample Date:	1-Aug-01		6-Aug-01		1-Aug-01		1-Aug-01		6-Aug-01	
					Low-Flow Sampled:	No		No		No		No		No	
Parameter	Units	RBSC	BSC	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives															
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	NE	931		3.9	nv	-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	ug/L	0.73	NE	1890		4.3	nv	-	-	-	-	-	-	-	-
Dinitrobenzene, 1,3-	ug/L	0.37	NE	0.802		-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	ug/L	0.099	NE	9.5		9.5	nv	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	ug/L	0.099	NE	4.9		4.9	nv	-	-	-	-	-	-	-	-
Dinitrotoluene, total	ug/L	0.099	NE	21100											
Nitrobenzene	ug/L	0.34	NE	5.37		-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	ug/L	0.049	NE	2510		24	nv	-	-	-	-	-	-	-	-
Nitrotoluene, 3-	ug/L	12.2	NE	190		1.3	nv	-	-	-	-	-	-	-	-
Nitrotoluene, 4-	ug/L	0.66	NE	1880		3.1	nv	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	ug/L	110	NE	19		-	-	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	32400		4.1	nv	-	-	0.14	nv	-	-	4	nv
Volatiles															
Acetone	ug/L	548	NE	13.4		8.8	nv	17	nv	10	nv	8.8	nv	-	-
Benzene	ug/L	0.35	2.4	4.81		-	-	-	-	-	-	-	-	-	-
Carbon disulfide	ug/L	104	NE	1.16		-	-	-	-	-	-	-	-	0.75	nv
Chloroform	ug/L	0.17	NE	1		1	nv	-	-	-	-	-	-	-	-
Chloromethane	ug/L	16	NE	0.53		-	-	-	-	-	-	-	-	-	-
Dichloroethene, cis-1,2-	ug/L	6.1	NE	2.11											
Ethylbenzene	ug/L	134	0.87	2.33		-	-	-	-	-	-	-	-	-	-
Methylene chloride	ug/L	4.3	NE	NA		-	-	-	-	-	-	-	-	-	-
Toluene	ug/L	72	1.7	1350		-	-	-	-	-	-	-	-	-	-
Xylene, o-	ug/L	21	NE	5.29											
Xylenes, m,p-	ug/L	21	NE	6.9											
Semivolatiles															
Di-n-butyl phthalate	ug/L	370	NE	NA											
Dinitrotoluene, 2,4-	ug/L	0.099	NE	37600											
Dinitrotoluene, 2,6-	ug/L	0.099	NE	5610											

Table 7-1

Detected Constituents in Overburden/Shale Temporary Piezometer Sampling Locations
TNT Manufacturing Areas A, B, and C
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:		TNTA-DP21		TNTB-DP02		TNTB-DP03		TNTC-DP13		TNTC-DP19	
					Sample Number:		BA3021		BB3002		BB3003		BC3013		BC3019	
					Sample Date:		1-Aug-01		6-Aug-01		1-Aug-01		1-Aug-01		6-Aug-01	
					Low-Flow Sampled:		No		No		No		No		No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Unfiltered																
Aluminum	ug/L	3,650	309	221000												
Antimony	ug/L	1.5	NE	12.5												
Arsenic	ug/L	0.045	7.4	432												
Barium	ug/L	255	11,800	3540												
Beryllium	ug/L	7.3	NE	17.2												
Cadmium	ug/L	1.8	NE	6.39												
Calcium	ug/L	NE	316,000	2664000												
Chromium	ug/L	11	NE	450												
Cobalt	ug/L	73	12.1	471												
Copper	ug/L	146	19.8	1110												
Iron	ug/L	1,095	1,550	979000												
Lead	ug/L	15	NE	2050												
Magnesium	ug/L	NE	217,000	726000												
Manganese	ug/L	88	636	38100												
Mercury	ug/L	1.1	NE	9.3												
Nickel	ug/L	73	8.6	1540												
Potassium	ug/L	NE	116,000	32500												
Selenium	ug/L	18	NE	202												
Silver	ug/L	18	NE	0.987												
Sodium	ug/L	NE	1,390,000	113000												
Vanadium	ug/L	3.7	NE	647												
Zinc	ug/L	1,095	507	3960												
Metals - Filtered																
Aluminum	ug/L	3,650	309	334												
Barium	ug/L	255	11,800	76.1												
Beryllium	ug/L	7.3	NE	NA												
Cadmium	ug/L	1.8	NE	0.702												
Calcium	ug/L	NE	316,000	240000												
Chromium	ug/L	11	NE	1.54												
Cobalt	ug/L	73	12.1	5.42												
Copper	ug/L	146	19.8	2.59												
Iron	ug/L	1,095	1,550	771												
Lead	ug/L	15	NE	4.61												
Magnesium	ug/L	NE	217,000	59300												
Manganese	ug/L	88	636	2060												
Mercury	ug/L	1.1	NE	0.11												
Nickel	ug/L	73	8.6	8.84												
Potassium	ug/L	NE	116,000	9110												
Selenium	ug/L	18	NE	2.73												
Silver	ug/L	18	NE	0.975												
Sodium	ug/L	NE	1,390,000	117000												
Vanadium	ug/L	3.7	NE	1.27												
Zinc	ug/L	1,095	507	25												
PCBs																
Aroclor 1260	ug/L	0.034	NE	0.239												

Shaded cell indicates value is greater than the RBSC.

Bold text indicates value is greater than the BSC.

RBSC - Values reflect an incremental lifetime cancer risk (ILCR) of 1E-6 or a noncancer hazard quotient (HQ) of 0.1. For chemicals that exhibit both cancer and noncancer effects, whichever type of effect results in a lower concentration (using an ILCR of 1E-6 and an HQ of 0.1), that concentration is selected as the RBSC.

"-" - Not detected.

BSC - Background screening concentration

MDC - Maximum detected concentration for the AOC ("B" qualified data not included).

µg/L - Micrograms per liter.

nv - Non validated.

NA - Not applicable; only B qualified data detected.

NE - Not established (RBSCs), not evaluated (BSCs).

NTU - Nephelometric turbidity unit.

Validation Qualifiers (Qual)

B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.

J - The compound/analyte was positively identified; the reported value is an estimated concentration.

Table 7-2

Detected Constituents in Overburden/Shale Monitoring Wells
TNT Manufacturing Area A
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:	MK-MW22				MK-MW23				MK-MW24			
					Sample Number:	5820		5825		5830		5835		5840		5845	
					Sample Date:	14-Nov-97		18-May-98		16-Nov-97		29-May-98		13-Nov-97		20-May-98	
					Low-Flow Sampled:	No		No		No		No		No		No	
Parameter	Units	RBSC	BSC	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																	
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	NE	16		0.62		0.86		-	-	-	-	-	-	-	-
Amino-4,6-dinitrotoluene, 2-	ug/L	0.73	NE	46													
Dinitrotoluene, 2,4-	ug/L	0.099	NE	0.35		0.2		0.35		-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	ug/L	0.099	NE	1.2		0.53		1.2		-	-	-	-	-	-	-	-
Nitrobenzene	ug/L	0.34	NE	0.26		-	-	0.26		-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	ug/L	110	NE	0.43		0.24		0.43		-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	110		0.74		1.7		-	-	-	-	-	-	-	-
Volatiles																	
Acetone	ug/L	548	NE	68		-	-	-	-	68	J	-	-	-	-	-	-
Benzene	ug/L	0.35	2.4	0.17		-	-	-	-	-	-	0.17	J	-	-	-	-
Carbon disulfide	ug/L	104	NE	0.37		-	-	-	-	0.37	J	-	-	-	-	-	-
Methylene chloride	ug/L	4.3	NE	NA		-	-	0.52	B	0.27	B	4.2	B	-	-	0.29	B
Toluene	ug/L	72	1.7	10		-	-	7.8		-	-	0.16	B	-	-	10	
Semivolatiles																	
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	890		-	-	-	-	-	-	890		-	-	-	-
Di-n-octyl phthalate	ug/L	146	NE	9.3		-	-	-	-	9.3	J	-	-	-	-	-	-

Table 7-2

Detected Constituents in Overburden/Shale Monitoring Wells
TNT Manufacturing Area A
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:	MK-MW22			MK-MW23				MK-MW24			
					Sample Number:	5820		5825		5830		5835		5840		5845	
					Sample Date:	14-Nov-97		18-May-98		16-Nov-97		29-May-98		13-Nov-97		20-May-98	
					Low-Flow Sampled:	No		No		No		No		No		No	
Parameter	Units	RBSC	BSC	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Unfiltered																	
Aluminum	ug/L	3,650	309	143000		**7,790**		**6,200**		**27,300**		**143,000**	J	**6,620**		242	J
Antimony	ug/L	1.5	NE	82		-	-	-	-	-	-	82		-	-	-	-
Arsenic	ug/L	0.045	7.4	113		-	-	-	-	**59.8**		**113**		-	-	-	-
Barium	ug/L	255	11,800	373		-	-	-	-	-	-	232		-	-	-	-
Beryllium	ug/L	7.3	NE	6.9		-	-	-	-	-	-	6.9		-	-	-	-
Cadmium	ug/L	1.8	NE	NA		-	-	-	-	-	-	-	-	-	-	-	-
Calcium	ug/L	NE	316,000	1010000		118,000	J	112,000		236,000		**1,010,000**	J	**641,000**	J	**612,000**	
Chromium	ug/L	11	NE	258		16.6		13.7		57.1		258		25.2		-	-
Cobalt	ug/L	73	12.1	222		-	-	-	-	**50.8**		**222**		-	-	-	-
Copper	ug/L	146	19.8	225		-	-	-	-	**47.3**		**225**		-	-	-	-
Iron	ug/L	1,095	1,550	304000		**10,900**		**10,900**	J	**68,200**		**304,000**		**13,500**		**1,960**	
Lead	ug/L	15	NE	108		6.7		4.3		29.8		108		13.1		-	-
Magnesium	ug/L	NE	217,000	172000		17,500		16,200		61,400		172,000		47,400		29,700	
Manganese	ug/L	88	636	7550		185		142		**1,370**		**7,550**		**788**		458	
Mercury	ug/L	1.1	NE	0.25		-	-	-	-	-	-	0.25		-	-	-	-
Nickel	ug/L	73	8.6	628		-	-	-	-	**125**		**628**		-	-	-	-
Potassium	ug/L	NE	116,000	35700		-	-	-	-	14,400		35,700		5,640		-	-
Sodium	ug/L	NE	1,390,000	91400		7,100		5,720		60,200		60,000		8,130		5,530	
Vanadium	ug/L	3.7	NE	244		-	-	-	-	75.2		244		60.9		52.3	B
Zinc	ug/L	1,095	507	735		35.6		36.2	B	167		**735**		127		20	B
Metals - Filtered																	
Aluminum	ug/L	3,650	309	NA		-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	ug/L	0.045	7.4	13.8		-	-	-	-	**13.8**		-	-	-	-	-	-
Barium	ug/L	255	11,800	338		-	-	-	-	-	-	-	-	-	-	-	-
Calcium	ug/L	NE	316,000	984000		127,000		114,000		140,000	J	152,000	J	**984,000**		**643,000**	
Chromium	ug/L	11	NE	14.2		-	-	-	-	-	-	-	-	14.2		-	-
Cobalt	ug/L	73	12.1	2.4		-	-	-	-	-	-	-	-	-	-	-	-
Iron	ug/L	1,095	1,550	9330		-	-	-	-	139	B	-	-	**2,920**		1,440	
Magnesium	ug/L	NE	217,000	67600		17,900		17,700		49,900		57,100	J	41,300		33,900	
Manganese	ug/L	88	636	1440		149		114		265		134		562		454	
Mercury	ug/L	1.1	NE	0.76		-	-	-	-	-	-	-	-	0.76		-	-
Nickel	ug/L	73	8.6	3.4		-	-	-	-	-	-	-	-	-	-	-	-
Potassium	ug/L	NE	116,000	18400		-	-	-	-	8,540		12,300		-	-	-	-
Sodium	ug/L	NE	1,390,000	107000		8,360		10,100		68,500		66,800		8,250		6,820	
Vanadium	ug/L	3.7	NE	53		-	-	-	-	-	-	-	-	53		57.3	B
Zinc	ug/L	1,095	507	45.4		-	-	-	-	-	-	23.6	B	-	-	-	-
Water Quality Parameters																	
Alkalinity	ug/L	NE	NE	490000		280,000		370,000						370,000		370,000	
Chloride	ug/L	NE	NE	180000		7,000		3,000						6,000		7,000	
Hardness	ug/L	NE	NE	1900000		420,000		520,000						1,900,000		1,600,000	
Sulfate	ug/L	NE	NE	1200000		36,000		30,000						1,200,000		1,100,000	
Total dissolved solids	ug/L	NE	NE	2400000		360,000		370,000						2,400,000		2,000,000	
Total organic carbon	ug/L	NE	NE	21000		11,000		2,000				-	-	21,000		9,000	
Total suspended solids	ug/L	NE	NE	400000		150,000		130,000						400,000		7,000	
Turbidity	NTU	NE	NE	78.5													

Table 7-2

Detected Constituents in Overburden/Shale Monitoring Wells
TNT Manufacturing Area A
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:	TNTA-MW10						TNTA-MW11							
					Sample Number:	5610		5615		CB3042		5620		5625		BD3034		CB3043	
					Sample Date:	18-Nov-97		29-May-98		15-Apr-02		18-Nov-97		29-May-98		3-Oct-01		15-Apr-02	
					Low-Flow Sampled:	No		No		No		No		No		No		No	
Parameter	Units	RBSC	BSC	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																			
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	NE	16		-	-	-	-	-	-	-	-	-	-	1.5		16	
Amino-4,6-dinitrotoluene, 2-	ug/L	0.73	NE	46						-	-					2.1		46	
Dinitrotoluene, 2,4-	ug/L	0.099	NE	0.35		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	ug/L	0.099	NE	1.2		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrobenzene	ug/L	0.34	NE	0.26		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	ug/L	110	NE	0.43		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	110		-	-	-	-	-	-	-	-	-	-	0.29		110	
Volatiles																			
Acetone	ug/L	548	NE	68		35	J	7.6	J	6.8	J	-	-	-	-	2.8	B	1.7	J
Benzene	ug/L	0.35	2.4	0.17		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbon disulfide	ug/L	104	NE	0.37		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methylene chloride	ug/L	4.3	NE	NA		-	-	2.1	B	0.43	B	-	-	0.95	B	-	-	0.32	B
Toluene	ug/L	72	1.7	10		-	-	0.25	B	-	-	-	-	0.26	B	-	-	-	-
Semivolatiles																			
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	890		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Di-n-octyl phthalate	ug/L	146	NE	9.3		-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 7-2

Detected Constituents in Overburden/Shale Monitoring Wells
TNT Manufacturing Area A
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:	TNTA-MW10						TNTA-MW11							
					Sample Number:	5610		5615		CB3042		5620		5625		BD3034		CB3043	
					Sample Date:	18-Nov-97		29-May-98		15-Apr-02		18-Nov-97		29-May-98		3-Oct-01		15-Apr-02	
					Low-Flow Sampled:	No		No		No		No		No		No		No	
Parameter	Units	RBSC	BSC	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Unfiltered																			
Aluminum	ug/L	3,650	309	143000		877	J	2,280	J	60	B	3,170	J	2,990	J	8,950	J	807	
Antimony	ug/L	1.5	NE	82		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	ug/L	0.045	7.4	113		12.2		14.5		-	-	10.5		-	-	7.2	J	-	-
Barium	ug/L	255	11,800	373		373		-	-	56	J	-	-	-	-	88.4	J	24	J
Beryllium	ug/L	7.3	NE	6.9		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	ug/L	1.8	NE	NA		-	-	-	-	-	-	-	-	-	-	1.2	B	-	-
Calcium	ug/L	NE	316,000	1010000		186,000		136,000	J	174,000		180,000		162,000	J	209,000	J	206,000	
Chromium	ug/L	11	NE	258		-	-	-	-	-	-	15.6		12.2		18.2	J	2	J
Cobalt	ug/L	73	12.1	222		-	-	-	-	-	-	-	-	-	-	10	J	-	-
Copper	ug/L	146	19.8	225		-	-	-	-	-	-	-	-	-	-	15.9	J	-	-
Iron	ug/L	1,095	1,550	304000		18,200		18,700		4,710		13,300		6,610		16,400	J	1,700	
Lead	ug/L	15	NE	108		-	-	5.6		-	-	10.4		3.2		9.4	J	3	
Magnesium	ug/L	NE	217,000	172000		52,900		46,900		45,100		63,000		58,700		63,200	J	35,200	
Manganese	ug/L	88	636	7550		1,530		1,250		607		1,030		444		383	J	86.5	
Mercury	ug/L	1.1	NE	0.25		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	ug/L	73	8.6	628		-	-	-	-	2.1	J	-	-	-	-	22.4	J	3.9	J
Potassium	ug/L	NE	116,000	35700		-	-	7,500		1,420	J	17,400		16,500		16,500	J	-	-
Sodium	ug/L	NE	1,390,000	91400		39,300		52,100		28,600		91,400		90,500		66,700	J	7,210	
Vanadium	ug/L	3.7	NE	244		-	-	-	-	-	-	-	-	-	-	17.8	J	1.9	J
Zinc	ug/L	1,095	507	735		27		48.1	B	31.8	J	47.1		37.5	B	39.2	J	5.9	J
Metals - Filtered																			
Aluminum	ug/L	3,650	309	NA		-	-	-	-	36	B	-	-	-	-			35.6	B
Arsenic	ug/L	0.045	7.4	13.8		-	-	-	-	-	-	-	-	-	-			-	-
Barium	ug/L	255	11,800	338		338		-	-	56.6	J	-	-	-	-			27.3	J
Calcium	ug/L	NE	316,000	984000		191,000		131,000	J	177,000		167,000		183,000	J			226,000	
Chromium	ug/L	11	NE	14.2		-	-	-	-	-	-	-	-	-	-			-	-
Cobalt	ug/L	73	12.1	2.4		-	-	-	-	-	-	-	-	-	-			2.4	J
Iron	ug/L	1,095	1,550	9330		7,610		9,330		3,270		-	-	-	-			-	-
Magnesium	ug/L	NE	217,000	67600		54,800		48,100	J	45,900		62,900		67,600	J			42,500	
Manganese	ug/L	88	636	1440		1,440		1,370		625		865		355				80.7	
Mercury	ug/L	1.1	NE	0.76		-	-	-	-	-	-	-	-	-	-			-	-
Nickel	ug/L	73	8.6	3.4		-	-	-	-	-	-	-	-	-	-			3.4	J
Potassium	ug/L	NE	116,000	18400		-	-	7,710		1,450	J	17,800		18,400				176	J
Sodium	ug/L	NE	1,390,000	107000		41,000		55,900		28,600		96,500		107,000				11,500	
Vanadium	ug/L	3.7	NE	53		-	-	-	-	-	-	-	-	-	-			-	-
Zinc	ug/L	1,095	507	45.4		25		22.7	B	30.4	J	45.4		-	-			26.8	J
Water Quality Parameters																			
Alkalinity	ug/L	NE	NE	490000		490,000		410,000		378,000		450,000		460,000				402,000	
Chloride	ug/L	NE	NE	180000		47,000		100,000		40,100		140,000		180,000				10,500	
Hardness	ug/L	NE	NE	1900000		1,100,000		730,000		738,000		940,000		680,000				611,000	
Sulfate	ug/L	NE	NE	1200000		160,000		100,000		261,000		150,000		93,000				309,000	
Total dissolved solids	ug/L	NE	NE	2400000		780,000		760,000		792,000		1,000,000		1,000,000				848,000	
Total organic carbon	ug/L	NE	NE	21000		4,200		2,000		4,000		4,500		3,000		4,300		9,000	
Total suspended solids	ug/L	NE	NE	400000		7,000		-	-	14,000		140,000		7,000				74,000	
Turbidity	NTU	NE	NE	78.5						36.2								78.5	

Table 7-2

Detected Constituents in Overburden/Shale Monitoring Wells
TNT Manufacturing Area A
Former Plum Brook Ordnance Works, Sandusky, Ohio

Shaded cell indicates value is greater than the RBSC.

Bold text indicates value is greater than the BSC.

RBSC - Values reflect an incremental lifetime cancer risk (ILCR) of 1E-6 or a noncancer hazard quotient (HQ) of 0.1. For chemicals that exhibit both cancer and noncancer effects, whichever type of effect results in a lower concentration (using an ILCR of 1E-6 and an HQ of 0.1), that concentration is selected as the RBSC.

BSC - Background screening concentration.

MDC - Maximum detected concentration for the AOC ("B" qualified data not included).

"-" - Not detected.

µg/L - Micrograms per liter.

ND - Not detected.

NA - Not applicble; only B qualified d‹ 0.22

NE - Not established (RBSCs), not evaluated (BSCs).

NTU - Nephelometric turbidity unit.

Validation Qualifiers (Qual)

B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.

J - The compound/analyte was positively identified; the reported value is an estimated concentration.

Table 7-3

Detected Constituents in Bedrock Monitoring Wells
TNT Manufacturing Area A
Former Plum Brook Ordnance Works, Sandusky, Ohio

(Page 1 of 3)

			Location Code:		BED-MW18								TNTA-BEDGW-001			
			Sample Number:		5940		5945		BD3024		CB3015		BD3037		CB3044	
			Sample Date:		19-Nov-97		19-May-98		2-Oct-01		5-Apr-02		9-Oct-01		15-Apr-02	
			Low-Flow Sampled:		No		No		Yes		Yes		No		No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	NE	1.3	-	-	-	-	-	-	-	-	1.3		1.3	
Amino-4,6-dinitrotoluene, 2-	ug/L	0.73	NE	0.55					-	-	-	-	0.33		0.55	
Dinitrobenzene, 1,3-	ug/L	0.37	NE	1	1		-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	ug/L	0.099	NE	0.49	-	-	0.49		-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	ug/L	0.099	NE	3.6	-	-	3.6		-	-	-	-	-	-	-	-
Nitrobenzene	ug/L	0.34	NE	2	2		-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	ug/L	0.049	NE	0.31	-	-	-	-	-	-	0.31		-	-	-	-
Nitrotoluene, 3-	ug/L	12.2	NE	0.3	-	-	-	-	-	-	0.3		-	-	-	-
Trinitrobenzene, 1,3,5-	ug/L	110	NE	1.5	1.5		-	-	-	-	-	-	-	-	-	-
Volatiles																
Acetone	ug/L	548	NE	290	-	-	34	J	88	J	-	-	-	-	290	J
Benzene	ug/L	0.35	2.4	700	11		5.7		-	-	14	J	700	J	490	J
Carbon disulfide	ug/L	104	NE	32	32		7.9		-	-	4.8	J	-	-	-	-
Chloromethane	ug/L	16	NE	35	-	-	-	-	35	J	-	-	-	-	-	-
Ethylbenzene	ug/L	134	0.87	240	32		88		32	J	100	J	240	J	210	J
Methylene chloride	ug/L	4.3	NE	330	-	-	2.4	B	47	J	-	-	330	J	170	J
Toluene	ug/L	72	1.7	730	21		53		-	-	74	J	730	J	630	J
Xylenes, total	ug/L	21	5.5	1400	170		420		150		420	J	1,400		1,200	
Semivolatiles																
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	8.6	3.5	J	16	B	-	-	-	-	8.6	J	-	-
Chrysene	ug/L	9.2	NE	15	-	-	-	-	-	-	-	-	15	J	0.62	J
Dibenzofuran	ug/L	1.2	NE	12	-	-	-	-	-	-	-	-	12	J	-	-
Dimethylphenol, 2,4-	ug/L	73	NE	18	5.1	J	11		7.2	J	12		13	J	18	J
Fluorene	ug/L	24.3	NE	28	-	-	-	-	-	-	-	-	28	J	1.9	J
Methylnaphthalene, 2-	ug/L	12	NE	470	2.2	J	5	J	1.6	J	5.3	J	470		47	
Methylphenol, 2-	ug/L	182	NE	12	2.6	J	3.3	J	2.6	J	4.7	J	-	-	12	J
Methylphenol, 4-	ug/L	18	NE	15	2.8	J	4	J	1.2	J	4.4	J	9.8	J	15	J
Naphthalene	ug/L	0.62	NE	170	3.8	J	10		3.1	J	9.9	J	170		39	
Phenanthrene	ug/L	18	NE	74	-	-	-	-	-	-	-	-	74	J	3.4	J
Phenol	ug/L	1,095	NE	27	21	J	-	-	3.5	J	1.4	J	13	J	27	J

Table 7-3

Detected Constituents in Bedrock Monitoring Wells
TNT Manufacturing Area A
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:		BED-MW18						TNTA-BEDGW-001			
					Sample Number:		5940		5945		BD3024		CB3015		BD3037		CB3044	
					Sample Date:		19-Nov-97		19-May-98		2-Oct-01		5-Apr-02		9-Oct-01		15-Apr-02	
					Low-Flow Sampled:		No		No		Yes		Yes		No		No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Unfiltered																
Aluminum	ug/L	3,650	309	8300	283	J	-	-	54.6	B	79.2	J	-	-	8,300	J
Arsenic	ug/L	0.045	7.4	17.3	-	-	-	-	-	-	-	-	10.8	J	17.3	J
Barium	ug/L	255	11,800	1290	893		942		916		1,290		1,000	J	471	J
Beryllium	ug/L	7.3	NE	1.1	-	-	-	-	-	-	-	-	1.1	B	1.1	J
Cadmium	ug/L	1.8	NE	1.2	-	-	-	-	-	-	-	-	-	-	1.2	J
Calcium	ug/L	NE	316,000	12000000	809,000		1,370,000		724,000		1,390,000		12,000,000	J	1,780,000	J
Chromium	ug/L	11	NE	37.2	-	-	-	-	-	-	-	-	-	-	37.2	J
Cobalt	ug/L	73	12.1	12.7	-	-	-	-	-	-	-	-	6.4	J	12.7	J
Copper	ug/L	146	19.8	53.1	-	-	-	-	-	-	-	-	3.2	J	53.1	J
Iron	ug/L	1,100	1,550	33400	476	B	166		40	J	-	-	127	J	33,400	J
Lead	ug/L	15	NE	18.4	-	-	-	-	-	-	-	-	-	-	18.4	J
Magnesium	ug/L	NE	217,000	943000	384,000		938,000		534,000		943,000		711,000	J	408,000	J
Manganese	ug/L	88	636	11700	36.8		80.8		41.8		109		11,700	J	1,830	J
Mercury	ug/L	1.1	NE	1	1		-	-	-	-	-	-	0.067	J	-	-
Nickel	ug/L	73	8.6	75.7	-	-	-	-	-	-	-	-	75.7	J	48.8	J
Potassium	ug/L	NE	116,000	334000	148,000		155,000		150,000		188,000	J	94,200	J	334,000	J
Sodium	ug/L	NE	1,390,000	4050000	2,190,000		3,530,000		2,580,000		4,050,000		442,000	J	1,610,000	J
Vanadium	ug/L	3.7	NE	36.9	-	-	-	-	-	-	-	-	-	-	36.9	J
Zinc	ug/L	1,095	507	425	31		-	-	-	-	48.1		297	J	425	J
Metals - Filtered																
Aluminum	ug/L	3,650	309	239	-	-	-	-	55.4	B	71.3	B	239	J	74	J
Barium	ug/L	255	11,800	1330	1,010		994		938		1,330		382	J	398	J
Calcium	ug/L	NE	316,000	1470000	1,010,000		1,470,000		720,000		1,370,000		425,000	J	577,000	J
Chromium	ug/L	11	NE	6.8	-	-	-	-	-	-	-	-	-	-	6.8	J
Iron	ug/L	1,095	1,550	856	-	-	-	-	-	-	-	-	856	J	152	J
Magnesium	ug/L	NE	217,000	1020000	572,000		1,020,000		534,000		929,000		26,400	J	349,000	J
Manganese	ug/L	88	636	107	35.9		80.9		37.7		107		54.6	J	26.7	J
Potassium	ug/L	NE	116,000	310000	172,000		163,000		149,000		187,000	J	128,000	J	310,000	J
Selenium	ug/L	18	NE	4.5	-	-	-	-	-	-	-	-	-	-	4.5	J
Sodium	ug/L	NE	1,390,000	4000000	3,010,000		3,820,000		2,560,000		4,000,000		705,000	J	1,540,000	J
Vanadium	ug/L	3.7	NE	12.5	-	-	-	-	-	-	-	-	12.5	J	-	-
Zinc	ug/L	1,095	507	17.1	-	-	23.5	B	-	-	9.1	J	17.1	J	5.7	J
Water Quality Parameters																
Alkalinity	ug/L	NE	NE	550000	120,000		550,000		170,000	J	350,000				282,000	
Chloride	ug/L	NE	NE	12900000	6,900,000		1,200,000		9,450,000		12,900,000	J			4,810,000	
Hardness	ug/L	NE	NE	10000000	4,000,000		10,000,000		3,980,000		7,000,000				5,020,000	
Sulfate	ug/L	NE	NE	388000	16,000		18,000		56,500		440	B			388,000	
Total dissolved solids	ug/L	NE	NE	33000000	12,000,000		33,000,000		13,400,000		15,200,000				7,960,000	
Total organic carbon	ug/L	NE	NE	12300	6,500		3,000		2,500	J	1,400		12,300		10,700	
Total suspended solids	ug/L	NE	NE	1080000	61,000		100,000		33,000		4,000				1,080,000	
Turbidity	NTU	NE	NE	605					99.2	J	69	J			605	

Table 7-3

Detected Constituents in Bedrock Monitoring Wells
TNT Manufacturing Area A
Former Plum Brook Ordnance Works, Sandusky, Ohio

Shaded cell indicates value is greater than the RBSC.

Bold text indicates value is greater than the BSC.

RBSC - Values reflect an incremental lifetime cancer risk (ILCR) of 1E-6 or a noncancer hazard quotient (HQ) of 0.1. For chemicals that exhibit both cancer and noncancer effects, whichever type of effect results in a lower concentration (using an ILCR of 1E-6 and an HQ of 0.1), that concentration is selected as the RBSC.

BSC - Background screening concentration.

MDC - Maximum detected concentration for the AOC ("B" qualified data not included).

"-" - Not detected.

µg/L - Micrograms per liter.

ND - Not detected.

NE - Not established (RBSCs), not evaluated (BSCs).

NTU - Nephelometric turbidity unit.

Validation Qualifiers (Qual)

B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.

J - The compound/analyte was positively identified; the reported value is an estimated concentration.

Table 7-4

Detected Constituents in Overburden/Shale Monitoring Wells
TNT Manufacturing Area B
Former Plum Brook Ordnace Works, Sandusky, Ohio

					Location Code:		MK-MW16				MK-MW17							
					Sample No:		5780		5785		CB3017		5790		5795		BD3012		CB3038	
					Sample Date:		21-Nov-97		18-May-98		8-Apr-02		21-Nov-97		27-May-98		1-Oct-01		12-Apr-02	
					Low Flow Sampled:		No		No		No		No		No		Yes		Yes	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																				
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	NE	22	-	-	-	-	-	-	3.6		5.7		21		22	
Amino-4,6-dinitrotoluene, 2-	ug/L	0.73	NE	26					-	-					24		26	
Dinitrotoluene, 2,4-	ug/L	0.099	NE	5.8	-	-	-	-	-	-	-	-	1.7		5.6		5.8	
Dinitrotoluene, 2,6-	ug/L	0.099	NE	4	-	-	-	-	-	-	-	-	-	-	-	-	4	J
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	68	-	-	-	-	-	-	-	-	0.68		23		68	
Volatiles																				
Acetone	ug/L	548	NE	5.2	-	-	5.2	J	-	-	-	-	-	-	4	B	2.4	J
Methylene chloride	ug/L	4.3	NE	NA	0.4	B	0.52	B	-	-	0.39	B	0.28	B	-	-	-	-
Toluene	ug/L	72	1.7	NA	-	-	-	-	-	-	-	-	0.21	B	-	-	-	-
Semivolatiles																				
Benzo(ghi)perylene	ug/L	18	NE	0.97	-	-	-	-	-	-	-	-	-	-	0.97	J	-	-
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	2.4	2.4	J	2.8	B	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	ug/L	0.099	NE	4	-	-	-	-	-	-	-	-	1.8	J	2	J	4	J
Dinitrotoluene, 2,6-	ug/L	0.099	NE	1.4	-	-	-	-	-	-	-	-	-	-	-	-	1.4	J
Indeno(1,2,3-cd)pyrene	ug/L	0.092	NE	1	-	-	-	-	-	-	-	-	-	-	1	J	-	-
Metals - Unfiltered																				
Aluminum	ug/L	3,650	309	6920	4,990	J	1,180		2,380		1,830	J	6,920	J	3,310		4,600	
Arsenic	ug/L	0.045	7.4	18.7	-	-	-	-	-	-	12.6		18.7		6.6	J	-	-
Barium	ug/L	255	11,800	23.1	-	-	-	-	13.1	J	-	-	-	-	23.1	J	14.6	J
Beryllium	ug/L	7.3	NE	2	-	-	-	-	0.82	J	-	-	-	-	2	J	2.4	B
Cadmium	ug/L	1.8	NE	0.59	-	-	-	-	0.59	J	-	-	-	-	0.58	B	-	-
Calcium	ug/L	NE	316,000	146000	146,000	J	133,000		125,000		127,000	J	104,000	J	115,000		79,400	
Cobalt	ug/L	73	12.1	101	-	-	69.8		47.3	J	78.8		54.9		101		95.7	
Copper	ug/L	146	19.8	32.9	-	-	-	-	7.4	J	-	-	32.9		6.7	J	-	-
Iron	ug/L	1,095	1,550	44300	19,800		20,700	J	11,300		44,300		41,900		14,300		11,800	J
Lead	ug/L	15	NE	16.4	8	B	-	-	1.9	J	4.4	B	16.4		-	-	-	-
Magnesium	ug/L	NE	217,000	53800	53,800		52,700		48,600		29,900		24,300		32,100		23,000	
Manganese	ug/L	88	636	13600	6,970		13,600		8,520		1,410		1,120		1,770		1,350	
Nickel	ug/L	73	8.6	240	61.8		108		80.4		156		130		240		208	
Potassium	ug/L	NE	116,000	5460	5,460		-	-	1,360	J	-	-	5,040		4,060	J	1,470	J
Selenium	ug/L	18	NE	5.1	5		-	-	-	-	5.1		-	-	-	-	-	-
Sodium	ug/L	NE	1,390,000	10500	6,560	J	10,500		6,030		6,090	J	6,030		6,070		3,240	J
Thallium	ug/L	0.24	NE	NA	-	-	-	-	-	-	-	-	-	-	-	-	8.6	B
Vanadium	ug/L	3.7	NE	2	-	-	-	-	2	J	-	-	-	-	-	-	-	-
Zinc	ug/L	1,095	507	214	75.5		209		59.8		137		152		214		194	

Table 7-4

Detected Constituents in Overburden/Shale Monitoring Wells
TNT Manufacturing Area B
Former Plum Brook Ordnace Works, Sandusky, Ohio

(Page 2 of 2)

					Location Code:		MK-MW16				MK-MW17							
					Sample No:		5780		5785		CB3017		5790		5795		BD3012		CB3038	
					Sample Date:		21-Nov-97		18-May-98		8-Apr-02		21-Nov-97		27-May-98		1-Oct-01		12-Apr-02	
					Low Flow Sampled:		No		No		No		No		No		Yes		Yes	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Filtered																				
Aluminum	ug/L	3,650	309	7430	**1,080**		**663**		**1,480**		-	-	7,430		**3,390**		**4,680**	
Arsenic	ug/L	0.045	7.4	22	-	-	-	-	-	-	-	-	22		6.5	J	-	-
Barium	ug/L	255	11,800	23.4	-	-	-	-	8.4	J	-	-	-	-	23.4	J	14.1	J
Beryllium	ug/L	7.3	NE	2.3	-	-	-	-	0.76	J	-	-	-	-	2.3	J	2	J
Cadmium	ug/L	1.8	NE	0.54	-	-	-	-	-	-	-	-	-	-	0.54	J	-	-
Calcium	ug/L	NE	316,000	147000	147,000		127,000		127,000		114,000		106,000	J	119,000		78,200	
Cobalt	ug/L	73	12.1	105	-	-	**51.9**		**45.3**	J	**72.9**		**56.7**		105		**95.5**	
Copper	ug/L	146	19.8	39.2	-	-	**39.2**		3.2	B	-	-	**32.2**		2.2	B	-	-
Iron	ug/L	1,095	1,550	41600	**2,410**		**5,970**		695		**34,100**		**41,600**		**14,800**		**11,500**	J
Lead	ug/L	15	NE	17	-	-	7.4		-	-	-	-	17		-	-	-	-
Magnesium	ug/L	NE	217,000	52300	52,300		47,900		47,900		26,300		25,100	J	33,300		22,200	
Manganese	ug/L	88	636	8850	**6,900**		**8,850**		**8,290**		**1,260**		**1,170**		**1,830**		**1,330**	
Mercury	ug/L	1.1	NE	0.3	-	-	-	-	-	-	0.3		-	-	-	-	-	-
Nickel	ug/L	73	8.6	248	**47.2**		**81.7**		**76**		**140**		**131**		**248**		**214**	
Potassium	ug/L	NE	116,000	4130	-	-	-	-	1,120	J	-	-	-	-	4,130	J	1,460	J
Selenium	ug/L	18	NE	5	5		-	-	-	-	-	-	-	-	-	-	-	-
Sodium	ug/L	NE	1,390,000	9070	6,470		9,070		6,040		5,170		6,010		6,090		3,260	J
Thallium	ug/L	0.24	NE	NA	-	-	-	-	-	-	-	-	10.1	B	-	-	-	-
Zinc	ug/L	1,095	507	231	54.7	J	141	B	70.1	J	87.7	J	157		231		200	
Water Quality Parameters																				
Alkalinity	ug/L	NE	NE	320000	36,000		320,000		2,600	B	38,000		-	-	2,700	B	1,900	B
Chloride	ug/L	NE	NE	6000	3,000	B	3,000		1,700	J	4,000	B	6,000		4,800		2,100	
Hardness	ug/L	NE	NE	750000	490,000		750,000		430,000		440,000		490,000		443,000		272,000	
Nitrate	ug/L	1000	NE	42			-	-	42	J			-	-	-	-	-	-
Sulfate	ug/L	NE	NE	719000	470,000		550,000		719,000		300,000		330,000		504,000		286,000	
Total dissolved solids	ug/L	NE	NE	868000	290,000		800,000		868,000		660,000		590,000		764,000		518,000	
Total organic carbon	ug/L	NE	NE	3400	2,500		2,000		2,000		3,400		3,000		2,700		1,600	
Total suspended solids	ug/L	NE	NE	150000	-	-	9,000		150,000		5,000		120,000		5,000		-	-
Turbidity	NTU	NE	NE	156					156						2.5	J	0.98	

Shaded cell indicates value is greater than the RBSC.

Bold text indicates value is greater than the BSC.

RBSC - Values reflect an incremental lifetime cancer risk (ILCR) of 1E-6 or a noncancer hazard quotient (HQ) of 0.1. For chemicals that exhibit both cancer and noncancer effects, whichever type of effect results in a lower concentration (using an ILCR of 1E-6 and an HQ of 0.1), that concentration is selected as the RBSC.

MDC - Maximum detected concentration for the AOC ("B" qualified data not included).

BSC - Background screening concentration.

"-" - Not detected.

µg/L - Micrograms per liter.

NA - Not applicable; detection is the result of blank contamination.

NE - Not established (RBSCs), not evaluated (BSCs).

NTU - Nephelometric turbidity unit.

Validation Qualifiers (VQ)

J - The compound/analyte was positively identified; the reported value is an estimated concentration.

B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.

Table 7-5

Detected Constituents in Bedrock Monitoring Wells
TNT Manufacturing Area B
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:		TNTB-BEDGW-001						TNTB-BEDGW-002							
					Sample No:		5420		5425		BD3009		CB3019		5430		5435		BD3010		CB3018	
					Sample Date:		17-Nov-97		18-May-98		28-Sep-01		5-Apr-02		16-Nov-97		18-May-98		27-Sep-01		5-Apr-02	
					Low Flow Sampled:		No		No		Yes		Yes		No		No		Yes		Yes	
Parameter	Units	RBSC	BCS	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Volatiles																				
Acetone	ug/L	548	NE	110	-	-	1.9	B	3	B	2.3	B	-	-	-	-	2	B	3.2	B
Benzene	ug/L	0.35	2.4	17	0.14	J	-	-	-	-	-	-	0.91	J	-	-	-	-	-	-
Butanone, 2-	ug/L	697	NE	75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbon disulfide	ug/L	104	NE	8	0.82	J	7.2		-	-	-	-	6.4		-	-	-	-	-	-
Dichloroethane, 1,1-	ug/L	81	NE	0.38	-	-	0.19	J	-	-	0.38	J	-	-	-	-	-	-	-	-
Ethylbenzene	ug/L	134	0.87	0.85	-	-	-	-	-	-	-	-	0.85	J	-	-	-	-	-	-
Hexanone, 2-	ug/L	150	NE	0.56	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methyl-2-pentanone, 4-	ug/L	199	NE	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methylene chloride	ug/L	4.3	NE	4.8	-	-	-	-	0.5	B	-	-	4.8	B	3.1	B	-	-	-	-
Toluene	ug/L	72	1.7	5.2	0.22	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Xylenes, total	ug/L	21	5.5	12	0.44	B	-	-	-	-	-	-	**12**		-	-	-	-	-	-
Semivolatiles																				
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	3.6	3.6	J	13	B	-	-	-	-	3	J	3.1	B	-	-	-	-
Methylnaphthalene, 2-	ug/L	12	NE	4.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Naphthalene	ug/L	0.62	NE	2.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phenanthrene	ug/L	18	NE	0.73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phenol	ug/L	1,095	NE	2.3	-	-	-	-	-	-	-	-	2.3	J	-	-	-	-	-	-
Metals - Unfiltered																				
Aluminum	ug/L	3,650	309	16900	**654**		**1,130**	J	69.7	B	54.8	J	**317**		-	-	48.3	B	45.4	J
Arsenic	ug/L	0.045	7.4	22.7	-	-	**12.9**		-	-	-	-	-	-	-	-	-	-	-	-
Barium	ug/L	255	11,800	1780	-	-	1,100		1,410		1,080		326		406		391	J	411	
Beryllium	ug/L	73	NE	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	ug/L	NE	316,000	217000	105,000		101,000		111,000		91,500		114,000	J	92,600		102,000	J	110,000	
Chromium	ug/L	11	NE	32.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cobalt	ug/L	73	12.1	18.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Copper	ug/L	146	19.8	99.2	**33.9**		**80.9**		6	B	-	-	-	-	-	-	2	B	-	-
Iron	ug/L	1,095	1,550	41700	**41,700**		**13,000**		132		-	-	1,030		168	J	-	-	-	-
Lead	ug/L	15	NE	15.7	3.9		6.2		-	-	-	-	4.8		7.1		-	-	-	-
Magnesium	ug/L	NE	217,000	72500	22,800		57,800		70,100		55,500		43,800		37,400		40,300	J	43,000	
Manganese	ug/L	88	636	1140	**677**		196		35.3		33.2		85.4		36.6		31.4	J	33.8	
Mercury	ug/L	1.1	NE	0.079	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	ug/L	73	8.6	71.2	**42.1**		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potassium	ug/L	NE	116,000	136000	7,240		37,000		48,500		43,400	J	10,400		8,190		7,540	J	6,070	J
Selenium	ug/L	18	NE	14.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	ug/L	NE	1,390,000	849000	34,900		415,000		535,000		435,000		127,000		109,000		109,000	J	109,000	
Thallium	ug/L	0.24	NE	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	ug/L	3.7	NE	48.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc	ug/L	1,095	507	184	48.8		150	J	9.1	J	2.6	J	73.9		39.6	B	5	B	-	-

Table 7-5

Detected Constituents in Bedrock Monitoring Wells
TNT Manufacturing Area B
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:		TNTB-BEDGW-001						TNTB-BEDGW-002							
					Sample No:		5420		5425		BD3009		CB3019		5430		5435		BD3010		CB3018	
					Sample Date:		17-Nov-97		18-May-98		28-Sep-01		5-Apr-02		16-Nov-97		18-May-98		27-Sep-01		5-Apr-02	
					Low Flow Sampled:		No		No		Yes		Yes		No		No		Yes		Yes	
Parameter	Units	RBSC	BCS	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Filtered																				
Aluminum	ug/L	3,650	309	56.7	-	-	-	-	76.3	B	66.6	B	-	-	-	-	48.9	B	64.2	B
Arsenic	ug/L	0.045	7.4	4.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Barium	ug/L	255	11,800	1750	-	-	1,040		1,380		974		384		414		391	J	403	
Calcium	ug/L	NE	316,000	156000	116,000	J	104,000		107,000		91,800		130,000		96,800		104,000	J	105,000	
Chromium	ug/L	11	NE	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Copper	ug/L	146	19.8	3.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iron	ug/L	1,095	1,550	16300	16,300		302		-	-	-	-	586		-	-	-	-	-	-
Lead	ug/L	15	NE	3	-	-	-	-	-	-	-	-	3		-	-	-	-	-	-
Magnesium	ug/L	NE	217,000	68200	25,600		60,400		68,200		52,600		51,100		38,600		40,900	J	41,400	
Manganese	ug/L	88	636	812	694		278		36		51.1	J	71		36.5		31.6	J	32.2	
Nickel	ug/L	73	8.6	2.1	-	-	-	-	2.1	J	-	-	-	-	-	-	-	-	-	-
Potassium	ug/L	NE	116,000	191000	8,130		36,700		46,900		38,300	J	10,700		7,990		7,540	J	5,790	J
Selenium	ug/L	18	NE	20.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	ug/L	NE	1,390,000	1120000	36,100		419,000		520,000		366,000		153,000		112,000		109,000	J	106,000	
Vanadium	ug/L	3.7	NE	8.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc	ug/L	1,095	507	45.9	-	-	-	-	-	-	-	-	-	-	40.4	B	-	-	-	-
Water Quality Parameters																				
Alkalinity	ug/L	NE	NE	432000	180,000		360,000		381,000	J	375,000		220,000		380,000		432,000	J	365,000	
Chloride	ug/L	NE	NE	3720000	90,000		600,000		704,000		761,000	J	91,000		74,000		77,900		117,000	J
Dissolved Oxygen	ppm	NE	NE	6.5			6.5													
Hardness	ug/L	NE	NE	2500000	360,000		650,000		443,000		420,000		450,000		530,000		414,000		390,000	
Nitrate	ug/L	1000	NE	48			-	-	-	-	-	-			-	-	-	-	-	-
Sulfate	ug/L	NE	NE	165000	140,000		120,000		72,500		32,100		90,000		140,000		152,000		165,000	
Total dissolved solids	ug/L	NE	NE	7600000	730,000		1,200,000		1,390,000		1,520,000		760,000		7,600,000		776,000		740,000	
Total organic carbon	ug/L	NE	NE	12100	12,000		5,000		4,900		3,400		5,000		4,000		3,700		3,000	
Total suspended solids	ug/L	NE	NE	1430000	480,000		9,000		-	-	-	-	5,000		6,000		-	-	-	-
Turbidity	NTU	NE	NE	9250			21		68.4	J	38.4	J					178	J	72.6	J

Table 7-5

Detected Constituents in Bedrock Monitoring Wells
TNT Manufacturing Area B
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:	TNTB-BEDGW-003			TNTB-BEDGW-004			
					Sample No:	BD3038		CB3024	BD3041		CB3023	
					Sample Date:	8-Oct-01		10-Apr-02	5-Oct-01		8-Apr-02	
					Low Flow Sampled:	No		No	Yes		Yes	
Parameter	Units	RBSC	BCS	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ
Volatiles													
Acetone	ug/L	548	NE	110		110	J	85	J	36	J	1.8	B
Benzene	ug/L	0.35	2.4	17		**17**		**14**		1.4	J	0.5	J
Butanone, 2-	ug/L	697	NE	75		75	J	69	J	-	-	-	-
Carbon disulfide	ug/L	104	NE	8		8		0.37	J	-	-	-	-
Dichloroethane, 1,1-	ug/L	81	NE	0.38		-	-	-	-	-	-	-	-
Ethylbenzene	ug/L	134	0.87	0.85		-	-	0.52	J	-	-	-	-
Hexanone, 2-	ug/L	150	NE	0.56		-	-	0.56	J	-	-	-	-
Methyl-2-pentanone, 4-	ug/L	199	NE	0.7		-	-	0.7	J	-	-	-	-
Methylene chloride	ug/L	4.3	NE	4.8		1.5	B	0.44	B	0.5	B	-	-
Toluene	ug/L	72	1.7	5.2		**5.2**		**4.7**		1.3	J	-	-
Xylenes, total	ug/L	21	5.5	12		-	-	2.3		-	-	-	-
Semivolatiles													
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	3.6		2	J	-	-	-	-	-	-
Methylnaphthalene, 2-	ug/L	12	NE	4.8		-	-	4.8	J	-	-	-	-
Naphthalene	ug/L	0.62	NE	2.8		-	-	2.8	J	-	-	-	-
Phenanthrene	ug/L	18	NE	0.73		-	-	0.73	J	-	-	-	-
Phenol	ug/L	1,095	NE	2.3		2.2	J	1.6	J	-	-	-	-
Metals - Unfiltered													
Aluminum	ug/L	3,650	309	16900		**16,900**	J	**6,410**		**1,010**	J	163	J
Arsenic	ug/L	0.045	7.4	22.7		**22.7**		**12.5**		-	-	-	-
Barium	ug/L	255	11,800	1780		1,500		1,780		51.3	J	39.9	J
Beryllium	ug/L	73	NE	NA		1.5	B	0.66	B	-	-	-	-
Calcium	ug/L	NE	316,000	217000		217,000		180,000		81,600		76,500	
Chromium	ug/L	11	NE	32.3		32.3		14.8		1.3	J	-	-
Cobalt	ug/L	73	12.1	18.7		**18.7**	J	10.1	J	-	-	-	-
Copper	ug/L	146	19.8	99.2		**99.2**		**49.4**		10.9	J	-	-
Iron	ug/L	1,095	1,550	41700		**35,000**		**17,100**	J	**8,090**		**6,560**	
Lead	ug/L	15	NE	15.7		15.7		7		-	-	-	-
Magnesium	ug/L	NE	217,000	72500		72,500		58,900		24,500		22,900	
Manganese	ug/L	88	636	1140		**1,140**		509		**928**		634	
Mercury	ug/L	1.1	NE	0.079		0.079	J	-	-	-	-	-	-
Nickel	ug/L	73	8.6	71.2		**71.2**		**37.7**	J	5.4	J	-	-
Potassium	ug/L	NE	116,000	136000		**121,000**	J	**136,000**		2,920	J	851	J
Selenium	ug/L	18	NE	14.4		14.4		5.6		-	-	-	-
Sodium	ug/L	NE	1,390,000	849000		605,000		849,000		7,520		6,660	
Thallium	ug/L	0.24	NE	NA		-	-	7.7	B	-	-	-	-
Vanadium	ug/L	3.7	NE	48.6		48.6	J	23.2	J	2.3	J	-	-
Zinc	ug/L	1,095	507	184		184		98.7		37.5		51.3	

Table 7-5

Detected Constituents in Bedrock Monitoring Wells
TNT Manufacturing Area B
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:	TNTB-BEDGW-003			TNTB-BEDGW-004			
					Sample No:	BD3038		CB3024	BD3041		CB3023	
					Sample Date:	8-Oct-01		10-Apr-02	5-Oct-01		8-Apr-02	
					Low Flow Sampled:	No		No	Yes		Yes	
Parameter	Units	RBSC	BCS	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Filtered													
Aluminum	ug/L	3,650	309	56.7		96.7	B	56.7	J	69	B	68.3	B
Arsenic	ug/L	0.045	7.4	4.9		4.9	J	-	-	-	-	-	-
Barium	ug/L	255	11,800	1750		628		1,750		40.8	J	39.2	J
Calcium	ug/L	NE	316,000	156000		107,000		156,000		72,000		78,000	
Chromium	ug/L	11	NE	1.2		1.2	J	-	-	-	-	-	-
Copper	ug/L	146	19.8	3.2		2.4	B	3.2	J	-	-	-	-
Iron	ug/L	1,095	1,550	16300		-	-	-	-	**5,670**		**5,550**	
Lead	ug/L	15	NE	3		-	-	-	-	-	-	-	-
Magnesium	ug/L	NE	217,000	68200		133	J	67,000		20,900		23,400	
Manganese	ug/L	88	636	812		1.6	J	-	-	**812**		**641**	
Nickel	ug/L	73	8.6	2.1		-	-	-	-	2	J	-	-
Potassium	ug/L	NE	116,000	191000		**191,000**	J	**137,000**		2,480	J	850	J
Selenium	ug/L	18	NE	20.4		20.4		-	-	-	-	-	-
Sodium	ug/L	NE	1,390,000	1120000		428,000		1,120,000		7,480		6,840	
Vanadium	ug/L	3.7	NE	8.5		8.5	J	6.3	J	-	-	-	-
Zinc	ug/L	1,095	507	45.9		-	-	-	-	19.9	J	45.9	J
Water Quality Parameters													
Alkalinity	ug/L	NE	NE	432000		86,300	J	68,600		126,000	J	123,000	
Chloride	ug/L	NE	NE	3720000		1,460,000		3,720,000		7,400		2,800	J
Dissolved Oxygen	ppm	NE	NE	6.5									
Hardness	ug/L	NE	NE	2500000		453,000		2,500,000		229,000		330,000	
Nitrate	ug/L	1000	NE	48		48	J	-	-	-	-	-	-
Sulfate	ug/L	NE	NE	165000		86,200		31,100		129,000		160,000	
Total dissolved solids	ug/L	NE	NE	7600000		2,180,000		5,370,000		347,000		378,000	
Total organic carbon	ug/L	NE	NE	12100		12,100	J	4,600		3,600	B	2,900	
Total suspended solids	ug/L	NE	NE	1430000		1,430,000		115,000		65,000		26,000	
Turbidity	NTU	NE	NE	9250		370	J	9,250		91.2	J	53.6	

Shaded cell indicates value is greater than the RBSC.

Bold text indicates value is greater than the BSC.

RBSC - Values reflect an incremental lifetime cancer risk (ILCR) of 1E-6 or a noncancer hazard quotient (HQ) of 0.1. For chemicals that exhibit both cancer and noncancer effects, whichever type of effect results in a lower concentration (using an ILCR of 1E-6 and an HQ of 0.1), that concentration is selected as the RBSC.

MDC - Maximum detected concentration for the AOC ("B" qualified data not included).

BSC - Background screening concentration.

"-" - Not detected.

µg/L - Micrograms per liter.

NA - Not applicable; detection is the result of blank contamination.

NE - Not established (RBSCs), not evaluated (BSCs).

NTU - Nephelometric turbidity unit.

Validation Qualifiers (VQ)

J - The analyte was positively identified; the reported value is estimated.

B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.

Table 7-6

Detected Constituents in Overburden/Shale Monitoring Wells
TNT Manufacturing Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:		TNTC-MW3				TNTC-MW4							
					Sample No:		5630		5635		CB3027		5640		5645		BD3043		CB3028	
					Sample Date:		21-Nov-97		18-May-98		10-Apr-02		24-Nov-97		18-May-98		4-Oct-01		10-Apr-02	
					Low Flow Sampled:		No		No		No		No		No		No		No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																		
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	0.61	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Volatiles																		
Acetone	ug/L	548	NE	13	-	-	-	-	13	J	-	-	2.5	B	39	B	-	-
Butanone, 2-	ug/L	697	NE	4.9	-	-	-	-	4.9	J	-	-	-	-	-	-	-	-
Carbon disulfide	ug/L	104	NE	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methylene chloride	ug/L	4.3	NE	NA	-	-	0.47	B	-	-	-	-	-	-	1.5	B	-	-
Xylenes, total	ug/L	21	5.5	3.3	-	-	-	-	-	-	-	-	-	-	3.3	J	-	-
Metals - Unfiltered																		
Aluminum	ug/L	3,650	309	6160	-	-	**6,030**		128	B	**3,820**	J	**4,570**	J	**1,800**	J	**1,190**	
Arsenic	ug/L	0.045	7.4	21.5	-	-	**18.6**		-	-	**21.5**		-	-	-	-	-	-
Barium	ug/L	255	11,800	203	-	-	-	-	27.5	J	-	-	-	-	29.5	J	28.6	J
Calcium	ug/L	NE	316,000	566000	**566,000**	J	**341,000**		86,600		285,000	J	299,000		262,000		254,000	
Chromium	ug/L	11	NE	30	-	-	30		-	-	25.2		11		3.4	J	2.4	J
Cobalt	ug/L	73	12.1	67.5	**67.5**		-	-	-	-	-	-	-	-	7.2	J	10.3	J
Copper	ug/L	146	19.8	31.5	-	-	**31.5**		-	-	-	-	-	-	6.7	B	-	-
Iron	ug/L	1,095	1,550	23500	805		**23,500**	J	61.3	J	**17,400**		**8,230**		**3,050**		**3,060**	J
Lead	ug/L	15	NE	20.1	-	-	13.8		-	-	14.5		3.2		-	-	2	J
Magnesium	ug/L	NE	217,000	215000	215,000		137,000		25,000		145,000		136,000		121,000		128,000	
Manganese	ug/L	88	636	2950	**2,950**		**973**		8.1	J	**800**		**715**		613		**684**	
Nickel	ug/L	73	8.6	120	**120**		-	-	-	-	**52.4**		-	-	**10.4**	J	**9.2**	J
Potassium	ug/L	NE	116,000	28200	26,700		10,100		406	J	28,200		22,100		15,600		15,500	
Selenium	ug/L	18	NE	7.2	-	-	-	-	-	-	7.2		-	-	-	-	-	-
Sodium	ug/L	NE	1,390,000	161000	86,100	J	58,900		16,300		79,700	J	62,100		57,400		62,600	
Thallium	ug/L	0.24	NE	NA	-	-	-	-	5.9	B	-	-	-	-	6.4	B	-	-
Vanadium	ug/L	3.7	NE	14.4	-	-	-	-	-	-	-	-	-	-	3.1	J	2.1	J
Zinc	ug/L	1,095	507	58.7	34.5		80.8	B	4.7	J	58.7		41.2	B	25.2		13	J
Metals - Filtered																		
Aluminum	ug/L	3,650	309	433	-	-	-	-	57.2	J	**432**		-	-	64.8	B	59.5	J
Barium	ug/L	255	11,800	64.1	-	-	-	-	31.2	J	-	-	-	-	24	J	14.9	J
Calcium	ug/L	NE	316,000	529000	**529,000**		**402,000**		117,000		**386,000**		306,000		252,000		262,000	
Cobalt	ug/L	73	12.1	7.5	-	-	-	-	-	-	-	-	-	-	7.5	J	3.1	J
Iron	ug/L	1,095	1,550	515	132	B	-	-	-	-	403	B	-	-	-	-	-	-
Lead	ug/L	15	NE	11	-	-	-	-	-	-	11		-	-	-	-	-	-
Magnesium	ug/L	NE	217,000	204000	204,000		171,000		36,400		181,000		140,000		138,000		127,000	
Manganese	ug/L	88	636	2900	**2,900**		617		6.7	J	**1,120**		582		**686**		448	
Nickel	ug/L	73	8.6	77.1	**77.1**		-	-	-	-	**56.8**		-	-	**15.6**	J	6.6	J
Potassium	ug/L	NE	116,000	34500	25,800		12,000		1,000	J	34,500		21,100		21,100		15,200	
Selenium	ug/L	18	NE	11.4	-	-	-	-	-	-	11.4		-	-	-	-	-	-
Sodium	ug/L	NE	1,390,000	163000	79,400		74,000		24,400		94,900		60,200		78,800		63,300	
Thallium	ug/L	0.24	NE	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc	ug/L	1,095	507	64.7	28.5	J	45.5	B	18.2	J	52	J	-	-	64.7		7.9	J

Table 7-6

Detected Constituents in Overburden/Shale Monitoring Wells
TNT Manufacturing Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

				Location Code:	TNTC-MW3						TNTC-MW4							
				Sample No:	5630		5635		CB3027		5640		5645		BD3043		CB3028	
				Sample Date:	21-Nov-97		18-May-98		10-Apr-02		24-Nov-97		18-May-98		4-Oct-01		10-Apr-02	
				Low Flow Sampled:	No		No		No		No		No		No		No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Water Quality Parameters																		
Alkalinity	ug/L	NE	NE	380000	270,000		350,000		233,000		330,000		250,000		350,000	J	351,000	
Chloride	ug/L	NE	NE	50000	17,000		14,000		4,500		23,000		27,000		19,800		20,000	
Hardness	ug/L	NE	NE	13000000	13,000,000		1,800,000		496,000		9,200,000		720,000		1,120,000		980,000	
Nitrate	ug/L	1000	NE	400			-	-	-	-			400		-	-	120	
Nitrate-Nitrite	ug/L	100	NE	91000	-	-					91,000	J						
Sulfate	ug/L	NE	NE	2000000	2,000,000		1,300,000		248,000		1,100,000		990,000		839,000	J	749,000	
Total dissolved solids	ug/L	NE	NE	3000000	3,000,000		2,900,000		670,000		2,100,000		1,600,000		1,650,000		784,000	
Total organic carbon	ug/L	NE	NE	5700	2,400		3,000		2,000		2,600		3,000		5,700		1,100	
Total suspended solids	ug/L	NE	NE	355000	-	-	150,000		21,000		5,000		280,000		48,000		37,000	
Turbidity	NTU	NE	NE	520					59						73.5	J	147	

Table 7-6

Detected Constituents in Overburden/Shale Monitoring Wells
TNT Manufacturing Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

(Page 3 of 4)

					Location Code:	TNTC-MW5						
					Sample No:	5650		5655		BD3035		CB3029
					Sample Date:	21-Nov-97		18-May-98		3-Oct-01		8-Apr-02
					Low Flow Sampled:	No		No		No		No
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives												
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	0.61	-	-	-	-	0.61		-	-
Volatiles												
Acetone	ug/L	548	NE	13	-	-	-	-	3.7	B	-	-
Butanone, 2-	ug/L	697	NE	4.9	-	-	-	-	-	-	-	-
Carbon disulfide	ug/L	104	NE	NA	0.51	B	-	-	-	-	-	-
Methylene chloride	ug/L	4.3	NE	NA	0.43	B	0.51	B	-	-	-	-
Xylenes, total	ug/L	21	5.5	3.3	-	-	-	-	-	-	-	-
Metals - Unfiltered												
Aluminum	ug/L	3,650	309	6160	**3,490**	J	**5,230**		**6,160**	J	164	J
Arsenic	ug/L	0.045	7.4	21.5	**10.1**		**21.3**		**8.8**	J	-	-
Barium	ug/L	255	11,800	203	-	-	-	-	203	J	24	J
Calcium	ug/L	NE	316,000	566000	146,000	J	132,000		137,000	J	122,000	
Chromium	ug/L	11	NE	30	18.4		28		13.9	J	-	-
Cobalt	ug/L	73	12.1	67.5	-	-	-	-	**16.7**	J	-	-
Copper	ug/L	146	19.8	31.5	-	-	**31**		19.5	J	-	-
Iron	ug/L	1,095	1,550	23500	**13,900**		**22,700**	J	**13,300**	J	199	
Lead	ug/L	15	NE	20.1	13.8		20.1		10.5	J	-	-
Magnesium	ug/L	NE	217,000	215000	55,900		46,400		48,300	J	22,200	
Manganese	ug/L	88	636	2950	**713**		616		**1,520**	J	56.3	
Nickel	ug/L	73	8.6	120	-	-	-	-	**17.2**	J	2.2	J
Potassium	ug/L	NE	116,000	28200	15,400		11,700		14,200	J	451	J
Selenium	ug/L	18	NE	7.2	-	-	-	-	-	-	-	-
Sodium	ug/L	NE	1,390,000	161000	161,000	J	113,000		139,000	J	29,600	
Thallium	ug/L	0.24	NE	NA	-	-	-	-	5	B	-	-
Vanadium	ug/L	3.7	NE	14.4	-	-	-	-	14.4	J	-	-
Zinc	ug/L	1,095	507	58.7	53		56.3	B	31	J	2.8	J
Metals - Filtered												
Aluminum	ug/L	3,650	309	433	-	-	-	-	**433**		70.4	B
Barium	ug/L	255	11,800	64.1	-	-	-	-	64.1	J	21.3	J
Calcium	ug/L	NE	316,000	529000	138,000		130,000		129,000		117,000	
Cobalt	ug/L	73	12.1	7.5	-	-	-	-	6.7	J	-	-
Iron	ug/L	1,095	1,550	515	-	-	-	-	515		-	-
Lead	ug/L	15	NE	11	4.2		-	-	-	-	-	-
Magnesium	ug/L	NE	217,000	204000	54,600		47,700		47,400		21,200	
Manganese	ug/L	88	636	2900	522		452		**1,180**		24.2	
Nickel	ug/L	73	8.6	77.1	-	-	-	-	6.7	J	-	-
Potassium	ug/L	NE	116,000	34500	14,700		12,300		12,700		326	J
Selenium	ug/L	18	NE	11.4	-	-	-	-	-	-	-	-
Sodium	ug/L	NE	1,390,000	163000	163,000		127,000		143,000		28,400	
Thallium	ug/L	0.24	NE	NA	-	-	-	-	5.9	B	-	-
Zinc	ug/L	1,095	507	64.7	-	-	27	B	3.2	J	16	J

Table 7-6

Detected Constituents in Overburden/Shale Monitoring Wells
TNT Manufacturing Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:		TNTC-MW5					
					Sample No:		5650		5655		BD3035		CB3029	
					Sample Date:		21-Nov-97		18-May-98		3-Oct-01		8-Apr-02	
					Low Flow Sampled:		No		No		No		No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Water Quality Parameters												
Alkalinity	ug/L	NE	NE	380000	320,000		380,000		296,000	J	229,000	
Chloride	ug/L	NE	NE	50000	50,000		26,000		46,900		4,800	J
Hardness	ug/L	NE	NE	13000000	500,000		850,000		517,000		284,000	
Nitrate	ug/L	1000	NE	400			200		-	-	-	-
Nitrate-Nitrite	ug/L	100	NE	91000	-	-						
Sulfate	ug/L	NE	NE	2000000	430,000		240,000		423,000		163,000	
Total dissolved solids	ug/L	NE	NE	3000000	1,000,000		1,200,000		1,020,000		506,000	
Total organic carbon	ug/L	NE	NE	5700	3,000		3,000		2,100		2,900	
Total suspended solids	ug/L	NE	NE	355000	7,000		240,000		355,000		75,000	
Turbidity	NTU	NE	NE	520					520	J	112	

Shaded cell indicates value is greater than the RBSC.
Bold text indicates value is greater than the BSC.
RBSC - Values reflect an incremental lifetime cancer risk (ILCR) of 1E-6 or a noncancer hazard quotient (HQ) of 0.1. For chemicals that exhibit both cancer and noncancer effects, whichever type of effect results in a lower concentration (using an ILCR of 1E-6 and an HQ of 0.1), that concentration is selected as the RBSC.
MDC - Maximum detected concentration for the AOC ("B" qualified data not included).
BSC - Background screening concentration.
"-" - Not detected.
µg/L - Micrograms per liter.
NA - Not applicable; detection is the result of blank contamination.
NE - Not established (RBSCs), not evaluated (BSCs).
NTU - Nephelometric turbidity unit.

Validation Qualifiers (VQ)
J - The analyte was positively identified; the reported value is estimated.
B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.

Table 7-7

Detected Constituents in Bedrock Monitoring Wells
TNT Manufacturing Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:	BED-MW13							TNTC-BEDGW-001			
					Sample No:	5890		5895		BD3017		CB3025		BD3042		CB3026	
					Sample Date:	13-Nov-97		29-May-98		3-Oct-01		10-Apr-02		4-Oct-01		9-Apr-02	
					Low Flow Sampled:	No		No		No		No		Yes		Yes	
Parameter	Units	RBSC	BSC	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Volatiles																	
Acetone	ug/L	548	NE	53		-	-	-	-	-	-	-	-	54	B	53	J
Benzene	ug/L	0.35	2.4	410		**130**		**47**		**270**	J	**410**	J	-	-	**8.4**	J
Carbon disulfide	ug/L	104	NE	5.8		5.8		-	-	-	-	-	-	-	-	-	-
Ethylbenzene	ug/L	134	0.87	130		**73**		**57**		**120**	J	**130**	J	**22**	J	**12**	J
Methylene chloride	ug/L	4.3	NE	160		-	-	51	B	43	J	49	J	160	J	19	J
Toluene	ug/L	72	1.7	300		**170**		**120**		**270**	J	**300**	J	-	-	**8.8**	J
Xylenes, total	ug/L	21	5.5	1300		**520**		**540**		**1,200**	J	**1,300**		**190**		**90**	
Semivolatiles																	
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	55		39		55	J	7.7	J	5.2	J	-	-	-	-
Dimethylphenol, 2,4-	ug/L	73	NE	22		16		13	J	22		21		-	-	-	-
Fluorene	ug/L	24.3	NE	1.4		-	-	-	-	1	J	1.4	J	-	-	-	-
Isophorone	ug/L	71	NE	2.7		-	-	2.7	J	-	-	-	-	-	-	-	-
Methylnaphthalene, 2-	ug/L	12	NE	34		20		14	J	25		34		4.5	J	3.2	J
Methylphenol, 2-	ug/L	182	NE	6.6		4.1	J	3.3	J	6.6	J	6	J	-	-	-	-
Methylphenol, 4-	ug/L	18	NE	6.9		4.7	J	3.3	J	6.9	J	5.8	J	-	-	-	-
Naphthalene	ug/L	0.62	NE	34		15		10	J	27		34		5.2	J	2.5	J
Phenanthrene	ug/L	18	NE	1.9		-	-	-	-	1.3	J	1.9	J	-	-	-	-
Phenol	ug/L	1,095	NE	69		62		69	J	12		11		-	-	-	-
Metals - Unfiltered																	
Aluminum	ug/L	3,650	309	96.8		-	-	-	-	96.8	J	177	B	130	B	90.6	B
Arsenic	ug/L	0.045	7.4	4.1		-	-	-	-	-	-	-	-	4.1	J	-	-
Barium	ug/L	255	11,800	2680		1,550		-	-	2,090	J	2,680		29.4	J	16.5	J
Calcium	ug/L	NE	316,000	439000		248,000	J	125,000	J	**418,000**	J	**351,000**		**439,000**		**434,000**	
Copper	ug/L	146	19.8	6.1		-	-	-	-	6.1	J	-	-	-	-	-	-
Iron	ug/L	1,095	1,550	335		244	B	207		106	J	335	J	66.6	J	-	-
Magnesium	ug/L	NE	217,000	334000		180,000		9,250		201,000	J	**334,000**		150,000		152,000	
Manganese	ug/L	88	636	271		17.4		41.9		29.1	J	23.7		271		5.1	J
Nickel	ug/L	73	8.6	2.3		-	-	-	-	-	-	-	-	2.3	J	-	-
Potassium	ug/L	NE	116,000	101000		101,000		-	-	96,900	J	89,000		22,400		9,610	
Sodium	ug/L	NE	1,390,000	1330000		1,330,000		29,500		1,190,000	J	1,150,000		56,500		51,900	
Thallium	ug/L	0.24	NE	NA		-	-	-	-	6	B	5.1	B	-	-	4.8	B
Zinc	ug/L	1,095	507	47.2		47.2		-	-	5.6	J	7.1	J	-	-	-	-

Table 7-7

Detected Constituents in Bedrock Monitoring Wells
TNT Manufacturing Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:		BED-MW13						TNTC-BEDGW-001			
					Sample No:		5890		5895		BD3017		CB3025		BD3042		CB3026	
					Sample Date:		13-Nov-97		29-May-98		3-Oct-01		10-Apr-02		4-Oct-01		9-Apr-02	
					Low Flow Sampled:		No		No		No		No		Yes		Yes	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Filtered																
Aluminum	ug/L	3,650	309	86.4	-	-	-	-	80.9	B	86.4	J	82.5	B	64.1	J
Arsenic	ug/L	0.045	7.4	6	-	-	-	-	-	-	2.5	J	6	J	-	-
Barium	ug/L	255	11,800	2680	1,680		208		2,090	J	2,680		30.8	J	18	J
Calcium	ug/L	NE	316,000	462000	270,000		140,000	J	**416,000**	J	**364,000**		**427,000**		**462,000**	
Iron	ug/L	1,095	1,550	NA	116	B	-	-	-	-	-	-	-	-	-	-
Magnesium	ug/L	NE	217,000	347000	200,000		14,600	J	202,000	J	**347,000**		147,000		157,000	
Manganese	ug/L	88	636	290	-	-	43.8		28.1	J	18		290		5.2	J
Nickel	ug/L	73	8.6	2.3	-	-	-	-	-	-	-	-	2.3	J	-	-
Potassium	ug/L	NE	116,000	110000	110,000		-	-	96,700	J	95,000		22,500		10,900	
Sodium	ug/L	NE	1,390,000	1510000	**1,510,000**		53,500		1,230,000	J	1,210,000		55,300		57,100	
Zinc	ug/L	1,095	507	30.1	30.1		-	-	5	J	9.5	J	-	-	-	-
Water Quality Parameters																
Alkalinity	ug/L	NE	NE	562000	430,000		300,000		402,000	J	476,000		440,000	J	562,000	
Chloride	ug/L	NE	NE	4290000	2,500,000		-	-	4,290,000		4,220,000		274,000		242,000	
Hardness	ug/L	NE	NE	2050000	1,600,000		450,000		2,050,000		1,960,000		1,720,000		1,450,000	
Sulfate	ug/L	NE	NE	1340000	13,000		5,000		78,400		66,600		1,340,000	J	1,030,000	
Total dissolved solids	ug/L	NE	NE	5970000	4,800,000		510,000		5,970,000		4,810,000		2,350,000		2,200,000	
Total organic carbon	ug/L	NE	NE	9600	9,600		2,000		6,600		7,400		2,500	B	1,400	
Total suspended solids	ug/L	NE	NE	32000	16,000		-	-	23,000		32,000		18,000		11,000	
Turbidity	NTU	NE	NE	585					76.8	J	585		172	J	158	

Shaded cell indicates value is greater than the RBSC.

Bold text indicates value is greater than the BSC.

RBSC - Values reflect an incremental lifetime cancer risk (ILCR) of 1E-6 or a noncancer hazard quotient (HQ) of 0.1. For chemicals that exhibit both cancer and noncancer effects, whichever type of effect results in a lower concentration (using an ILCR of 1E-6 and an HQ of 0.1), that concentration is selected as the RBSC.

MDC - Maximum detected concentration for the AOC ("B" qualified data not included).

BSC - Background screening concentration.

"-" - Not detected.

µg/L - Micrograms per liter.

NA - Not applicable; detection is the result of blank contamination.

NE - Not established (RBSCs), not evaluated (BSCs).

NTU - Nephelometric turbidity unit.

Validation Qualifiers (VQ)

J - The analyte was positively identified; the reported value is estimated.

B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.

Table 7-8

Detected Constituents in Overburden/Shale Temporary Piezometer Sampling Locations
Red Water Pond Areas
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:		PRRP-DP01		PRRP-DP02		PRRP-DP03		PRRP-DP04		PRRP-DP05		PRRP-DP06		PRRP-DP07		PRRP-DP08		PRRP-DP09	
					Sample No.:		7230		7270		7310		7350		7390		7430		7470		7510		7550	
					Sample Date:		12-Jun-98		14-Jun-98		8-Jun-98		9-Jun-98		14-Jun-98		9-Jun-98		10-Jun-98		10-Jun-98		14-Jun-98	
					Low-Flow Sampled:		No		No		No		No		No		No		No		No		No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																								
Dinitrobenzene, 1,3-	ug/L	0.37	NE	4800	-	-	-	-	4,800		0.28		-	-	10		0.42		1.2		-	-		
Dinitrotoluene, 2,4-	ug/L	0.099	NE	6800	10		-	-	6,800		0.47		-	-	31		0.82		1.4		-	-		
Dinitrotoluene, 2,6-	ug/L	0.099	NE	400	-	-	-	-	-	-	-	-	-	-	5.1		-	-	0.28		-	-		
Tetryl	ug/L	37	NE	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Trinitrobenzene, 1,3,5-	ug/L	110	NE	680	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	7.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Volatiles																								
Acetone	ug/L	548	NE	20	4.3	B	-	-	20	J	4	B	3.1	B			4.3	B	2.1	B	2.8	B		
Benzene	ug/L	0.35	2.4	0.15	-	-	-	-	0.14	J	-	-	-	-			-	-	-	-	-	-		
Butanone, 2-	ug/L	697	NE	24	-	-	-	-	24	J	-	-	-	-			-	-	-	-	-	-		
Carbon disulfide	ug/L	104	NE	0.26	-	-	-	-	-	-	0.26	J	-	-			-	-	0.16	J	-	-		
Ethylbenzene	ug/L	134	0.87	0.19	-	-	-	-	0.19	J	-	-	-	-			-	-	-	-	-	-		
Hexanone, 2-	ug/L	150	NE	1.8	-	-	-	-	1.8	J	-	-	-	-			-	-	-	-	-	-		
Methylene chloride	ug/L	4.3	NE	NA	-	-	-	-	-	-	-	-	-	-			-	-	-	-	0.59	B		
Tetrachloroethene	ug/L	0.104	NE	0.26	-	-	0.14	J	0.22	J	-	-	0.26	J			0.17	J	-	-	-	-		
Toluene	ug/L	72	1.7	1.9	-	-	0.22	B	0.51	B	0.63	B	0.3	B			0.3	B	0.51	B	-	-		
Trichloroethene	ug/L	0.028	NE	0.43	-	-	-	-	-	-	-	-	-	-			0.43	J	0.16	J	-	-		
Xylenes, total	ug/L	21	5.5	0.88	-	-	-	-	0.88	J	-	-	-	-			-	-	-	-	-	-		
Semivolatiles																								
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	10	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-		
Dinitro-2-methylphenol, 4,6-	ug/L	0.37	NE	2300	-	-	-	-	2,300		-	-	-	-			-	-	-	-	-	-		
Dinitrophenol, 2,4-	ug/L	7.3	NE	5900	8.3	J	-	-	5,800	D	-	-	-	-			-	-	-	-	-	-		
Dinitrotoluene, 2,4-	ug/L	0.099	NE	9200	20		-	-	9,200	D	-	-	-	-			-	-	2.8	J	-	-		
Dinitrotoluene, 2,6-	ug/L	0.099	NE	550	3.3	J	-	-	550		-	-	-	-			-	-	-	-	-	-		
Naphthalene	ug/L	0.62	NE	1.9	-	-	-	-	-	-	-	-	1.9	J			-	-	-	-	-	-		
Nitroaniline, 2-	ug/L	11	NE	3.2	3.2	J	-	-	-	-	-	-	-	-			-	-	-	-	-	-		
Nitroaniline, 3-	ug/L	3.2	NE	88	88		-	-	-	-	-	-	-	-			-	-	-	-	-	-		
Nitrophenol, 2-	ug/L	4.9	NE	2.1	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-		
Nitrophenol, 4-	ug/L	4.9	NE	290	-	-	-	-	290	J	-	-	-	-			-	-	-	-	-	-		

Table 7-8

Detected Constituents in Overburden/Shale Temporary Piezometer Sampling Locations
Red Water Pond Areas
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:		PRRP-DP01		PRRP-DP02		PRRP-DP03		PRRP-DP04		PRRP-DP05		PRRP-DP06		PRRP-DP07		PRRP-DP08		PRRP-DP09	
					Sample No.:		7230		7270		7310		7350		7390		7430		7470		7510		7550	
					Sample Date:		12-Jun-98		14-Jun-98		8-Jun-98		9-Jun-98		14-Jun-98		9-Jun-98		10-Jun-98		10-Jun-98		14-Jun-98	
					Low-Flow Sampled:		No		No		No		No		No		No		No		No		No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Unfiltered																								
Aluminum	ug/L	3,650	309	280000	**52,900**		**52,200**		**88,400**		**280,000**		**32,700**						**69,000**		**178,000**		**56,800**	
Antimony	ug/L	1.5	NE	118	-	-	-	-	-	-	-	-	-	-					-	-	118	J	-	-
Arsenic	ug/L	0.045	7.4	1780	-	-	**63.3**		-	-	305	J	**53.9**						-	-	**259**	J	-	-
Barium	ug/L	255	11,800	1680	-	-	-	-	-	-	1,680		-	-					556		1,210		-	-
Beryllium	ug/L	7.3	NE	9.5	-	-	-	-	-	-	-	-	-	-					-	-	8.8		-	-
Cadmium	ug/L	1.8	NE	6.5	-	-	-	-	-	-	-	-	-	-					-	-	6.5		-	-
Calcium	ug/L	NE	316,000	2680000	**432,000**		221,000		**683,000**		**1,530,000**		**606,000**						**650,000**		**863,000**		**873,000**	
Chromium	ug/L	11	NE	561	112		113		208		561		82.6						114		273		141	
Cobalt	ug/L	73	12.1	5610	-	-	-	-	**2,610**		-	-	-	-					**77.6**		**208**		-	-
Copper	ug/L	146	19.8	2800	**277**		-	-	**1,410**		**669**		-	-					**194**		**472**		**438**	
Iron	ug/L	1,095	1,550	679000	**125,000**		**100,000**		**200,000**		**679,000**		**98,200**						**176,000**		**468,000**		**134,000**	
Lead	ug/L	15	NE	459	58.3	J	42.6		96.7	J	292	J	48.4						86.2	J	323	J	67.1	
Magnesium	ug/L	NE	217,000	651000	101,000		66,300		172,000		**616,000**		204,000						**217,000**		**253,000**		195,000	
Manganese	ug/L	88	636	55100	**4,040**		**1,120**		**39,600**		**12,400**		**3,240**						**4,310**		**11,800**		**4,050**	
Mercury	ug/L	1.1	NE	0.65	-	-	0.23		-	-	0.55		-	-					-	-	0.2		0.29	
Nickel	ug/L	73	8.6	5040	-	-	-	-	**2,380**		**740**		-	-					**191**		**521**		**407**	
Potassium	ug/L	NE	116,000	33100	-	-	-	-	-	-	31,500		-	-					12,300		22,700		-	-
Selenium	ug/L	18	NE	1790	-	-	-	-	-	-	-	-	-	-					-	-	-	-	-	-
Sodium	ug/L	NE	1,390,000	9410000	788,000		266,000		**5,930,000**		-	-	107,000						7,060		-	-	707,000	
Thallium	ug/L	0.24	NE	1770	-	-	-	-	-	-	-	-	-	-					-	-	-	-	-	-
Vanadium	ug/L	3.7	NE	1000	-	-	-	-	-	-	821		-	-					212		438		-	-
Zinc	ug/L	1,095	507	2010	374		299		**597**		**2,010**		279						**525**		**1,550**		441	
Metals - Filtered																								
Aluminum	ug/L	3,650	309	1350	-	-	-	-	-	-	-	-	-	-					-	-	-	-	-	-
Arsenic	ug/L	0.045	7.4	22.9	-	-	-	-	-	-	**13.4**		-	-					**11**		-	-	-	-
Barium	ug/L	255	11,800	237	-	-	-	-	-	-	-	-	-	-					-	-	-	-	-	-
Cadmium	ug/L	1.8	NE	46	-	-	-	-	-	-	-	-	-	-					-	-	-	-	-	-
Calcium	ug/L	NE	316,000	780000	207,000		193,000		**542,000**		90,900		274,000						66,500		58,000		269,000	
Chromium	ug/L	11	NE	495	-	-	-	-	-	-	-	-	-	-					-	-	-	-	-	-
Cobalt	ug/L	73	12.1	6660	-	-	-	-	**3,090**		-	-	-	-					-	-	-	-	-	-
Copper	ug/L	146	19.8	3260	-	-	-	-	**1,600**		-	-	-	-					-	-	-	-	**311**	
Iron	ug/L	1,095	1,550	15300	-	-	150		**7,480**		166		-	-					190		116		-	-
Lead	ug/L	15	NE	31.5	-	-	-	-	-	-	-	-	-	-					-	-	-	-	31.5	
Magnesium	ug/L	NE	217,000	348000	52,800		44,400		139,000		25,300		96,100						15,800		12,900		73,600	
Manganese	ug/L	88	636	62400	**1,680**		257		**42,700**		39.3		**818**						71.4		-	-	**1,120**	
Nickel	ug/L	73	8.6	5820	-	-	-	-	**2,760**		-	-	-	-					-	-	-	-	-	-
Potassium	ug/L	NE	116,000	18200	-	-	-	-	-	-	-	-	-	-					-	-	-	-	-	-
Sodium	ug/L	NE	1,390,000	12600000	1,130,000		288,000		**7,260,000**		-	-	119,000						5,490		-	-	754,000	
Zinc	ug/L	1,095	507	1100	-	-	-	-	-	-	21.6		-	-					77.7		26.5		-	-

Table 7-8

Detected Constituents in Overburden/Shale Temporary Piezometer Sampling Locations
Red Water Pond Areas
Former Plum Brook Ordnance Works, Sandusky, Ohio

				Location Code:	PRRP-DP01		PRRP-DP02		PRRP-DP03		PRRP-DP04		PRRP-DP05		PRRP-DP06		PRRP-DP07		PRRP-DP08		PRRP-DP09	
				Sample No.:	7230		7270		7310		7350		7390		7430		7470		7510		7550	
				Sample Date:	12-Jun-98		14-Jun-98		8-Jun-98		9-Jun-98		14-Jun-98		9-Jun-98		10-Jun-98		10-Jun-98		14-Jun-98	
				Low-Flow Sampled:	No		No		No		No		No		No		No		No		No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Water Quality Parameters																						
Alkalinity	ug/L	NE	NE	1500000			450,000		1,500,000		263,000										476,000	
Chloride	ug/L	NE	NE	9800			9,800		-	-	2,300										-	-
Cyanide, total	ug/L	73	NE	780			-	-	780		-	-									23	
Hardness	ug/L	NE	NE	3400000			780,000		3,400,000		940,000										1,640,000	
Nitrate	ug/L	1000	NE	465000			-	-	465,000		-	-									16,900	
Sulfate	ug/L	NE	NE	10000000			574,000		10,000,000		22,700										1,150,000	
Total dissolved solids	ug/L	NE	NE	22100000			1,410,000		15,000,000		401,000										4,370,000	
Total organic carbon	ug/L	NE	NE	6600000			19,300		6,600,000		-	-									671,000	
Total suspended solids	ug/L	NE	NE	110000			-	-	110,000		-	-									12,000	

Table 7-8

Detected Constituents in Overburden/Shale Temporary Piezometer Sampling Locations
Red Water Pond Areas
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:	PRRP-DP10		PRRP-DP11		PRRP-DP12		PRRP-DP13		PRRP-DP14		PRRP-DP15		PRRP-DP16		PRRP-DP17	
					Sample No.:	7590		7630/7630R		7670		7710		7750		7790		7830		7870	
					Sample Date:	10-Jun-98		14-Jun-98/25-Jun-98		11-Jun-98		12-Jun-98		12-Jun-98		12-Jun-98		13-Jun-98		11-Jun-98	
					Low-Flow Sampled:	No		No		No		No		No		No		No		No	
Parameter	Units	RBSC	BSC	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																					
Dinitrobenzene, 1,3-	ug/L	0.37	NE	4800		2,100		840		1.3		1.6		-	-	-	-	-	-	6.4	
Dinitrotoluene, 2,4-	ug/L	0.099	NE	6800		2,200		150		2.3		2.4		-	-	-	-	-	-	8.9	
Dinitrotoluene, 2,6-	ug/L	0.099	NE	400		400		-	-	0.35		0.36		-	-	-	-	-	-	1.7	
Tetryl	ug/L	37	NE	0.2		-	-	-	-	-	-	0.2		-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	ug/L	110	NE	680		-	-	600		-	-	-	-	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	7.1		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Volatiles																					
Acetone	ug/L	548	NE	20		17	B	-	-	5.9	B	1.5	B	5.7	B	4.3	B	4.6	B	1.5	B
Benzene	ug/L	0.35	2.4	0.15		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Butanone, 2-	ug/L	697	NE	24		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbon disulfide	ug/L	104	NE	0.26		-	-	-	-	0.16	J	-	-	-	-	-	-	-	-	-	-
Ethylbenzene	ug/L	134	0.87	0.19		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hexanone, 2-	ug/L	150	NE	1.8		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methylene chloride	ug/L	4.3	NE	NA		-	-	2.2	B	-	-	-	-	-	-	-	-	0.63	B	-	-
Tetrachloroethene	ug/L	0.104	NE	0.26		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Toluene	ug/L	72	1.7	1.9		-	-	-	-	1.9	J	0.26	B	1.1	B	-	-	-	-	0.56	B
Trichloroethene	ug/L	0.028	NE	0.43		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Xylenes, total	ug/L	21	5.5	0.88		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Semivolatiles																					
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	10		-	-	-	-	10		-	-	3.2	J	-	-	-	-	-	-
Dinitro-2-methylphenol, 4,6-	ug/L	0.37	NE	2300		1,700		-	-	-	-	-	-	-	-	830	J	-	-	-	-
Dinitrophenol, 2,4-	ug/L	7.3	NE	5900		5,900	D	-	-	-	-	-	-	-	-	-	-	22	J	-	-
Dinitrotoluene, 2,4-	ug/L	0.099	NE	9200		4,100	D	380	J	-	-	-	-	2.5	J	80	J	35		1.5	J
Dinitrotoluene, 2,6-	ug/L	0.099	NE	550		390		-	-	-	-	-	-	-	-	-	-	6.2	J	-	-
Naphthalene	ug/L	0.62	NE	1.9		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitroaniline, 2-	ug/L	11	NE	3.2		-	-	-	-	-	-	-	-	-	-	-	-	1.3	J	-	-
Nitroaniline, 3-	ug/L	3.2	NE	88		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrophenol, 2-	ug/L	4.9	NE	2.1		-	-	-	-	-	-	-	-	-	-	-	-	2.1	J	-	-
Nitrophenol, 4-	ug/L	4.9	NE	290		210	J	-	-	-	-	-	-	-	-	-	-	5	J	-	-

Table 7-8

Detected Constituents in Overburden/Shale Temporary Piezometer Sampling Locations
Red Water Pond Areas
Former Plum Brook Ordnance Works, Sandusky, Ohio

(Page 5 of 12)

					Location Code:	PRRP-DP10		PRRP-DP11		PRRP-DP12		PRRP-DP13		PRRP-DP14		PRRP-DP15		PRRP-DP16		PRRP-DP17	
					Sample No.:	7590		7630/7630R		7670		7710		7750		7790		7830		7870	
					Sample Date:	10-Jun-98		14-Jun-98/25-Jun-98		11-Jun-98		12-Jun-98		12-Jun-98		12-Jun-98		13-Jun-98		11-Jun-98	
					Low-Flow Sampled:	No		No		No		No		No		No		No		No	
Parameter	Units	RBSC	BSC	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Unfiltered																					
Aluminum	ug/L	3,650	309	280000		78,300		4,820		170,000		7,220		7,970		-	-	15,500		38,600	
Antimony	ug/L	1.5	NE	118		-	-	-	-	105	J	-	-	-	-	-	-	-	-	-	-
Arsenic	ug/L	0.045	7.4	1780		-	-	-	-	238	J	11.1	J	-	-	-	-	-	-	-	-
Barium	ug/L	255	11,800	1680		-	-	-	-	896		-	-	-	-	-	-	-	-	218	
Beryllium	ug/L	7.3	NE	9.5		-	-	-	-	8.5		-	-	-	-	-	-	-	-	-	-
Cadmium	ug/L	1.8	NE	6.5		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	ug/L	NE	316,000	2680000		662,000		848,000		926,000		249,000		281,000		-	-	283,000		1,270,000	
Chromium	ug/L	11	NE	561		223		-	-	277		16		105		-	-	-	-	65.8	
Cobalt	ug/L	73	12.1	5610		5,610		3,360		172		-	-	-	-	-	-	668		-	-
Copper	ug/L	146	19.8	2800		2,800		1,530		515		27.7		-	-	-	-	510		106	
Iron	ug/L	1,095	1,550	679000		202,000		15,500		426,000		18,800		27,500		-	-	40,200		87,000	
Lead	ug/L	15	NE	459		-	-	-	-	202	J	9.5	J	38.1	J	33	J	-	-	-	-
Magnesium	ug/L	NE	217,000	651000		326,000		249,000		313,000		71,900		83,800		-	-	88,000		286,000	
Manganese	ug/L	88	636	55100		55,100		35,300		6,460		496		927		-	-	2,080		3,280	
Mercury	ug/L	1.1	NE	0.65		-	-	-	-	0.32		-	-	-	-	-	-	-	-	-	-
Nickel	ug/L	73	8.6	5040		5,040		1,950		490		-	-	-	-	-	-	468		113	
Potassium	ug/L	NE	116,000	33100		-	-	-	-	21,600		-	-	-	-	-	-	-	-	6,430	
Selenium	ug/L	18	NE	1790		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	ug/L	NE	1,390,000	9410000		9,410,000		3,640,000		5,960		29,700		79,400		-	-	1,180,000		6,010	
Thallium	ug/L	0.24	NE	1770		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	ug/L	3.7	NE	1000		-	-	-	-	391		52.3		877		1,000		-	-	163	
Zinc	ug/L	1,095	507	2010		736		-	-	1,350		76		-	-	-	-	-	-	341	
Metals - Filtered																					
Aluminum	ug/L	3,650	309	1350		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	ug/L	0.045	7.4	22.9		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Barium	ug/L	255	11,800	237		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	ug/L	1.8	NE	46		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	ug/L	NE	316,000	780000		681,000		745,000		98,800		189,000		405,000		780,000		212,000		55,000	
Chromium	ug/L	11	NE	495		-	-	495		-	-	-	-	-	-	-	-	-	-	-	-
Cobalt	ug/L	73	12.1	6660		6,660		3,030		-	-	-	-	-	-	1,290		784		-	-
Copper	ug/L	146	19.8	3260		3,260		2,000		-	-	-	-	-	-	531		568		-	-
Iron	ug/L	1,095	1,550	15300		15,300		5,870		125		237		2,400		3,240		1,950		-	-
Lead	ug/L	15	NE	31.5		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magnesium	ug/L	NE	217,000	348000		348,000		218,000		25,100		53,800		143,000		260,000		67,700		13,200	
Manganese	ug/L	88	636	62400		62,400		31,300		150		108		454		1,460		1,700		22.4	
Nickel	ug/L	73	8.6	5820		5,820		1,970		-	-	-	-	-	-	2,370		441		-	-
Potassium	ug/L	NE	116,000	18200		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	ug/L	NE	1,390,000	12600000		12,600,000		3,210,000		-	-	33,500		256,000		2,560,000		1,450,000		-	-
Zinc	ug/L	1,095	507	1100		225		1,100		-	-	-	-	-	-	-	-	-	-	28.7	

Table 7-8

Detected Constituents in Overburden/Shale Temporary Piezometer Sampling Locations
Red Water Pond Areas
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:	PRRP-DP10		PRRP-DP11		PRRP-DP12		PRRP-DP13		PRRP-DP14		PRRP-DP15		PRRP-DP16		PRRP-DP17	
					Sample No.:	7590		7630/7630R		7670		7710		7750		7790		7830		7870	
					Sample Date:	10-Jun-98		14-Jun-98/25-Jun-98		11-Jun-98		12-Jun-98		12-Jun-98		12-Jun-98		13-Jun-98		11-Jun-98	
					Low-Flow Sampled:	No		No		No		No		No		No		No		No	
Parameter	Units	RBSC	BSC	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Water Quality Parameters																					
Alkalinity	ug/L	NE	NE	1500000				864,000													
Chloride	ug/L	NE	NE	9800				-	-												
Cyanide, total	ug/L	73	NE	780				400													
Hardness	ug/L	NE	NE	3400000				2,440,000													
Nitrate	ug/L	1000	NE	465000				350,000	J												
Sulfate	ug/L	NE	NE	10000000				3,730,000													
Total dissolved solids	ug/L	NE	NE	22100000				22,100,000													
Total organic carbon	ug/L	NE	NE	6600000				3,060,000													
Total suspended solids	ug/L	NE	NE	110000				34,000													

Table 7-8

Detected Constituents in Overburden/Shale Temporary Piezometer Sampling Locations
Red Water Pond Areas
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:		PRRP-DP18		PRRP-DP19		PRRP-DP20		WARP-DP01		WARP-DP02		WARP-DP04		WARP-DP04		WARP-DP06		WARP-DP07	
					Sample No.:		7910		7950		7990		8130		8170		8250		8250B		8330		8370	
					Sample Date:		12-Jun-98		13-Jun-98		14-Jun-98		25-Jun-98		24-Jun-98		24-Jun-98		25-Jun-98		23-Jun-98		26-Jun-98	
					Low-Flow Sampled:		No		No		No		No		No		No		No		No		No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																								
Dinitrobenzene, 1,3-	ug/L	0.37	NE	4800	1.1		-	-	-	-	-	-	-	-	-	-	-	-			0.2		-	-
Dinitrotoluene, 2,4-	ug/L	0.099	NE	6800	2.4		-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Dinitrotoluene, 2,6-	ug/L	0.099	NE	400	0.36		-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Tetryl	ug/L	37	NE	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Trinitrobenzene, 1,3,5-	ug/L	110	NE	680	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	7.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Volatiles																								
Acetone	ug/L	548	NE	20	4.4	B	5.4	B	-	-	4.3	B	3	B	2.4	B			2.5	B	7.2	B		
Benzene	ug/L	0.35	2.4	0.15	-	-	-	-	-	-	-	-	0.15	J	-	-			-	-	-	-		
Butanone, 2-	ug/L	697	NE	24	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-		
Carbon disulfide	ug/L	104	NE	0.26	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-		
Ethylbenzene	ug/L	134	0.87	0.19	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-		
Hexanone, 2-	ug/L	150	NE	1.8	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-		
Methylene chloride	ug/L	4.3	NE	NA	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-		
Tetrachloroethene	ug/L	0.104	NE	0.26	-	-	0.13	J	-	-	-	-	-	-	-	-			-	-	-	-		
Toluene	ug/L	72	1.7	1.9	0.37	B	0.15	B	0.14	B	-	-	0.43	B	-	-			-	-	0.34	B		
Trichloroethene	ug/L	0.028	NE	0.43	-	-	-	-	-	-	-	-	0.3	B	-	-			-	-	-	-		
Xylenes, total	ug/L	21	5.5	0.88	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-		
Semivolatiles																								
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	10	-	-	-	-	-	-							5.1	B			-	-		
Dinitro-2-methylphenol, 4,6-	ug/L	0.37	NE	2300	-	-	-	-	-	-							-	-			-	-		
Dinitrophenol, 2,4-	ug/L	7.3	NE	5900	-	-	-	-	-	-							-	-			-	-		
Dinitrotoluene, 2,4-	ug/L	0.099	NE	9200	-	-	2.3	J	-	-							-	-			-	-		
Dinitrotoluene, 2,6-	ug/L	0.099	NE	550	-	-	-	-	-	-							-	-			-	-		
Naphthalene	ug/L	0.62	NE	1.9	-	-	-	-	-	-							-	-			-	-		
Nitroaniline, 2-	ug/L	11	NE	3.2	-	-	-	-	-	-							-	-			-	-		
Nitroaniline, 3-	ug/L	3.2	NE	88	-	-	-	-	-	-							3.2	J			-	-		
Nitrophenol, 2-	ug/L	4.9	NE	2.1	-	-	-	-	-	-							-	-			-	-		
Nitrophenol, 4-	ug/L	4.9	NE	290	-	-	-	-	-	-							-	-			-	-		

Table 7-8

Detected Constituents in Overburden/Shale Temporary Piezometer Sampling Locations
Red Water Pond Areas
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:		PRRP-DP18		PRRP-DP19		PRRP-DP20		WARP-DP01		WARP-DP02		WARP-DP04		WARP-DP04		WARP-DP06		WARP-DP07	
					Sample No.:		7910		7950		7990		8130		8170		8250		8250B		8330		8370	
					Sample Date:		12-Jun-98		13-Jun-98		14-Jun-98		25-Jun-98		24-Jun-98		24-Jun-98		25-Jun-98		23-Jun-98		26-Jun-98	
					Low-Flow Sampled:		No		No		No		No		No		No		No		No		No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Unfiltered																								
Aluminum	ug/L	3,650	309	280000	-	-	**118,000**		**13,400**						**13,100**				**1,240**				**51,100**	
Antimony	ug/L	1.5	NE	118	-	-	77.8	J	-	-					-	-			-	-			-	-
Arsenic	ug/L	0.045	7.4	1780	**584**	J	**122**	J	**31.3**						**21.4**				-	-			-	-
Barium	ug/L	255	11,800	1680	-	-	1,020		-	-					-	-			-	-			248	
Beryllium	ug/L	7.3	NE	9.5	-	-	5.5		-	-					-	-			-	-			-	-
Cadmium	ug/L	1.8	NE	6.5	-	-	-	-	-	-					-	-			-	-			-	-
Calcium	ug/L	NE	316,000	2680000	-	-	**787,000**		300,000						**336,000**				**569,000**				**644,000**	
Chromium	ug/L	11	NE	561	-	-	176		26.9						28.8				-	-			91.6	
Cobalt	ug/L	73	12.1	5610	-	-	**140**		-	-					-	-			-	-			**68.4**	
Copper	ug/L	146	19.8	2800	-	-	**334**		**33.2**						**90.2**				-	-			**126**	
Iron	ug/L	1,095	1,550	679000	-	-	**266,000**		**31,500**						**39,900**				**2,650**				**123,000**	
Lead	ug/L	15	NE	459	320	J	142	J	21.6						14.4				-	-			-	-
Magnesium	ug/L	NE	217,000	651000	-	-	**240,000**		75,900						95,100	J			**234,000**	J			105,000	J
Manganese	ug/L	88	636	55100	-	-	**5,940**		**1,220**						**750**				**1,410**				**3,310**	
Mercury	ug/L	1.1	NE	0.65	0.25		-	-	-	-					-	-			-	-			-	-
Nickel	ug/L	73	8.6	5040	-	-	**338**		-	-					**61.5**				-	-			**220**	
Potassium	ug/L	NE	116,000	33100	-	-	20,800		-	-					6,880				17,400				17,100	
Selenium	ug/L	18	NE	1790	-	-	-	-	-	-					-	-			-	-			-	-
Sodium	ug/L	NE	1,390,000	9410000	-	-	14,500		6,480						408,000				81,800				182,000	
Thallium	ug/L	0.24	NE	1770	-	-	-	-	-	-					-	-			-	-			-	-
Vanadium	ug/L	3.7	NE	1000	101		288		76.5						62				-	-			125	
Zinc	ug/L	1,095	507	2010	-	-	**799**		151						123				22.1				411	
Metals - Filtered																								
Aluminum	ug/L	3,650	309	1350	-	-	-	-	-	-					-	-			-	-			-	-
Arsenic	ug/L	0.045	7.4	22.9	-	-	**22.9**		**16.9**						-	-			-	-			-	-
Barium	ug/L	255	11,800	237	-	-	237		-	-					-	-			-	-			-	-
Cadmium	ug/L	1.8	NE	46	-	-	-	-	-	-					-	-			-	-			-	-
Calcium	ug/L	NE	316,000	780000	244,000		63,400		58,800						211,000				**549,000**				**364,000**	
Chromium	ug/L	11	NE	495	-	-	-	-	-	-					-	-			-	-			-	-
Cobalt	ug/L	73	12.1	6660	-	-	-	-	-	-					-	-			-	-			-	-
Copper	ug/L	146	19.8	3260	-	-	-	-	-	-					**42.1**				-	-			-	-
Iron	ug/L	1,095	1,550	15300	1,260		119		456						-	-			-	-			-	-
Lead	ug/L	15	NE	31.5	-	-	-	-	-	-					-	-			-	-			-	-
Magnesium	ug/L	NE	217,000	348000	80,300		16,400		14,300						62,800	J			**242,000**	J			71,400	J
Manganese	ug/L	88	636	62400	252		28.4		78.4						84.5				**1,450**				480	
Nickel	ug/L	73	8.6	5820	-	-	-	-	-	-					-	-			-	-			-	-
Potassium	ug/L	NE	116,000	18200	-	-	-	-	-	-					-	-			18,200				6,170	
Sodium	ug/L	NE	1,390,000	12600000	140,000		11,500		6,810						443,000				114,000				185,000	
Zinc	ug/L	1,095	507	1100	-	-	-	-	-	-					-	-			-	-			-	-

Table 7-8

Detected Constituents in Overburden/Shale Temporary Piezometer Sampling Locations
Red Water Pond Areas
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:		PRRP-DP18		PRRP-DP19		PRRP-DP20		WARP-DP01		WARP-DP02		WARP-DP04		WARP-DP04		WARP-DP06		WARP-DP07	
					Sample No.:		7910		7950		7990		8130		8170		8250		8250B		8330		8370	
					Sample Date:		12-Jun-98		13-Jun-98		14-Jun-98		25-Jun-98		24-Jun-98		24-Jun-98		25-Jun-98		23-Jun-98		26-Jun-98	
					Low-Flow Sampled:		No		No		No		No		No		No		No		No		No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Water Quality Parameters																								
Alkalinity	ug/L	NE	NE	1500000							155,000													
Chloride	ug/L	NE	NE	9800							2,300													
Cyanide, total	ug/L	73	NE	780							-	-												
Hardness	ug/L	NE	NE	3400000							670,000													
Nitrate	ug/L	1000	NE	465000							-	-												
Sulfate	ug/L	NE	NE	10000000							24,700													
Total dissolved solids	ug/L	NE	NE	22100000							276,000													
Total organic carbon	ug/L	NE	NE	6600000							1,800													
Total suspended solids	ug/L	NE	NE	110000							6,000													

Table 7-8

Detected Constituents in Overburden/Shale Temporary Piezometer Sampling Locations
Red Water Pond Areas
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:		WARP-DP08		WARP-DP09		WARP-DP11		WARP-DP12		WARP-DP13		WARP-DP15		WARP-DP16		WARP-DP17		WARP-DP19	
					Sample No.:		8410		8450		8530		8570		8610		8690		8730		8770		8850	
					Sample Date:		16-Jun-98		16-Jun-98		26-Jun-98		15-Jun-98		15-Jun-98		26-Jun-98		25-Jun-98		25-Jun-98		26-Jun-98	
					Low-Flow Sampled:		No		No		No		No		No		No		No		No		No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																								
Dinitrobenzene, 1,3-	ug/L	0.37	NE	4800	0.74		8.6		-	-	0.69		270		-	-	-	-	-	-	0.24	
Dinitrotoluene, 2,4-	ug/L	0.099	NE	6800	2.3		28		-	-	2		950		1.1		-	-	22		-	-
Dinitrotoluene, 2,6-	ug/L	0.099	NE	400	0.28		2.7		-	-	0.25		-	-	-	-	-	-	-	-	-	-
Tetryl	ug/L	37	NE	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrobenzene, 1,3,5-	ug/L	110	NE	680	-	-	9.4		7.2		-	-	680		-	-	40		32		-	-
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	7.1	-	-	-	-	7.1		-	-	-	-	-	-	-	-	-	-	-	-
Volatiles																								
Acetone	ug/L	548	NE	20	3.3	B	-	-	4.9	B	2.4	B	1.5	B	9.6	B	1.6	B	1.6	B	10	B
Benzene	ug/L	0.35	2.4	0.15	-	-	-	-	0.13	J	-	-	-	-	-	-	-	-	-	-	-	-
Butanone, 2-	ug/L	697	NE	24	-	-	-	-	-	-	-	-	-	-	1.2	J	-	-	-	-	1.8	J
Carbon disulfide	ug/L	104	NE	0.26	0.15	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.18	J
Ethylbenzene	ug/L	134	0.87	0.19	-	-	-	-	-	-	-	-	0.19	J	-	-	-	-	-	-	-	-
Hexanone, 2-	ug/L	150	NE	1.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methylene chloride	ug/L	4.3	NE	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tetrachloroethene	ug/L	0.104	NE	0.26	0.2	J	0.15	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Toluene	ug/L	72	1.7	1.9	0.17	B	-	-	0.57	B	0.14	B	0.53	B	0.15	B	0.26	B	0.16	B	-	-
Trichloroethene	ug/L	0.028	NE	0.43	-	-	-	-	0.16	B	-	-	-	-	-	-	-	-	-	-	-	-
Xylenes, total	ug/L	21	5.5	0.88	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Semivolatiles																								
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	10			-	-	-	-			-	-			-	-	-	-		
Dinitro-2-methylphenol, 4,6-	ug/L	0.37	NE	2300			24	J	-	-			-	-			-	-	-	-		
Dinitrophenol, 2,4-	ug/L	7.3	NE	5900			-	-	-	-			-	-			-	-	-	-		
Dinitrotoluene, 2,4-	ug/L	0.099	NE	9200			60		1.8	J			660				60	J	52	J		
Dinitrotoluene, 2,6-	ug/L	0.099	NE	550			6.3	J	-	-			56	J			15	J	18	J		
Naphthalene	ug/L	0.62	NE	1.9			-	-	-	-			-	-			-	-	-	-		
Nitroaniline, 2-	ug/L	11	NE	3.2			-	-	-	-			-	-			-	-	-	-		
Nitroaniline, 3-	ug/L	3.2	NE	88			5.1	J	2.1	J			15	J			43	J	49	J		
Nitrophenol, 2-	ug/L	4.9	NE	2.1			-	-	-	-			-	-			-	-	-	-		
Nitrophenol, 4-	ug/L	4.9	NE	290			2.4	J	-	-			-	-			-	-	-	-		

Table 7-8

Detected Constituents in Overburden/Shale Temporary Piezometer Sampling Locations
Red Water Pond Areas
Former Plum Brook Ordnance Works, Sandusky, Ohio

			Location Code:	WARP-DP08		WARP-DP09		WARP-DP11		WARP-DP12		WARP-DP13		WARP-DP15		WARP-DP16		WARP-DP17		WARP-DP19	
			Sample No.:	8410		8450		8530		8570		8610		8690		8730		8770		8850	
			Sample Date:	16-Jun-98		16-Jun-98		26-Jun-98		15-Jun-98		15-Jun-98		26-Jun-98		25-Jun-98		25-Jun-98		26-Jun-98	
			Low-Flow Sampled:	No		No		No		No		No		No		No		No		No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Unfiltered																						
Aluminum	ug/L	3,650	309	280000			**11,100**		**59,700**				**77,200**				**206,000**		**38,500**			
Antimony	ug/L	1.5	NE	118			-	-	-	-			-	-			106		-	-		
Arsenic	ug/L	0.045	7.4	1780			**15.2**		**56.2**				**1,780**				**111**		-	-		
Barium	ug/L	255	11,800	1680			-	-	386				-	-			773		217			
Beryllium	ug/L	7.3	NE	9.5			-	-	-	-			-	-			9.5		-	-		
Cadmium	ug/L	1.8	NE	6.5			-	-	-	-			-	-			-	-	-	-		
Calcium	ug/L	NE	316,000	2680000			230,000		**982,000**				315,000				**2,680,000**		**555,000**			
Chromium	ug/L	11	NE	561			-	-	96.8				127				296		58.7			
Cobalt	ug/L	73	12.1	5610			-	-	**85.2**				-	-			**264**		**173**			
Copper	ug/L	146	19.8	2800			-	-	**214**				-	-			**654**		**153**			
Iron	ug/L	1,095	1,550	679000			**28,500**		**137,000**				**153,000**				**339,000**		**73,000**			
Lead	ug/L	15	NE	459			11.8		68.3				459				157		28.9			
Magnesium	ug/L	NE	217,000	651000			**219,000**		**242,000**	J			86,200				**651,000**	J	178,000	J		
Manganese	ug/L	88	636	55100			**8,610**		**4,840**				**12,600**				**9,280**		**2,470**			
Mercury	ug/L	1.1	NE	0.65			-	-	0.24				0.65				0.47		0.25			
Nickel	ug/L	73	8.6	5040			-	-	**249**				-	-			**515**		**134**			
Potassium	ug/L	NE	116,000	33100			-	-	20,500				-	-			33,100		7,640			
Selenium	ug/L	18	NE	1790			-	-	-	-			1,790				-	-	-	-		
Sodium	ug/L	NE	1,390,000	9410000			44,300		503,000				187,000				907,000		1,060,000			
Thallium	ug/L	0.24	NE	1770			-	-	-	-			1,770				-	-	-	-		
Vanadium	ug/L	3.7	NE	1000			-	-	161				-	-			381		113			
Zinc	ug/L	1,095	507	2010			-	-	467				397				**1,260**		265			
Metals - Filtered																						
Aluminum	ug/L	3,650	309	1350			-	-	-	-			-	-			203		**1,350**			
Arsenic	ug/L	0.045	7.4	22.9			-	-	-	-			-	-			-	-	-	-		
Barium	ug/L	255	11,800	237			-	-	-	-			-	-			-	-	-	-		
Cadmium	ug/L	1.8	NE	46			-	-	-	-			-	-			46		-	-		
Calcium	ug/L	NE	316,000	780000			237,000		**395,000**				156,000				**735,000**		301,000			
Chromium	ug/L	11	NE	495			-	-	-	-			-	-			-	-	32.9			
Cobalt	ug/L	73	12.1	6660			-	-	-	-			-	-			162		142			
Copper	ug/L	146	19.8	3260			-	-	**67**				-	-			**117**		**94.6**			
Iron	ug/L	1,095	1,550	15300			120		121				-	-			373		**2,600**			
Lead	ug/L	15	NE	31.5			4.4		-	-			-	-			-	-	-	-		
Magnesium	ug/L	NE	217,000	348000			**227,000**		80,100	J			-	-			193,000	J	145,000	J		
Manganese	ug/L	88	636	62400			**8,480**		**1,070**				**7,870**				635		**891**			
Nickel	ug/L	73	8.6	5820			-	-	**62**				-	-			**46.3**		-	-		
Potassium	ug/L	NE	116,000	18200			-	-	10,200				-	-			-	-	-	-		
Sodium	ug/L	NE	1,390,000	12600000			44,800		614,000				192,000				1,040,000		993,000			
Zinc	ug/L	1,095	507	1100			-	-	-	-			-	-			28.2		-	-		

Table 7-8

Detected Constituents in Overburden/Shale Temporary Piezometer Sampling Locations
Red Water Pond Areas
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:	WARP-DP08		WARP-DP09		WARP-DP11		WARP-DP12		WARP-DP13		WARP-DP15		WARP-DP16		WARP-DP17		WARP-DP19	
					Sample No.:	8410		8450		8530		8570		8610		8690		8730		8770		8850	
					Sample Date:	16-Jun-98		16-Jun-98		26-Jun-98		15-Jun-98		15-Jun-98		26-Jun-98		25-Jun-98		25-Jun-98		26-Jun-98	
					Low-Flow Sampled:	No		No		No		No		No		No		No		No		No	
Parameter	Units	RBSC	BSC	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Water Quality Parameters																							
Alkalinity	ug/L	NE	NE	1500000				1,000,000						643,000									
Chloride	ug/L	NE	NE	9800				-	-					-	-								
Cyanide, total	ug/L	73	NE	780				-	-					-	-								
Hardness	ug/L	NE	NE	3400000				1,400,000						960,000									
Nitrate	ug/L	1000	NE	465000				-	-					1,600									
Sulfate	ug/L	NE	NE	10000000				305,000						278,000									
Total dissolved solids	ug/L	NE	NE	22100000				1,710,000						1,260,000									
Total organic carbon	ug/L	NE	NE	6600000				32,000						36,600									
Total suspended solids	ug/L	NE	NE	110000				85,000						15,000									

Shaded cell indicates value is greater than the RBSC.
Bold text indicates value is greater than the BSC.
RBSC - Values reflect an incremental lifetime cancer risk (ILCR) of 1E-6 or a noncancer hazard quotient (HQ) of 0.1. For chemicals that exhibit both cancer and noncancer effects, whichever type of effect results in a lower concentration (using an ILCR of 1E-6 and an HQ of 0.1), that concentration is selected as the RBSC.
BSC - Background screening concentration
MDC - Maximum detected concentration for the AOC ("B" qualified data not included).
"-" - Not detected.
µg/L - Micrograms per liter.
NA - Not applicable; only B qualified data detected.
NE - Not established (RBSCs), not evaluated (BSCs).
NTU - Nephelometric turbidity unit.

Validation Qualifiers (Qual)
B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.
J - The compound/analyte was positively identified; the reported value is an estimated concentration.

Table 7-9

Detected Constituents in Bedrock Monitoring Well
West Area Red Water Ponds
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:		BED-MW14					
					Sample No:		5900		5905/5905R		BD3018/BD3018R		CB3022	
					Sample Date:		18-Nov-97		16-May-98		28-Sep-01		8-Apr-02	
					Low-Flow Sampled:		No		No		Yes		Yes	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Volatiles												
Acetone	ug/L	548	NE	NA	-	-	-	-	9.4	B	-	-
Benzene	ug/L	0.35	2.4	1.1	1.1		-	-	-	-	-	-
Carbon disulfide	ug/L	104	NE	1.3	1.3		0.25	J	-	-	-	-
Ethylbenzene	ug/L	134	0.87	0.59	0.59	J	-	-	-	-	-	-
Methylene chloride	ug/L	4.3	NE	NA	-	-	-	-	1.4	B	1.9	B
Toluene	ug/L	72	1.7	NA	**1.7**	B	-	-	-	-	-	-
Xylenes, total	ug/L	21	5.5	3.9	3.9		-	-	-	-	-	-
Semivolatiles												
Dinitro-2-methylphenol, 4,6-	ug/L	0.37	NE	28	-	-	28	NJ	-	-	-	-
Dinitrophenol, 2,4-	ug/L	7.3	NE	14	-	-	14	J	-	-	-	-
Dinitrotoluene, 2,4-	ug/L	0.098	NE	19	-	-	16		-	-	19	
Nitroaniline, 3-	ug/L	3.2	NE	150	-	-	-	-	-	-	150	
Nitrobenzene	ug/L	0.34	NE	5.8	-	-	5.8	J	-	-	-	-
Metals - Unfiltered												
Aluminum	ug/L	3,650	309	374	**374**	J	-	-	64.9	B	87.5	B
Arsenic	ug/L	0.045	7.4	9.5	-	-	-	-	6.1	J	**9.5**	J
Barium	ug/L	255	11,800	51.4	-	-	-	-	49.5	J	51.4	J
Calcium	ug/L	NE	316,000	325000	152,000		99,000		215,000		**325,000**	
Chromium	ug/L	11	NE	10.2	10.2		-	-	1.6	J	3.4	J
Cobalt	ug/L	73	12.1	267	-	-	-	-	**102**		**267**	
Copper	ug/L	146	19.8	94.8	-	-	-	-	**30.7**		**94.8**	
Iron	ug/L	1,095	1,550	923	923		427	J	164		438	
Lead	ug/L	15	NE	3.6	-	-	-	-	-	-	3.6	
Magnesium	ug/L	NE	217,000	230000	70,700		59,700		146,000		**230,000**	
Manganese	ug/L	88	636	136	54		32		65.2		136	
Nickel	ug/L	73	8.6	278	**42.3**		**45.5**		**111**		**278**	
Potassium	ug/L	NE	116,000	56800	44,700		49,000		42,100		56,800	J
Selenium	ug/L	18	NE	7.8	-	-	-	-	5.5		7.8	
Sodium	ug/L	NE	1,390,000	1020000	311,000		269,000		629,000		1,020,000	
Thallium	ug/L	0.24	NE	NA	-	-	-	-	5	B	-	-
Vanadium	ug/L	3.7	NE	5.5	-	-	-	-	2.4	B	5.5	J
Zinc	ug/L	1,095	507	64.8	39.8		42.2	B	10.8	J	64.8	

Table 7-9

Detected Constituents in Bedrock Monitoring Well
West Area Red Water Ponds
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:	BED-MW14						
					Sample No:	5900		5905/5905R		BD3018/BD3018R		CB3022
					Sample Date:	18-Nov-97		16-May-98		28-Sep-01		8-Apr-02
					Low-Flow Sampled:	No		No		Yes		Yes
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Filtered												
Aluminum	ug/L	3,650	309	NA	-	-	-	-	54.9	B	94.8	B
Arsenic	ug/L	0.045	7.4	9	-	-	-	-	5.5	J	**9**	J
Barium	ug/L	255	11,800	51.4	-	-	-	-	50.8	J	51.4	J
Calcium	ug/L	NE	316,000	321000	120,000		149,000		223,000		**321,000**	
Chromium	ug/L	11	NE	3	-	-	-	-	1.9	J	3	J
Cobalt	ug/L	73	12.1	265	-	-	**65.4**		**105**		**265**	
Copper	ug/L	146	19.8	92	-	-	-	-	**27**		**92**	
Iron	ug/L	1,095	1,550	417	-	-	269		145		417	
Lead	ug/L	15	NE	3.6	-	-	-	-	-	-	3.6	
Magnesium	ug/L	NE	217,000	229000	82,500		99,900		153,000		**229,000**	
Manganese	ug/L	88	636	136	29.1		32.6		68		136	
Nickel	ug/L	73	8.6	276	**40.7**		**71.3**		**117**		**276**	
Potassium	ug/L	NE	116,000	57000	40,500		32,400		43,800	J	57,000	J
Selenium	ug/L	18	NE	7.4	-	-	-	-	8.2	B	7.4	
Sodium	ug/L	NE	1,390,000	1010000	360,000		365,000		662,000		1,010,000	
Thallium	ug/L	0.24	NE	NA	-	-	-	-	7.2	B	-	-
Vanadium	ug/L	3.7	NE	5.8	-	-	-	-	2.4	J	5.8	J
Zinc	ug/L	1,095	507	68.2	32.4		53.9	B	12.6	J	68.2	J
Water Quality Parameters												
Alkalinity	ug/L	NE	NE	500000	210,000		500,000		482,000	J	481,000	
Chloride	ug/L	NE	NE	79000	79,000		3,000		72,200		75,600	J
Cyanide, total	ug/L	73	NE	44	16		44		-	-	38	
Hardness	ug/L	NE	NE	1230000	640,000		730,000		1,200,000		1,230,000	
Nitrate	ug/L	1000	NE	79300			24,000		22,000		79,300	
Nitrate-Nitrite	ug/L	100	NE	300	300							
Sulfate	ug/L	NE	NE	2660000	610,000		630,000				2,660,000	
Total dissolved solids	ug/L	NE	NE	7360000	2,500,000		2,300,000				7,360,000	
Total organic carbon	ug/L	NE	NE	937000	190,000		160,000				937,000	
Total suspended solids	ug/L	NE	NE	54000	37,000		23,000				54,000	
Turbidity	NTU	NE	NE	4.2					4.2	J	-	-

Shaded cell indicates value is greater than the RBSC.

Bold text indicates value is greater than the BSC.

RBSC - Values reflect an incremental lifetime cancer risk (ILCR) of 1E-6 or a noncancer hazard quotient (HQ) of 0.1. For chemicals that exhibit both cancer and noncancer effects, whichever type of effect results in a lower concentration (using an ILCR of 1E-6 and an HQ of 0.1), that concentration is selected as the RBSC.

MDC - Maximum detected concentration for the AOC ("B" qualified data not included).

BSC - Background screening concentration.

"-" - Not detected.

µg/L - Micrograms per liter.

NA - Not applicable; detection is the result of blank contamination.

NE - Not established (RBSCs), not evaluated (BSCs).

NTU - Nephelometric turbidity unit.

Validation Qualifiers (VQ)

J - The analyte was positively identified; the reported value is estimated.

B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.

N - Tentative identification. Condsider present.

Table 7-10

Detected Constituents in Bedrock Monitoring Wells
Pentolite Road Red Water Ponds
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:	BED-MW15								BED-MW23			
					Sample No:	5910		5915		BD3019		CB3041		BD3028		CB3040	
					Sample Date:	18-Nov-97		28-May-98		9-Oct-01		15-Apr-02		9-Oct-01		11-Apr-02	
					Low Flow Sampled:	No		No		No		No		No		Yes	
Parameter	Units	RBSC	BSC	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																	
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	NE	0.97		-	-	-	-	-	-	0.97		-	-	-	-
Dinitrotoluene, 2,4-	ug/L	0.099	NE	0.89		-	-	0.89		-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	ug/L	0.099	NE	0.89		-	-	0.89		-	-	-	-	-	-	-	-
Nitrobenzene	ug/L	0.34	NE	0.35		-	-	-	-	-	-	0.35		-	-	-	-
RDX	ug/L	0.61	NE	0.51		-	-	-	-	-	-	0.51		-	-	-	-
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	1.6		-	-	-	-	1.6		1.3		-	-	-	-
Volatiles																	
Acetone	ug/L	548	NE	1600		-	-	-	-	170	J	87	J	1,600	J	1,400	J
Benzene	ug/L	0.35	2.4	2500		**570**		**780**		**670**		**600**		**2,100**		**2,500**	
Carbon disulfide	ug/L	104	NE	3.1		-	-	-	-	-	-	3.1	J	-	-	-	-
Chlorobenzene	ug/L	10.6	NE	5.5		-	-	5.5	J	-	-	-	-	-	-	-	-
Chloroform	ug/L	0.17	NE	NA		8.4	B	-	-	-	-	-	-	-	-	-	-
Ethylbenzene	ug/L	134	0.87	230		**130**		**140**		**150**	J	**130**		**190**	J	**230**	
Methylene chloride	ug/L	4.3	NE	160		31	B	83	B	120	J	31	J	160	J	100	J
Toluene	ug/L	72	1.7	1000		**490**		**550**		**630**		**460**		**910**		**1,000**	
Trichloroethane, 1,1,2-	ug/L	0.2	NE	4.9		-	-	4.9	J	-	-	-	-	-	-	-	-
Xylenes, total	ug/L	21	5.5	1600		**920**		**880**		**1,000**		**880**		**1,300**		**1,600**	
Semivolatiles																	
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	37		37		28	B	2.2	J	1.8	J	7.1	J	3.3	J
Butyl benzyl phthalate	ug/L	730	NE	1.5		-	-	-	-	-	-	-	-	1.5	J	-	-
Diethyl phthalate	ug/L	2,900	NE	1.2		-	-	-	-	-	-	-	-	1.2	J	0.68	J
Dimethylphenol, 2,4-	ug/L	73	NE	51		6.7	J	10		5.6	J	6.8	J	42		51	
Di-n-butyl phthalate	ug/L	370	NE	1.1		-	-	-	-	-	-	-	-	1.1	J	-	-
Fluorene	ug/L	24.3	NE	1.7		1.7	J	-	-	-	-	-	-	-	-	1.4	J
Isophorone	ug/L	71	NE	4.2		4.2	J	3.8	J	-	-	-	-	-	-	-	-
Methylnaphthalene, 2-	ug/L	12	NE	37		31		37		25		27		22		32	
Methylphenol, 2-	ug/L	182	NE	37		3	J	6.7	J	3.3	J	3.9	J	25		37	
Methylphenol, 4-	ug/L	18	NE	43		3.9	J	7.7	J	4.2	J	5.6	J	21		43	
Naphthalene	ug/L	0.62	NE	31		22		31		24		25		21		31	
n-Nitrosodiphenylamine	ug/L	14	NE	0.64		-	-	-	-	-	-	-	-	0.64	J	-	-
Phenanthrene	ug/L	18	NE	2.4		2.2	J	2	J	0.98	J	1.3	J	1.3	J	2.4	J
Phenol	ug/L	1,095	NE	150		18		32		12		15		80		150	
Metals - Unfiltered																	
Aluminum	ug/L	3,650	309	513		-	-	**513**	J	51.1	B	74.8	B	**350**		104	B
Arsenic	ug/L	0.045	7.4	NA		-	-	-	-	-	-	-	-	4.2	B	-	-
Barium	ug/L	255	11,800	1710		605		1,710		481		856		64.2	J	106	J
Calcium	ug/L	NE	316,000	859000		280,000		**662,000**	J	199,000		287,000		**369,000**		**859,000**	
Chromium	ug/L	11	NE	20.6		-	-	20.6		-	-	-	-	15		6.1	J
Cobalt	ug/L	73	12.1	5.9		-	-	-	-	-	-	-	-	5.9	J	-	-
Copper	ug/L	146	19.8	39.5		-	-	**39.5**		-	-	-	-	4.8	J	-	-
Iron	ug/L	1,095	1,550	7280		930		**4,810**		-	-	142		**7,280**		**5,640**	J
Magnesium	ug/L	NE	217,000	591000		177,000		**259,000**		169,000		**234,000**		210,000		**591,000**	
Manganese	ug/L	88	636	1170		26.3		139		5.6	J	7	J	**1,170**		219	
Nickel	ug/L	73	8.6	13.6		-	-	-	-	3.8	J	-	-	**13.6**	J	7.2	J
Potassium	ug/L	NE	116,000	96000		58,800		62,500		62,100		75,100	J	77,700		96,000	
Sodium	ug/L	NE	1,390,000	1810000		559,000		811,000		566,000		705,000		590,000		**1,810,000**	
Thallium	ug/L	0.24	NE	50.8		-	-	50.8		-	-	-	-	-	-	-	-
Zinc	ug/L	1,095	507	30.6		30.6		105	B	-	-	-	-	18	J	3	J

Table 7-10

Detected Constituents in Bedrock Monitoring Wells
Pentolite Road Red Water Ponds
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:	BED-MW15							BED-MW23			
					Sample No:	5910		5915		BD3019		CB3041		BD3028		CB3040	
					Sample Date:	18-Nov-97		28-May-98		9-Oct-01		15-Apr-02		9-Oct-01		11-Apr-02	
					Low Flow Sampled:	No		No		No		No		No		Yes	
Parameter	Units	RBSC	BSC	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Filtered																	
Aluminum	ug/L	3,650	309	38.1		-	-	-	-	64.5	B	52.4	B	93.6	B	38.1	J
Arsenic	ug/L	0.045	7.4	2.9		-	-	-	-	-	-	-	-	2.9	J	-	-
Barium	ug/L	255	11,800	1390		555		1,390		484		855		54.4	J	104	J
Calcium	ug/L	NE	316,000	857000		245,000	J	**390,000**	J	199,000		286,000		279,000		**857,000**	
Chromium	ug/L	11	NE	1.5		-	-	-	-	-	-	-	-	1.5	J	-	-
Cobalt	ug/L	73	12.1	2.6		-	-	-	-	-	-	-	-	2.6	J	-	-
Iron	ug/L	1,095	1,550	4450		-	-	-	-	-	-	-	-	**3,060**		**4,450**	J
Magnesium	ug/L	NE	217,000	575000		182,000		**299,000**	J	171,000		**236,000**		203,000		**575,000**	
Manganese	ug/L	88	636	988		-	-	-	-	5.2	J	6.3	J	**988**		212	
Nickel	ug/L	73	8.6	5		-	-	-	-	2.4	J	-	-	5	J	4.8	J
Potassium	ug/L	NE	116,000	91900		61,100		74,800		62,200		75,900	J	75,500	J	91,900	
Sodium	ug/L	NE	1,390,000	1810000		582,000		1,010,000		572,000		716,000		596,000		**1,810,000**	
Thallium	ug/L	0.24	NE	62.2		-	-	62.2		-	-	-	-	-	-	-	-
Zinc	ug/L	1,095	507	30.9		30.9		47.3	B	-	-	9.4	J	-	-	8.6	J
Water Quality Parameters																	
Alkalinity	ug/L	NE	NE	501000		85,000		500,000		382,000	J	501,000		227,000	J	246,000	
Chloride	ug/L	NE	NE	6400000		1,400,000		2,200,000		1,910,000		2,100,000		2,480,000		6,400,000	
Hardness	ug/L	NE	NE	5740000		1,500,000		1,800,000		855,000		1,490,000		5,410,000	J	5,740,000	
Sulfate	ug/L	NE	NE	218000		-	-	82,000		89,200		103,000		85,800		218,000	
Total dissolved solids	ug/L	NE	NE	12500000		3,200,000		3,800,000		2,570,000		3,720,000		3,080,000		12,500,000	
Total organic carbon	ug/L	NE	NE	13000		11,000		13,000		8,400		6,500		6,200		6,400	
Total suspended solids	ug/L	NE	NE	1660000		7,000		13,000		-	-	25,000		292,000		1,660,000	
Turbidity	NTU	NE	NE	6500						203		140		324		6,500	

Shaded cell indicates value is greater than the RBSC.
Bold text indicates value is greater than the BSC.
BSC - Background screening concentration.
MDC - Maximum detected concentration for the AOC ("B" qualified data not included).
RBSC - Values reflect an incremental lifetime cancer risk (ILCR) of 1E-6 or a noncancer hazard quotient (HQ) of 0.1. For chemicals that exhibit both cancer and noncancer effects, whichever type of effect results in a lower concentration (using an ILCR of 1E-6 and an HQ of 0.1), that concentration is selected as the RBSC.
"-" - Not detected.
NA - Not applicable; detection is the result of blank contamination.
NE - Not established (RBSCs), not evaluated (BSCs).
NTU - Nephelometric turbidity unit.
µg/L - Micrograms per liter.

Validation Qualifiers (VQ)
B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.
J - The analyte was positively identified; the reported value is estimated.

Table 7-11

Detected Constituents in Bedrock Monitoring Wells
Acid Area No. 1
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:		AA1-BEDGW-001	
					Sample No:		5450	5455
					Sample Date:		16-Nov-97	12-May-98
					Low-Flow Sampled:		No	No
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ
Explosives								
Dinitrotoluene, 2,4-	ug/L	0.099	NE	0.23	-	-	0.23	
Nitrotoluene, 2-	ug/L	0.049	NE	1.1	-	-	1.1	
Nitrotoluene, 3-	ug/L	12.2	NE	0.31	-	-	0.31	
RDX	ug/L	0.61	NE	2.8	-	-	2.8	
Tetryl	ug/L	37	NE	2.4	-	-	2.4	
Volatiles								
Benzene	ug/L	0.35	2.4	31	**11**	J	**31**	
Carbon disulfide	ug/L	104	NE	63	29	J	63	
Ethylbenzene	ug/L	134	0.87	39	**7.7**	J	**39**	
Methylene chloride	ug/L	4.3	NE	NA	8.8	B	4.4	B
Toluene	ug/L	72	1.7	50	**18**	B	**50**	
Xylenes, total	ug/L	21	5.5	500	**150**		**500**	
Semivolatiles								
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	28	28		23	B
Dimethylphenol, 2,4-	ug/L	73	NE	3.6	-	-	3.6	J
Isophorone	ug/L	71	NE	2.9	2.9	J	-	-
Methylnaphthalene, 2-	ug/L	12	NE	31	28		31	
Naphthalene	ug/L	0.62	NE	18	16		18	
Phenanthrene	ug/L	18	NE	2.3	-	-	2.3	J
Phenol	ug/L	1,095	NE	43	43		15	
Metals - Unfiltered								
Aluminum	ug/L	3,650	309	637	**637**		**468**	
Arsenic	ug/L	0.045	7.4	21.2	**16.5**		**21.2**	
Barium	ug/L	255	11,800	1330	1,060		1,330	
Calcium	ug/L	NE	316,000	302000	302,000		295,000	
Chromium	ug/L	11	NE	12.7	12.7		-	-
Copper	ug/L	146	19.8	26.2	**26.2**		-	-
Iron	ug/L	1,095	1,550	2540	**1,920**		**2,540**	
Magnesium	ug/L	NE	217,000	230000	**218,000**		**230,000**	
Manganese	ug/L	88	636	732	575		**732**	
Potassium	ug/L	NE	116,000	43200	38,500		43,200	
Sodium	ug/L	NE	1,390,000	682000	582,000		682,000	
Zinc	ug/L	1,095	507	32.8	32.8		38.3	B
Metals - Filtered								
Arsenic	ug/L	0.045	7.4	19.6	-	-	**19.6**	
Barium	ug/L	255	11,800	1490	1,260		1,490	
Calcium	ug/L	NE	316,000	321000	305,000	J	**321,000**	
Iron	ug/L	1,095	1,550	NA	137	B	-	-
Magnesium	ug/L	NE	217,000	259000	**237,000**		**259,000**	
Manganese	ug/L	88	636	696	516		**696**	
Potassium	ug/L	NE	116,000	47800	42,400		47,800	
Sodium	ug/L	NE	1,390,000	786000	644,000		786,000	
Zinc	ug/L	1,095	507	105	105		66.3	B
Water Quality Parameters								
Alkalinity	ug/L	NE	NE	900000	830,000		900,000	
Chloride	ug/L	NE	NE	3000000	1,900,000		3,000,000	J
Hardness	ug/L	NE	NE	2000000	1,800,000		2,000,000	
Sulfate	ug/L	NE	NE	40000	7,000		40,000	J
Total dissolved solids	ug/L	NE	NE	3600000	3,600,000		730,000	
Total organic carbon	ug/L	NE	NE	16000	16,000		11,000	J
Total suspended solids	ug/L	NE	NE	330000	6,000		330,000	

Shaded cell indicates value is greater than the RBSC.
Bold text indicates value is greater than the BSC.
BSC - Background screening concentration.
MDC - Maximum detected concentration for the AOC ("B" qualified data not included).
RBSC - Values reflect an incremental lifetime cancer risk (ILCR) of 1E-6 or a noncancer hazard quotient (HQ) of 0.1. For chemicals that exhibit both cancer and noncancer effects, whichever type of effect results in a lower concentration (using an ILCR of 1E-6 and an HQ of 0.1), that concentration is selected as the RBSC.
"-" - Not detected.
NA - Not applicable; detection is the result of blank contamination.
NE - Not established (RBSCs), not evaluated (BSCs).
NTU - Nephelometric turbidity unit.
µg/L - Micrograms per liter.

Validation Qualifiers (VQ)
B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.
J - The analyte was positively identified; the reported value is estimated.

Table 7-12

Detected Constituents in Bedrock Monitoring Wells
Acid Area No. 2
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:		AA2-BEDGW-001					
					Sample No:		5460		5465		BD3004		CB3030	
					Sample Date:		20-Nov-97		12-May-98		8-Oct-01		10-Apr-02	
					Low-Flow Sampled:		No		No		Yes		No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives												
Dinitrobenzene, 1,3-	ug/L	0.37	NE	0.81	-	-	0.81		-	-	-	-
Dinitrotoluene, 2,4-	ug/L	0.099	NE	2.5	-	-	2.5		-	-	-	-
Dinitrotoluene, 2,6-	ug/L	0.099	NE	1.2	-	-	1.2		-	-	-	-
Nitrobenzene	ug/L	0.34	NE	0.32	-	-	-	-	-	-	-	-
Nitrotoluene, 3-	ug/L	12.2	NE	0.62	-	-	-	-	-	-	-	-
RDX	ug/L	0.61	NE	0.17	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	1.6	-	-	-	-	1.6		-	-
Volatiles												
Acetone	ug/L	548	NE	68	-	-	41	J	54	B	-	-
Benzene	ug/L	0.35	2.4	130	33		130		45	J	4.8	J
Bromomethane	ug/L	0.87	NE	7.9	-	-	-	-	-	-	-	-
Butanone, 2-	ug/L	697	NE	18	-	-	18	J	-	-	-	-
Carbon disulfide	ug/L	104	NE	6.9	5.5	J	1.7	J	-	-	0.84	J
Chlorobenzene	ug/L	10.6	NE	21	21	J	-	-	-	-	-	-
Chloromethane	ug/L	16	NE	30	-	-	10		30	J	-	-
Ethylbenzene	ug/L	134	0.87	64	23	J	43		64	J	13	
Methylene chloride	ug/L	4.3	NE	100	7.4	B	3.2	B	100	J	3.9	J
Toluene	ug/L	72	1.7	21	32	B	20		-	-	2.2	J
Xylenes, total	ug/L	21	5.5	360	200		220		360		98	
Semivolatiles												
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	9.7	-	-	5.6	B	-	-	2	J
Dimethylphenol, 2,4-	ug/L	73	NE	8.6	1.3	J	8.6	J	2.5	J	1.8	J
Methylnaphthalene, 2-	ug/L	12	NE	12	1.3	J	5.6	J	9.8	J	3.2	J
Methylphenol, 2-	ug/L	182	NE	1.6	-	-	1.6	J	-	-	-	-
Methylphenol, 4-	ug/L	18	NE	1.6	-	-	1.6	J	-	-	-	-
Naphthalene	ug/L	0.62	NE	12	-	-	8.1	J	12		2.5	J
Phenanthrene	ug/L	18	NE	0.89	-	-	-	-	-	-	-	-
Phenol	ug/L	1,095	NE	74	-	-	74		2.2	J	-	-
Metals - Unfiltered												
Aluminum	ug/L	3,650	309	10200	1,060	J	10,200		1,170	J	195	B
Arsenic	ug/L	0.045	7.4	34.2	-	-	34.2		9.1	J	6.6	J
Barium	ug/L	255	11,800	1800	220		645		843		368	
Calcium	ug/L	NE	316,000	1970000	186,000	J	1,970,000		81,800		99,400	
Chromium	ug/L	11	NE	307	-	-	307		2.4	J	1.3	J
Cobalt	ug/L	73	12.1	63.3	-	-	63.3		5.9	J	9.2	J
Copper	ug/L	146	19.8	99	-	-	62.7		3.6	B	-	-
Iron	ug/L	1,095	1,550	51600	5,240		51,600		7,210		2,020	J
Lead	ug/L	15	NE	38.6	6.5	B	38.6		-	-	-	-
Magnesium	ug/L	NE	217,000	132000	56,900		132,000		60,000		58,000	
Manganese	ug/L	88	636	5130	522		5,130		1,030		228	
Nickel	ug/L	73	8.6	238	-	-	238		3.7	J	4	J
Potassium	ug/L	NE	116,000	49500	29,100		34,200		30,100	J	28,900	
Sodium	ug/L	NE	1,390,000	132000	99,100	J	124,000		132,000		100,000	
Thallium	ug/L	0.24	NE	NA	-	-	-	-	5.3	B	5.2	B
Vanadium	ug/L	3.7	NE	108	-	-	108		-	-	-	-
Zinc	ug/L	1,095	507	144	55		137	B	10.2	J	6.2	J

Table 7-12

Detected Constituents in Bedrock Monitoring Wells
Acid Area No. 2
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:		AA2-BEDGW-001					
					Sample No:		5460		5465		BD3004		CB3030	
					Sample Date:		20-Nov-97		12-May-98		8-Oct-01		10-Apr-02	
					Low-Flow Sampled:		No		No		Yes		No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Filtered												
Aluminum	ug/L	3,650	309	45.2	-	-	-	-	75.6	B	42.6	J
Arsenic	ug/L	0.045	7.4	9	-	-	-	-	3.7	J	9	J
Barium	ug/L	255	11,800	1740	212		279		724		336	
Beryllium	ug/L	7.3	NE	NA	-	-	-	-	0.56	B	-	-
Calcium	ug/L	NE	316,000	220000	88,600		70,400		59,300		89,900	
Cobalt	ug/L	73	12.1	3.4	-	-	-	-	-	-	3.4	J
Copper	ug/L	146	19.8	13	-	-	-	-	-	-	-	-
Iron	ug/L	1,095	1,550	1300	106	B	-	-	1,300		124	J
Magnesium	ug/L	NE	217,000	81000	54,800		54,300		54,600		57,100	
Manganese	ug/L	88	636	995	351		995		946		207	
Nickel	ug/L	73	8.6	7.9	-	-	-	-	-	-	-	-
Potassium	ug/L	NE	116,000	46200	30,000		31,200		27,500	J	29,600	
Selenium	ug/L	18	NE	1.8	-	-	-	-	-	-	-	-
Sodium	ug/L	NE	1,390,000	127000	104,000		124,000		127,000		103,000	
Thallium	ug/L	0.24	NE	2.6	-	-	-	-	-	-	-	-
Zinc	ug/L	1,095	507	66.2	66.2	J	29.1	B	7.1	J	5	J
Water Quality Parameters												
Alkalinity	ug/L	NE	NE	1050000	510,000		600,000		552,000	J	586,000	
Chloride	ug/L	NE	NE	396000	47,000		53,000	J	68,100		56,000	
Cyanide, total	ug/L	73	NE	16	-	-	-	-	-	-	-	-
Hardness	ug/L	NE	NE	1700000	700,000		860,000		360,000		700,000	
Sulfate	ug/L	NE	NE	70000	48,000		70,000	J	31,700		32,700	
Total dissolved solids	ug/L	NE	NE	1200000	750,000		310,000		716,000		712,000	
Total organic carbon	ug/L	NE	NE	16000	7,400		6,000	J	3,100		3,100	
Total suspended solids	ug/L	NE	NE	199000	4,000		-	-	113,000		22,000	
Turbidity	NTU	NE	NE	662					313	J	137	

Table 7-12

Detected Constituents in Bedrock Monitoring Wells
Acid Area No. 2
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:		BED-MW19									
					Sample No:		5950		5955		BD3025		CB3013		DF3001		DH3001	
					Sample Date:		14-Nov-97		16-May-98		4-Oct-01		4-Apr-02		5-May-04		25-Aug-04	
					Low-Flow Sampled:		No		No		Yes		Yes		Yes		Yes	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																		
Dinitrobenzene, 1,3-	ug/L	0.37	NE	0.81	0.22		-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	ug/L	0.099	NE	2.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	ug/L	0.099	NE	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrobenzene	ug/L	0.34	NE	0.32	0.32		-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 3-	ug/L	12.2	NE	0.62	-	-	0.62		-	-	-	-	-	-	-	-	-	-
RDX	ug/L	0.61	NE	0.17	-	-	-	-	-	-	-	-	0.17	J	-	-	-	-
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	1.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Volatiles																		
Acetone	ug/L	548	NE	68	68	J	-	-	66	B	-	-	220	B	-	-		
Benzene	ug/L	0.35	2.4	130	**11**		1.9	J	**46**		**42**	J	**18**	J	**28**			
Bromomethane	ug/L	0.87	NE	7.9	-	-	-	-	7.9	J	-	-	-	-	-	-	-	-
Butanone, 2-	ug/L	697	NE	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbon disulfide	ug/L	104	NE	6.9	2		6.9		-	-	-	-	3.2	J	1.7	J		
Chlorobenzene	ug/L	10.6	NE	21	-	-	-	-	-	-	-	-	2.2	J	-	-		
Chloromethane	ug/L	16	NE	30	-	-	-	-	-	-	-	-	-	-	-	-		
Ethylbenzene	ug/L	134	0.87	64	**5.1**		**1.2**	J	**17**	J	**16**	J	**6.8**	J	**8.8**			
Methylene chloride	ug/L	4.3	NE	100	-	-	2.3	B	30	J	9.7	J	7.3	J	-	-		
Toluene	ug/L	72	1.7	21	**8.9**		1.5	B	**21**	J	**18**	J	**8**	J	**11**			
Xylenes, total	ug/L	21	5.5	360	**38**		**10**		180		170		**66**		**95**			
Semivolatiles																		
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	9.7	5.8	J	24	B	-	-	9.7	J	-	-	-	-		
Dimethylphenol, 2,4-	ug/L	73	NE	8.6	-	-	-	-	-	-	-	-	-	-	-	-		
Methylnaphthalene, 2-	ug/L	12	NE	12	3.3	J	1.5	J	12		10		5.2	J	11			
Methylphenol, 2-	ug/L	182	NE	1.6	-	-	-	-	-	-	-	-	-	-	-	-		
Methylphenol, 4-	ug/L	18	NE	1.6	-	-	-	-	-	-	-	-	-	-	-	-		
Naphthalene	ug/L	0.62	NE	12	2.1	J	-	-	8.6	J	6.1	J	3.7	J	7	J		
Phenanthrene	ug/L	18	NE	0.89	-	-	-	-	0.82	J	0.74	J	-	-	0.89	J		
Phenol	ug/L	1,095	NE	74	55		-	-	1.2	J	-	-	-	-	-	-		
Metals - Unfiltered																		
Aluminum	ug/L	3,650	309	10200	-	-	-	-	94.8	B	56.2	J	61.7	J	67.3	B		
Arsenic	ug/L	0.045	7.4	34.2	-	-	-	-	-	-	-	-	-	-	-	-		
Barium	ug/L	255	11,800	1800	1,520		1,800		1,060		892		1,120		1,190			
Calcium	ug/L	NE	316,000	1970000	255,000	J	171,000		221,000		121,000		184,000		185,000			
Chromium	ug/L	11	NE	307	10		-	-	1.2	J	-	-	-	-	-	-		
Cobalt	ug/L	73	12.1	63.3	-	-	-	-	-	-	-	-	-	-	-	-		
Copper	ug/L	146	19.8	99	**61.7**		-	-	**99**		15.6	J	**52.2**		**31.5**			
Iron	ug/L	1,095	1,550	51600	376	B	141	J	149		-	-	-	-	-	-		
Lead	ug/L	15	NE	38.6	6.8		-	-	-	-	-	-	-	-	-	-		
Magnesium	ug/L	NE	217,000	132000	57,200		80,000		66,200		41,900		44,600		36,300			
Manganese	ug/L	88	636	5130	30.4		-	-	2.2	J	2.2	J	-	-	2	J		
Nickel	ug/L	73	8.6	238	-	-	-	-	**13.8**	J	3.5	J	**9.2**	J	4.9	B		
Potassium	ug/L	NE	116,000	49500	49,500		26,000		43,800		41,500	J	36,500	J	38,900			
Sodium	ug/L	NE	1,390,000	132000	120,000		129,000		75,400		88,400		74,300	J	80,500			
Thallium	ug/L	0.24	NE	NA	-	-	-	-	-	-	-	-	5.1	B	-	-		
Vanadium	ug/L	3.7	NE	108	-	-	-	-	-	-	-	-	-	-	-	-		
Zinc	ug/L	1,095	507	144	62.3		29.5	B	144		31.3		65.9		96.6			

Table 7-12

Detected Constituents in Bedrock Monitoring Wells
Acid Area No. 2
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:		BED-MW19									
					Sample No:		5950		5955		BD3025		CB3013		DF3001		DH3001	
					Sample Date:		14-Nov-97		16-May-98		4-Oct-01		4-Apr-02		5-May-04		25-Aug-04	
					Low-Flow Sampled:		No		No		Yes		Yes		Yes		Yes	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Filtered																		
Aluminum	ug/L	3,650	309	45.2	-	-	-	-	86	B	66.6	B	45.2	J	50.3	B		
Arsenic	ug/L	0.045	7.4	9	-	-	-	-	-	-	-	-	-	-	-	-		
Barium	ug/L	255	11,800	1740	1,520		1,740		1,080		852		1,050		1,140			
Beryllium	ug/L	7.3	NE	NA	-	-	-	-	-	-	-	-	-	-	-	-		
Calcium	ug/L	NE	316,000	220000	220,000		162,000		202,000		109,000		170,000		181,000			
Cobalt	ug/L	73	12.1	3.4	-	-	-	-	-	-	-	-	-	-	-	-		
Copper	ug/L	146	19.8	13	-	-	-	-	-	-	-	-	-	-	13	J		
Iron	ug/L	1,095	1,550	1300	-	-	-	-	-	-	-	-	-	-	-	-		
Magnesium	ug/L	NE	217,000	81000	65,100		77,900		81,000		44,000		44,800		36,500			
Manganese	ug/L	88	636	995	-	-	16.3		4	J	2.5	J	2.2	J	2.8	J		
Nickel	ug/L	73	8.6	7.9	-	-	-	-	7.9	J	4.3	J	7.9	J	5.1	B		
Potassium	ug/L	NE	116,000	46200	46,200		24,800		42,100		42,900	J	36,500	J	39,300	J		
Selenium	ug/L	18	NE	1.8	-	-	-	-	-	-	-	-	2.6	B	1.8	J		
Sodium	ug/L	NE	1,390,000	127000	125,000		127,000		94,900		92,900		75,400	J	80,800			
Thallium	ug/L	0.24	NE	2.6	-	-	-	-	-	-	-	-	4.4	B	2.6	J		
Zinc	ug/L	1,095	507	66.2	57.4		24.4	B	5.2	J	3.1	J	-	-	43.6			
Water Quality Parameters																		
Alkalinity	ug/L	NE	NE	1050000	310,000		750,000		707,000	J	302,000		1,050,000	J	634,000			
Chloride	ug/L	NE	NE	396000	330,000		280,000		248,000	J	373,000	J	229,000		396,000			
Cyanide, total	ug/L	73	NE	16	-	-	16		-	-	-	-						
Hardness	ug/L	NE	NE	1700000	1,700,000		750,000		905,000		424,000		662,000		584,000			
Sulfate	ug/L	NE	NE	70000	14,000		49,000		27,700	J	32,200		21,000		29,500			
Total dissolved solids	ug/L	NE	NE	1200000	1,200,000		590,000		1,110,000		651,000		887,000		836,000			
Total organic carbon	ug/L	NE	NE	16000	16,000		9,000		8,600		5,900		5,600		5,600			
Total suspended solids	ug/L	NE	NE	199000	41,000		5,000		199,000		44,000		32,000		79,000			
Turbidity	NTU	NE	NE	662					662	J	164		220		118			

Shaded cell indicates value is greater than the RBSC.
Bold text indicates value is greater than the BSC.
BSC - Background screening concentration.
MDC - Maximum detected concentration for the AOC ("B" qualified data not included).
RBSC - Values reflect an incremental lifetime cancer risk (ILCR) of 1E-6 or a noncancer hazard quotient (HQ) of 0.1. For chemicals that exhibit both cancer and noncancer effects, whichever type of effect results in a lower concentration (using an ILCR of 1E-6 and an HQ of 0.1), that concentration is selected as the RBSC.
"-" - Not detected.
NA - Not applicable; detection is the result of blank contamination.
NE - Not established (RBSCs), not evaluated (BSCs).
NTU - Nephelometric turbidity unit.
µg/L - Micrograms per liter.

Validation Qualifiers (VQ)
B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.
J - The analyte was positively identified; the reported value is estimated.

Table 7-13

Detected Constituents in Bedrock Monitoring Well
Acid Area No. 3
Former Plum Brook Ordnance Works, Sandusky, Ohio

			Location Code:		AA3-BEDGW-001							
			Sample No:		5470		5475		BD3005		CB3033	
			Sample Date:		19-Nov-97		14-May-98		27-Sep-01		10-Apr-02	
			Low-Flow Sampled:		No		No		Yes		Yes	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Volatiles												
Acetone	ug/L	548	NE	36	36	J	-	-	22	B	-	-
Benzene	ug/L	0.35	2.4	11	-	-	-	-	**11**		**8**	J
Carbon disulfide	ug/L	104	NE	4.2	4.2	J	-	-	-	-	-	-
Ethylbenzene	ug/L	134	0.87	4.6	-	-	-	-	**4**	J	**4.6**	J
Methylene chloride	ug/L	4.3	NE	9.2	2.1	B	160	B	2.2	B	9.2	J
Toluene	ug/L	72	1.7	12	-	-	**29**	B	**11**		**12**	J
Xylenes, total	ug/L	21	5.5	31	-	-	-	-	**28**		**31**	
Semivolatiles												
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	5.8	5.8	J	-	-	-	-	-	-
Naphthalene	ug/L	0.62	NE	0.7	-	-	-	-	-	-	0.7	J
Phenol	ug/L	1,095	NE	3.1	3.1	J	-	-	-	-	-	-
Metals - Unfiltered												
Aluminum	ug/L	3,650	309	397	-	-	**397**		59.6	B	104	B
Barium	ug/L	255	11,800	102	-	-	-	-	102	J	80.2	J
Calcium	ug/L	NE	316,000	189000	189,000		131,000		122,000	J	104,000	
Chromium	ug/L	11	NE	NA	-	-	-	-	1.6	B	-	-
Iron	ug/L	1,095	1,550	450	168	B	450		126		118	J
Magnesium	ug/L	NE	217,000	108000	108,000		76,800		80,700		69,300	
Manganese	ug/L	88	636	83.8	74.6		83.8		28.7		20.7	
Potassium	ug/L	NE	116,000	49600	49,600		38,500		43,900		40,400	
Sodium	ug/L	NE	1,390,000	368000	368,000		282,000		293,000		237,000	
Thallium	ug/L	0.24	NE	NA	-	-	10.1	B	-	-	6.9	B
Zinc	ug/L	1,095	507	29.2	29.2		67.6	B	-	-	-	-
Metals - Filtered												
Aluminum	ug/L	3,650	309	49.2	-	-	-	-	50.2	B	49.2	J
Barium	ug/L	255	11,800	99.5	-	-	-	-	99.5	J	78.1	J
Calcium	ug/L	NE	316,000	160000	160,000		143,000		122,000		104,000	
Magnesium	ug/L	NE	217,000	96300	96,300		89,400		80,900		67,100	
Manganese	ug/L	88	636	57.6	57.6		51.3		23.9		17	
Potassium	ug/L	NE	116,000	44700	44,700		43,800		43,100		40,000	
Sodium	ug/L	NE	1,390,000	331000	331,000		321,000		293,000		237,000	
Thallium	ug/L	0.24	NE	NA	-	-	-	-	6.4	B	-	-
Zinc	ug/L	1,095	507	23	23		42.8	B	-	-	-	-

Table 7-13

Detected Constituents in Bedrock Monitoring Well
Acid Area No. 3
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:	AA3-BEDGW-001							
					Sample No:	5470		5475		BD3005		CB3033	
					Sample Date:	19-Nov-97		14-May-98		27-Sep-01		10-Apr-02	
					Low-Flow Sampled:	No		No		Yes		Yes	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Water Quality Parameters												
Alkalinity	ug/L	NE	NE	790000	670,000		790,000		750,000	J	650,000	
Chloride	ug/L	NE	NE	860000	790,000		860,000	J	451,000		369,000	
Hardness	ug/L	NE	NE	13000000	13,000,000		860,000		630,000		480,000	
Sulfate	ug/L	NE	NE	31100	-	-	8,000	J	31,100		-	-
Total dissolved solids	ug/L	NE	NE	1900000	1,900,000		1,800,000		1,440,000		1,200,000	
Total organic carbon	ug/L	NE	NE	5300	5,300	J	2,000	J	840	J	1,000	
Total suspended solids	ug/L	NE	NE	54000	38,000		54,000		-	-	16,000	
Turbidity	NTU	NE	NE	179					179	J	118	

Shaded cell indicates value is greater than the RBSC.
Bold text indicates value is greater than the BSC.
BSC - Background screening concentration.
MDC - Maximum detected concentration for the AOC ("B" qualified data not included).
RBSC - Values reflect an incremental lifetime cancer risk (ILCR) of 1E-6 or a noncancer hazard quotient (HQ) of 0.1. For chemicals that exhibit both cancer and noncancer effects, whichever type of effect results in a lower concentration (using an ILCR of 1E-6 and an HQ of 0.1), that concentration is selected as the RBSC.
"-" - Not detected.
NA - Not applicable; detection is the result of blank contamination.
NE - Not established (RBSCs), not evaluated (BSCs).
NTU - Nephelometric turbidity unit.
µg/L - Micrograms per liter.

Validation Qualifiers (VQ)
B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.
J - The analyte was positively identified; the reported value is estimated.

Table 7-14

Detected Constituents in Bedrock Monitoring Well
Maintenance Shop Area
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:		MNTA-BEDGW-001					
					Sample No:		5440		5445		BD3008		CB3039	
					Sample Date:		20-Nov-97		28-May-98		3-Oct-01		12-Apr-02	
					Low-Flow Sampled:		No		No		Yes		No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives												
Dinitrobenzene, 1,3-	ug/L	0.37	NE	0.86	-	-	0.86		-	-	-	-
Dinitrotoluene, 2,4-	ug/L	0.099	NE	2	-	-	2		-	-	-	-
Dinitrotoluene, 2,6-	ug/L	0.099	NE	0.34	-	-	0.34		-	-	-	-
Volatiles												
Acetone	ug/L	548	NE	140	-	-	-	-	-	-	140	J
Benzene	ug/L	0.35	2.4	110	-	-	19		110	J	36	J
Carbon disulfide	ug/L	104	NE	21	3.7	J	21		-	-	-	-
Ethylbenzene	ug/L	134	0.87	61	-	-	7.7		61	J	25	J
Methylene chloride	ug/L	4.3	NE	200	5.1	B	2.6	B	200	J	110	J
Toluene	ug/L	72	1.7	140	-	-	18		140	J	40	J
Trichloroethene	ug/L	0.028	NE	18	-	-	-	-	-	-	18	J
Xylenes, total	ug/L	21	5.5	490	8.2	B	150		490		310	
Semivolatiles												
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	5	3.9	J	6.5	B	5	J	0.91	J
Chrysene	ug/L	9.2	NE	0.8	-	-	-	-	0.8	J	0.54	J
Dimethylphenol, 2,4-	ug/L	73	NE	1.8	1.7	J	1.8	J	-	-	-	-
Dinitrotoluene, 2,4-	ug/L	0.099	NE	1.3	-	-	1.3	J	-	-	-	-
Fluorene	ug/L	24.3	NE	1.6	-	-	-	-	1.6	J	1.2	J
Methylnaphthalene, 2-	ug/L	12	NE	23	1.9	J	1.2	J	21		23	
Naphthalene	ug/L	0.62	NE	16	2.3	J	-	-	11		16	
Phenanthrene	ug/L	18	NE	2.8	-	-	-	-	2.8	J	1.9	J
Phenol	ug/L	1,095	NE	17	17		11		-	-	-	-
Metals - Unfiltered												
Aluminum	ug/L	3,650	309	119	249	B	-	-	119	J	129	B
Arsenic	ug/L	0.045	7.4	2.9	-	-	-	-	2.9	J	-	-
Barium	ug/L	255	11,800	457	424		457		381		388	
Calcium	ug/L	NE	316,000	441000	336,000	J	441,000	J	299,000		305,000	
Chromium	ug/L	11	NE	2.9	-	-	-	-	2.9	J	-	-
Copper	ug/L	146	19.8	24.3	-	-	-	-	24.3	J	-	-
Iron	ug/L	1,095	1,550	6400	6,400		481		978		376	J
Magnesium	ug/L	NE	217,000	317000	235,000		317,000		224,000		236,000	
Manganese	ug/L	88	636	849	849		181		641		388	
Potassium	ug/L	NE	116,000	98800	58,800		60,900		98,800	J	92,000	
Sodium	ug/L	NE	1,390,000	1330000	1,140,000	J	1,320,000		1,330,000		1,210,000	
Thallium	ug/L	0.24	NE	NA	-	-	-	-	5.4	B	8.7	B
Vanadium	ug/L	3.7	NE	NA	-	-	-	-	2.1	B	-	-
Zinc	ug/L	1,095	507	16.2	34.4	B	68	B	16.2	J	12.9	J

Table 7-14

Detected Constituents in Bedrock Monitoring Well
Maintenance Shop Area
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:		MNTA-BEDGW-001					
					Sample No:		5440		5445		BD3008		CB3039	
					Sample Date:		20-Nov-97		28-May-98		3-Oct-01		12-Apr-02	
					Low-Flow Sampled:		No		No		Yes		No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Filtered												
Aluminum	ug/L	3,650	309	51.1	-	-	-	-	86	B	51.1	J
Barium	ug/L	255	11,800	596	449		596		387		398	
Calcium	ug/L	NE	316,000	483000	**358,000**		**483,000**	J	298,000		**316,000**	
Iron	ug/L	1,095	1,550	NA	298	B	-	-	-	-	-	-
Magnesium	ug/L	NE	217,000	345000	**254,000**		**345,000**	J	**227,000**		**239,000**	
Manganese	ug/L	88	636	899	**899**		183		621		380	
Potassium	ug/L	NE	116,000	97200	63,500		65,800		97,200		96,300	
Sodium	ug/L	NE	1,390,000	1520000	1,190,000		**1,520,000**		1,350,000		1,280,000	
Thallium	ug/L	0.24	NE	NA	-	-	-	-	4.8	B	-	-
Zinc	ug/L	1,095	507	24.8	24.8	J	32.8	B	-	-	2.6	J
Water Quality Parameters												
Alkalinity	ug/L	NE	NE	691000	670,000		-	-	630,000	J	691,000	
Chloride	ug/L	NE	NE	4130000	55,000		3,800,000		4,130,000		3,480,000	
Hardness	ug/L	NE	NE	2100000	2,000,000		2,100,000		1,660,000		1,580,000	
Sulfate	ug/L	NE	NE	64000	62,000		64,000		-	-	1,400	J
Total dissolved solids	ug/L	NE	NE	7200000	5,300,000		7,200,000		5,860,000		6,010,000	
Total organic carbon	ug/L	NE	NE	11000	11,000		7,000		3,900		5,900	
Total suspended solids	ug/L	NE	NE	79000	4,000		29,000		79,000		24,000	
Turbidity	NTU	NE	NE	392					392	J	277	

Shaded cell indicates value is greater than the RBSC.
Bold text indicates value is greater than the BSC.
BSC - Background screening concentration.
MDC - Maximum detected concentration for the AOC ("B" qualified data not included).
RBSC - Values reflect an incremental lifetime cancer risk (ILCR) of 1E-6 or a noncancer hazard quotient (HQ) of 0.1. For chemicals that exhibit both cancer and noncancer effects, whichever type of effect results in a lower concentration (using an ILCR of 1E-6 and an HQ of 0.1), that concentration is selected as the RBSC.
"-" - Not detected.
NA - Not applicable; detection is the result of blank contamination.
NE - Not established (RBSCs), not evaluated (BSCs).
NTU - Nephelometric turbidity unit.
µg/L - Micrograms per liter.

Validation Qualifiers (VQ)
B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.
J - The analyte was positively identified; the reported value is estimated.

Table 7-15

Detected Constituents in Bedrock Monitoring Well
Additional Burning Ground Area
Former Plum Brook Ordnance Works, Sandusky, Ohio

				Location Code:	ABG-BEDGW-01							
				Sample No:	5480		5485		BD3006/BD3006R		CB3016	
				Sample Date:	13-Nov-97		13-May-98		28-Sept-01/5-Oct-01		5-Apr-02	
				Low-Flow Sampled:	No		No		Yes		Yes	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Volatiles												
Acetone	ug/L	548	NE	NA	-	-	-	-	2.7	B	-	-
Carbon disulfide	ug/L	104	NE	0.97	-	-	0.97	J	-	-	-	-
Methylene chloride	ug/L	4.3	NE	NA	-	-	0.41	B	-	-	0.49	B
Trichloroethene	ug/L	0.028	NE	0.25	0.25	J	-	-	-	-	-	-
Semivolatiles												
Benzo(a)pyrene	ug/L	0.0092	NE	1.2	-	-	-	-	1.2	J	-	-
Benzo(ghi)perylene	ug/L	18	NE	1.7	-	-	-	-	1.7	J	-	-
Chrysene	ug/L	9.2	NE	0.54	-	-	-	-	0.54	J	-	-
Dibenz(a,h)anthracene	ug/L	0.0092	NE	1.2	-	-	-	-	1.2	J	-	-
Indeno(1,2,3-cd)pyrene	ug/L	0.092	NE	1.7	-	-	-	-	1.7	J	-	-
Metals - Unfiltered												
Aluminum	ug/L	3,700	309	522	**522**		-	-	45.3	B	39.2	J
Arsenic	ug/L	0.045	7.4	11.7	**11.7**		-	-	-	-	-	-
Barium	ug/L	255	11,800	89.2	-	-	-	-	89.2	J	82.7	J
Calcium	ug/L	NE	316,000	186000	176,000	J	153,000		172,000		186,000	
Iron	ug/L	1,095	1,550	9130	**8,890**		**5,770**		**7,900**		**9,130**	
Lead	ug/L	15	NE	20.2	6.9		20.2		-	-	-	-
Magnesium	ug/L	NE	217,000	36700	34,300		30,500		33,200		36,700	
Manganese	ug/L	88	636	912	**912**		**745**		**846**		**872**	
Mercury	ug/L	1.1	NE	3.6	3.6		-	-	-	-	-	-
Potassium	ug/L	NE	116,000	1670	-	-	-	-	1,670	J	444	J
Sodium	ug/L	NE	1,390,000	5070	5,070		-	-	4,610	J	4,900	J
Zinc	ug/L	1,095	507	35.3	27.7		37.4	B	14.9	J	35.3	

Table 7-15

Detected Constituents in Bedrock Monitoring Well
Additional Burning Ground Area
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:		ABG-BEDGW-01					
					Sample No:		5480		5485		BD3006/BD3006R		CB3016	
					Sample Date:		13-Nov-97		13-May-98		28-Sept-01/5-Oct-01		5-Apr-02	
					Low-Flow Sampled:		No		No		Yes		Yes	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Filtered												
Aluminum	ug/L	3,700	309	408	-	-	**408**		67.6	B	63.7	B
Barium	ug/L	255	11,800	88	-	-	-	-	88	J	78.2	J
Beryllium	ug/L	7.3	NE	NA	-	-	-	-	0.55	B	-	-
Calcium	ug/L	NE	316,000	184000	179,000		169,000		169,000		184,000	
Iron	ug/L	1,095	1,550	7400	**7,260**		**5,580**		**7,400**		**5,630**	
Magnesium	ug/L	NE	217,000	36600	34,900		33,000		33,000		36,600	
Manganese	ug/L	88	636	990	**990**		**813**		**818**		**860**	
Potassium	ug/L	NE	116,000	1640	-	-	-	-	1,640	J	432	J
Sodium	ug/L	NE	1,390,000	5070	5,000		-	-	4,670	J	5,070	
Zinc	ug/L	1,095	507	35.4	-	-	38.9	B	14.3	J	35.4	J
Water Quality Parameters												
Alkalinity	ug/L	NE	NE	370000	280,000		270,000		370,000	J	250,000	
Chloride	ug/L	NE	NE	10000	2,000	B	3,000	J	4,400		10,000	J
Hardness	ug/L	NE	NE	552000	500,000		530,000		552,000		440,000	
Sulfate	ug/L	NE	NE	292000	140,000		190,000	J	163,000		292,000	
Total dissolved solids	ug/L	NE	NE	731000	640,000		600,000		644,000		731,000	
Total organic carbon	ug/L	NE	NE	7000	3,800		3,000	J	7,000		3,300	
Total suspended solids	ug/L	NE	NE	24000	11,000		7,000		21,000		24,000	
Turbidity	NTU	NE	NE	151					64.2	J	151	J

Shaded cell indicates value is greater than the RBSC.
Bold text indicates value is greater than the BSC.
BSC - Background screening concentration.
MDC - Maximum detected concentration for the AOC ("B" qualified data not included).
RBSC - Values reflect an incremental lifetime cancer risk (ILCR) of 1E-6 or a noncancer hazard quotient (HQ) of 0.1. For chemicals that exhibit both cancer and noncancer effects, whichever type of effect results in a lower concentration (using an ILCR of 1E-6 and an HQ of 0.1), that concentration is selected as the RBSC.
"-" - Not detected.
NA - Not applicable; detection is the result of blank contamination.
NE - Not established (RBSCs), not evaluated (BSCs).
NTU - Nephelometric turbidity unit.
µg/L - Micrograms per liter.

Validation Qualifiers (VQ)
B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.
J - The analyte was positively identified; the reported value is estimated.

Table 7-16

Detected Constituents in Bedrock Monitoring Well
Upper Toluene Tanks Area
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:	BED-MW16						MK-MW20	
					Sample No:	5920	5925	BD3020	CB3037	CC3002			
					Sample Date:	24-Nov-97	1-Jun-98	10-Oct-01	11-Apr-02	11-Jul-02			
					Low-Flow Sampled:	No	No	No	No	No			
Parameter	Units	RBSC	BSC	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives															
Dinitrotoluene, 2,6-	µg/L	0.099	NE	11		-	-	-	-	-	-	11			
Volatiles															
Acetone	µg/L	548	NE	930		-	-	-	-	930	J	60	J		
Benzene	µg/L	0.35	2.4	800		**490**		**450**	J	**800**	J	**150**	J		
Ethylbenzene	µg/L	134	0.87	200		**130**		**140**	J	**200**	J	**40**	J		
Methylene chloride	µg/L	4.3	NE	52		8.8	B	100	B	52	J	11	J		
Toluene	µg/L	72	1.7	590		**390**		**350**	J	**590**	J	**150**	J		
Xylenes, total	µg/L	21	5.5	1500		**1,100**		**1,000**	J	**1,500**		**610**			
Semivolatiles															
Bis(2-ethylhexyl)phthalate	µg/L	4.8	NE	920		920	J	4.9	B	2.4	J	2.1	J		
Chrysene	µg/L	9.2	NE	0.87		-	-	-	-	0.87	J	-	-		
Dibenzofuran	µg/L	1.2	NE	1.2		-	-	-	-	1.2	J	-	-		
Dichlorobenzene, 1,3-	µg/L	18.3	NE	4.4		-	-	4.4	J	-	-	-	-		
Dimethylphenol, 2,4-	µg/L	73	NE	13		-	-	-	-	3	J	13			
Fluorene	µg/L	24.3	NE	2.8		-	-	-	-	2.8	J	1.8	J		
Methylnaphthalene, 2-	µg/L	12	NE	64		-	-	-	-	64		24			
Methylphenol, 2-	µg/L	182	NE	1.6		-	-	-	-	1.6	J	0.88	J		
Methylphenol, 4-	µg/L	18	NE	1.7		-	-	-	-	1.7	J	-	-		
Naphthalene	µg/L	0.62	NE	52		-	-	-	-	52		5	J		
Phenanthrene	µg/L	18	NE	5.1		-	-	-	-	5.1	J	2.6	J		
Phenol	µg/L	1,095	NE	4.6		-	-	-	-	4.6	J	1	J		
Trichlorobenzene, 1,2,4-	µg/L	0.72	NE	1.6		-	-	1.6	J	-	-	-	-		
Trichlorophenol, 2,4,5-	µg/L	365	NE	35		-	-	35		-	-	-	-		
Metals - Unfiltered															
Aluminum	µg/L	3,650	309	11000		**502**	J	**11,000**		36.2	B	85.3	B		
Barium	µg/L	255	11,800	612		463		612		147	J	19.2	J		
Calcium	µg/L	NE	316,000	2880000		**875,000**	J	**2,880,000**		**645,000**	J	**318,000**			
Chromium	µg/L	11	NE	105		24.4		105		-	-	-	-		
Cobalt	µg/L	73	12.1	2.4		-	-	-	-	2.4	J	-	-		
Copper	µg/L	146	19.8	84.9		-	-	**84.9**		-	-	-	-		
Iron	µg/L	1,095	1,550	45900		1,140		**45,900**		73.2	J	-	-		
Lead	µg/L	15	NE	40.4		-	-	40.4		-	-	-	-		
Magnesium	µg/L	NE	217,000	105000		6,190		105,000		303	J	31,700			
Manganese	µg/L	88	636	2200		133		**2,200**		2.9	J	17			
Nickel	µg/L	73	8.6	54.7		-	-	**54.7**		**10.8**	J	3.2	J		
Potassium	µg/L	NE	116,000	26400		26,400		22,800		18,600	J	4,420	J		
Sodium	µg/L	NE	1,390,000	88200		73,200	J	46,600		88,200	J	30,100			
Thallium	µg/L	0.24	NE	101		-	-	101		-	-	5.9	B		
Vanadium	µg/L	3.7	NE	126		64.7		126		-	-	-	-		
Zinc	µg/L	1,095	507	235		30		235		-	-	-	-		

Table 7-16

Detected Constituents in Bedrock Monitoring Well
Upper Toluene Tanks Area
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:		BED-MW16						MK-MW20	
					Sample No:		5920		5925		BD3020		CB3037		CC3002	
					Sample Date:		24-Nov-97		1-Jun-98		10-Oct-01		11-Apr-02		11-Jul-02	
					Low-Flow Sampled:		No		No		No		No		No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Filtered														
Aluminum	µg/L	3,650	309	NA	-	-	-	-	55.2	B	61.4	B		
Barium	µg/L	255	11,800	523	389		523		143	J	18.4	J		
Calcium	µg/L	NE	316,000	949000	**915,000**		**949,000**		**644,000**	J	**330,000**			
Chromium	µg/L	11	NE	14.8	13.6		14.8		-	-	-	-		
Magnesium	µg/L	NE	217,000	32000	-	-	-	-	43.9	B	32,000			
Manganese	µg/L	88	636	6.8	-	-	-	-	-	-	6.8	J		
Nickel	µg/L	73	8.6	10.2	-	-	-	-	**10.2**	J	-	-		
Potassium	µg/L	NE	116,000	24900	24,900		23,500		17,800	J	4,700	J		
Sodium	µg/L	NE	1,390,000	85600	68,600		57,200		85,600	J	31,700			
Thallium	µg/L	0.24	NE	53.1	-	-	53.1		6.4	B	6.2	B		
Vanadium	µg/L	3.7	NE	58.3	58.3		50.6		-	-	-	-		
Zinc	µg/L	1,095	507	365	-	-	-	-	4.2	J	365			
Water Quality Parameters														
Alkalinity	µg/L	NE	NE	1700000	1,600,000		1,700,000		1,060,000	J				
Chloride	µg/L	NE	NE	370000	88,000		140,000		370,000		75,900			
Hardness	µg/L	NE	NE	5300000	5,300,000		2,000,000		1,650,000		700,000			
Sulfate	µg/L	NE	NE	734000	150,000		37,000		212,000		734,000			
Total dissolved solids	µg/L	NE	NE	6400000	6,400,000		4,000,000		1,950,000		1,450,000			
Total organic carbon	µg/L	NE	NE	14000	8,400		14,000		6,800		5,500			
Total suspended solids	µg/L	NE	NE	330000	7,000		330,000		12,000		14,000			
Turbidity	NTU	NE	NE	8					3.6		8			
BTEX - Water														
Toluene	µg/L	72	1.7	37000									37000	
Range Organics - Water														
Diesel range organics	µg/L	NE	NE	65000									65000	
Gasoline range organics	µg/L	NE	NE	140									140	

Shaded cell indicates value is greater than the RBSC.
Bold text indicates value is greater than the BSC.
BSC - Background screening concentration.
MDC - Maximum detected concentration for the AOC ("B" qualified data not included).
RBSC - Values reflect an incremental lifetime cancer risk (ILCR) of 1E-6 or a noncancer hazard quotient (HQ) of 0.1. For chemicals that exhibit both cancer and noncancer effects, whichever type of effect results in a lower concentration (using an ILCR of 1E-6 and an HQ of 0.1), that concentration is selected as the RBSC.

"-" - Not detected.
NA - Not applicable; detection is the result of blank contamination.
NE - Not established (RBSCs), not evaluated (BSCs).
NTU - Nephelometric turbidity unit.
µg/L - Micrograms per liter.

Validation Qualifiers (VQ)
B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.
J - The analyte was positively identified; the reported value is estimated.

Detected Constituents in Bedrock Monitoring Wells
Downgradient Perimeter Wells
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:	BED-MW17												BED-MW19											
					Sample Number:	5930		5935		BD3021		CB3014		DF3000		DH3000		5950		5955		BD3025		CB3013		DF3001		DH3001	
					Sample Date:	20-Nov-97		29-May-98		3-Oct-01		11-Apr-02		6-May-04		26-Aug-04		14-Nov-97		16-May-98		4-Oct-01		4-Apr-02		5-May-04		25-Aug-04	
					Low-Flow Sampled:	No		No		Yes		Yes		Yes		Yes		No		No		Yes		Yes		Yes		Yes	
Parameter	Units	RBSC	BSC	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																													
Amino-4,6-dinitrotoluene, 2-	ug/L	0.73	NE	0.19						-	-	-	-	-	-	-	-					-	-	-	-	-	-	-	-
Dinitrobenzene, 1,3-	ug/L	0.37	NE	0.22	-	-	-	-	-	-	-	-	-	-	-	-	0.22		-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	ug/L	0.099	NE	1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	ug/L	0.099	NE	1.4	-	-	-	-	0.3	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrobenzene	ug/L	0.34	NE	0.34	0.34		-	-	-	-	-	-	-	-	-	-	0.32		-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	ug/L	0.049	NE	0.55	-	-	-	-	-	-	0.55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 3-	ug/L	12.2	NE	0.62	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.62		-	-	-	-	-	-	-	-	-
Nitrotoluene, 4-	ug/L	0.66	NE	0.23					-	-	-	-	-	-	-	-					-	-	-	-	-	-	-	-	-
RDX	ug/L	0.61	NE	0.22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.17	J	-	-	-	-	-
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	0.27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Volatiles																													
Acetone	ug/L	548	NE	310	-	-	-	-	87	B	-	-	1,300	B	-	-	68	J	-	-	66	B	-	-	220	B	-	-	
Benzene	ug/L	0.35	2.4	130	**10**	J	-	-	-	-	**13**	J	**15**	J	**13**	J	**11**		1.9	J	**46**		**42**	J	**18**	J	**28**		
Bromomethane	ug/L	0.87	NE	7.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.9	J	-	-	-	-	-	-	-
Butanone, 2-	ug/L	697	NE	130	-	-	-	-	-	-	-	-	130	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbon disulfide	ug/L	104	NE	40	40	J	-	-	-	-	2.3	J	-	-	8.9	J	2		6.9		-	-	-	-	3.2	J	1.7	J	
Chlorobenzene	ug/L	10.6	NE	11	-	-	-	-	-	-	-	-	11	J	-	-	-	-	-	-	-	-	-	-	2.2	J	-	-	-
Chloromethane	ug/L	16	NE	1.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ethylbenzene	ug/L	134	0.87	120	**79**		**9.9**	J	**120**		**100**		**86**	J	**62**		**5.1**		**1.2**	J	**17**	J	**16**	J	**6.8**	J	**8.8**		
Methylene chloride	ug/L	4.3	NE	98	18	B	65	B	41	J	20	J	34	J	-	-	-	-	2.3	B	30	J	9.7	J	7.3	J	-	-	
Toluene	ug/L	72	1.7	180	**140**		**20**	B	**180**		**150**		**120**		**98**		**8.9**		1.5	B	**21**	J	**18**	J	**8**	J	**11**		
Xylenes, total	ug/L	21	5.5	560	**360**		**46**		**550**		**440**		**390**		**280**		**38**		**10**		180		170		**66**		**95**		
Semivolatiles																													
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	9.7	-	-	6.8	B	4	J	4	J	2.3	J	-	-	5.8	J	24	B	-	-	9.7	J	-	-	-	-	
Chrysene	ug/L	9.2	NE	1	-	-	-	-	-	-	-	-	1	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dimethylphenol, 2,4-	ug/L	73	NE	5.1	-	-	2.8	J	3.8	J	3	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methylnaphthalene, 2-	ug/L	12	NE	24	-	-	20		9.2	J	7.5	J	7.7	J	12		3.3	J	1.5	J	12		10		5.2	J	11		
Methylphenol, 2-	ug/L	180	NE	1.1	-	-	-	-	1.1	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methylphenol, 4-	ug/L	18	NE	2	-	-	-	-	2	J	1.4	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Naphthalene	ug/L	0.62	NE	18	-	-	18		9.8	J	10	J	8	J	13		2.1	J	-	-	8.6	J	6.1	J	3.7	J	7	J	
Phenanthrene	ug/L	18	NE	1.4	-	-	-	-	0.99	J	-	-	0.85	J	1.2	J	-	-	-	-	0.82	J	0.74	J	-	-	0.89	J	
Phenol	ug/L	1,095	NE	55	-	-	-	-	2.6	J	2	J	2.2	J	2.6	J	55		-	-	1.2	J	-	-	-	-	-	-	
Metals - Unfiltered																													
Aluminum	ug/L	3,650	309	3650	**396**	B	-	-	106	J	97	B	122	J	136	B	-	-	-	-	94.8	B	56.2	J	61.7	J	67.3	B	
Arsenic	ug/L	0.045	7.4	17.7	-	-	-	-	5.4	J	4.5	J	4	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Barium	ug/L	255	11,800	1860	948		800		912		1,090		1,860		1,790		1,520		1,800		1,060		892		1,120		1,190		
Beryllium	ug/L	7.3	NE	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	ug/L	1.8	NE	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	ug/L	NE	316,000	462000	**318,000**	J	279,000	J	260,000		268,000		**316,000**		312,000		255,000	J	171,000		221,000		121,000		184,000		185,000		
Chromium	ug/L	11	NE	24.4	-	-	-	-	-	-	-	-	-	-	-	-	10		-	-	1.2	J	-	-	-	-	-	-	-
Cobalt	ug/L	73	12.1	10.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Copper	ug/L	146	19.8	99	-	-	-	-	-	-	-	-	-	-	-	-	**61.7**		-	-	**99**		15.6	J	**52.2**		**31.5**		
Iron	ug/L	1095	1,550	257000	**1,580**		456		160		-	-	-	-	-	-	376	B	141	J	149		-	-	-	-	-	-	-
Lead	ug/L	15	NE	6.8	-	-	-	-	-	-	-	-	-	-	-	-	6.8		-	-	-	-	-	-	-	-	-	-	-
Magnesium	ug/L	NE	217,000	279000	187,000		212,000		**230,000**		**250,000**		**277,000**		**279,000**		57,200		80,000		66,200		41,900		44,600		36,300		
Manganese	ug/L	88	636	4660	124		20.4		21.6		8.4	J	4.7	B	6.3	J	30.4		-	-	2.2	J	2.2	J	-	-	2	J	
Mercury	ug/L	1.1	NE	0.035	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	ug/L	73	8.6	17.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**13.8**	J	3.5	J	**9.2**	J	4.9	B	
Potassium	ug/L	NE	116,000	67200	38,500		37,200		62,700	J	67,200		64,400	J	67,000		49,500		26,000		43,800		41,500	J	36,500	J	38,900		
Selenium	ug/L	18	NE	2.1	-	-	-	-	-	-	-	-	2.1	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	ug/L	NE	1,390,000	685000	355,000	j	386,000		545,000		583,000		662,000		685,000		120,000		129,000		75,400		88,400		74,300	J	80,500		
Thallium	ug/L	0.24	NE	6.7	-	-	-	-	-	-	6.7	B	-	-	-	-	-	-	-	-	-	-	-	-	5.1	B	-	-	
Vanadium	ug/L	3.7	NE	8.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc	ug/L	1,095	507	173	49.9		30.8	B	-	-	5.7	J	24.7	J	11.5	J	62.3		29.5	B	144		31.3		65.9		96.6		

Detected Constituents in Bedrock Monitoring Wells
Downgradient Perimeter Wells
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

					BED-MW17												BED-MW19											
Location Code:																												
Sample Number:					5930		5935		BD3021		CB3014		DF3000		DH3000		5950		5955		BD3025		CB3013		DF3001		DH3001	
Sample Date:					20-Nov-97		29-May-98		3-Oct-01		11-Apr-02		6-May-04		26-Aug-04		14-Nov-97		16-May-98		4-Oct-01		4-Apr-02		5-May-04		25-Aug-04	
Low-Flow Sampled:					No		No		Yes		Yes		Yes		Yes		No		No		Yes		Yes		Yes		Yes	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Filtered																												
Aluminum	ug/L	3,650	309	352	-	-	-	-	77.8	B	53.2	J	82.4	B	95.3	B	-	-	-	-	86	B	66.6	B	45.2	J	50.3	B
Arsenic	ug/L	0.045	7.4	13.6	-	-	13.1		2.7	J	4	J	3.8	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Barium	ug/L	255	11,800	1910	1,100		871		911		1,070		1,910		1,810		1,520		1,740		1,080		852		1,050		1,140	
Beryllium	ug/L	7.3	NE	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	ug/L	NE	316,000	427000	263,000		289,000	J	252,000		273,000		**326,000**		**316,000**		220,000		162,000		202,000		109,000		170,000		181,000	
Chromium	ug/L	11	NE	1.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cobalt	ug/L	73	12.1	3.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Copper	ug/L	146	19.8	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	J
Iron	ug/L	1095	1,550	640	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lead	ug/L	15	NE	6.8	-	-	6.8		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magnesium	ug/L	NE	217,000	287000	213,000		**231,000**	J	**235,000**		**243,000**		**287,000**		**284,000**		65,100		77,900		81,000		44,000		44,800		36,500	
Manganese	ug/L	88	636	1460	-	-	-	-	9.8	J	10.2	J	4.4	B	5	J	-	-	16.3		4	J	2.5	J	2.2	J	2.8	J
Mercury	ug/L	1.1	NE	0.46	-	-	-	-	-	-	-	-	0.46		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	ug/L	73	8.6	7.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.9	J	4.3	J	7.9	J	5.1	B
Potassium	ug/L	NE	116,000	68500	45,400		43,100		62,600		66,900		66,700	J	68,500	J	46,200		24,800		42,100		42,900	J	36,500	J	39,300	J
Selenium	ug/L	18	NE	1.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.6	B	1.8	J
Sodium	ug/L	NE	1,390,000	699000	419,000		431,000		549,000		582,000		684,000		699,000		125,000		127,000		94,900		92,900		75,400	J	80,800	
Thallium	ug/L	0.24	NE	3.3	-	-	-	-	-	-	-	-	2.9	B	3.3	J	-	-	-	-	-	-	-	-	4.4	B	2.6	J
Vanadium	ug/L	3.7	NE	4.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc	ug/L	1,095	507	57.4	33.3	J	73.4	B	-	-	10	J	8.1	J	6.1	J	57.4		24.4	B	5.2	J	3.1	J	-	-	43.6	
Water Quality Parameters																												
Alkalinity	ug/L	NE	NE	1050000	830,000		930,000		741,000	J	874,000		789,000		855,000		310,000		750,000		707,000	J	302,000		1,050,000	J	634,000	
Chloride	ug/L	NE	NE	2790000	1,800,000		1,600,000		2,420,000		2,210,000		2,460,000		2,790,000		330,000		280,000		248,000	J	373,000	J	229,000		396,000	
Cyanide, total	ug/L	73	NE	320	320		-	-	-	-	-	-	-	-	-	-	-	-	16		-	-	-	-	-	-	-	-
Hardness	ug/L	NE	NE	2030000	1,800,000		1,300,000		1,680,000		1,330,000		2,030,000		1,940,000		1,700,000		750,000		905,000		424,000		662,000		584,000	
Sulfate	ug/L	NE	NE	1280000	59,000		80,000		53,600		42,700		-	-	-	-	14,000		49,000		27,700	J	32,200		21,000		29,500	
Total dissolved solids	ug/L	NE	NE	6040000	3,000,000		2,900,000		2,680,000		3,020,000		6,040,000		4,690,000		1,200,000		590,000		1,110,000		651,000		887,000		836,000	
Total organic carbon	ug/L	NE	NE	16000	1,200		3,000		5,700		5,300		6,400		1,000		16,000		9,000		8,600		5,900		5,600		5,600	
Total suspended solids	ug/L	NE	NE	499000	-	-	4,000		53,000		18,000		9,000		22,000		41,000		5,000		199,000		44,000		32,000		79,000	
Turbidity	NTU	NE	NE	1470			213		57.4	J	9.2		6.3		36.4						662	J	164		220		118	

Detected Constituents in Bedrock Monitoring Wells
Downgradient Perimeter Wells
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:	BED-MW22								BED-MW24																	
					Sample Number:	BD3027		CB3009		DF3002		DH3002		BD3029		CA3001		CB3008		CC3004		CD3004		DA3004		DC3002		DD3003		DE3002		DG3002	
					Sample Date:	8-Oct-01		4-Apr-02		5-May-04		26-Aug-04		9-Oct-01		17-Jan-02		3-Apr-02		12-Jul-02		19-Oct-02		9-Apr-03		17-Sep-03		11-Dec-03		10-Mar-04		16-Jun-04	
					Low-Flow Sampled:	Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes		No		Yes		Yes		Yes		Yes		Yes	
Parameter	Units	RBSC	BSC	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																																	
Amino-4,6-dinitrotoluene, 2-	ug/L	0.73	NE	0.19		-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrobenzene, 1,3-	ug/L	0.37	NE	0.22		-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	ug/L	0.099	NE	1.5		-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	ug/L	0.099	NE	1.4		-	-	-	-	-	-	-	-	-	-			0.43		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrobenzene	ug/L	0.34	NE	0.34		-	-	-	-	-	-	-	-	-	-			0.33		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	ug/L	0.049	NE	0.55		-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 3-	ug/L	12.2	NE	0.62		-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 4-	ug/L	0.66	NE	0.23		-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RDX	ug/L	0.61	NE	0.22		-	-	-	-	-	-	-	-	-	-			0.22	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	0.27		0.27		-	-	-	-	-	-	-	-			-	-	-	-	-	-	0.081	J	-	-	-	-	-	-	-	-
Volatiles																																	
Acetone	ug/L	548	NE	310		4.8	B	-	-	140	B	-	-	120	J	-	-	170	J	60		-	-	88	B	-	-	-	-	-	-	-	-
Benzene	ug/L	0.35	2.4	130		0.6	J	-	-	-	-	0.21	J	**60**		**91**		**110**		**14**	J	**9.3**	J	**36**	J	**32**		**36**		**22**		**100**	
Bromomethane	ug/L	0.87	NE	7.9		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Butanone, 2-	ug/L	697	NE	130		-	-	-	-	-	-	-	-	-	-	8.1		17	J	12	B	-	-	-	-	-	-	-	-	-	-	-	-
Carbon disulfide	ug/L	104	NE	40		-	-	-	-	-	-	0.19	B	-	-	1.2		0.59	J	-	-	29		-	-	-	-	3.4	J	9.1	J	7.3	J
Chlorobenzene	ug/L	10.6	NE	11		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloromethane	ug/L	16	NE	1.3		-	-	-	-	-	-	-	-	-	-	1.3	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ethylbenzene	ug/L	134	0.87	120		**1**	J	-	-	-	-	-	-	**19**	J	**32**		**38**		**8**	J	**4.8**	J	**15**	J	**13**	J	**10**		**9**	J	**45**	
Methylene chloride	ug/L	4.3	NE	98		0.63	B	11	J	5.8	J	-	-	21	J	-	-	-	-	-	-	-	-	14	J	-	-	-	-	-	-	-	-
Toluene	ug/L	72	1.7	180		1.2	J	-	-	-	-	0.11	B	**58**		**90**		**100**		**17**	J	**14**		**43**	J	**37**		**31**		**14**		**57**	
Xylenes, total	ug/L	21	5.5	560		**6.4**		-	-	-	-	-	-	**110**		**180**		**210**		**55**		**23**		**82**		**67**		**50**	J	**48**	J	**240**	
Semivolatiles																																	
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	9.7		-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.6	B	-	-	-	-	-	-	-	-	-	-	-	-
Chrysene	ug/L	9.2	NE	1		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dimethylphenol, 2,4-	ug/L	73	NE	5.1		-	-	-	-	-	-	-	-	1.1	J	-	-	-	-	0.76	J	-	-	-	-	-	-	-	-	-	-	-	-
Methylnaphthalene, 2-	ug/L	12	NE	24		1.7	J	-	-	-	-	-	-	3.6	J	5.6		4.6	J	10	J	1.4	J	5.5	J	4	J	2.9	J	-	-	2	J
Methylphenol, 2-	ug/L	180	NE	1.1		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methylphenol, 4-	ug/L	18	NE	2		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Naphthalene	ug/L	0.62	NE	18		-	-	-	-	-	-	-	-	2.9	J	7		4	J	8.7	J	-	-	4.6	J	3.5	J	2.3	J	-	-	1.9	J
Phenanthrene	ug/L	18	NE	1.4		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phenol	ug/L	1,095	NE	55		-	-	-	-	-	-	-	-	1.4	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Metals - Unfiltered																																	
Aluminum	ug/L	3,650	309	3650		**353**	J	71.3	J	**1,480**	J	**717**	J	37.8	J	77.7	B	35.7	J	**1,150**		115	J	141	B	78	B	194	J	61.5	B	78.4	J
Arsenic	ug/L	0.045	7.4	17.7		-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.3		-	-	-	-	-	-	-	-	-	-	-	-
Barium	ug/L	255	11,800	1860		649		620		732		695		932		938		1,160		680		1,080		1,140		690		642		489		535	
Beryllium	ug/L	7.3	NE	NA		-	-	-	-	-	-	-	-	-	-	1.2	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	ug/L	1.8	NE	1.1		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	ug/L	NE	316,000	462000		122,000		123,000		134,000		118,000		158,000		157,000		161,000		**346,000**		159,000		167,000		168,000		151,000		131,000		125,000	
Chromium	ug/L	11	NE	24.4		-	-	-	-	-	-	-	-	-	-	-	-	-	-	9.4		-	-	-	-	-	-	-	-	-	-	-	-
Cobalt	ug/L	73	12.1	10.9		-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.9		-	-	1.2	J	-	-	7.7	J	-	-	-	-
Copper	ug/L	146	19.8	99		-	-	-	-	-	-	-	-	-	-	-	-	-	-	8.6		-	-	-	-	-	-	-	-	18.5	J	-	-
Iron	ug/L	1095	1,550	257000		284		43.2	J	**2,220**	J	593		48.3	J	72.7	B	-	-	**13,400**		403		-	-	-	-	-	-	-	-	-	-
Lead	ug/L	15	NE	6.8		-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.2	B	-	-	-	-	-	-	-	-	-	-	-	-
Magnesium	ug/L	NE	217,000	279000		35,900		35,800		39,500		36,600		78,500		78,900		82,900		88,800		75,400		84,500		80,600		70,800		69,500		69,900	
Manganese	ug/L	88	636	4660		38.1		45.1		91.8		57.5		24.8		19.2		14.8	J	420		23.6		14.1	J	27.4		25.8		26.3		19.6	
Mercury	ug/L	1.1	NE	0.035		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.035	J	-	-	-	-	-	-	-	-
Nickel	ug/L	73	8.6	17.7		-	-	-	-	2.8	J	3.1	B	-	-	-	-	-	-	7.9		-	-	-	-	-	-	-	-	-	-	-	-
Potassium	ug/L	NE	116,000	67200		4,340	J	2,500	J	4,780	J	3,980	J	32,100		46,600		47,600	J	41,600		22,900	J	26,400	J	24,100	J	24,300		23,700	J	21,900	J
Selenium	ug/L	18	NE	2.1		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	ug/L	NE	1,390,000	685000		19,300		19,200		20,400	J	18,500		90,800		90,600		106,000		101,000		91,800		104,000		80,400		67,000		61,800		64,400	
Thallium	ug/L	0.24	NE	6.7		-	-	-	-	4.5	B	3.3	J	-	-	4.2	B	-	-	-	-	-	-	-	-	3.8	B	2.5	B	-	-	-	-
Vanadium	ug/L	3.7	NE	8.6		-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.1		-	-	-	-	-	-	-	-	-	-	-	-
Zinc	ug/L	1,095	507	173		-	-	20.2		22		4.5	J	-	-	-	-	-	-	28.4		3.9	J	1.2	B	-	-	9.3	J	6.4	J	-	-

Detected Constituents in Bedrock Monitoring Wells
Downgradient Perimeter Wells
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

					Location Code:		BED-MW22						BED-MW24																	
					Sample Number:		BD3027		CB3009		DF3002		DH3002		BD3029		CA3001		CB3008		CC3004		CD3004		DA3004		DC3002		DD3003		DE3002		DG3002	
					Sample Date:		8-Oct-01		4-Apr-02		5-May-04		26-Aug-04		9-Oct-01		17-Jan-02		3-Apr-02		12-Jul-02		19-Oct-02		9-Apr-03		17-Sep-03		11-Dec-03		10-Mar-04		16-Jun-04	
					Low-Flow Sampled:		Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes		No		Yes		Yes		Yes		Yes	
Parameter	Units	RBSC	BSC	MDC			Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Filtered																																
Aluminum	ug/L	3,650	309	352	69.3	B	64.5	B	41.4	J	63.6	B	55.1	B	89.6	B	74	B	110	B	87	B	128	B	69.9	B	50.8	B	56.9	B	84	J
Arsenic	ug/L	0.045	7.4	13.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Barium	ug/L	255	11,800	1910	634		617		730		700		942		962		1,170		670		1,140		1,160		689		669		489		590	
Beryllium	ug/L	7.3	NE	NA	-	-	-	-	-	-	-	-	-	-	1.5	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	ug/L	NE	316,000	427000	117,000		121,000		118,000		117,000		159,000		158,000		161,000		147,000		160,000		168,000		169,000		152,000	J	126,000		135,000	
Chromium	ug/L	11	NE	1.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cobalt	ug/L	73	12.1	3.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.4	J	1.5	J	3.7	J	-	-	-	-	-	-
Copper	ug/L	146	19.8	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iron	ug/L	1095	1,550	640	-	-	-	-	-	-	-	-	-	-	40.7	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lead	ug/L	15	NE	6.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magnesium	ug/L	NE	217,000	287000	34,700		35,700		37,900		37,000		78,500		78,800		82,800		79,400		77,600		83,600		79,900		71,100		67,300		72,000	
Manganese	ug/L	88	636	1460	34.3		43.3		47.4		47		22.1		18.7		16.6		44.2		15.5		13.7	J	35		25.5		26		22.6	
Mercury	ug/L	1.1	NE	0.46	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	ug/L	73	8.6	7.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potassium	ug/L	NE	116,000	68500	4,080	J	2,470	J	4,300	J	3,730	J	30,700	J	43,300		44,400	J	38,300		24,000	J	25,800	J	23,200	J	24,500	J	23,900	J	22,300	J
Selenium	ug/L	18	NE	1.8	-	-	-	-	1.7	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	ug/L	NE	1,390,000	699000	18,700		19,100		20,600	J	18,700		90,500		87,800	J	105,000		98,500		92,500		105,000		79,600		67,900	J	61,200		66,400	
Thallium	ug/L	0.24	NE	3.3	-	-	-	-	5.3	B	-	-	-	-	4.1	B	-	-	-	-	-	-	-	-	-	-	-	-	2.8	J	-	-
Vanadium	ug/L	3.7	NE	4.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc	ug/L	1,095	507	57.4	-	-	12.7	J	-	-	4.2	J	-	-	-	-	3.4	J	-	-	5.7	B	0.97	J	2.9	B	-	-	-	-	4.2	B
Water Quality Parameters																																
Alkalinity	ug/L	NE	NE	1050000	410,000	J	416,000		545,000	J	467,000		697,000	J	810,000		157,000		979,000		757,000		803,000		846,000		726,000		700,000		769,000	
Chloride	ug/L	NE	NE	2790000	43,400		86,300	J	47,100		33,400		149,000		140,000		175,000	J	155,000		126,000		105,000		98,000		48,700		79,700		79,000	
Cyanide, total	ug/L	73	NE	320	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	B	-	-	-	-	-	-	-	-
Hardness	ug/L	NE	NE	2030000	412,000		388,000		466,000		424,000		566,000		710,000		715,000		1,370,000		808,000		820,000		761,000		130,000		670,000		584,000	
Sulfate	ug/L	NE	NE	1280000	27,100		-	-	11,300		-	-	21,400		150,000		23,600		32,300		-	-	20,300		24,600		32,600		40,500		25,500	
Total dissolved solids	ug/L	NE	NE	6040000	489,000		476,000		513,000		519,000		948,000		1,000,000		2,200,000		1,020,000		990,000		949,000		988,000		779,000		755,000		824,000	
Total organic carbon	ug/L	NE	NE	16000	1,700		2,200		2,000		1,800		3,000		1,800		2,400		3,700		3,700		2,400		1,900		1,600		1,500		-	-
Total suspended solids	ug/L	NE	NE	499000	9,000		4,000		49,000		31,000		-	-	-	-	14,000		124,000		62,000		5,000		-	-	4,000		-	-	-	-
Turbidity	NTU	NE	NE	1470	129	J	76.4		192		252		266		61		116		742		49.6		68.8		138		74		23.5		56.6	

					Location Code:	BED-MW27						BED-MW30				BED-MW33				PT-5912	
					Sample Number:	BD3032		CB3012		CD3009		DF3003		DH3003		DF3004		DH3004		DH3007	
					Sample Date:	9-Oct-01		9-Apr-02		18-Oct-02		7-May-04		25-Aug-04		7-May-04		27-Aug-04		27-Aug-04	
					Low-Flow Sampled:	No		No		No		Yes		Yes		No		No		Yes	
Parameter	Units	RBSC	BSC	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																					
Amino-4,6-dinitrotoluene, 2-	ug/L	0.73	NE	0.19		-	-	-	-	0.19	J	-	-	-	-	-	-	-	-	-	-
Dinitrobenzene, 1,3-	ug/L	0.37	NE	0.22		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,4-	ug/L	0.099	NE	1.5		1.5		0.58		0.98		-	-	-	-	-	-	-	-	-	-
Dinitrotoluene, 2,6-	ug/L	0.099	NE	1.4		1.1		0.59		1.4		-	-	-	-	-	-	-	-	-	-
Nitrobenzene	ug/L	0.34	NE	0.34		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	ug/L	0.049	NE	0.55		-	-	-	-	-	-	-	-	0.16	J	-	-	-	-	-	-
Nitrotoluene, 3-	ug/L	12.2	NE	0.62		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 4-	ug/L	0.66	NE	0.23		-	-	-	-	-	-	-	-	0.23		-	-	-	-	-	-
RDX	ug/L	0.61	NE	0.22		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	0.27		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Volatiles																					
Acetone	ug/L	548	NE	310		210	J	100	J	-	-	230		-	-	290	J	310	J	-	-
Benzene	ug/L	0.35	2.4	130		**130**	J	**70**	J	**60**	J	**2.4**	J	3.4	J	**17**	J	**18**	J	7.6	
Bromomethane	ug/L	0.87	NE	7.9		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Butanone, 2-	ug/L	697	NE	130		-	-	-	-	-	-	-	-	-	-	73	J	-	-	-	-
Carbon disulfide	ug/L	104	NE	40		-	-	-	-	11	J	4.2	J	3.7	J	5.9	J	17	J	0.96	J
Chlorobenzene	ug/L	10.6	NE	11		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloromethane	ug/L	16	NE	1.3		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ethylbenzene	ug/L	134	0.87	120		**100**	J	**83**	J	**76**	J	**7.5**		**9.1**		**15**	J	**14**	J	**1.7**	J
Methylene chloride	ug/L	4.3	NE	98		98	J	18	J	-	-	-	-	-	-	24	J	-	-	-	-
Toluene	ug/L	72	1.7	180		**120**	J	**73**	J	**75**	J	**7.2**		**10**		**15**	J	**9.5**	J	**3**	J
Xylenes, total	ug/L	21	5.5	560		**560**		**460**		**370**		**47**		**56**		**84**		**56**		3.6	J
Semivolatiles																					
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	9.7		2.9	J	-	-	-	-	-	-	-	-					-	-
Chrysene	ug/L	9.2	NE	1		-	-	-	-	-	-	-	-	-	-					-	-
Dimethylphenol, 2,4-	ug/L	73	NE	5.1		3.1	J	5.1	J	4.2	J	-	-	-	-					-	-
Methylnaphthalene, 2-	ug/L	12	NE	24		24		18		19		2.2	J	6.2	J					-	-
Methylphenol, 2-	ug/L	180	NE	1.1		-	-	0.89	J	-	-	-	-	-	-					-	-
Methylphenol, 4-	ug/L	18	NE	2		-	-	1.1	J	-	-	-	-	-	-					-	-
Naphthalene	ug/L	0.62	NE	18		17		14		12		-	-	3.8	J					-	-
Phenanthrene	ug/L	18	NE	1.4		1.4	J	0.75	J	-	-	-	-	-	-					-	-
Phenol	ug/L	1,095	NE	55		1.3	J	2	J	1.2	J	-	-	-	-					-	-
Metals - Unfiltered																					
Aluminum	ug/L	3,650	309	3650		152	J	232	B	105	J	**481**		**377**	J	**3,650**		**567**	J	**443**	J
Arsenic	ug/L	0.045	7.4	17.7		4	B	-	-	-	-	**10.2**	B	6.1	J	**17.7**		**11.9**		-	-
Barium	ug/L	255	11,800	1860		133	J	93.8	J	86.2	J	165	J	187	J	278		161	J	187	J
Beryllium	ug/L	7.3	NE	NA		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	ug/L	1.8	NE	1.1		-	-	1.1	J	0.25	J	-	-	-	-	-	-	-	-	-	-
Calcium	ug/L	NE	316,000	462000		**462,000**		**370,000**		**371,000**		124,000		140,000		162,000		134,000		95,900	
Chromium	ug/L	11	NE	24.4		7.1	J	24.4		1.6	J	-	-	-	-	11.6		-	-	-	-
Cobalt	ug/L	73	12.1	10.9		3.1	J	10.9	J	1.6	J	-	-	-	-	4.2	J	-	-	-	-
Copper	ug/L	146	19.8	99		13.3	J	6.3	B	-	-	-	-	-	-	13.1	J	-	-	-	-
Iron	ug/L	1095	1,550	257000		**43,100**		**257,000**	J	**31,600**		251		175		**4,920**		**2,320**		**1,680**	
Lead	ug/L	15	NE	6.8		-	-	-	-	-	-	-	-	-	-	1.7	J	-	-	-	-
Magnesium	ug/L	NE	217,000	279000		166,000		165,000		178,000		61,900		69,600		117,000		108,000		31,500	
Manganese	ug/L	88	636	4660		**680**		**4,660**		**1,250**		46.9		27.9		164		80.3		95	
Mercury	ug/L	1.1	NE	0.035		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	ug/L	73	8.6	17.7		**12.4**	J	**17.7**	J	6.4	J	-	-	-	-	**12.7**	J	-	-	-	-
Potassium	ug/L	NE	116,000	67200		41,500		30,400		27,600	J	15,400		15,900		39,100		26,800		1,460	J
Selenium	ug/L	18	NE	2.1		-	-	-	-	-	-	-	-	-	-	1.6	J	-	-	1.8	B
Sodium	ug/L	NE	1,390,000	685000		96,000		98,100		109,000		72,500		83,600		278,000		187,000		9,720	
Thallium	ug/L	0.24	NE	6.7		-	-	-	-	-	-	3.9	B	-	-	3	B	3.8	J	-	-
Vanadium	ug/L	3.7	NE	8.6		-	-	7.8	J	-	-	-	-	-	-	8.6	J	5.1	J	-	-
Zinc	ug/L	1,095	507	173		21.6		18.5	J	12.3	J	80.6		9.5	J	69.8		12.1	J	173	

					Location Code:	BED-MW27					BED-MW30				BED-MW33				PT-5912	
					Sample Number:	BD3032		CB3012		CD3009	DF3003		DH3003		DF3004		DH3004		DH3007	
					Sample Date:	9-Oct-01		9-Apr-02		18-Oct-02	7-May-04		25-Aug-04		7-May-04		27-Aug-04		27-Aug-04	
					Low-Flow Sampled:	No		No		No	Yes		Yes		No		No		Yes	
Parameter	Units	RBSC	BSC	MDC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Metals - Filtered																					
Aluminum	ug/L	3,650	309	352		58	B	59	J	76.3	B	91.6	B	**352**		121	B	118	B	83.4	B
Arsenic	ug/L	0.045	7.4	13.6		-	-	5.2	J	-	-	**8.7**	B	5.4	B	**13.6**		**12**		-	-
Barium	ug/L	255	11,800	1910		126	J	83.6	J	81.4	J	170	J	187	J	259		148	J	180	J
Beryllium	ug/L	7.3	NE	NA		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	ug/L	NE	316,000	427000		**427,000**		**378,000**		**364,000**		127,000		140,000		153,000		131,000		94,900	
Chromium	ug/L	11	NE	1.4		-	-	1.4	J	-	-	-	-	-	-	-	-	-	-	-	-
Cobalt	ug/L	73	12.1	3.7		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Copper	ug/L	146	19.8	13		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iron	ug/L	1095	1,550	640		144		189	J	159		-	-	190		120		640		77.9	J
Lead	ug/L	15	NE	6.8		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magnesium	ug/L	NE	217,000	287000		162,000		168,000		177,000		63,600		69,800		116,000		108,000		31,300	
Manganese	ug/L	88	636	1460		141		**1,460**		**816**		41.4		28.5		129		77.8		92.2	
Mercury	ug/L	1.1	NE	0.46		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	ug/L	73	8.6	7.9		2	J	-	-	-	-	3.2	J	-	-	4.2	J	-	-	-	-
Potassium	ug/L	NE	116,000	68500		42,200	J	32,100		27,800	J	15,500		15,700	J	38,200		27,200	J	1,340	J
Selenium	ug/L	18	NE	1.8		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	ug/L	NE	1,390,000	699000		95,500		103,000		107,000		73,500		83,700		278,000		187,000		9,630	
Thallium	ug/L	0.24	NE	3.3		-	-	-	-	-	-	3.5	B	4	J	3	B	-	-	-	-
Vanadium	ug/L	3.7	NE	4.2		-	-	-	-	-	-	-	-	-	-	-	-	4.2	J	-	-
Zinc	ug/L	1,095	507	57.4		-	-	3	J	2.8	B	13.4	J	10.9	J	5.4	J	4.7	J	4.4	J
Water Quality Parameters																					
Alkalinity	ug/L	NE	NE	1050000		473,000	J	488,000		493,000		586,000		646,000						333,000	
Chloride	ug/L	NE	NE	2790000		260,000		194,000		206,000		104,000		101,000						14,900	
Cyanide, total	ug/L	73	NE	320		-	-	-	-	-	-	-	-	-	-					-	-
Hardness	ug/L	NE	NE	2030000		1,910,000		1,750,000		1,660,000		580,000		564,000						350,000	
Sulfate	ug/L	NE	NE	1280000		1,280,000		868,000		1,110,000		32,600		52,500						70,500	
Total dissolved solids	ug/L	NE	NE	6040000		2,560,000		2,280,000		2,210,000		739,000		857,000						452,000	
Total organic carbon	ug/L	NE	NE	16000		3,700		3,500		2,600		10,500		8,900						2,900	
Total suspended solids	ug/L	NE	NE	499000		200,000		499,000		65,000		11,000		34,000						21,000	
Turbidity	NTU	NE	NE	1470		188		1,470		67.4		98.5		90.5						37	

Shaded cell indicates value is greater than the RBSC.
Bold text indicates value is greater than the BSC.
RBSC - Values reflect an incremental lifetime cancer risk (ILCR) of 1E-6 or a noncancer hazard quotient (HQ) of 0.1. For chemicals that exhibit both cancer and noncancer effects, whichever type of effect results in a lower concentration (using an ILCR of 1E-6 and an HQ of 0.1), that concentration is selected as the RBSC.
MDC - Maximum detected concentration for the AOC ("B" qualified data not included).
BSC - Background screening concentration.

"-" - Not detected.
µg/L - Micrograms per liter.
NA - Not applicable; detection is the result of blank contamination.
NE - Not established (RBSCs), not evaluated (BSCs).
NTU - Nephelometric turbidity unit.

Validation Qualifiers (VQ)
J - The analyte was positively identified; the reported value is estimated.
B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.

Detected Constituents in Bedrock Monitoring Wells
Background Monitoring Wells
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

			BG8-BEDGW-001																						IT-MW01									
Location Code:																																		
Sample Number:			5410		5415		BD3007		CA3006		CB3007		CC3001		CD3001		DA3001		DC3000		DD3001		DE3000		DG3000		5530		5535/5535R		CC3009		CD3002		DA3002	
Sample Date:			17-Nov-97		15-May-98		27-Sep-01		16-Jan-02		3-Apr-02		12-Jul-02		18-Oct-02		10-Apr-03		18-Sep-03		10-Dec-03		11-Mar-04		16-Jun-04		19-Nov-97		16-May-98		10-Jul-02		16-Oct-02		9-Apr-03	
Low-Flow Sampled:			No		No		Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes		No		No		No		No		No	
Parameter	Units	MDC	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual
Explosives																																				
Amino-2,6-dinitrotoluene, 4-	ug/L	0.19	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrobenzene	ug/L	0.12	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RDX	ug/L	0.17	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Volatiles																																				
Acetone	ug/L	17	-	-	-	-	-	-	-	-	3.5	J	2.6	B	3.4	J	1.9	B	-	-	-	-	-	-	5.6	B	-	-	-	-	3.5	B	-	-	1.5	B
Benzene	ug/L	3.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bromomethane	ug/L	0.27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Butanone, 2-	ug/L	9.8	-	-	-	-	-	-	-	-	-	-	3.2	B	-	-	0.53	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.7	B	-	-
Carbon disulfide	ug/L	13	0.65	J	-	-	-	-	-	-	-	-	-	-	0.43	J	-	-	-	-	0.3	J	0.19	J	0.16	J	-	-	-	-	-	-	-	-	0.1	J
Chloroform	ug/L	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloromethane	ug/L	0.97	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.26	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ethylbenzene	ug/L	0.87	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methyl-2-pentanone, 4-	ug/L	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methylene chloride	ug/L	NA	0.37	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.33	B	0.58	B	0.19	B	-	-	-	-
Toluene	ug/L	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	22	-	-	-	-	-	-	-
Trichloroethene	ug/L	0.59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Xylenes, total	ug/L	5.5	0.38	B	-	-	-	-	-	-	1		-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.31	B	-	-	-	-	-	-	-	-
Semivolatiles																																				
Bis(2-ethylhexyl)phthalate	ug/L	5.4	1.7	J	4	B	-	-	-	-	-	-	4.3	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diethyl phthalate	ug/L	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.5	B
Methylnaphthalene, 2-	ug/L	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Metals - Unfiltered																																				
Aluminum	ug/L	9,020	9,020		307		51.6	B	78.7	B	31.5	J	65.2	B	83.6	B	141	B	101	B	-	-	-	-	71.8	J	-	-	-	-	117	J	10,200	J	1,400	
Antimony	ug/L	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	J	-	-	-	-
Arsenic	ug/L	17.6	17.6		-	-	-	-	-	-	-	-	3.6	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	52.6		-	-
Barium	ug/L	26900	520		-	-	285		68	J	29.9	J	229		279		43.5	J	292		73.2	J	25.8	J	27.6	J	-	-	-	-	75.9	J	139	J	60.7	J
Beryllium	ug/L	1.2	-	-	-	-	-	-	1.2	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.6	J	0.84	B		
Cadmium	ug/L	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.5	J	0.38	J		
Calcium	ug/L	2290000	161,000		57,700		124,000	J	91,300		81,500		134,000		122,000		66,600		131,000		86,200		66,800		81,800		46,400		47,900		39,400		56,300		44,400	
Chromium	ug/L	18.2	18.2		-	-	1.4	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14.1		-	-
Cobalt	ug/L	12.1	-	-	-	-	-	-	-	-	-	-	12.1	J	-	-	1	J	-	-	-	-	-	-	-	-	-	-	-	-	7.5	J	14	J	35.8	J
Copper	ug/L	59.5	59.5		-	-	-	-	-	-	3.3	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9.1	J	72.2		48.8	
Iron	ug/L	22600	22,600		1,230	J	204		118	B	38.2	J	1,490		74.5	J	-	-	218		908		-	-	-	-	1,320		2,200	J	563		52,100		3,530	
Lead	ug/L	26.3	26.3		6.8		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	101		8.8	
Magnesium	ug/L	1040000	79,500		19,300		77,300		38,400		31,700		73,500		77,000		29,000		81,900		37,100		25,000		29,000		17,500		16,300		15,900		19,500		19,800	
Manganese	ug/L	2240	2,240		130		71.6		107		29		688		51.1		35		63.8		166		3.6	J	40.9		323		348		292		490		396	
Mercury	ug/L	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.45		-	-	-	-	-	-	-	-	-	-
Nickel	ug/L	8.6	-	-	-	-	-	-	-	-	6.8	J	8.6	J	-	-	8.6	J	-	-	4.8	J	3.6	B	-	-	-	-	-	-	15	J	35	J	74.9	
Potassium	ug/L	174000	32,900		-	-	41,100		13,300		2,530	J	30,500		41,200	J	5,290	J	42,700	J	7,630		2,530	J	4,310	J	6,160		5,560		6,780	J	6,480		7,450	J
Selenium	ug/L	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5		-	-
Sodium	ug/L	9130000	399,000		-	-	459,000		93,200		23,600		395,000		462,000		48,900		471,000		86,300		21,300		13,300		22,800		22,000		19,400		17,800		19,200	
Thallium	ug/L	7.1	-	-	-	-	-	-	3.3	B	-	-	-	-	-	-	-	-	3.8	B	2.5	B	3.1	B	4	B	-	-	-	-	-	-	5.7	J	4	B
Vanadium	ug/L	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	35.9	J	-	-
Zinc	ug/L	612	126		49.7	B	-	-	12.6	J	15.6	J	10		0.83	J	2.5	B	-	-	30.1		4.3	B	16.6	B	51.6		149		34.3		124	J	74.8	
Metals - Filtered																																				
Aluminum	ug/L	152	-	-	-	-	56.6	B	83.6	B	52	B	113	B	86.7	B	113	B	75	B	-	-	61.6	B	74.3	J	-	-	276		62.2	B	71.6	B	1,470	
Arsenic	ug/L	6.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Barium	ug/L	26200	366		-	-	279		83.6	J	30.6	J	236		285		47.6	J	292		81.8	J	27.8	J	29.8	J	-	-	-	-	82.5	J	89.1	J	52.6	J
Beryllium	ug/L	NA	-	-	-	-	-	-	1.5	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.2	B
Cadmium	ug/L	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.2	J	-	-	-	-	-	-	-	-	-	-	-	-	0.48	J
Calcium	ug/L	2570000	121,000	J	92,100		125,000		98,300		82,900		133,000		127,000		70,000		131,000		89,900	J	66,100		81,300		44,900		53,100		39,300		57,700		47,400	
Cobalt	ug/L	23.8	-	-	-	-	-	-	-	-	-	-	8.2	J	-	-	2.5	J	-	-	-	-	-	-	-	-	-	-	-	-	10.3	J	4.9	J	34.8	J
Copper	ug/L	26.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.8	J	3.7	J	49.2	
Iron	ug/L	6180	563		-	-	169		216		-	-	1,160		53.4	J	-	-	195		856		-	-	-	-	1,090		1,970		745		1,840		2,480	
Lead	ug/L	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8.7	
Magnesium	ug/L	1090000	72,400		41,000		77,600		43,300		32,300		76,000		79,800		30,400		81,900		40,000		24,800		29,400		17,000		19,500		14,600		20,300		20,900	
Manganese	ug/L	1300	1,300		658		73.5		117		23.6		728		52.2		73.8		64		164		3.6	J	47.5		331		395		326		424		360	
Mercury	ug/L	0.24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	ug/L	9.8	-	-	-	-	-	-	-	-	7	J	8.5	J	-	-	9.8	J	-	-	4.8	J	4.8	J	2.8	J	-	-	-	-	26.2	J	10.5	J	82.9	
Potassium	ug/L	173000	32,000		14,400		40,700		16,700		2,470	J	31,000		43,200	J	5,930	J	42,100	J	9,690	J	2,620	J	4,770	J	6,180		6,390		6,390	J	6,400	J	7,270	J
Sodium	ug/L	9110000	398,000		139,000		459,000		121,000	J	24,400		392,000		472,000		62,800		472,000		112,000	J	22,400		17,600		22,200		25,100		19,200		19,400		18,400	
Thallium	ug/L	6.4	-	-	-	-	-	-	4.6	B	-	-	-	-	-	-	6.9	B	4.7	B	2.7	B	5.1	J	-	-	-	-	-	-	-	-	-	-	4.9	B
Zinc	ug/L	673	-	-	44.9	B	-	-	13.5	J	17.3	J	7.3	J	1.2	B	5.8	J	-	-	35.9		3.9	B	17.5	B	46.9		47.5	B	124		13.1	J	73.8	
Water Quality Parameters																																				
Alkalinity	ug/L	481000	350,000		180,000		357,000	J	200,000		157,000		367,000		332,000		168,000		355,000		255,000		189,000		317,000		360,000		110,000		90,000		209,000		9,900	
Chloride	ug/L	34600000	780,000		34,000		932,000		78,000		63,200	J	896,000		999,000		77,700		1,000,000		132,000		24,500		9,600		4,000		3,000		3,400		9,900		3,000	
Cyanide, total	ug/L	NA			-		-		-		-		-		-		-	-	-	-	-	-	-	-	-	-									-	-
Hardness	ug/L	20000000	1,000,000		340,000		719,000		380,000		314,000		647,000		687,000		320,000		710,000		313,000		340,000		312,000		420,000		200,000		144,000		263,000		196,000	
Nitrate	ug/L	22000			7,300		-	-	22,000		10,400		-	-	-	-	8,600		-	-	580		16,000	R	1,500						190		-	-	-	-
Nitrate-Nitrite	ug/L	200	200																								-	-								
Sulfate	ug/L	514000	70,000		45,000		28,300		68,000		63,300		9,200		11,200		57,500		23,300		54,400		46,400		36,000		79,000		140,000		118,000		67,300		211,000	
Total dissolved solids	ug/L	43800000	1,800,000		300,000		1,990,000		500,000		458,000		2,040,000		1,870,000		174,000		1,880,000		584,000		352,000		383,000		310,000		400,000		279,000		342,000		137,000	
Total organic carbon	ug/L	5900	-	-	1,000		-	-	-	-			1,900		1,300		-	-	1,200		1,200		1,100		-	-	8,600		7,000		7,100		9,900		3,800	
Total suspended solids	ug/L	760000	10,000		280,000		4,000		-	-	3,000	J	21,000		-	-	4,000		7,000		4,000		-	-	-	-	84,000		5,000		4,000		5,000		21,000	
Turbidity	NTU	112					104	J	-	-	0.61		39		44.2		0.56		78.5		5.2	J	-	-	-	-					1.7		10.6		14	

	Location Code:		BED-MW20																					
	Sample Number:		5960		5965		BD3026		CA3005		CB3001		CC3003		CD3003		DA3003		DC3001		DD3002		DE3001		DG3001	
	Sample Date:		17-Nov-97		28-May-98		26-Sep-01		15-Jan-02		4-Apr-02		10-Jul-02		17-Oct-02		11-Apr-03		18-Sep-03		9-Dec-03		10-Mar-04		17-Jun-04	
	Low-Flow Sampled:		No		No		No		Yes		Yes		Yes		No		Yes		Yes		Yes		Yes		Yes	
Parameter	Units	MDC	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual
Explosives																										
Amino-2,6-dinitrotoluene, 4-	ug/L	0.19	-	-	-	-	-	-			-	-	-	-	-	-	-	-	0.19	J	-	-	-	-	-	-
Nitrobenzene	ug/L	0.12	-	-	-	-	-	-			0.088	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RDX	ug/L	0.17	-	-	-	-	-	-			-	-	-	-	-	-	0.17	J	-	-	-	-	-	-	-	-
Volatiles																										
Acetone	ug/L	17	-	-	-	-	1.2	J	-	-	5.3	J	10	B	-	-	-	-	-	-	-	-	2.1	J	5.7	B
Benzene	ug/L	3.2	0.93	J	1.6		0.25	J	-	-	-	-	3.2		1.3	J	0.23	J	1.4	J	1.2		1.1		0.34	J
Bromomethane	ug/L	0.27	-	-	-	-	-	-	-	-	-	-	0.27	J	-	-	-	-	-	-	-	-	-	-	-	-
Butanone, 2-	ug/L	9.8	-	-	-	-	-	-	-	-	-	-	9.8		-	-	-	-	-	-	-	-	-	-	-	-
Carbon disulfide	ug/L	13	-	-	0.17	J	-	-	-	-	-	-	-	-	1.1	J	0.21	J	-	-	0.16	J	0.21	J	-	-
Chloroform	ug/L	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloromethane	ug/L	0.97	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.47	B	-	-	-	-	-	-
Ethylbenzene	ug/L	0.87	0.15	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methyl-2-pentanone, 4-	ug/L	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methylene chloride	ug/L	NA	0.3	B	0.49	B	-	-	-	-	-	-	-	-	-	-	0.31	B	-	-	-	-	0.28	B	-	-
Toluene	ug/L	22	0.73	B	0.95	B	-	-	2.4	B	-	-	0.76	B	0.35	J	-	-	0.45	B	0.26	B	0.28	J	-	-
Trichloroethene	ug/L	0.59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Xylenes, total	ug/L	5.5	2.6		0.91	J	-	-	-	-	0.67	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Semivolatiles																										
Bis(2-ethylhexyl)phthalate	ug/L	5.4	-	-	5.4	B	2.9	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diethyl phthalate	ug/L	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methylnaphthalene, 2-	ug/L	1.1	1.1	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Metals - Unfiltered																										
Aluminum	ug/L	9,020	3,290		678	J	207	J	-	-	48.6	J	83.4	B	155	J	143	B	115	B	57.9	B	63.2	B	180	J
Antimony	ug/L	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	ug/L	17.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.3	J	-	-	3.4	B	3	B
Barium	ug/L	26900	19,000		16,400				22,500		23,700		24,000		25,700		26,900		25,200		26,100		25,500		22,500	
Beryllium	ug/L	1.2	-	-	-	-	-	-	-	-	-	-	-	-	0.51	B	-	-	-	-	-	-	-	-	-	-
Cadmium	ug/L	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	ug/L	2290000	2,140,000		1,960,000	J	2,060,000	J	1,860,000		1,890,000		2,000,000		2,050,000		2,180,000		2,180,000		2,290,000		2,100,000		1,880,000	
Chromium	ug/L	18.2	-	-	-	-	7.6	B	-	-	1.7	J	-	-	-	-	1.3	B	-	-	-	-	-	-	-	-
Cobalt	ug/L	12.1	-	-	-	-	7.1	J	-	-	6.1	J	8	J	8.1	J	8.5	J	8.6	J	6.8	J	7.1	J	11.4	J
Copper	ug/L	59.5	32.8		-	-	15.8	B	32.8		30.5		-	-	-	-	-	-	-	-	-	-	-	-	3.2	B
Iron	ug/L	22600	13,200		6,770		5,920	J	6,480		853		4,970		5,310		257		4,120		2,030		794		584	
Lead	ug/L	26.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magnesium	ug/L	1040000	920,000		861,000		943,000	J	860,000		884,000		960,000		941,000		981,000		1,040,000		1,040,000		992,000		915,000	
Manganese	ug/L	2240	180		153		189	J	128		156		190		185		162		192		202		183		170	
Mercury	ug/L	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	ug/L	8.6	-	-	-	-	3.5	J	-	-	3.4	J	-	-	-	-	7.2	J	4	J	-	-	-	-	6.2	J
Potassium	ug/L	174000	92,300		78,600		85,800	J	165,000		86,700	J	101,000	J	91,700	J	81,700	J	104,000	J	72,600	J	174,000	J	164,000	J
Selenium	ug/L	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	ug/L	9130000	7,660,000		7,300,000		7,980,000	J	6,830,000		7,770,000		8,380,000		8,190,000		8,430,000		8,540,000		9,130,000		8,600,000		7,930,000	
Thallium	ug/L	7.1	-	-	-	-	-	-	7.1	B	-	-	-	-	4.1	B	-	-	4.6	B	-	-	-	-	4.2	B
Vanadium	ug/L	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc	ug/L	612	41.6		42.1	B	5.3		23.4		64.9		9.7	J	15.6	J	5.3	B	5.7	J	612		43.6		85.5	
Metals - Filtered																										
Aluminum	ug/L	152	-	-	-	-	40.9	B	-	-	55.9	B	63.1	B	69.8	B	109	B	91.4	B	-	-	77.8	B	128	J
Arsenic	ug/L	6.9	-	-	-	-	2.8	J	-	-	-	-	-	-	-	-	-	-	4.8	J	4.1	J	-	-	2.8	B
Barium	ug/L	26200	21,000		4,950		24,400		21,300		23,800		23,900		24,500		26,200		25,700		25,700		24,300		23,100	
Beryllium	ug/L	NA	-	-	-	-	-	-	-	-	-	-	-	-	0.24	B	-	-	-	-	-	-	-	-	-	-
Cadmium	ug/L	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	ug/L	2570000	2,570,000	J	491,000	J	2,110,000		1,720,000		1,910,000		2,020,000		1,990,000		2,120,000		2,270,000		2,240,000	J	2,000,000		1,940,000	
Cobalt	ug/L	23.8	-	-	-	-	6.4	J	-	-	5.9	J	8	J	7.5	J	9.3	J	23.8	J	6.2	J	6.2	J	13	J
Copper	ug/L	26.5	-	-	-	-	2	B	5.7	J	26.5		-	-	-	-	-	-	-	-	-	-	5.3	B	-	-
Iron	ug/L	6180	2,310		1,320		5,350		6,180		1,130		5,100		4,940		-	-	3,800		1,830		510		636	
Lead	ug/L	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magnesium	ug/L	1090000	1,090,000		223,000	J	965,000		829,000		888,000		969,000		911,000		953,000		1,070,000		1,020,000		944,000		942,000	
Manganese	ug/L	1300	162		47		188		129		156		193		182		160		220		200		178		178	
Mercury	ug/L	0.24	-	-	0.24		-	-	-	-	-	-	-	-	-	-	0.032	J	-	-	-	-	-	-	-	-
Nickel	ug/L	9.8	-	-	-	-	2.9	J	-	-	3.2	J	-	-	-	-	6.5	J	6	J	-	-	-	-	7.2	J
Potassium	ug/L	173000	103,000		21,600		87,400	J	170,000		86,900	J	102,000	J	88,400	J	79,000	J	105,000	J	70,500	J	173,000	J	170,000	J
Sodium	ug/L	9110000	9,110,000		1,870,000		8,100,000		6,870,000		7,830,000		8,120,000		7,750,000		8,210,000		8,710,000		9,000,000	J	8,220,000		8,240,000	
Thallium	ug/L	6.4	-	-	-	-	-	-	7.3	B	-	-	-	-	-	-	-	-	4.1	B	-	-	-	-	3.8	B
Zinc	ug/L	673	-	-	-	-	3.3	J	21.6		59.2	J	3.2	J	78.3		4.8	J	6.4	J	673		31.4		102	
Water Quality Parameters																										
Alkalinity	ug/L	481000	240,000		260,000		255,000	J	280,000		229,000		293,000		259,000		246,000		248,000		238,000		248,000		264,000	
Chloride	ug/L	34600000	19,000,000		21,000,000		22,400,000		18,000,000		17,300,000	J	19,000,000		21,100,000		34,600,000		19,100,000		21,300,000		20,800,000		24,200,000	
Cyanide, total	ug/L	NA															-	-	-	-	-	-	-	-	-	-
Hardness	ug/L	20000000	20,000,000		10,000,000		9,360,000		8,200,000		8,850,000		8,140,000		9,390,000		9,200,000		9,690,000		9,940,000		9,550,000		8,900,000	
Nitrate	ug/L	22000			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	180	
Nitrate-Nitrite	ug/L	200	-	-																						
Sulfate	ug/L	514000	-	-	-	-	-	-	3,200		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total dissolved solids	ug/L	43800000	32,000,000		24,000,000		27,400,000	J	26,000,000		27,800,000		35,500,000		43,800,000		32,600,000		42,700,000		33,600,000		28,700,000		36,100,000	
Total organic carbon	ug/L	5900	-	-	-	-	500	J	1,100	J	740	J	-	-	-	-	-	-	-	-	-	-	-	-	2,100	
Total suspended solids	ug/L	760000	74,000		90,000		125,000		13,000		13,000		33,000		19,000		100,000		112,000		39,000		760,000		22,000	
Turbidity	NTU	112					48.4	J	8.8		10.5		7.4		19.2		3.9		6.2		18.4	J	5.7		4	

	Location Code:		BED-MW25																			
	Sample Number:		BD3030		CA3002		CB3004		CC3005		CD3005		DA3005		DC3003		DD3004		DE3003		DG3003	
	Sample Date:		5-Oct-01		16-Jan-02		3-Apr-02		11-Jul-02		17-Oct-02		10-Apr-03		18-Sep-03		11-Dec-03		11-Mar-04		17-Jun-04	
	Low-Flow Sampled:		Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes	
Parameter	Units	MDC	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual
Explosives																						
Amino-2,6-dinitrotoluene, 4-	ug/L	0.19	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrobenzene	ug/L	0.12	-	-			0.076	J	-	-	0.12	J	-	-	-	-	-	-	-	-	-	-
RDX	ug/L	0.17	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Volatiles																						
Acetone	ug/L	17	1.7	B	-	-	-	-	1.4	B	1.6	J	-	-	-	-	-	-	-	-	4.9	B
Benzene	ug/L	3.2	0.37	J	-	-	-	-	-	-	0.15	J	-	-	-	-	-	-	-	-	-	-
Bromomethane	ug/L	0.27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Butanone, 2-	ug/L	9.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbon disulfide	ug/L	13	0.48	J	1.5		0.36	J	0.17	J	1.3	J	1.5	J	-	-	0.77	J	1.2		1.9	J
Chloroform	ug/L	1.1	1.1		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloromethane	ug/L	0.97	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ethylbenzene	ug/L	0.87	0.22	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methyl-2-pentanone, 4-	ug/L	0.3	0.3	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methylene chloride	ug/L	NA	0.3	B	-	-	0.21	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Toluene	ug/L	22	0.8	J	-	-	0.25	J	-	-	-	-	-	-	-	-	-	-	0.13	J	-	-
Trichloroethene	ug/L	0.59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Xylenes, total	ug/L	5.5	1.5		-	-	-	-	-	-	0.37	J	-	-	-	-	-	-	-	-	-	-
Semivolatiles																						
Bis(2-ethylhexyl)phthalate	ug/L	5.4	0.86	J	-	-	-	-	3	B	-	-	-	-	-	-	-	-	-	-	-	-
Diethyl phthalate	ug/L	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methylnaphthalene, 2-	ug/L	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Metals - Unfiltered																						
Aluminum	ug/L	9,020	78.2	B	79.8	B	41.3	J	44.6	J	79.7	J	137	B	86.5	B	61.2	B	50.3	B	84.8	J
Antimony	ug/L	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	ug/L	17.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Barium	ug/L	26900	226		247		434		164	J	277		558		177	J	187	J	233		112	J
Beryllium	ug/L	1.2	-	-	1.2	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	ug/L	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	ug/L	2290000	134,000		158,000		173,000		183,000		200,000		194,000		159,000		141,000		107,000		194,000	
Chromium	ug/L	18.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cobalt	ug/L	12.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Copper	ug/L	59.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iron	ug/L	22600	795		357		91.1	J	103		207		102		156		140		82.1	J	104	
Lead	ug/L	26.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magnesium	ug/L	1040000	79,500		80,000		68,000		69,100		80,200		81,200		62,000		54,000		41,900		70,400	
Manganese	ug/L	2240	89		56.2		68.8		95.6		86.5		79.8		72.9		58.5		45.1		105	
Mercury	ug/L	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	ug/L	8.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potassium	ug/L	174000	17,600		21,600		14,500	J	11,400	J	16,200	J	19,200	J	12,100	J	11,900		10,800	J	10,800	J
Selenium	ug/L	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.5	B
Sodium	ug/L	9130000	112,000		115,000		196,000		92,300		187,000		223,000		120,000		122,000		114,000		67,000	
Thallium	ug/L	7.1	-	-	4.7	B	-	-	-	-	-	-	-	-	3.1	B	3	B	-	-	5.2	B
Vanadium	ug/L	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc	ug/L	612	7.7	J	-	-	79.5		-	-	1.7	J	1.4	B	4.8	J	74.4		-	-	5.1	B
Metals - Filtered																						
Aluminum	ug/L	152	68.7	B	-	-	52.7	B	97.8	B	69.8	B	135	B	61.8	B	-	-	57.7	B	-	-
Arsenic	ug/L	6.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Barium	ug/L	26200	224		234		452		160	J	270		545		177	J	175	J	239		117	J
Beryllium	ug/L	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	ug/L	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	ug/L	2570000	128,000		146,000		176,000		187,000		198,000		188,000		158,000		135,000	J	112,000		193,000	
Cobalt	ug/L	23.8	-	-	-	-	-	-	-	-	-	-	2	J	-	-	-	-	-	-	-	-
Copper	ug/L	26.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iron	ug/L	6180	713		337		-	-	59.8	J	157		18.8	J	92.7	J	74.5	J	-	-	-	-
Lead	ug/L	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magnesium	ug/L	1090000	76,800		74,400		69,700		74,100		78,600		77,900		61,400		51,400		43,800		70,200	
Manganese	ug/L	1300	87		52.2		65.6		94		84.2		75.7		71.5		55.2		46.8		103	
Mercury	ug/L	0.24	-	-	-	-	-	-	-	-	-	-	0.056	J	-	-	-	-	-	-	0.06	B
Nickel	ug/L	9.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potassium	ug/L	173000	17,000		20,200		14,900	J	12,100	J	15,900	J	18,400	J	11,900	J	11,100	J	11,400	J	10,900	J
Sodium	ug/L	9110000	109,000		114,000		196,000		97,600		180,000		217,000		118,000		115,000	J	119,000		67,700	
Thallium	ug/L	6.4	-	-	-	-	-	-	6.4	J	-	-	-	-	-	-	-	-	-	-	-	-
Zinc	ug/L	673	3	J	-	-	19.9	J	-	-	1.5	B	1	J	2.6	B	21.7		-	-	-	-
Water Quality Parameters																						
Alkalinity	ug/L	481000	278,000	J	320,000		337,000		329,000		314,000		344,000		313,000		316,000		331,000		294,000	
Chloride	ug/L	34600000	404,000		460,000		558,000	J	219,000		631,000		615,000		257,000		221,000		199,000		95,400	
Cyanide, total	ug/L	NA											4	B	-	-	-	-	-	-	-	-
Hardness	ug/L	20000000	627,000		720,000		611,000		772,000		848,000		820,000		700,000		540,000		510,000		760,000	
Nitrate	ug/L	22000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrate-Nitrite	ug/L	200																				
Sulfate	ug/L	514000	121,000		79,000		36,200		416,000		79,500		38,600		264,000		136,000		142,000		514,000	
Total dissolved solids	ug/L	43800000	1,000,000		1,100,000		1,330,000		1,180,000		1,440,000		767,000		1,100,000		834,000		808,000		1,160,000	
Total organic carbon	ug/L	5900	4,000	B	2,000		3,000		2,700		2,700		2,000		2,800		2,400		2,300		1,900	
Total suspended solids	ug/L	760000	4,000		-	-	9,000		5,000		-	-	4,000		5,000		8,000		-	-	4,000	
Turbidity	NTU	112	21.7	J	21		112		23.6		35.8		98		22.9		64.4		86.5		2	

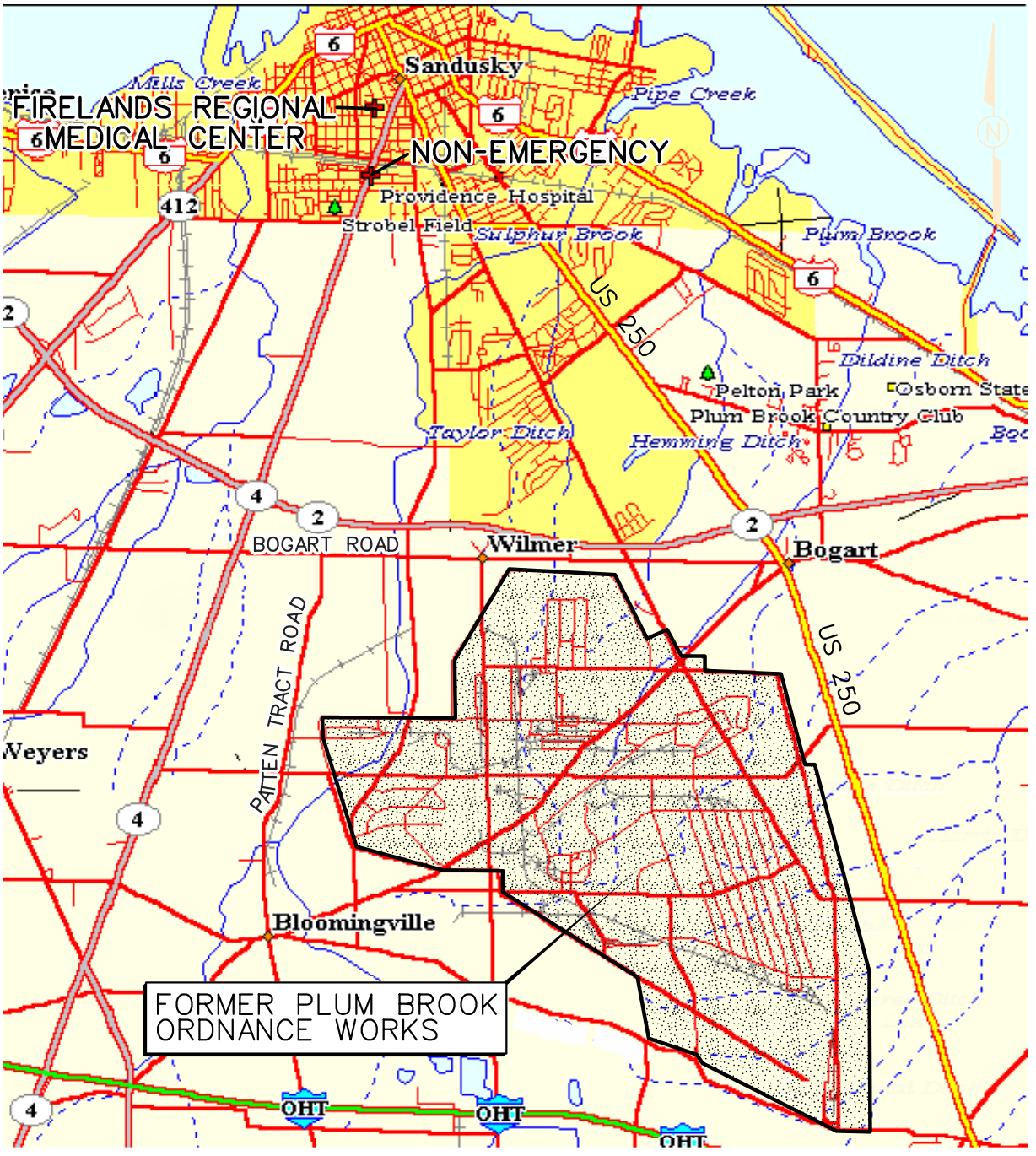
			Location Code:		BED-MW26		BED-MW28								BED-MW29							
			Sample Number:		CA3004		DC3004		DD3007		DE3004		DG3004		DC3005		DD3008		DE3005		DG3005	
			Sample Date:		17-Jan-02		17-Sep-03		9-Dec-03		9-Mar-04		15-Jun-04		16-Sep-03		9-Dec-03		10-Mar-04		16-Jun-04	
			Low-Flow Sampled:		No		Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes	
Parameter	Units	MDC	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual
Explosives																						
Amino-2,6-dinitrotoluene, 4-	ug/L	0.19			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrobenzene	ug/L	0.12			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RDX	ug/L	0.17			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Volatiles																						
Acetone	ug/L	17			-	-	-	-	2.1	J	-	-	17		-	-	2.1	J	9.1	B		
Benzene	ug/L	3.2			2.4	J	2.2		1.7		1.1		-	-	0.96	J	0.22	J	0.23	J		
Bromomethane	ug/L	0.27			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Butanone, 2-	ug/L	9.8			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Carbon disulfide	ug/L	13			-	-	-	-	1.3		0.1	J	0.44	J	13		1.9		-	-		
Chloroform	ug/L	1.1			-	-	-	-	-	-	-	-	0.25	J	-	-	-	-	-	-		
Chloromethane	ug/L	0.97			-	-	0.97	J	0.42	J	-	-	-	-	0.3	J	-	-	-	-		
Ethylbenzene	ug/L	0.87			-	-	0.13	J	-	-	-	-	0.86	J	0.87	J	0.66	J	0.55	J		
Methyl-2-pentanone, 4-	ug/L	0.3			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Methylene chloride	ug/L	NA			-	-	-	-	2.1	B	-	-	-	-	-	-	0.59	B	-	-		
Toluene	ug/L	22			1.7	J	0.62	J	0.18	J	0.13	J	0.12	J	-	-	-	-	-	-		
Trichloroethene	ug/L	0.59			0.59	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Xylenes, total	ug/L	5.5			-	-	0.41	J	-	-	-	-	5.5		5.1	J	4.5	J	3.7			
Semivolatiles																						
Bis(2-ethylhexyl)phthalate	ug/L	5.4			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Diethyl phthalate	ug/L	NA			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Methylnaphthalene, 2-	ug/L	1.1			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Metals - Unfiltered																						
Aluminum	ug/L	9,020	93,200		147	J	42.6	B	54.5	B	129	J	309		49.9	B	103	J	120	J		
Antimony	ug/L	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Arsenic	ug/L	17.6	56.8		7.4	J	5.4	J	5.5	B	-	-	-	-	3.3	J	2.6	B	-	-		
Barium	ug/L	26900	1,970		374		395		342		337		11,300		11,800		10,800		9,110			
Beryllium	ug/L	1.2	5.2		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Cadmium	ug/L	NA	3.3	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Calcium	ug/L	2290000	2,180,000		20,800		20,000		17,500		17,400		316,000		295,000		274,000		272,000			
Chromium	ug/L	18.2	454		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Cobalt	ug/L	12.1	82.8		-	-	-	-	-	-	-	-	3.9	J	3.6	J	3.5	B	2.6	J		
Copper	ug/L	59.5	293		-	-	-	-	-	-	-	-	-	-	-	-	-	-	19.8	J		
Iron	ug/L	22600	232,000		235		398		219		184		932		1,550		1,480		1,000			
Lead	ug/L	26.3	79.2		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Magnesium	ug/L	1040000	958,000		8,320		7,780		7,370		7,280		217,000		198,000		189,000		188,000			
Manganese	ug/L	2240	7,470		20.3		16.6		10.6	J	10.6	J	62.7		50.7		46.4		43.6			
Mercury	ug/L	NA	0.14	J	-	-	-	-	-	-	0.1	B	-	-	-	-	-	-	-	-		
Nickel	ug/L	8.6	457		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Potassium	ug/L	174000	334,000		7,240	J	6,050		18,300	J	15,900	J	75,800	J	67,800		112,000	J	116,000	J		
Selenium	ug/L	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Sodium	ug/L	9130000	3,790,000		290,000		285,000		275,000		269,000		1,390,000		1,350,000		1,350,000		1,320,000			
Thallium	ug/L	7.1	-	-	4.2	B	-	-	6.7	B	3.9	B	5.1	B	2.4	B	-	-	-	-		
Vanadium	ug/L	NA	142		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Zinc	ug/L	612	789		2.5	B	247		2.8	B	15.4	B	6.9	J	507		9	J	27.4	B		
Metals - Filtered																						
Aluminum	ug/L	152			152	J	-	-	74.6	B	78.1	J	83.1	B	66.9	B	85	B	107	J		
Arsenic	ug/L	6.9			6.9	J	5.6	J	5	B	-	-	2.6	J	3.1	J	-	-	-	-		
Barium	ug/L	26200			371		374		354		343		10,500		10,800		10,800		9,050			
Beryllium	ug/L	NA			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Cadmium	ug/L	1.2			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Calcium	ug/L	2570000			20,300		19,700	J	17,900		17,300		316,000		283,000	J	274,000		282,000			
Cobalt	ug/L	23.8			-	-	-	-	-	-	-	-	6.1	J	3.4	J	3.4	J	2.6	J		
Copper	ug/L	26.5			-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.1	J		
Iron	ug/L	6180			242		354		186		125		350		1,490		1,060		892			
Lead	ug/L	NA			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Magnesium	ug/L	1090000			8,120		7,670		7,540		7,250		219,000		189,000		190,000		196,000			
Manganese	ug/L	1300			15.8		16.4		11.8	J	11.6	J	55.1		49.3		45.5		44.8			
Mercury	ug/L	0.24			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Nickel	ug/L	9.8			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Potassium	ug/L	173000			7,140	J	5,920	J	17,300	J	14,000	J	76,500	J	60,700	J	114,000	J	120,000	J		
Sodium	ug/L	9110000			289,000		280,000	J	282,000		272,000		1,390,000		1,250,000	J	1,360,000		1,380,000			
Thallium	ug/L	6.4			4.1	B	3.8	B	5.2	J	4	B	6.2	B	3.8	B	-	-	2.5	B		
Zinc	ug/L	673			3.8	B	247		3	B	14.7	B	8.5	J	528		3.4	B	23.5	B		
Water Quality Parameters																						
Alkalinity	ug/L	481000			474,000		444,000		468,000		481,000		443,000		432,000		448,000		467,000			
Chloride	ug/L	34600000			171,000		148,000		168,000		162,000		3,540,000		2,930,000		3,050,000		3,340,000			
Cyanide, total	ug/L	NA			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Hardness	ug/L	20000000			99,500		81,600		78,000		30,400		1,750,000		1,500,000		1,540,000		1,470,000			
Nitrate	ug/L	22000			-	-	-	-	-	-	-	-	390		-	-	-	-	-	-		
Nitrate-Nitrite	ug/L	200																				
Sulfate	ug/L	514000			35,200		13,100		-	-	-	-	5,700		-	-	-	-	7,500			
Total dissolved solids	ug/L	43800000			833,000		697,000		774,000		746,000		6,580,000		3,880,000		5,450,000		5,720,000			
Total organic carbon	ug/L	5900			5,900		5,300		5,200		4,700		2,600		3,900		2,200		4,500			
Total suspended solids	ug/L	760000			-	-	4,000		-	-	8,000		46,000		7,000		105,000		14,000			
Turbidity	NTU	112			3.3		1.6	J	1.4		0.72		14.7		7	J	8.1		7.5			

MDC - Maximum detected concentration for the AOC ("B" qualified data not included). Data from wells IT-MW01 and BED-MW26 not included in the MDC.
Analytical results of monitoring wells BED-MW26 and IT-MW01 not included in the MDC column.

µg/L - Micrograms per liter.
"-" - Not detected.
ND - Not detected.
NE - Not established (RBSCs), not evaluated (BSCs).
NTU - Nephelometric turbidity unit.

Validation Qualifiers (Qual)
B - The analyte was not detected significantly above the levels found in the associated method blank or field blanks.
J - The compound/analyte was positively identified; the reported value is an estimated concentration.

FIGURES



NOT TO SCALE

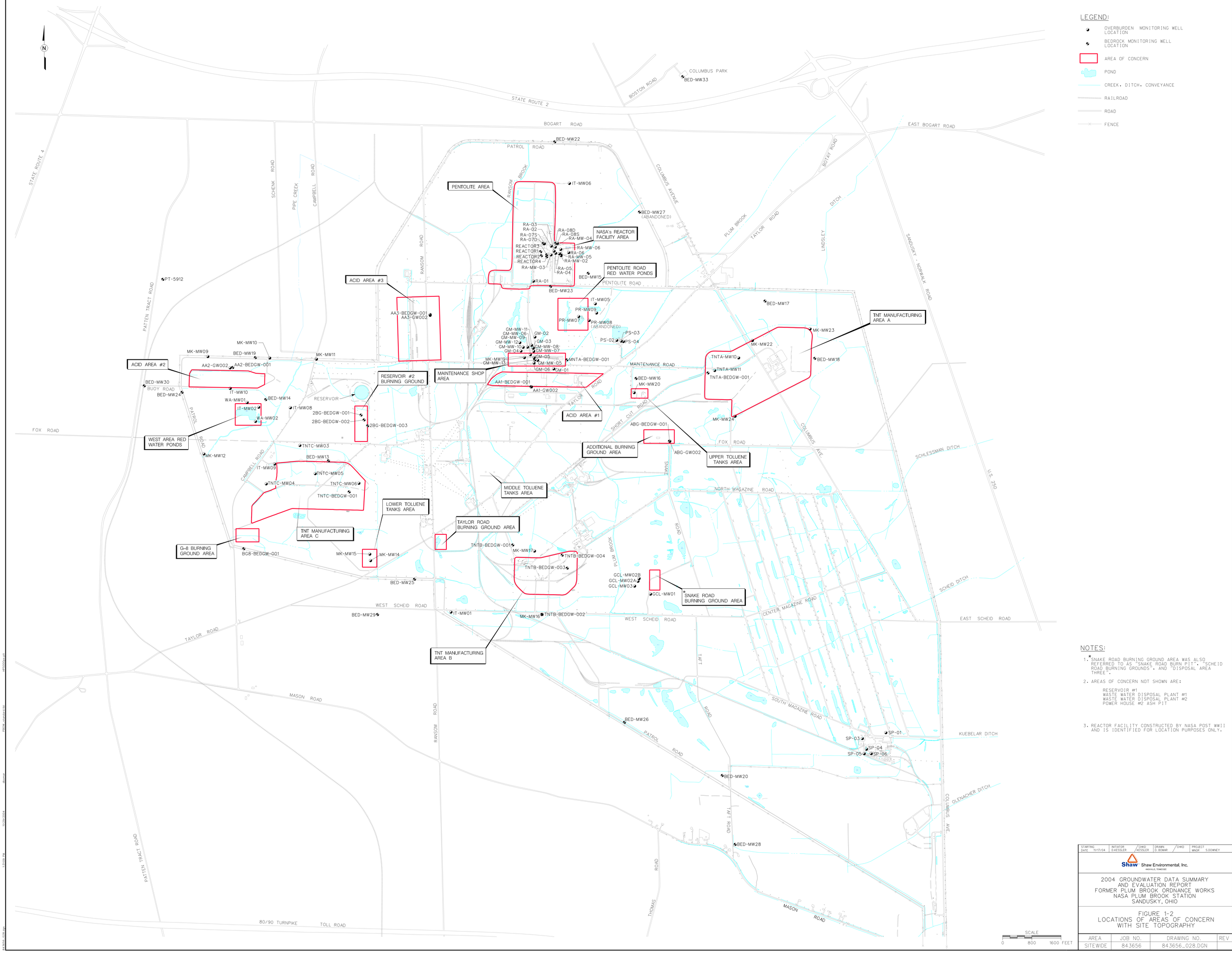
FIGURE 1-1
VICINITY MAP

2004 GROUNDWATER DATA SUMMARY
AND EVALUATION REPORT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw® Shaw Environmental, Inc.

STARTING DATE: 11/17/04 | DATE LAST REV.: | DRAFT. CHCK. BY: | INITIATOR: D. KESSLER | DWG. NO.843656_027.DGN
DRAWN BY: D. BOMAR | DRAWN BY: | ENGR. CHCK. BY: D. KESSLER | PROJ. MGR.: S. DOWNEY | PROJ. NO.: 843656

r2d2-color-letter.plt 9:32:19 AM 11/18/2004
PBOW_standard.tbl dbomar 843656_027.dgn



NOTES:

1. *SNAKE ROAD BURNING GROUND AREA WAS ALSO REFERRED TO AS "SNAKE ROAD BURN PIT", "SCHEID ROAD BURNING GROUNDS", AND "DISPOSAL AREA THREE".
2. AREAS OF CONCERN NOT SHOWN ARE:

   RESERVOIR #1
   WASTE WATER DISPOSAL PLANT #1
   WASTE WATER DISPOSAL PLANT #2
   POWER HOUSE #2 ASH PIT
3. REACTOR FACILITY CONSTRUCTED BY NASA POST WWII AND IS IDENTIFIED FOR LOCATION PURPOSES ONLY.

SCALE
0 800 1600 FEET

STARTING DATE 11/17/04	INITIATOR D.KESSLER	CHKD KESSLER	DRAWN D. BOMAR	CHKD	PROJECT MNGR S.DOWNEY

Shaw Environmental, Inc.
KNOXVILLE, TENNESSEE

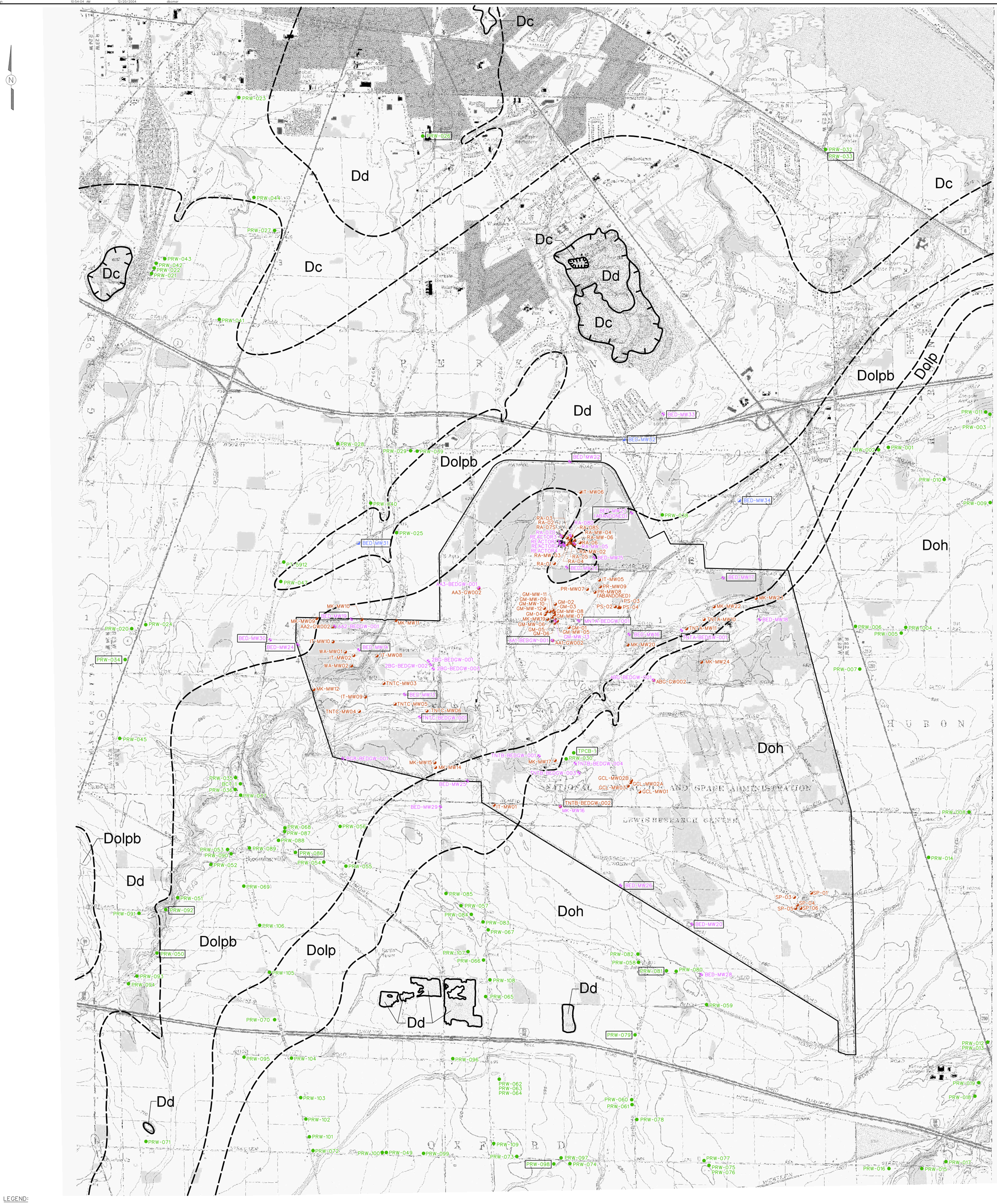
2004 GROUNDWATER DATA SUMMARY
AND EVALUATION REPORT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

FIGURE 1-2
LOCATIONS OF AREAS OF CONCERN
WITH SITE TOPOGRAPHY

AREA	JOB NO.	DRAWING NO.	REV
SITEWIDE	843656	843656_028.DGN	

34 x 44

843656_012.dgn 10:54:04 AM 12/20/2004 dbomar



LEGEND:

- PRIVATE WELL LOCATION
- OVERBURDEN WELL LOCATION
- BEDROCK WELL LOCATION
- SOIL BORING LOCATION
- H_2S AND/OR NATURAL GAS, AND/OR PETROLEUM HYDROCARBON WERE NOTED DURING DRILLING
- CONTACT SOLID LINE WHERE EXPOSED; DASHED WHERE CONCEALED BY SEDIMENTS

AGE	FORMATION/GROUP	ROCK DESCRIPTION
DEVONIAN	Doh - Ohio Shale	Shale: black, thin-bedded with bituminous and carboneous material, pyrite, natural gas pockets.
	Dolp - Prout Limestone Member (Olentangy Shale)	Limestone: light gray, calcareous.
	Dolpb - Plum Brook Member (Olentangy Shale)	Shale: dark gray, thin-bedded.
	Dd - Delaware Limestone	Limestone: buff, earthy, interbedded with brown crystalline dolomite, fossiliferous, hydrogen sulfide, petroleum hydrocarbon.
	Dc - Columbus Limestone	Limestone: brown to gray, fine crystalline, fossiliferous with tan to buff gray, partly sandy dolomite at base.

NOTE:

1. CONTACT LINES WERE ADJUSTED BASED ON 2004 MONITORING WELLS/SOIL BORING AND GIS DATA.

REFERENCE:

PRELIMINARY BEDROCK GEOLOGY OF THE KIMBALL AND SANDUSKY, OHIO, QUADRANGLES, STATE OF OHIO, DEPARTMENT OF NATURAL RESOURCES, DIVISION OF GEOLOGICAL SURVEY, 1995.

BASE MAPS (COMBINED BY SHAW) FROM KIMBALL AND SANDUSKY QUADRANGLES, 7.5 MINUTE SERVICES, (TOPOGRAPHIC), 1969. SANDUSKY MAP WAS PHOTOREVISED 1979.

SCALE
0 1250 2500 FEET

NO	DATE	REVISION	BY	CHKD	DSGN ENGR	ENGR	PROJ MGR	APPR

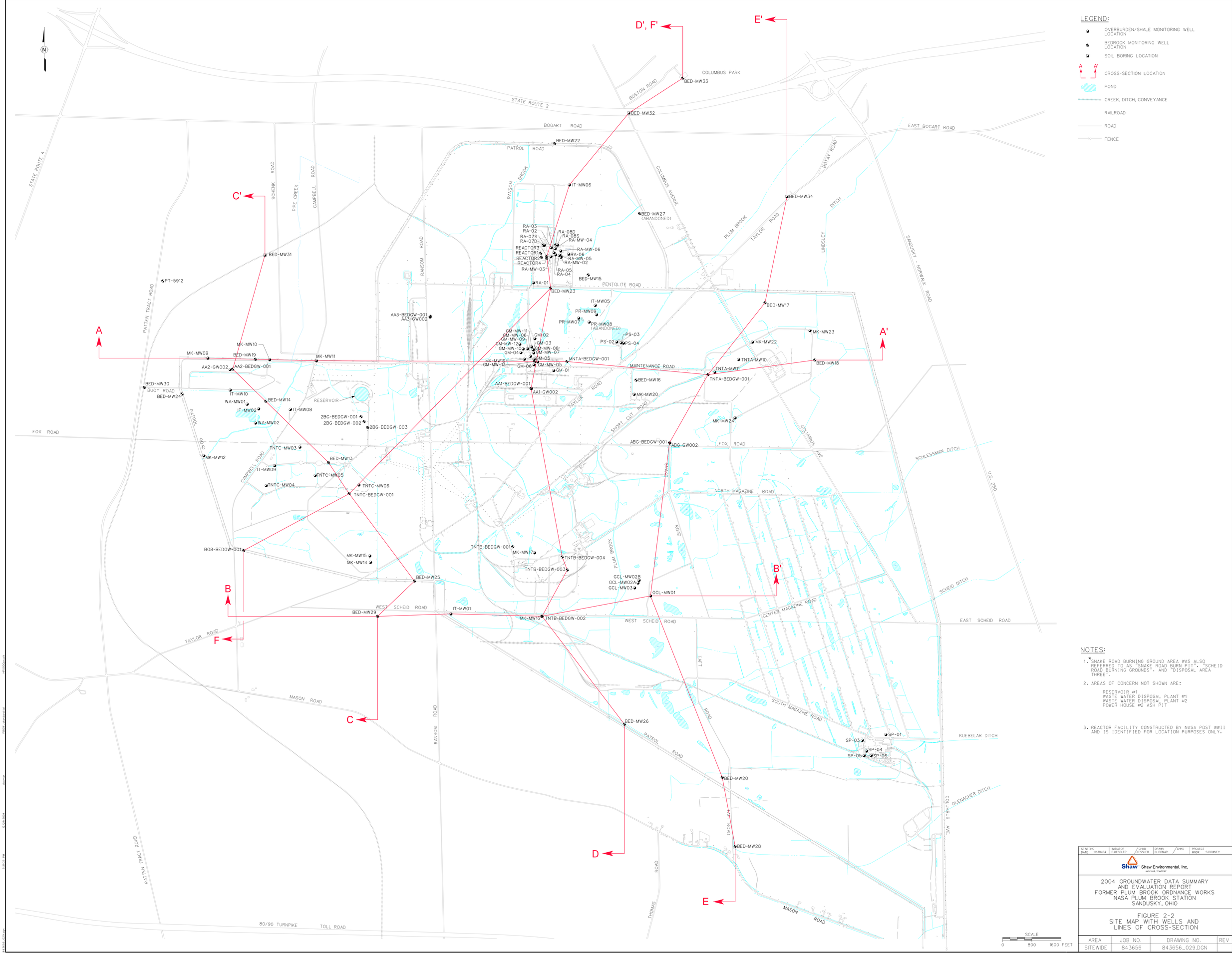
STARTING DATE 03/05/02 | INITIATOR D. KESSLER | CHKD | DRAWN VANDERGRIFF | CHKD | PROJECT MNGR S. DOWNEY

Shaw® Shaw Environmental, Inc.
KNOXVILLE, TENNESSEE

2004 GROUNDWATER DATA SUMMARY AND EVALUATION REPORT FORMER PLUM BROOK ORDNANCE WORKS NASA PLUM BROOK STATION SANDUSKY, OHIO

FIGURE 2-1 REGIONAL GEOLOGIC MAP WITH SITE TOPOGRAPHY

AREA	JOB NO.	DRAWING NO.	REV
SITEWIDE	843656	843656_012.DGN	



NOTES:

1. * SNAKE ROAD BURNING GROUND AREA WAS ALSO REFERRED TO AS "SNAKE ROAD BURN PIT", "SCHEID ROAD BURNING GROUNDS", AND "DISPOSAL AREA THREE".

2. AREAS OF CONCERN NOT SHOWN ARE:

   RESERVOIR #1
   WASTE WATER DISPOSAL PLANT #1
   WASTE WATER DISPOSAL PLANT #2
   POWER HOUSE #2 ASH PIT

3. REACTOR FACILITY CONSTRUCTED BY NASA POST WWII AND IS IDENTIFIED FOR LOCATION PURPOSES ONLY.

STARTING DATE	INITIATOR	CHKD	DRAWN	CHKD	PROJECT MNGR
11/30/04	D.KESSLER	KESSLER	D. BOMAR		S.DOWNEY

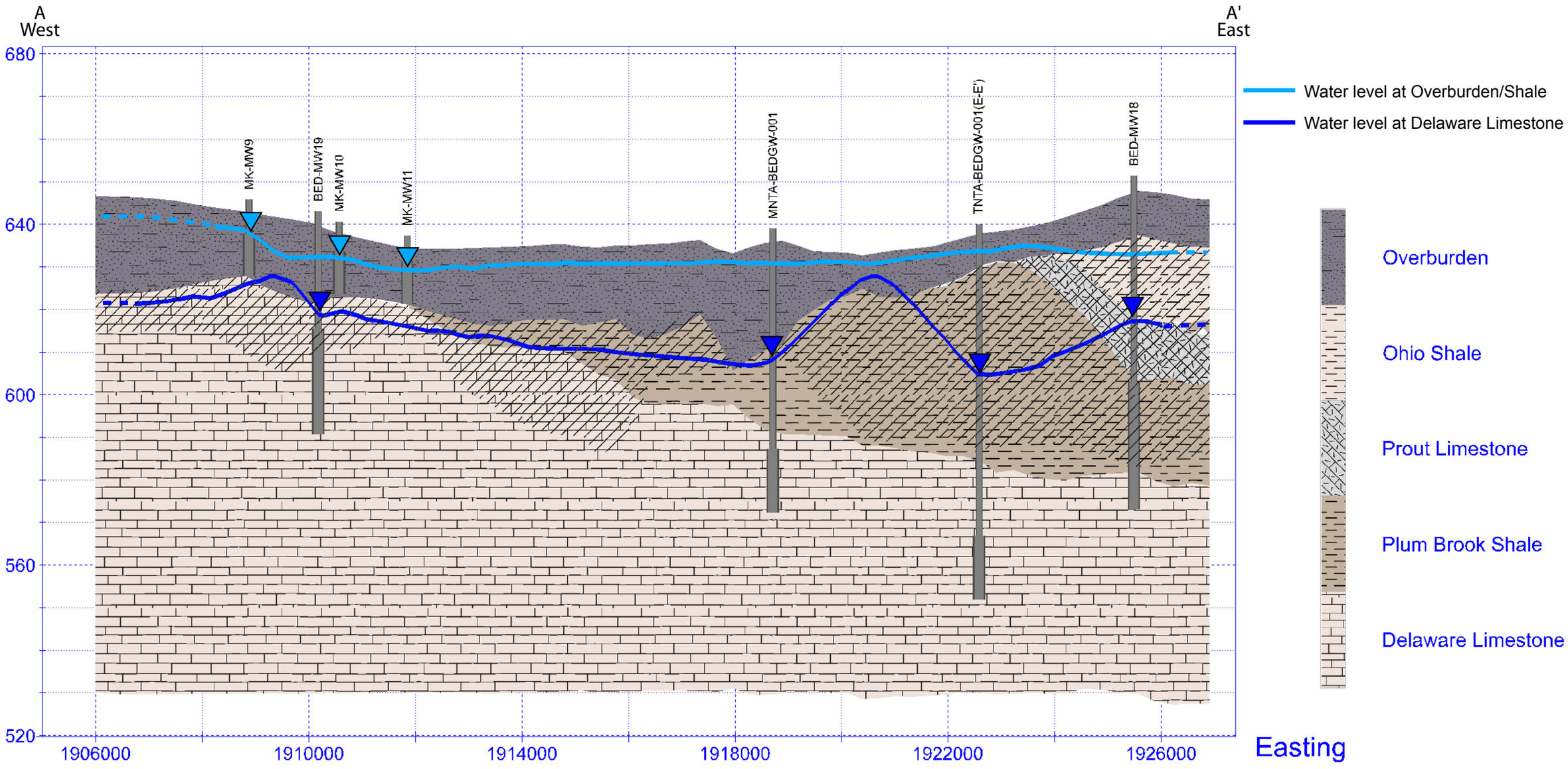
Shaw Environmental, Inc.
NASHVILLE, TENNESSEE

2004 GROUNDWATER DATA SUMMARY AND EVALUATION REPORT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

FIGURE 2-2
SITE MAP WITH WELLS AND LINES OF CROSS-SECTION

AREA	JOB NO.	DRAWING NO.	REV
SITEWIDE	843656	843656_029.DGN	

34 X 44



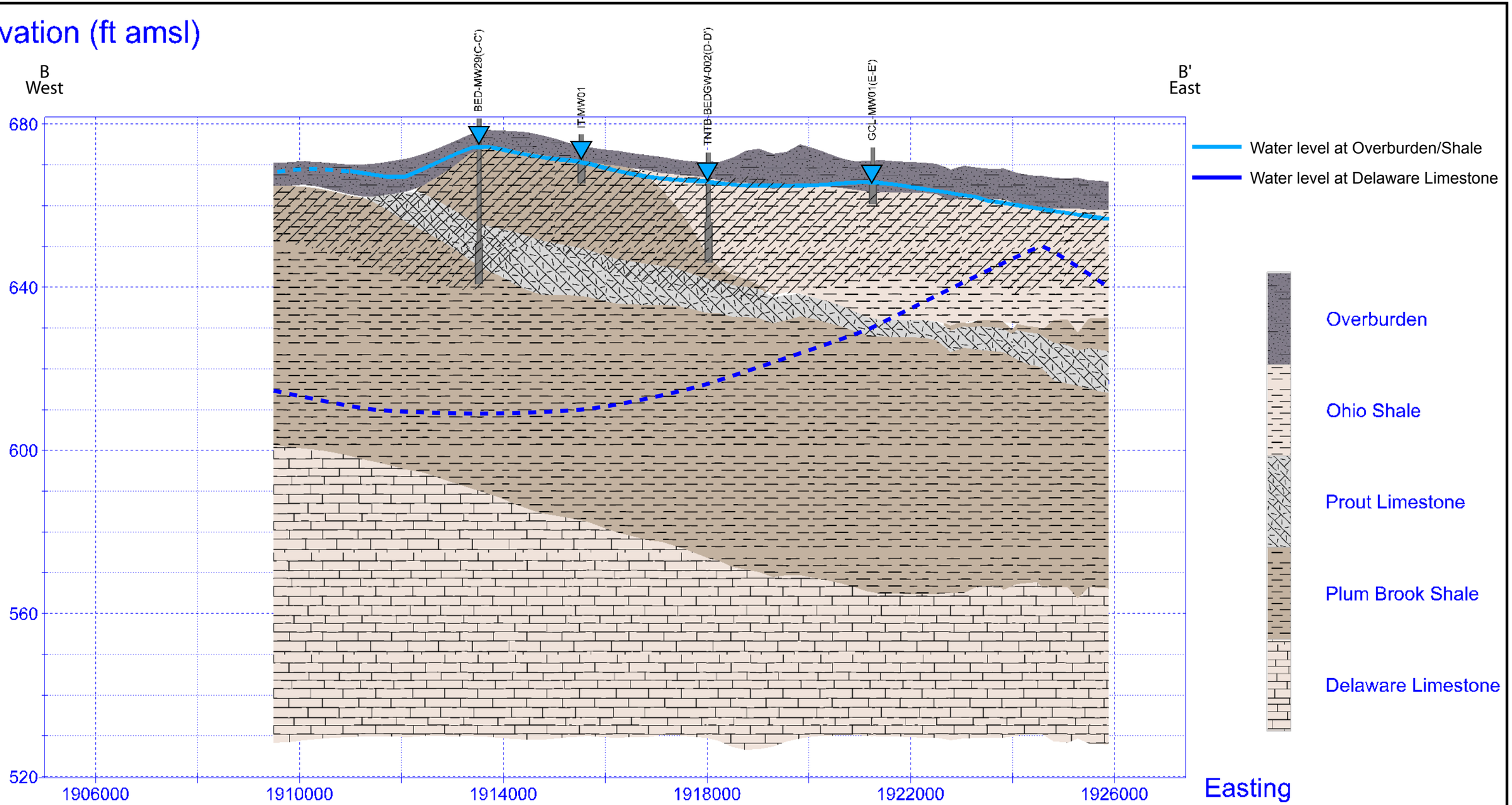
Note: (1) The area shaded by diagonal lines shows weathered bedrock.
(2) Water levels were measured from August 10-11, 2004

0 2000 ft 4000 ft

Figure 2-3
Geologic Cross-Section A-A'

2004 Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
NASA Plum Brook Station
Sandusky, Ohio

X:\PlumBrook\GISWorkspace\dpack\Illustrator Files\Ke Liu



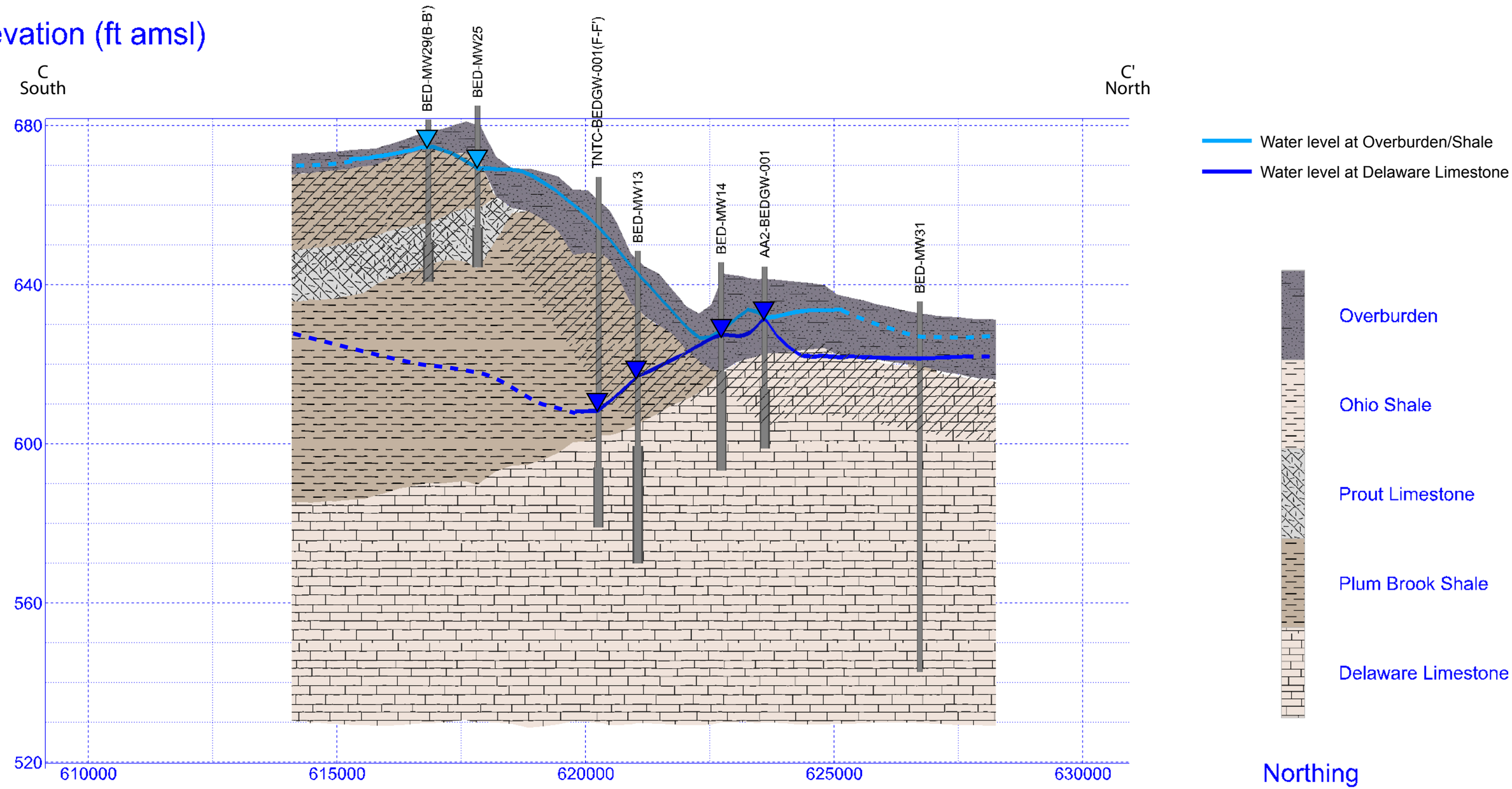
Note: (1) The area shaded by diagonal lines shows weathered bedrock.
(2) Water levels were measured from August 10-11, 2004

0 2000 ft 4000 ft

Figure 2-4
Geologic Cross-Section B-B'

2004 Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
NASA Plum Brook Station
Sandusky, Ohio

X:\PlumBrook\GISWorkspace\dpack\Illustrator Files\Ke Liu



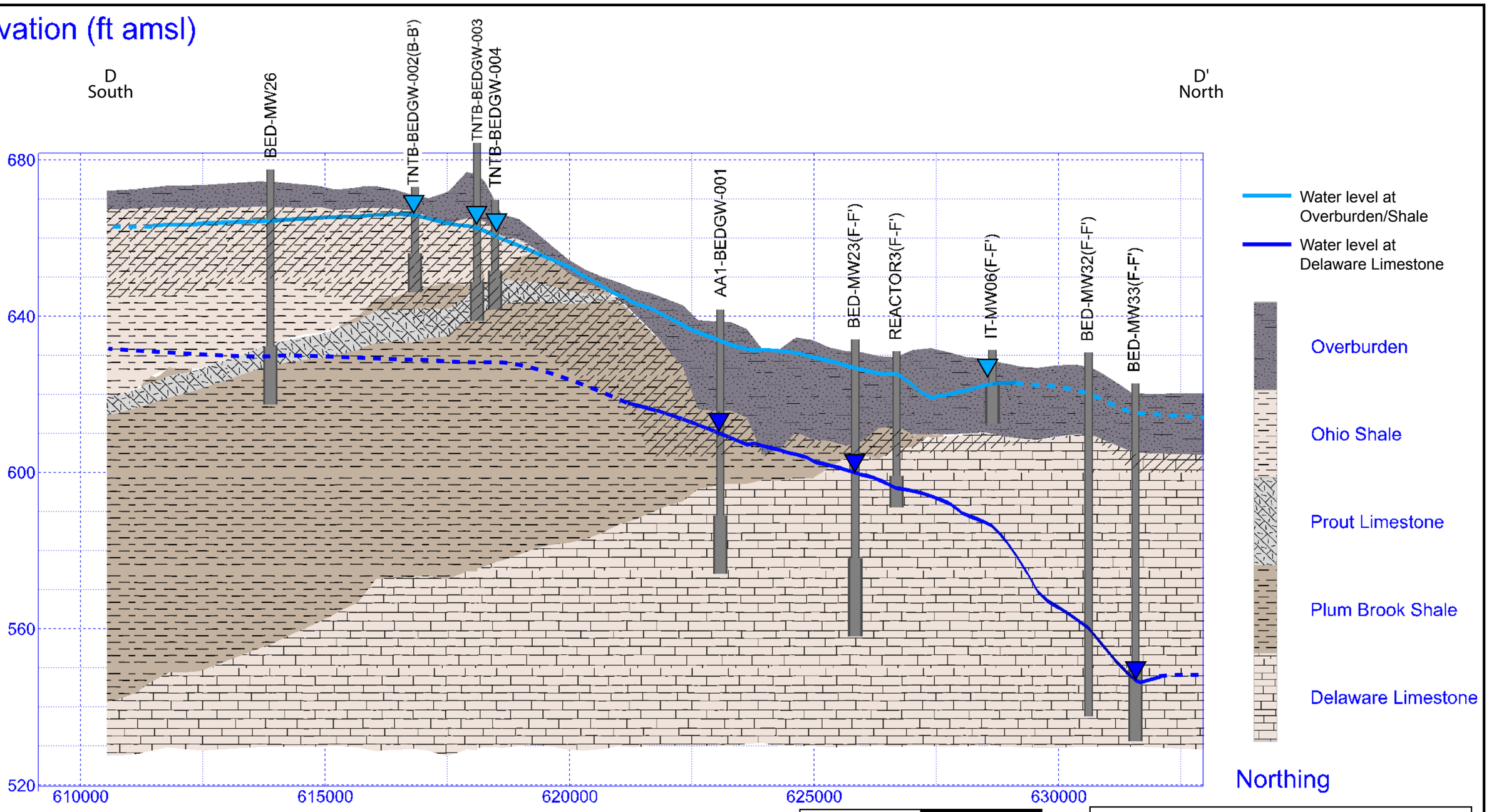
Note: (1) The area shaded by diagonal lines shows weathered bedrock.
(2) Water levels were measured from August 10-11, 2004

0 2500 ft 5000 ft

Figure 2-5
Geologic Cross-Section C-C'

2004 Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
NASA Plum Brook Station
Sandusky, Ohio

X:\PlumBrook\GISWorkspace\dpack\Illustrator Files\Ke Liu

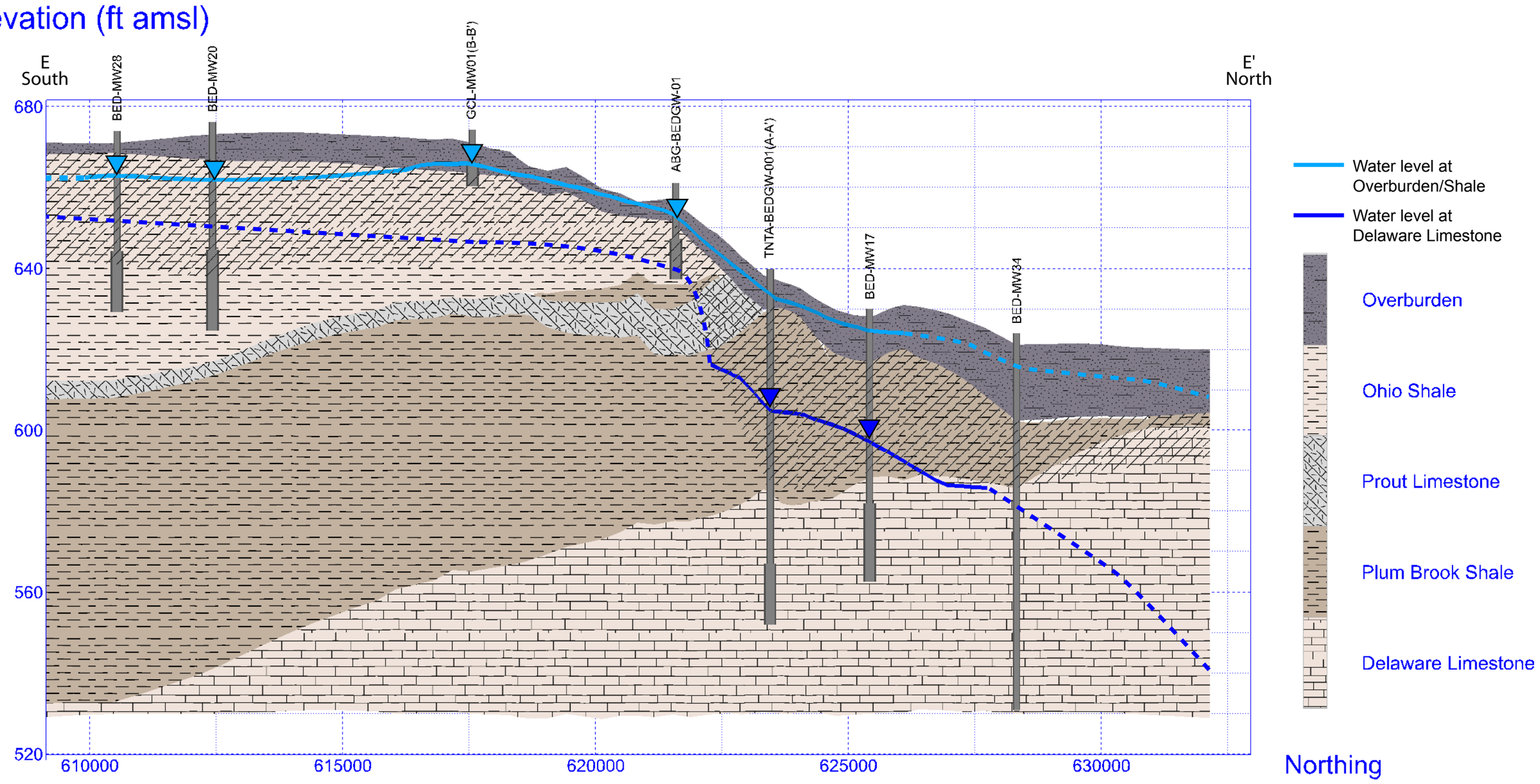


Note: (1) The area shaded by diagonal lines shows weathered bedrock.
(2) Water levels were measured from August 10-11, 2004

Figure 2-6
Geologic Cross-Section D-D'

2004 Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
NASA Plum Brook Station
Sandusky, Ohio

X:\PlumBrook\GISWorkspace\dpack\Illustrator Files\Ke Liu



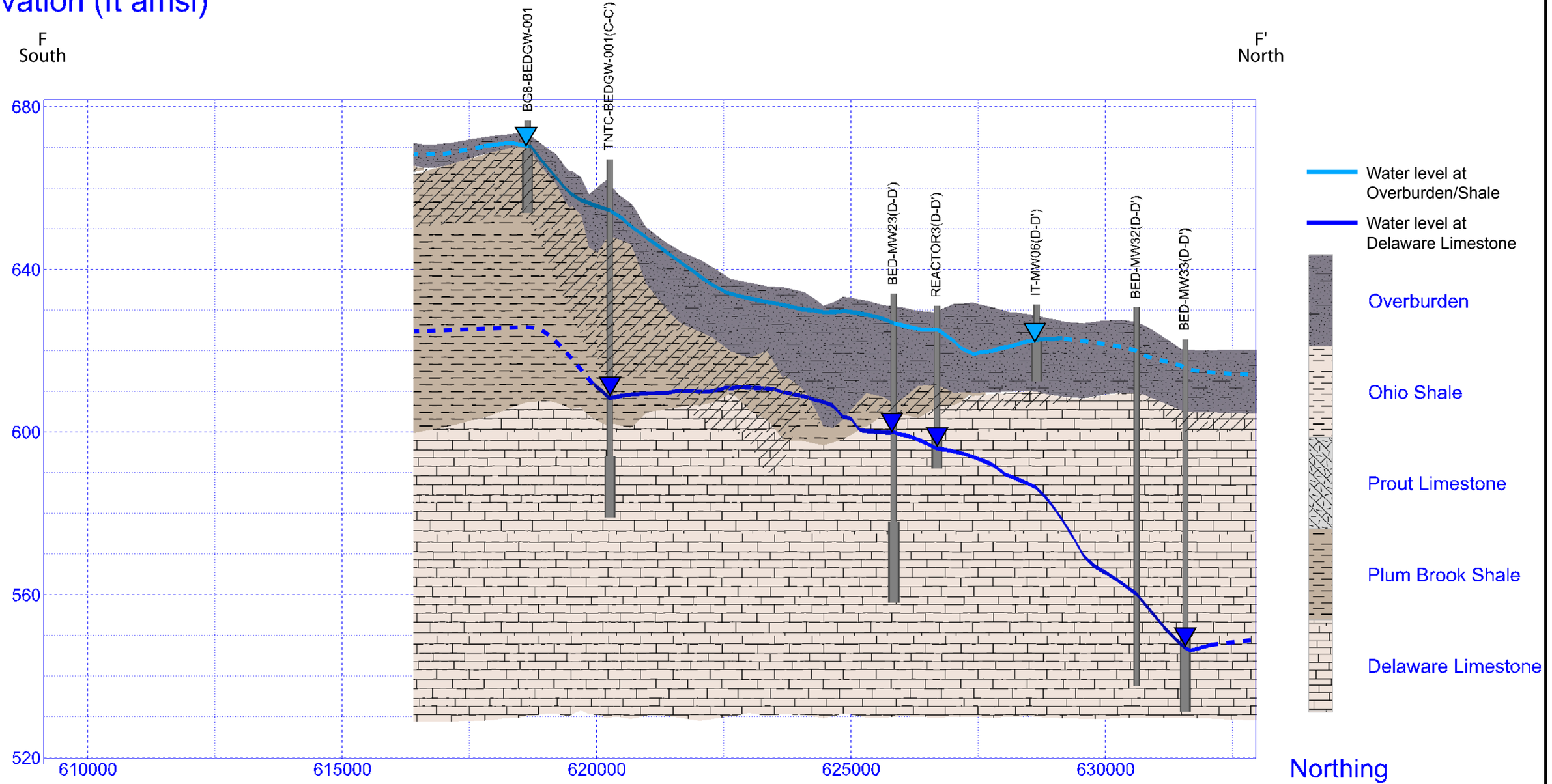
Note: (1) The area shaded by diagonal lines shows weathered bedrock.
(2) Water levels were measured from August 10-11, 2004

0 2500 ft 5000 ft

Figure 2-7
Geologic Cross-Section E-E'

2004 Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
NASA Plum Brook Station
Sandusky, Ohio

X:\PlumBrook\GISWorkspace\dpack\Illustrator Files\Ke Liu



Note: (1) The area shaded by diagonal lines shows weathered bedrock.
(2) Water levels were measured from August 10-11, 2004

0 2500 ft 5000 ft

Figure 2-8
Geologic Cross-Section F-F'

2004 Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
NASA Plum Brook Station
Sandusky, Ohio

X:\PlumBrook\GISWorkspace\dpack\Illustrator Files\Ke Liu

34 x 44

843656_030.dgn 10:06:18 AM 11/30/2004 dbomar

E 1,899,000 E 1,903,000 E 1,907,000 E 1,911,000 E 1,915,000 E 1,919,000 E 1,923,000 E 1,927,000 E 1,931,000 E 1,935,000

N 641,000
N 637,000
N 633,000
N 629,000
N 625,000
N 621,000
N 617,000
N 613,000
N 609,000
N 605,000

COLUMBUS LIMESTONE

PRW-023 (NE)
PRW-026 (NE)
PRW-032 (NE)
PRW-033
PRW-044 (NE)
PRW-027 (NE)
PRW-043 (NE)
PRW-042 (NE)
PRW-022 (NE)
PRW-021 (NE)
PRW-041
PRW-028 (NE)
PRW-029 (NE)
PRW-059 (NE)
BED-MW32 (NE)
BED-MW33 (NE)
BED-MW22 (NE)
PRW-011 (628)
PRW-003 (626)
PRW-002 (617)
PRW-001 (618)
PRW-010 (623)
PRW-009 (617)
PRW-040 (NE)
PRW-025 (NE)
BED-MW31 (619.10)
PT-5912 (NE)
PRW-047 (635)
IT-MW06 (620.10)
BED-MW34 (638.50)
BED-MW27 (ABANDONED) (608.44)
PRW-058 (NE)
RA-03 (608.90)
RA-02 (609.50)
RA-07S (609.65)
RA-07D (NE)
REACTOR3 (NE)
REACTOR2 (NE)
REACTOR1 (NE)
REACTOR4 (605.44)
RA-08S (NE)
RA-MW-04 (602.50)
RA-MW-06 (NE)
RA-06 (612.0)
RA-MW-05 (NE)
RA-MW-02 (604.50)
RA-MW-03 (606.11)
RA-05 (620.20)
BED-MW15 (NE)
RA-01 (615.40)
BED-MW29 (604.54)
RA-04 (620.70)
IT-MW05 (610.59)
BED-MW17 (616.02)
PR-MW07 (609.18)
PR-MW09 (611.38)
PR-MW08 (ABANDONED) (614.18)
AA3-BEDGW-001 (622.7)
AA3-GW002 (617.11)
(623.74) MK-MW10
(622.0) AA2-GW002
BED-MW19 (624.35)
(627.95) MK-MW09
MK-MW11 (627.39)
(NE) GM-MW-11
(NE) GM-MW-09
(NE) GM-MW-10
(NE) GM-MW-12
(NE) GM-MW-08
(NE) GM-MW-07
(NE) GM-04
(623.2) MK-MW19
(NE) GM-MW-06
(NE) GM-05
(NE) GM-06
GM-02 (NE)
GM-03 (NE)
PS-02 (NE)
PS-04 (NE)
PS-03 (NE)
MK-MW23 (620.65)
MK-MW22 (625.74)
TNTA-MW10 (631.18)
BED-MW18 (638.51)
MNT-BEDGW-001 (611.15)
GM-01 (NE)
BED-MW16 (627.56)
TNTA-MW11 (631.54)
TNTA-BEDGW-001 (628.49)
AA1-BEDGW-001 (627.7)
AA1-GW002 (615.6)
GM-MW-13 (NE)
MK-MW20 (661.50)
PRW-006 (623)
PRW-005 (631)
PRW-004 (628)
BED-MW30 (NE)
BED-MW24 (NE)
IT-MW10 (NE)
WA-MW01 (NE)
IT-MW02 (620.14)
WA-MW02
BED-MW14 (621.09)
IT-MW08 (620.2)
2BG-BEDGW-001 (615.89)
2BG-BEDGW-002 (616.09)
2BG-BEDGW-003 (621.04)
PRW-020 (NE)
PRW-024 (NE)
PRW-034 (NE)
PRW-007 (620)
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ABG-BEDGW-001 (652.2)
ABG-GW002 (652.2)
MK-MW12 (625.1)
TNTC-MW03 (629.25)
BED-MW35 (NE)
IT-MW09 (636.4)
TNTC-MW05 (619.05)
TNTC-MW06 (649.90)
TNTC-MW04 (633.57)
TNTC-BEDGW-001 (651.04)
PRW-045 (NE)
TPCB-1 (655)
PRW-050 (655)
TNTB-BEDGW-001 (656.8)
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MK-MW14 (667.01)
MK-MW17 (655.65)
TNTB-BEDGW-003 (666.59)
BED-MW25 (673.19)
GCL-MW02B (663.6)
GCL-MW02A (663.7)
GCL-MW03 (663.55)
GCL-MW01 (663.4)
TNTB-BEDGW-002 (667.3)
MK-MW16 (667.01)
IT-MW01 (671.0)
BED-MW29 (674.70)
PRW-035 (650) BVR-1
PRW-036 (630)
PRW-037 (640)
PRW-008 (621)
PRW-068 (NE)
PRW-087 (NE)
PRW-088 (668)
PRW-056 (679)
PRW-053 (680)
PRW-090 (NE)
PRW-089 (682)
PRW-086 (693)
PRW-052 (686)
PRW-054 (685)
PRW-055 (678)
PRW-014 (631)
BED-MW26 (668.11)
PRW-069 (NE)
PRW-085 (683)
PRW-057 (690)
PRW-051 (649)
PRW-092 (655)
PRW-091 (NE)
PRW-084 (697)
PRW-083 (692)
PRW-067 (692)
SP-03 (NE)
SP-01 (NE)
SP-04 (NE)
SP-05 (NE)
SP-06 (NE)
BED-MW20 (666.65)
PRW-106 (694)
PRW-050 (NE)
PRW-095 (NE)
PRW-094 (NE)
PRW-107 (708)
PRW-066 (699)
PRW-105 (699)
PRW-108 (695)
PRW-065 (693)
PRW-082 (670)
PRW-058 (668)
PRW-081 (681)
PRW-080 (671)
BED-MW28 (668.69)
PRW-059 (671)
PRW-070 (663)
PRW-095 (710)
PRW-104 (708)
PRW-096 (698)
PRW-062 (691.5)
PRW-063 (688.5)
PRW-064 (690.5)
PRW-079 (680)
PRW-012 (587)
PRW-013 (623)
PRW-019 (615)
PRW-018 (618)
PRW-103 (707.5)
PRW-102 (705.5)
PRW-101 (706)
PRW-072 (702)
PRW-060 (677)
PRW-061 (675)
PRW-078 (675)
PRW-071 (NE)
PRW-100 (706)
PRW-049 (699)
PRW-099 (703)
PRW-109 (692)
PRW-073 (697)
PRW-098 (689)
PRW-097 (686)
PRW-074 (685)
PRW-077 (655)
PRW-075 (662)
PRW-076 (661)
PRW-016 (650)
PRW-015 (634)
PRW-017 (623)

LEGEND:

- PRIVATE WELL LOCATION
- OVERBURDEN WELL LOCATION
- BEDROCK WELL LOCATION
- SOIL BORING LOCATION
- (NE) NOT ENCOUNTERED

REFERENCE:

PRELIMINARY BEDROCK GEOLOGY OF THE KIMBALL AND SANDUSKY, OHIO, QUADRANGLES, STATE OF OHIO, DEPARTMENT OF NATURAL RESOURCES, DIVISION OF GEOLOGICAL SURVEY, 1995.

BASE MAPS (COMBINED BY SHAW) FROM KIMBALL AND SANDUSKY QUADRANGLES, 7.5 MINUTE SERVICES, (TOPOGRAPHIC), 1969. SANDUSKY MAP WAS PHOTOREVISED 1979.

SCALE
0 1250 2500 FEET

NO	DATE	REVISION	BY	CHKD	DSGN ENGR	ENGR	PROJ MGR	APPR

STARTING DATE 11/22/04 | INITIATOR D. KESSLER | CHKD | DRAWN D. BOMAR | CHKD | PROJECT MNGR S. DOWNEY

Shaw Environmental, Inc.
KNOXVILLE, TENNESSEE

2004 GROUNDWATER DATA SUMMARY AND EVALUATION REPORT FORMER PLUM BROOK ORDNANCE WORKS NASA PLUM BROOK STATION SANDUSKY, OHIO

FIGURE 2-9
TOP-OF-SHALE ELEVATION CONTOUR MAP

AREA	JOB NO.	DRAWING NO.	REV
SITEWIDE	843656	843656_030.DGN	

M L K J I H G F E D C B A

17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1

34 x 44

843656_031.dgn 10:27:00 AM 11/30/2004 dbomar

E 1,899,000 E 1,903,000 E 1,907,000 E 1,911,000 E 1,915,000 E 1,919,000 E 1,923,000 E 1,927,000 E 1,931,000 E 1,935,000

N 641,000
N 637,000
N 633,000
N 629,000
N 625,000
N 621,000
N 617,000
N 613,000
N 609,000
N 605,000
N 601,000

COLUMBUS LIMESTONE

DELAWARE LIMESTONE

LEWIS RESEARCH CENTER

PLUM BROOK ORDNANCE WORKS

PRW-023 (NE)
PRW-026 (592)
PRW-032 (535)
PRW-033 (534)
PRW-044 (589)
PRW-027 (595.5)
PRW-043 (609)
PRW-042 (607)
PRW-022 (NE)
PRW-021 (NE)
PRW-041 (597)
PRW-028 (615)
PRW-029 (617.5)
PRW-059 (618.07)
BED-MW33 (604.87)
BED-MW32 (610.26)
BED-MW22 (607.72)
PRW-011 (NE)
PRW-003 (NE)
PRW-002 (NE)
PRW-001 (NE)
PRW-010 (585)
PRW-009 (NE)
PRW-040 (615)
IT-MW06 (NE)
BED-MW34 (585.50)
BED-MW27 (ABANDONED) (605.24)
PRW-038 (593)
PRW-025 (612)
BED-MW31 (619.10)
PT-5912 (611.81)
PRW-047 (613)
PRW-039 (NE)
RA-03 (NE)
RA-02 (NE)
RA-07S (NE)
RA-07D (NE)
RA-08D (NE)
RA-08S (610.71)
RA-MW-04 (NE)
RA-MW-06 (NE)
REACTOR3 (NE)
REACTOR2 (NE)
REACTOR1 (NE)
REACTOR4 (NE)
RA-06 (NE)
RA-MW-05 (604.00)
RA-MW-02 (NE)
RA-MW-03 (NE)
RA-05 (NE)
BED-MW15 (604.46)
RA-01 (NE)
BED-MW29 (604.81)
RA-04 (NE)
IT-MW05 (NE)
BED-MW17 (589.72)
AA3-BEDGW-001 (600.80)
AA3-GW002 (NE)
PR-MW07 (NE)
PR-MW08 (ABANDONED) (NE)
PR-MW09 (NE)
GM-MW-11 (NE)
GM-MW-09 (NE)
GM-MW-10 (NE)
GM-MW-12 (NE)
GM-04 (NE)
GM-02 (NE)
GM-03 (NE)
GM-MW-08 (NE)
GM-MW-07 (NE)
PS-03 (NE)
PS-02 (NE)
PS-04 (NE)
MK-MW22 (NE)
MK-MW23 (NE)
AA2-GW002 (NE)
BED-MW19 (621.09)
MK-MW10 (624.20)
MK-MW09 (NE)
MK-MW11 (NE)
AA2-BEDGW-001 (622.60)
GM-MW-19 (NE)
GM-MW-06 (NE)
GM-05 (NE)
GM-06 (NE)
GM-MW-05 (NE)
GM-MW-13 (NE)
AA1-BEDGW-001 (598.80)
AA1-GW002 (NE)
TNTA-MW10 (NE)
TNTA-MW11 (NE)
TNTA-BEDGW-001 (585.99)
BED-MW16 (589.16)
MK-MW20 (NE)
BED-MW18 (582.61)
PRW-020 (629)
PRW-024 (624)
BED-MW30 (623.25)
BED-MW24 (626.90)
IT-MW10 (624.20)
WA-MW01 (619.70)
IT-MW02 (617.87)
WA-MW02 (NE)
BED-MW14 (618.32)
IT-MW08 (NE)
ZBG-BEDGW-001 (614.12)
ZBG-BEDGW-002 (610.08)
ZBG-BEDGW-003 (609.84)
PRW-034 (629)
MK-MW12 (NE)
TNTC-MW03 (NE)
BED-MW13 (604.79)
IT-MW09 (NE)
TNTC-MW05 (NE)
TNTC-MW06 (NE)
TNTC-MW04 (NE)
TNTC-BEDGW-001 (604.74)
PRW-006 (NE)
PRW-005 (NE)
PRW-004 (NE)
PRW-007 (NE)
ABG-BEDGW-001 (NE)
ABG-GW002 (NE)
MK-MW24 (NE)
PRW-045 (630)
BG8-BEDGW-001 (NE)
MK-MW15 (NE)
MK-MW14 (NE)
TNTB-BEDGW-001 (NE)
TPCB-1 (613)
PRW-030 (655)
MK-MW17 (NE)
TNTB-BEDGW-004 (NE)
TNTB-BEDGW-003 (NE)
GCL-MW02B (NE)
GCL-MW02A (NE)
GCL-MW03 (NE)
GCL-MW01 (NE)
PRW-035 (NE)
BVR-1
PRW-036 (NE)
PRW-037 (625)
BED-MW25 (NE)
TNTB-BEDGW-002 (NE)
BED-MW29 (NE)
IT-MW01 (NE)
MK-MW16 (NE)
PRW-008 (NE)
PRW-068 (NE)
PRW-087 (598)
PRW-088 (NE)
PRW-056 (NE)
PRW-053 (NE)
PRW-090 (NE)
PRW-089 (NE)
PRW-086 (NE)
PRW-054 (NE)
PRW-055 (NE)
PRW-052 (626)
PRW-014 (508)
BED-MW26 (NE)
PRW-069 (NE)
PRW-085 (638)
PRW-057 (NE)
PRW-084 (NE)
PRW-083 (NE)
PRW-067 (NE)
PRW-051 (625)
PRW-092 (NE)
PRW-091 (NE)
PRW-106 (NE)
SP-01 (NE)
SP-03 (NE)
SP-04 (NE)
SP-05 (NE)
SP-06 (NE)
BED-MW20 (NE)
PRW-050 (642)
PRW-107 (NE)
PRW-066 (NE)
PRW-082 (NE)
PRW-058 (NE)
PRW-081 (NE)
PRW-080 (NE)
BED-MW28 (NE)
PRW-093 (NE)
PRW-094 (NE)
PRW-105 (NE)
PRW-108 (NE)
PRW-065 (NE)
PRW-059 (NE)
PRW-070 (NE)
PRW-079 (NE)
PRW-012 (NE)
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PRW-109 (NE)
PRW-073 (NE)
PRW-098 (NE)
PRW-097 (NE)
PRW-074 (599)
PRW-077 (NE)
PRW-075 (NE)
PRW-076 (NE)
PRW-016 (NE)
PRW-015 (NE)
PRW-017 (NE)

640 635 630 625 620 615 610 605 600 595 590 585 580 575 570 565 560 555

LEGEND:

- PRIVATE WELL LOCATION
- OVERBURDEN WELL LOCATION
- BEDROCK WELL LOCATION
- SOIL BORING LOCATION
- (NE) NOT ENCOUNTERED
- ELEVATION DATA NOT USED IN CONTOUR MAP CONSTRUCTION

REFERENCE:

PRELIMINARY BEDROCK GEOLOGY OF THE KIMBALL AND SANDUSKY, OHIO, QUADRANGLES, STATE OF OHIO, DEPARTMENT OF NATURAL RESOURCES, DIVISION OF GEOLOGICAL SURVEY, 1995.

BASE MAPS (COMBINED BY SHAW) FROM KIMBALL AND SANDUSKY QUADRANGLES, 7.5 MINUTE SERVICES, (TOPOGRAPHIC), 1969. SANDUSKY MAP WAS PHOTOREVISED 1979.

SCALE
0 1250 2500 FEET

NO	DATE	REVISION	BY	CHKD	DSGN ENGR	ENGR	PROJ MGR	APPR

STARTING DATE 11/22/04 | INITIATOR D. KESSLER | CHKD | DRAWN D. BOMAR | CHKD | PROJECT MNGR S. DOWNEY

Shaw® Shaw Environmental, Inc.
KNOXVILLE, TENNESSEE

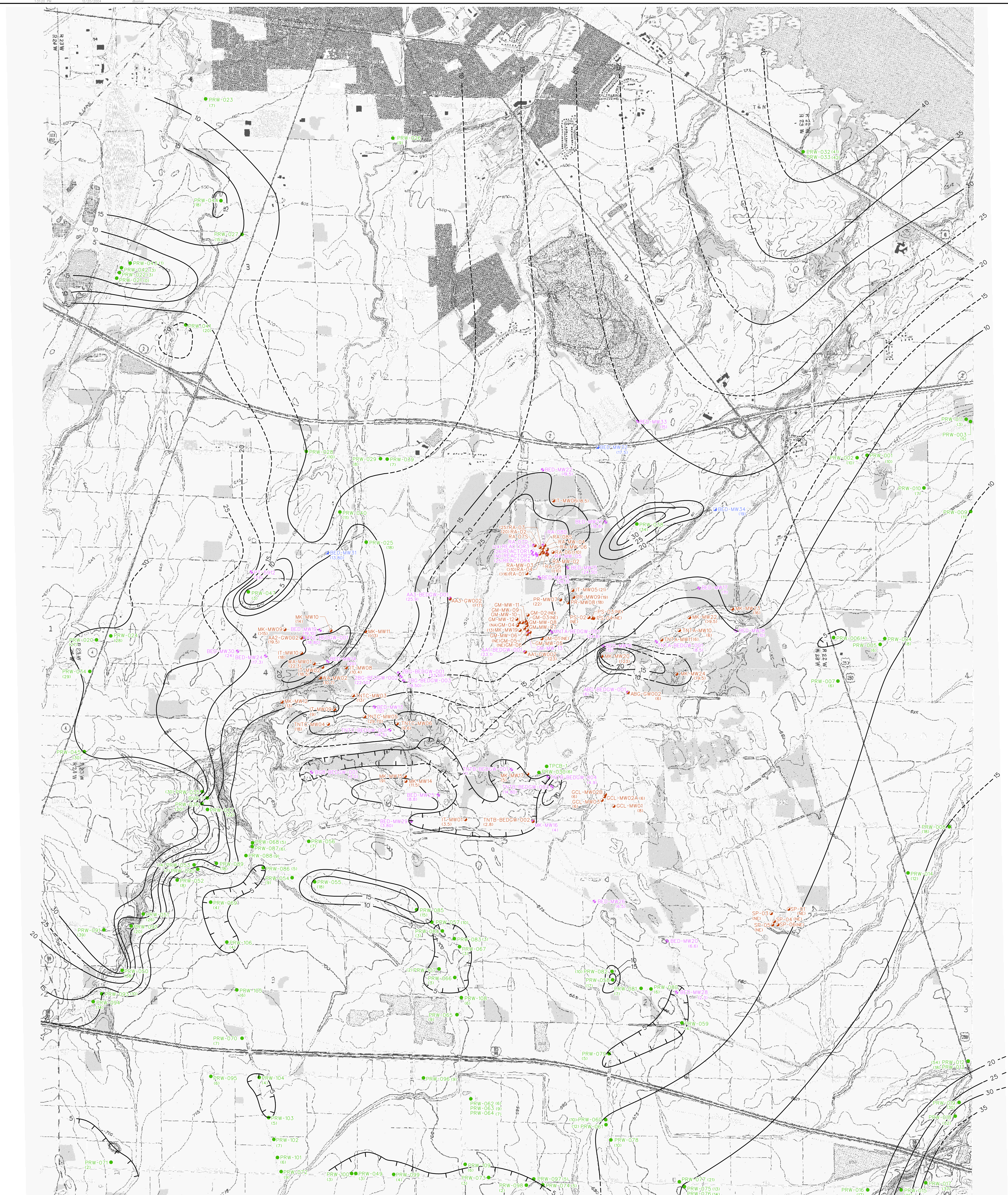
2004 GROUNDWATER DATA SUMMARY
AND EVALUATION REPORT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

FIGURE 2-10
TOP-OF-DELAWARE LIMESTONE
ELEVATION CONTOUR MAP

AREA	JOB NO.	DRAWING NO.	REV
SITEWIDE	843656	843656_031.DGN	

17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1

M L K J I H G F E D C B A



SCALE
0 1250 2500 FEET

LEGEND:

- ● PRIVATE WELL LOCATION
- OVERBURDEN WELL LOCATION
- BEDROCK WELL LOCATION
- SOIL BORING LOCATION
- (14) OVERBURDEN THICKNESS IN FEET

REFERENCE:

PRELIMINARY BEDROCK GEOLOGY OF THE KIMBALL AND SANDUSKY, OHIO, QUADRANGLES, STATE OF OHIO, DEPARTMENT OF NATURAL RESOURCES, DIVISION OF GEOLOGICAL SURVEY, 1995.

BASE MAPS (COMBINED BY SHAW) FROM KIMBALL AND SANDUSKY QUADRANGLES, 7.5 MINUTE SERVICES, (TOPOGRAPHIC), 1969. SANDUSKY MAP WAS PHOTOREVISED 1979.

NO	DATE	REVISION	BY	CHKD	DSGN ENGR	ENGR	PROJ MGR	APPR

STARTING DATE 11/30/04 | INITIATOR D. KESSLER | CHKD | DRAWN D. BOMAR | CHKD | PROJECT MNGR S. DOWNEY

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2004 GROUNDWATER DATA SUMMARY
AND EVALUATION REPORT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

FIGURE 2-11
OVERBURDEN THICKNESS CONTOUR MAP

AREA	JOB NO.	DRAWING NO.	REV
SITEWIDE	843656	843656_014.DGN	

M L K J I H G F E D C B A

17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1

NOTES:

1. *SNAKE ROAD BURNING GROUND AREA WAS ALSO REFERRED TO AS "SNAKE ROAD BURN PIT", "SCHEID ROAD BURNING GROUNDS", AND "DISPOSAL AREA THREE".
2. ONLY GROUNDWATER DATA FROM OVERBURDEN/SHALE MONITORING WELLS THAT ARE NOT ENTIRELY OR PARTIALLY SCREENED IN SHALE WERE USED FOR CONTOUR MAP CONSTRUCTION. SEE TABLE 4-2 FOR MONITORING WELL SCREENED LITHOLOGIC UNITS.

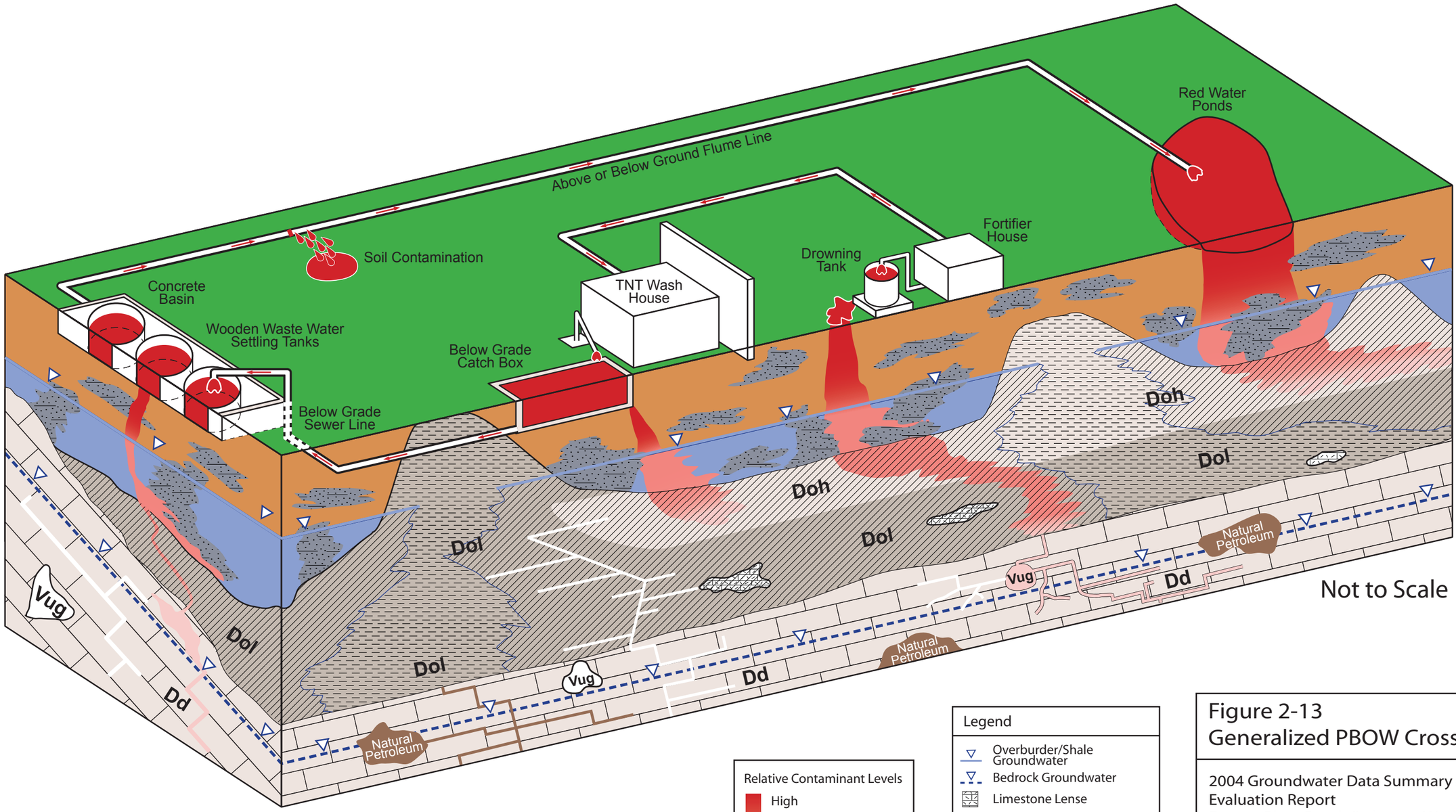
STARTING DATE	INITIATOR	CHKD	DRAWN	CHKD	PROJECT MNGR
11/29/04	D.KESSLER	/KESSLER	D. BOMAR	/	S.DOWNEY

Shaw Environmental, Inc.
NASHVILLE, TENNESSEE

2004 GROUNDWATER DATA SUMMARY AND EVALUATION REPORT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

FIGURE 2-12
OVERBURDEN GROUNDWATER ISOPACH MAP
(AUGUST 2001)

AREA	JOB NO.	DRAWING NO.	REV
SITEWIDE	843656	843656_023.DGN	



Relative Contaminant Levels

High

Low

Legend

- Overburder/Shale Groundwater
- Bedrock Groundwater
- Limestone Lense
- Sandy Silt/Sandy Clay Lense
- Silt/Clay/Shale Fragments
- Weathered Shale

Doh - Ohio Shale
Dol - Olentangy Shale (Prout and Olentangy Shale Members)
Dd- Delaware Limestone

Figure 2-13
Generalized PBOW Cross-Section

2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works
NASA Plum Brook Station
Sandusky, Ohio

Shaw™ Shaw Environmental, Inc.

X:\PlumBrook\GISWorkspace\dpack\Illustrator Files\plumbrook_csm_112904.ai

DWG. NO.:843656_016.dgn
PROJ. NO.: 843656
INITIATOR: D. KESSLER
PROJ. MGR.: S. DOWNEY
DRAFT. CHCK. BY:
ENGR. CHCK. BY: D. KESSLER
DATE LAST REV.:
DRAWN BY:
STARTING DATE: 11/16/04
DRAWN BY: D. BOMAR
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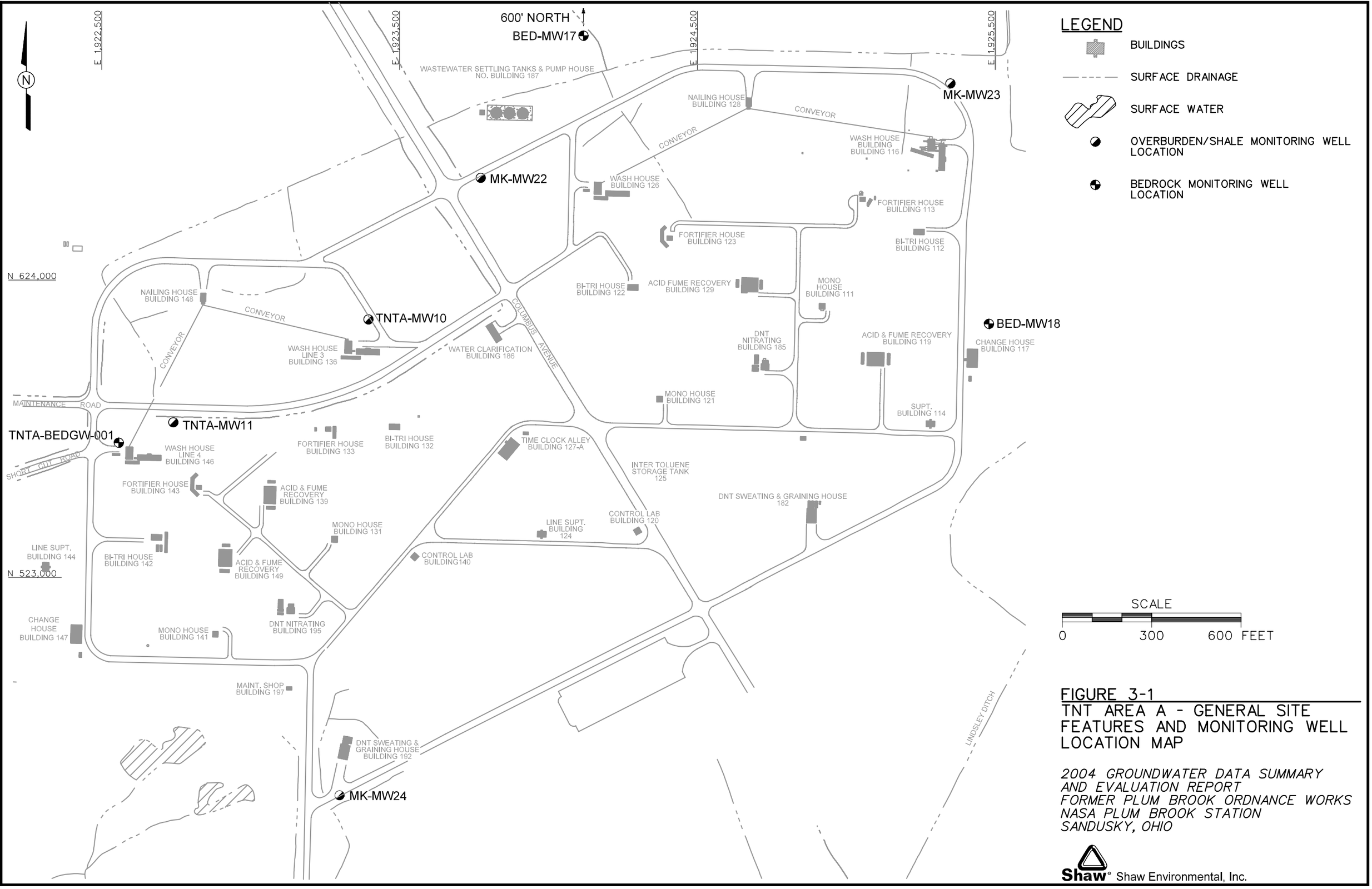
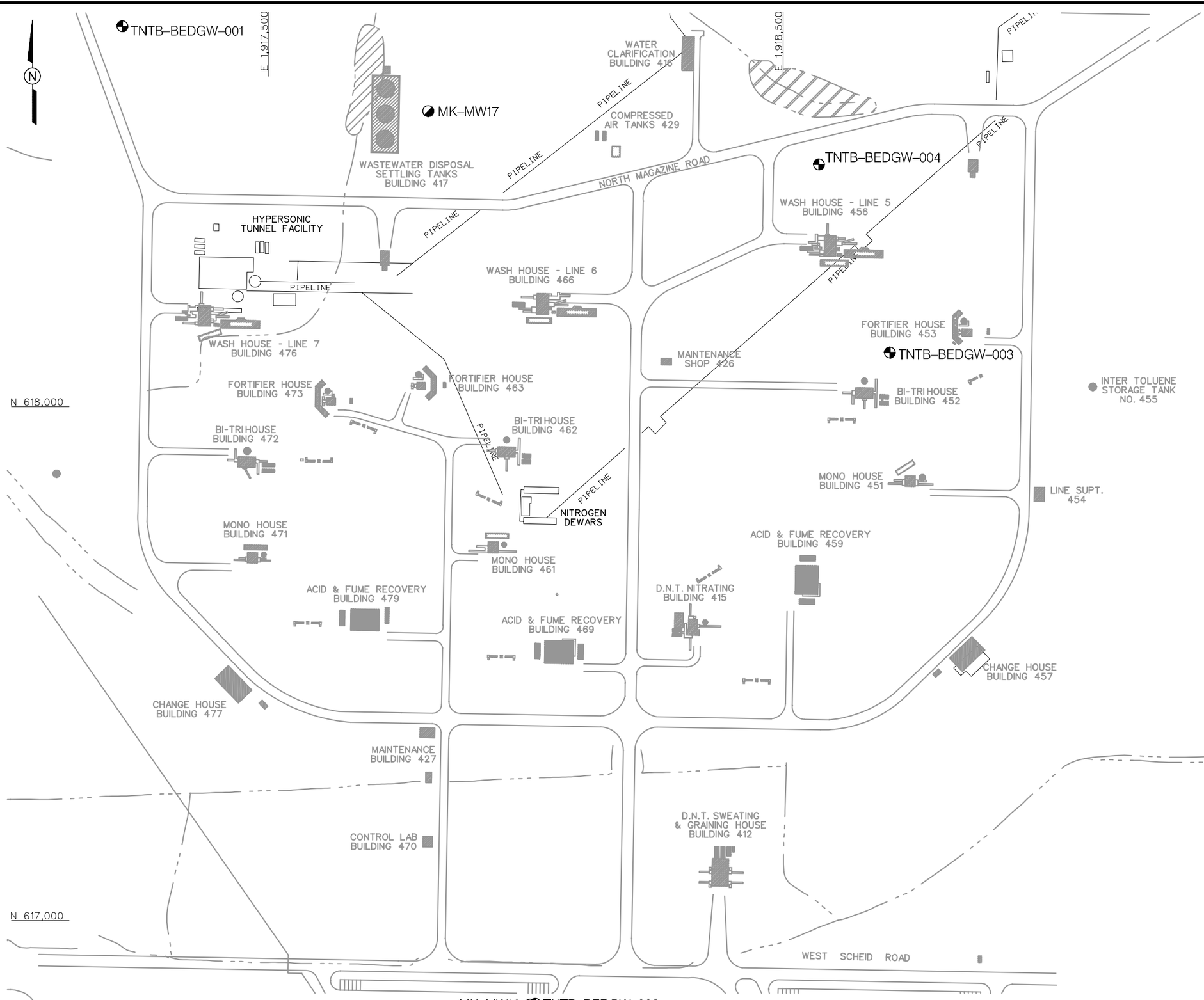


FIGURE 3-1
TNT AREA A - GENERAL SITE FEATURES AND MONITORING WELL LOCATION MAP

2004 GROUNDWATER DATA SUMMARY AND EVALUATION REPORT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw® Shaw Environmental, Inc.



LEGEND

- BUILDINGS
- SURFACE DRAINAGE
- SURFACE WATER
- OVERBURDEN/SHALE MONITORING WELL LOCATION
- BEDROCK MONITORING WELL LOCATION

SCALE

0 200 400 FEET

FIGURE 3-2
TNT AREA B - GENERAL SITE FEATURES AND MONITORING WELL LOCATION MAP

2004 GROUNDWATER DATA SUMMARY AND EVALUATION REPORT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw® Shaw Environmental, Inc.

DWG. NO.:843656_017.dgn | PROJ. NO.: 843656
INITIATOR: D. KESSLER | PROJ. MGR.: S. DOWNEY
DRAFT. CHCK. BY: | ENGR. CHCK. BY: D. KESSLER
DATE LAST REV.: | DRAWN BY:
STARTING DATE: 11/16/04 | DRAWN BY: D. BOMAR
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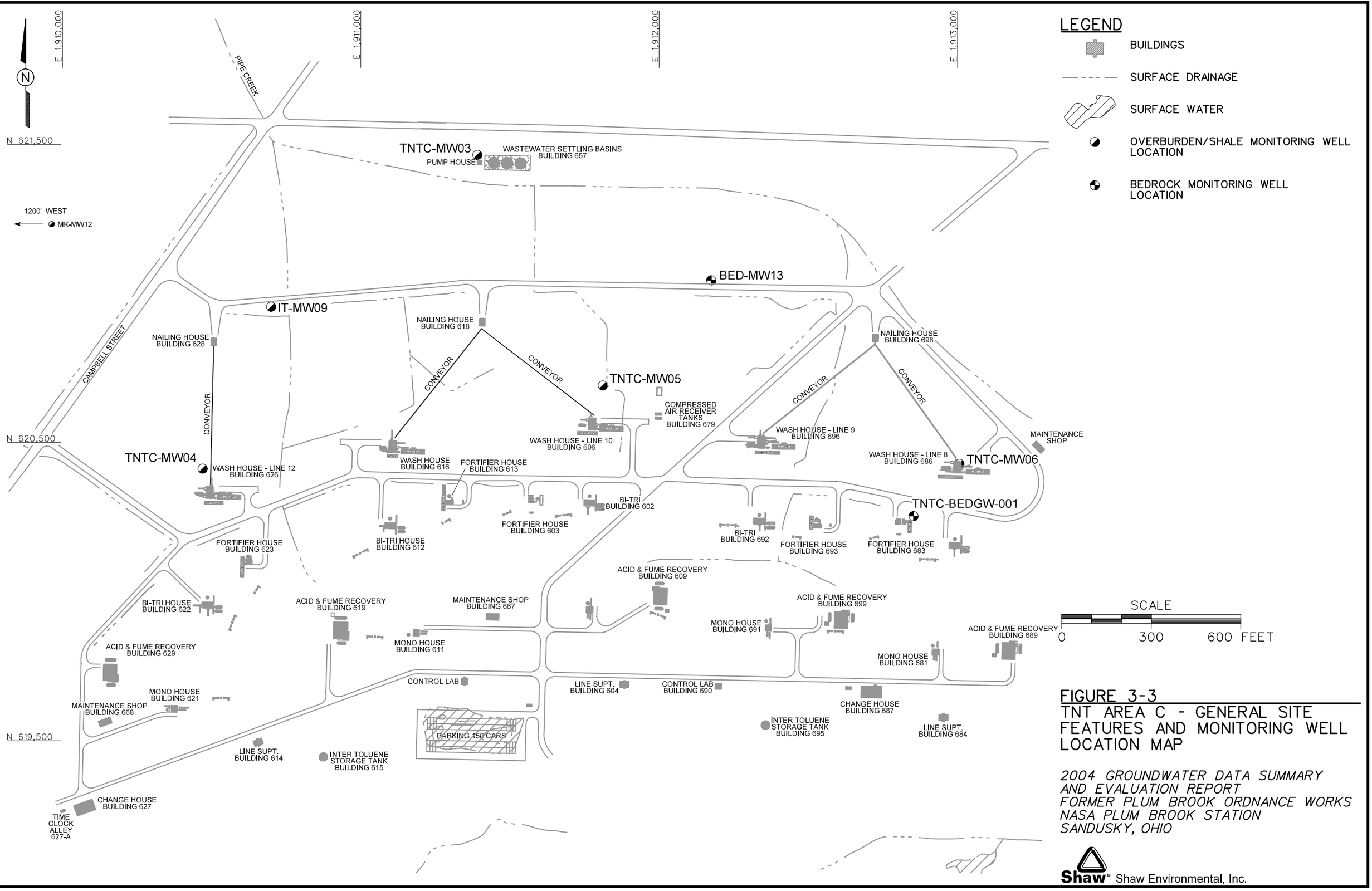

FIGURE 3-3
TNT AREA C - GENERAL SITE FEATURES AND MONITORING WELL LOCATION MAP

2004 GROUNDWATER DATA SUMMARY
AND EVALUATION REPORT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw® Shaw Environmental, Inc.

DRAFT. CHCK. BY:
ENGR. CHCK. BY: D. KESSLER
INITIATOR: D. KESSLER
PROJ. MGR.:S. DOWNEY
STARTING DATE: 11/16/04
DRAWN BY: D. BOMAR
DATE LAST REV.:
DRAWN BY:
DWG. NO.:843656_018.dgn
PROJ. NO.: 843656

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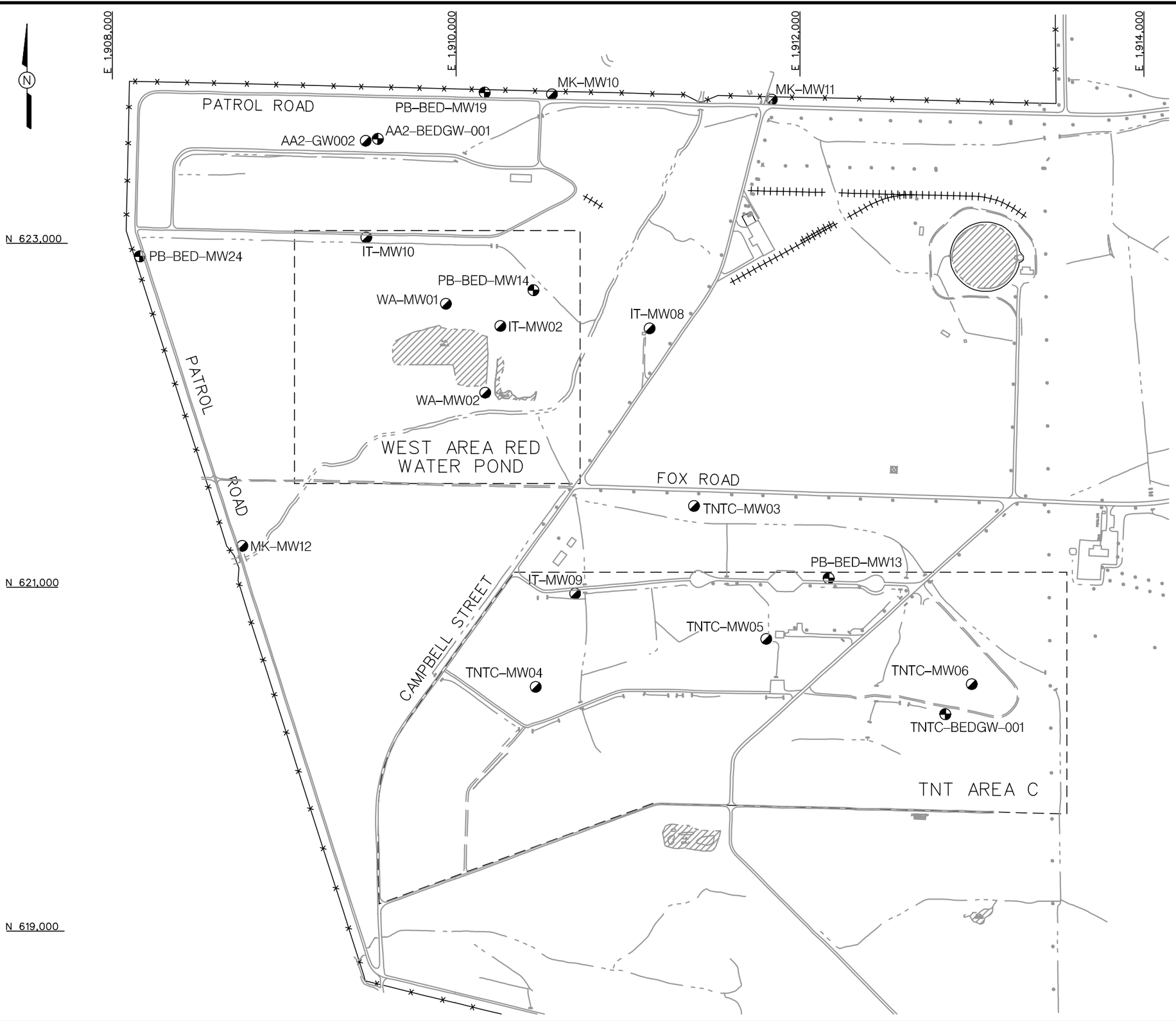
DWG. NO.843656_019.DGN | PROJ. NO.: 843656 | INITIATOR: D. KESSLER | PROJ. MGR.: S. DOWNEY | DRAFT. CHCK. BY: | ENGR. CHCK. BY: D. KESSLER | DATE LAST REV.: | DRAWN BY: | STARTING DATE: 11/16/04 | DRAWN BY: D. BOMAR | r2d2-b&w-tabloid.plt 10:28:16 AM 3/22/2005 | standard-test2.tbl dbomar 843656_019.DGN



LEGEND

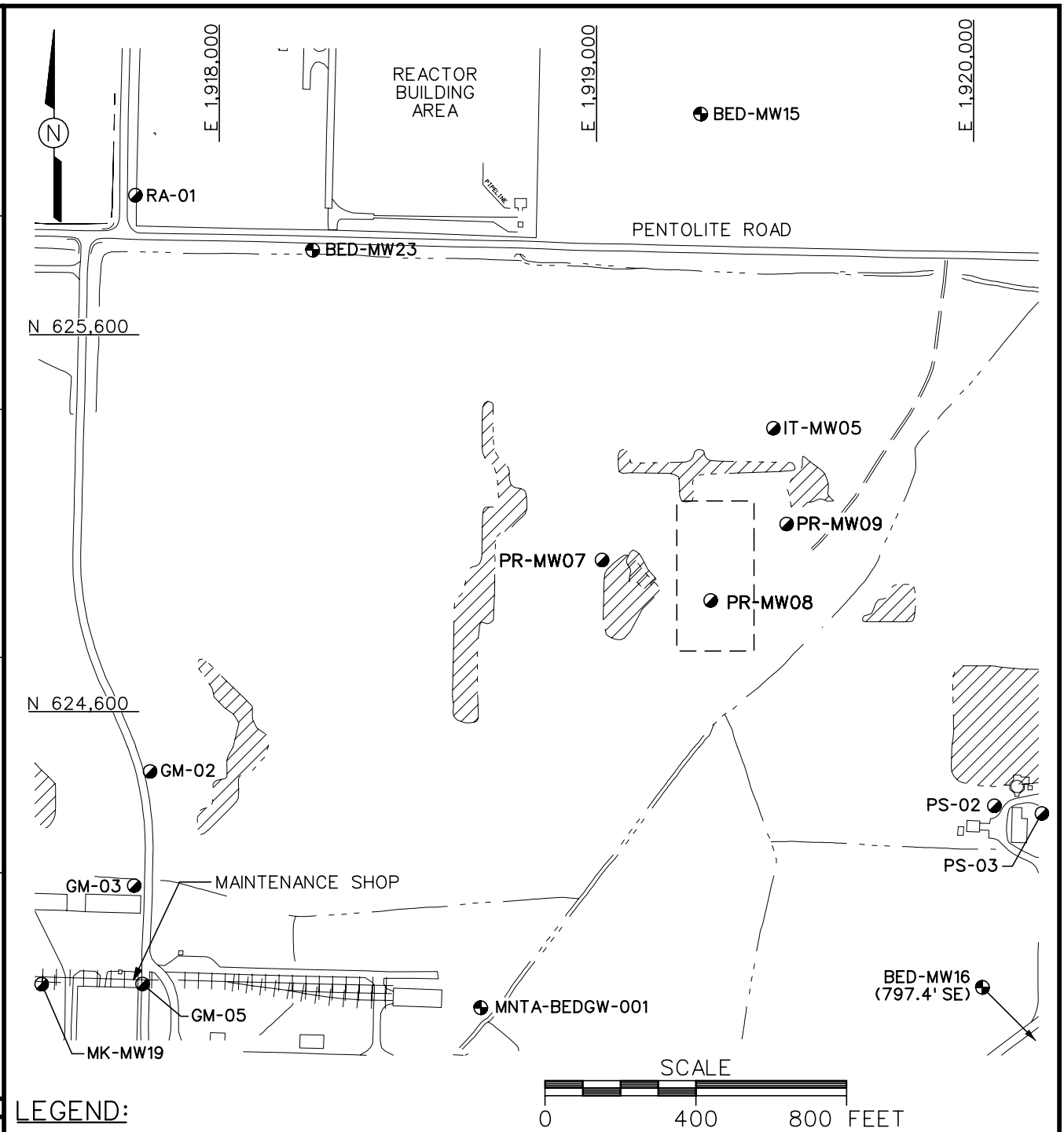
- BUILDINGS
- FENCE (PBOW BOUNDARY)
- RAILROAD
- SURFACE DRAINAGE
- SURFACE WATER
- OVERBURDEN/SHALE MONITORING WELL LOCATION
- BEDROCK MONITORING WELL LOCATION

SCALE
0 600 1200 FEET

FIGURE 3-4
WEST AREA RED WATER PONDS AND TNT AREA C - GENERAL SITE FEATURES AND MONITORING WELL LOCATION MAP

2004 GROUNDWATER DATA SUMMARY AND EVALUATION REPORT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw® Shaw Environmental, Inc.



LEGEND:

- BUILDINGS
- RAILROAD
- APPROXIMATE HISTORICAL LOCATION OF PONDS
- SURFACE DRAINAGE
- SURFACE WATER
- OVERBURDEN/SHALE MONITORING WELL LOCATION
- BEDROCK MONITORING WELL LOCATION

FIGURE 3-5
PENTOLITE ROAD RED WATER PONDS - GENERAL SITE FEATURES AND MONITORING WELL LOCATION MAP

2004 GROUNDWATER DATA SUMMARY AND EVALUATION REPORT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw® Shaw Environmental, Inc.

STARTING DATE: 11/15/04 | DATE LAST REV.: | DRAFT. CHCK. BY: | INITIATOR: D. KESSLER | DWG. NO.843656_020.DGN
DRAWN BY: D. BOMAR | DRAWN BY: | ENGR. CHCK. BY: D. KESSLER | PROJ. MGR.:S. DOWNEY | PROJ. NO.: 843656

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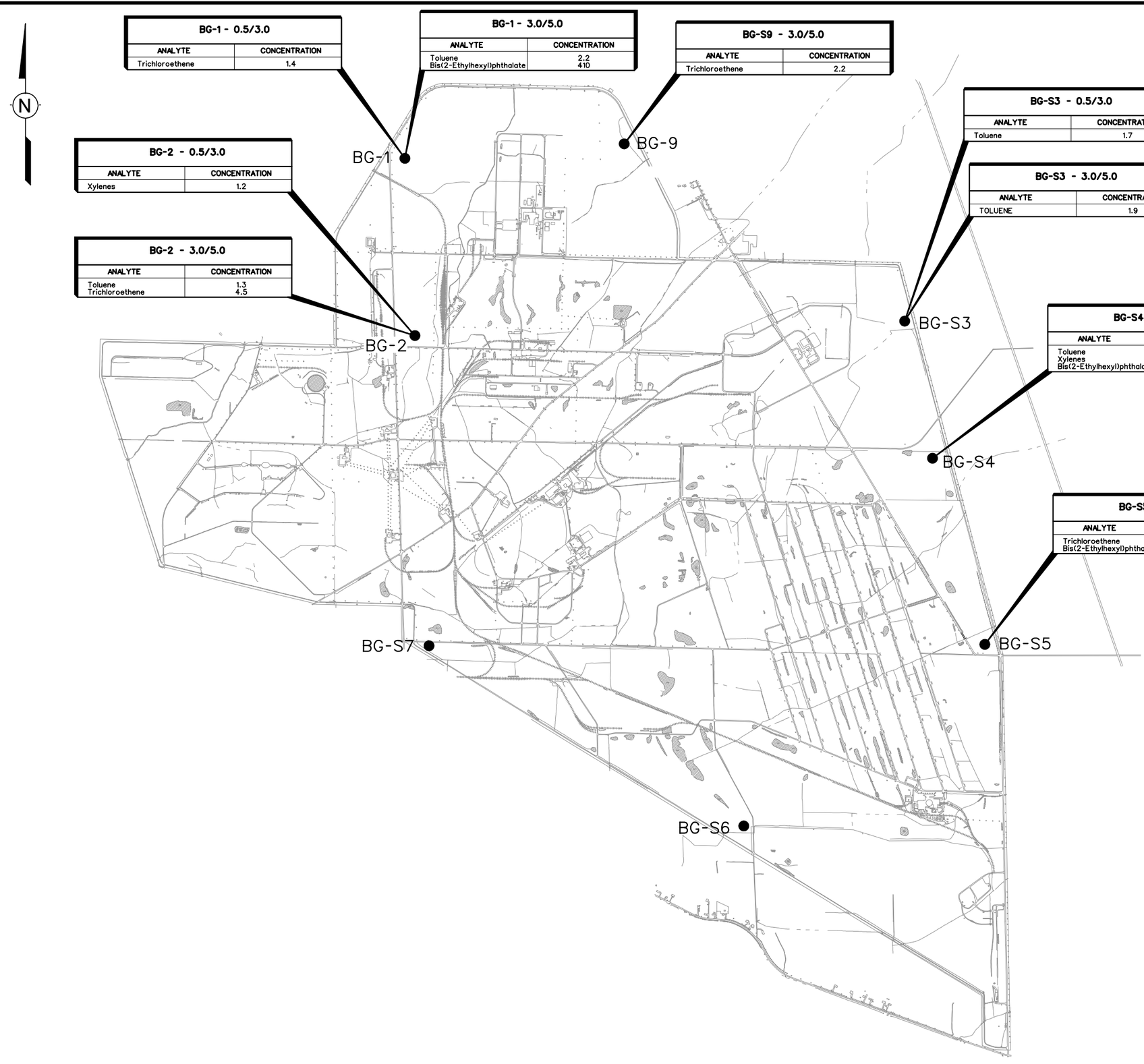

LEGEND

● SOIL BORING SAMPLING LOCATION (1994)

NOTE:

1. ANALTICAL RESULTS ARE FROM DAMES & MOORE, INC.

SCALE

0 2500 5000 FEET

FIGURE 3-6
BACKGROUND SOIL BORING LOCATIONS (1994)

2004 GROUNDWATER DATA SUMMARY
AND EVALUATION REPORT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw® Shaw Environmental, Inc.

DWG. NO.:843656_021.dgn | PROJ. NO.: 843656
INITIATOR: D. KESSLER | PROJ. MGR.: S. DOWNEY
DRAFT. CHCK. BY: | ENGR. CHCK. BY: D. KESSLER
LAST REV.: | DATE LAST REV.:
STARTING DATE: 11/17/04 | DRAWN BY:
DRAWN BY: D. BOMAR

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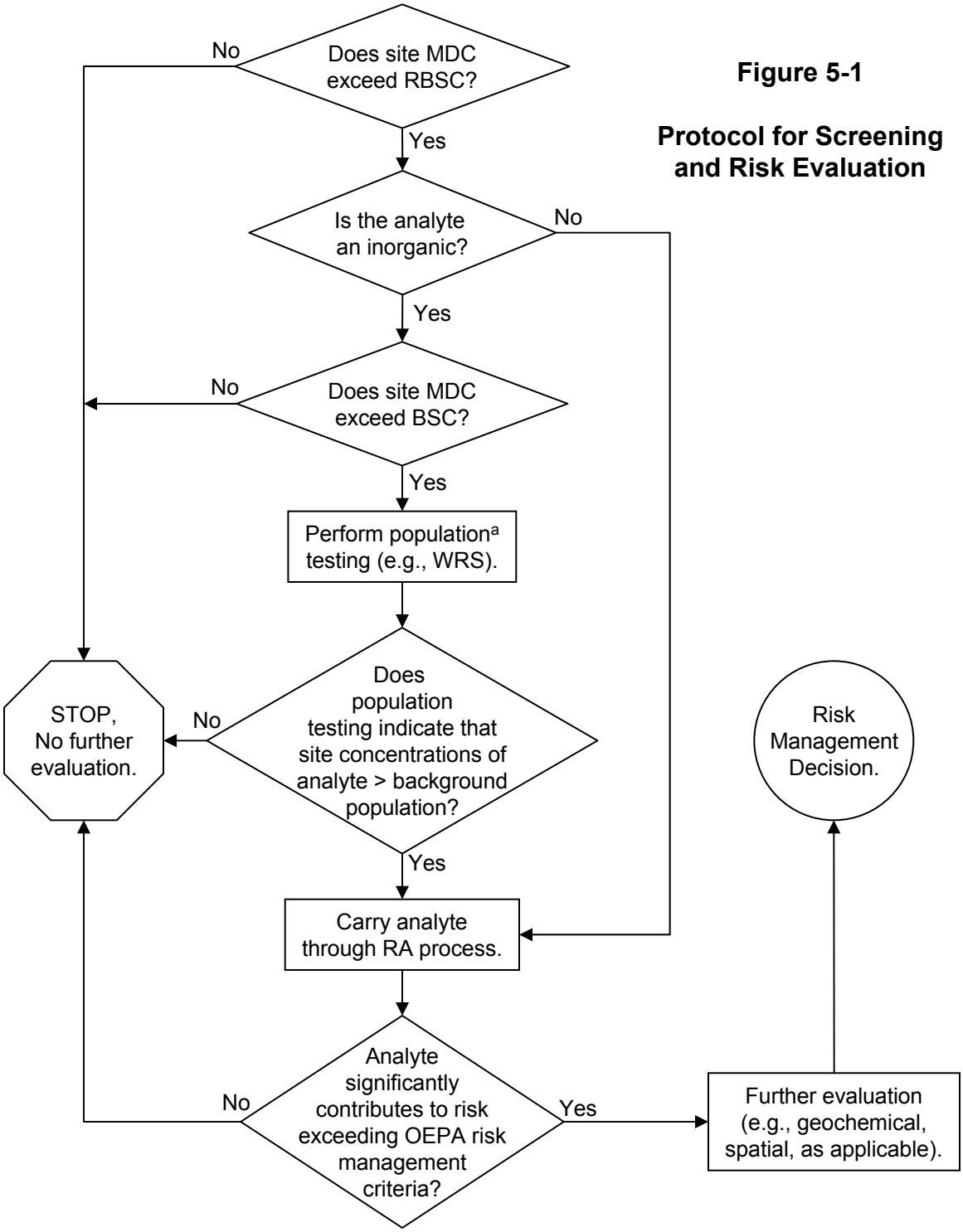
dbomar
843656_021.dgn

Figure 5-1

Protocol for Screening and Risk Evaluation



Notes:

[a] A judgment may be made at this step to forego or modify population testing if the site data is clearly greater than background and/or individual exceedances suggest the presence of a hot spot. In such cases, the analyte would be carried into the risk assessment process.

BSC - Background screening concentration.
MDC - Maximum detected concentration.
OEPA - Ohio Environmental Protection Agency.
RA - Risk assessment.
RBSC - Risk-based screening concentration.
WRS - Wilcoxon rank sum (test).

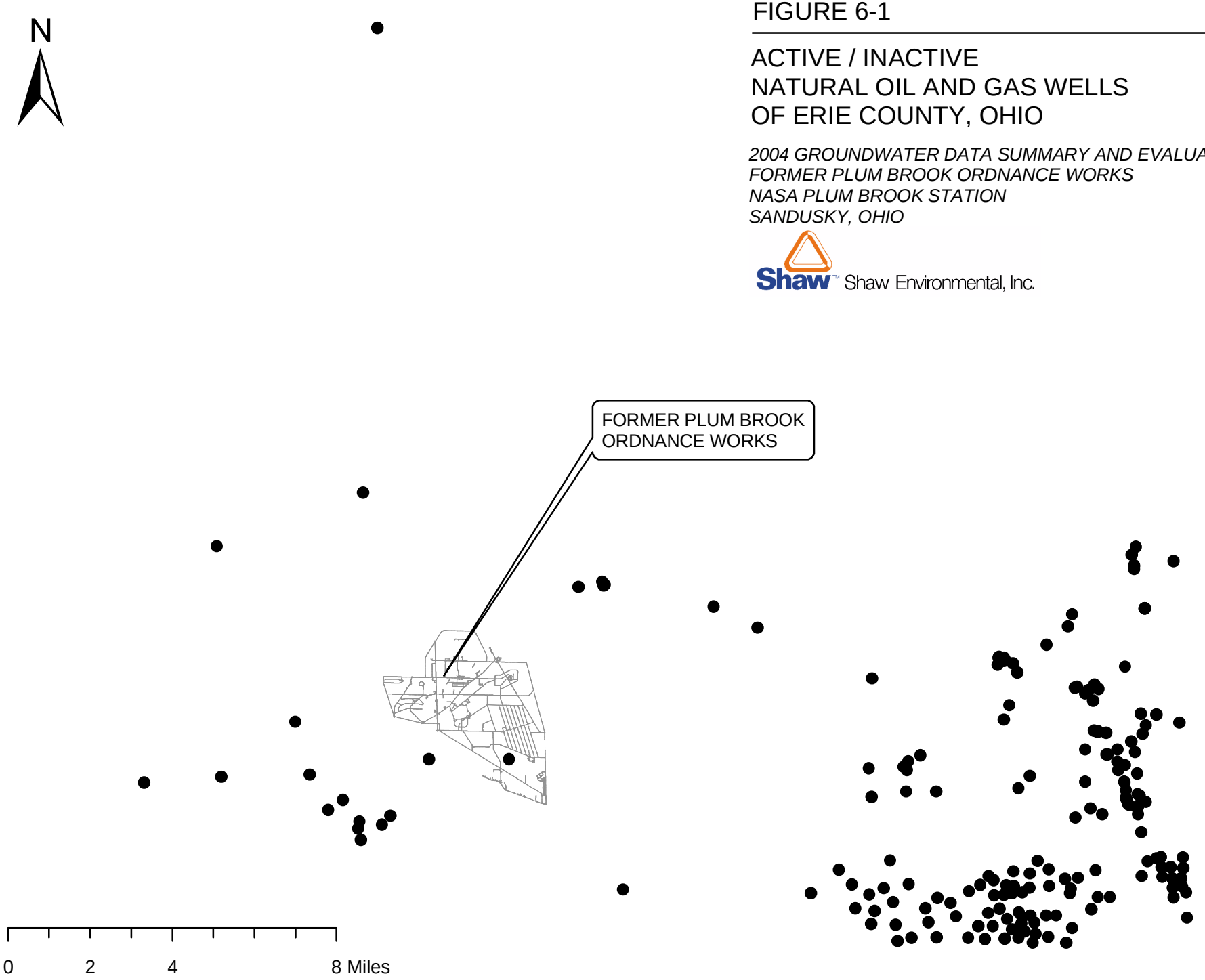
KN5\PBOW\04 GWDS\Final\Figure5-1.ppt\6/29/2005 10:12 AM

FIGURE 6-1

ACTIVE / INACTIVE NATURAL OIL AND GAS WELLS OF ERIE COUNTY, OHIO

2004 GROUNDWATER DATA SUMMARY AND EVALUATION REPORT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw™ Shaw Environmental, Inc.



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13 12 11 10 9 8 7 6 5 4 3 2 1

A B C D E F G H I

E 1,907,000 E 1,911,000 E 1,915,000 E 1,919,000 E 1,923,000 E 1,927,000

N 629,000 N 625,000 N 621,000 N 617,000 N 613,000 N 609,000

LEGEND:

ABG-GW002	OVERBURDEN/SHALE MONITORING WELL
TNTC-BEDGW-001 (LS)	BEDROCK MONITORING WELL SCREENED IN LIMESTONE
ABG-BEDGW-001 (SH)	BEDROCK MONITORING WELL SCREENED IN SHALE
	BUILDING
	RAILROAD
	SURFACE WATER
	DITCH
	FENCE (PBOW BOUNDARY)
(630.45)	GROUNDWATER ELEVATION (FT-MSL)
630	GROUNDWATER ELEVATION CONTOUR (FT-MSL) (DASHED WHERE INFERRED)
G.W. FLOW	GROUNDWATER FLOW DIRECTION
(NM)	NOT MEASURED

NOTES:

1. MONITORING WELLS PB-MW01, PB-MW02, PB-MW03, AND PB-MW04 ARE NOT SHOWN (SURVEY COORDINATES NOT AVAILABLE).
2. GROUNDWATER ELEVATION CONTOURS REFLECT THE INFLUENCE OF TOPOGRAPHY, INCLUDING DITCHES AND STREAMS; HOWEVER, TOPOGRAPHIC ELEVATION CONTOURS HAVE BEEN OMITTED FOR CLARITY.
3. MONITORING WELL BED-MW26 WAS NOT USED FOR GROUNDWATER ELEVATION CONTOURING.
4. BEDROCK MONITORING WELLS WITH (SH) DESIGNATION INDICATE THAT WELL IS SCREENED IN SHALE BEDROCK. GROUNDWATER LEVELS FROM (SH) WELLS AND OVERBURDEN WELLS USED IN CONTOUR MAP CONSTRUCTION.
5. LINES DASHED WHERE OVERBURDEN GROUNDWATER EXISTENCE OR LOCATION IS UNCERTAIN.
6. GROUNDWATER LEVELS WERE MEASURED ON MAY11, 12, 2004.

SCALE 0 1200 2400 FEET

NO	DATE	REVISION	BY	CHKD	DSGN ENGR	ENGR	PROJ MGR	APPR

STARTING DATE 07/24/02 | INITIATOR D. KESSLER | CHKD | DRAWN VANDERGRIFF | CHKD | PROJECT MNGR S. DOWNEY

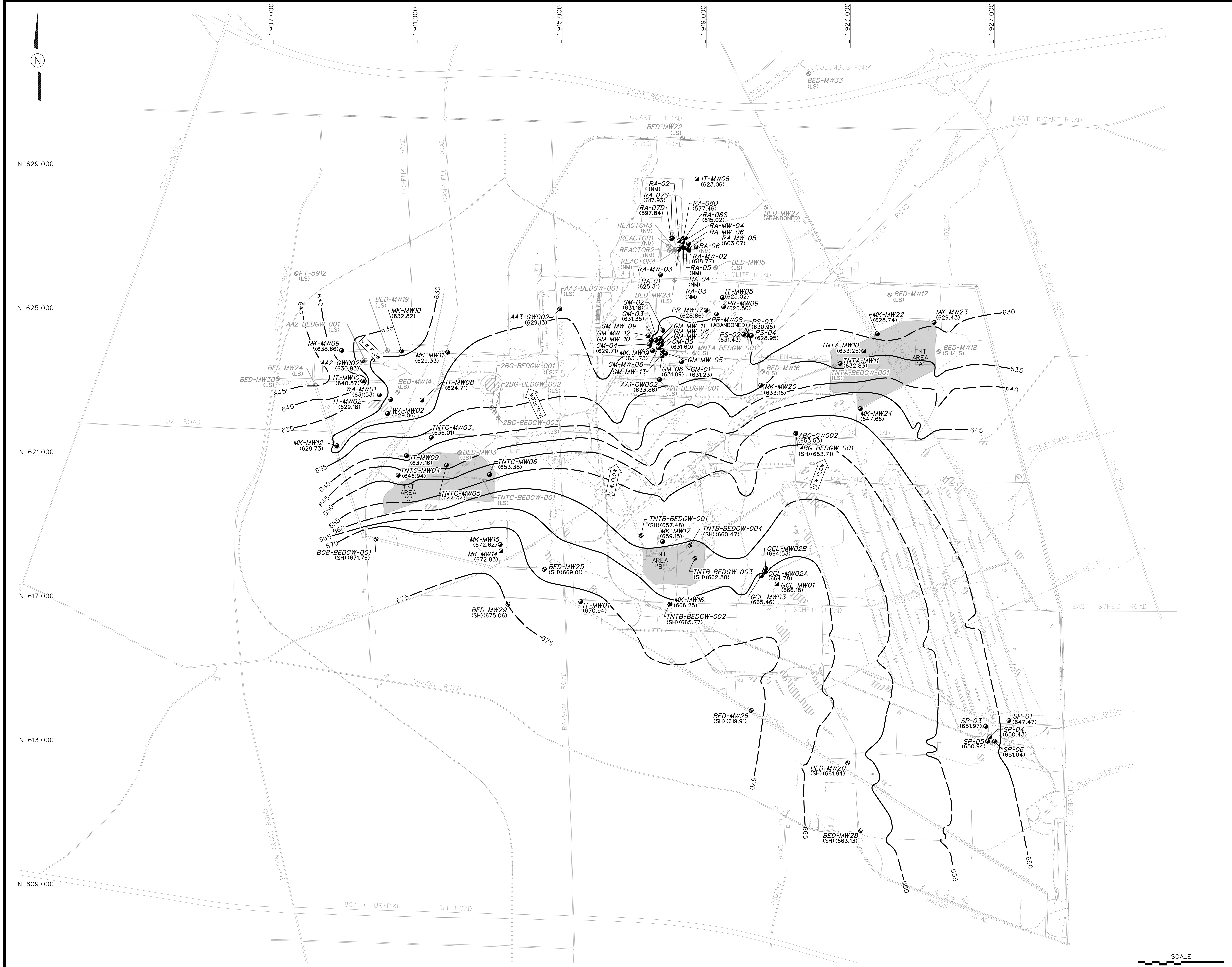
Shaw® Shaw Environmental, Inc.
KNOXVILLE, TENNESSEE

2004 GROUNDWATER DATA SUMMARY AND EVALUATION REPORT FORMER PLUM BROOK ORDNANCE WORKS NASA PLUM BROOK STATION SANDUSKY, OHIO

FIGURE 6-2 OVERBURDEN/SHALE GROUNDWATER ELEVATION CONTOUR MAP (MAY 2004)

AREA	JOB NO.	DRAWING NO.	REV.
SITEWIDE	843656	843656_026.dgn	

TIFF 400 PIXEL | FROM xtender via | dkumar | 12/29/2004 | 2:49:26 PM | 843656_026.dgn | 24 X 36



LEGEND:

ABG-GW002	OVERBURDEN/SHALE MONITORING WELL
TNTC-BEDGW-001 (LS)	BEDROCK MONITORING WELL SCREENED IN LIMESTONE
ABG-BEDGW-001 (SH)	BEDROCK MONITORING WELL SCREENED IN SHALE
	BUILDING
	RAILROAD
	SURFACE WATER
	DITCH
	FENCE (PBOW BOUNDARY)
(630.45)	GROUNDWATER ELEVATION (FT-MSL)
630	GROUNDWATER ELEVATION CONTOUR (FT-MSL) (DASHED WHERE INFERRED)
G.W. FLOW	GROUNDWATER FLOW DIRECTION
(NM)	NOT MEASURED

NOTES:

1. MONITORING WELLS PB-MW01, PB-MW02, PB-MW03, AND PB-MW04 ARE NOT SHOWN (SURVEY COORDINATES NOT AVAILABLE).
2. GROUNDWATER ELEVATION CONTOURS REFLECT THE INFLUENCE OF TOPOGRAPHY, INCLUDING DITCHES AND STREAMS; HOWEVER, TOPOGRAPHIC ELEVATION CONTOURS HAVE BEEN OMITTED FOR CLARITY.
3. MONITORING WELL BED-MW26 WAS NOT USED FOR GROUNDWATER ELEVATION CONTOURING.
4. BEDROCK MONITORING WELLS WITH (SH) DESIGNATION INDICATE THAT WELL IS SCREENED IN SHALE BEDROCK. GROUNDWATER LEVELS FROM (SH) WELLS AND OVERBURDEN WELLS USED IN CONTOUR MAP CONSTRUCTION.
5. LINES DASHED WHERE OVERBURDEN GROUNDWATER EXISTENCE OR LOCATION IS UNCERTAIN.
6. GROUNDWATER LEVELS WERE MEASURED ON AUGUST 10 AND 11, 2004.

SCALE 0 1200 2400 FEET

NO	DATE	REVISION	BY	CHKD	DSGN ENGR	ENGR	PROJ MGR	APPR

STARTING DATE 11/18/04 | INITIATOR D. KESSLER | CHKD | DRAWN D. BOMAR | CHKD | PROJECT MNGR S. DOWNEY

Shaw Environmental, Inc.
KNOXVILLE, TENNESSEE

2004 GROUNDWATER DATA SUMMARY AND EVALUATION REPORT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

FIGURE 6-3
OVERBURDEN/SHALE GROUNDWATER ELEVATION CONTOUR MAP (AUGUST 2004)

AREA	JOB NO.	DRAWING NO.	REV
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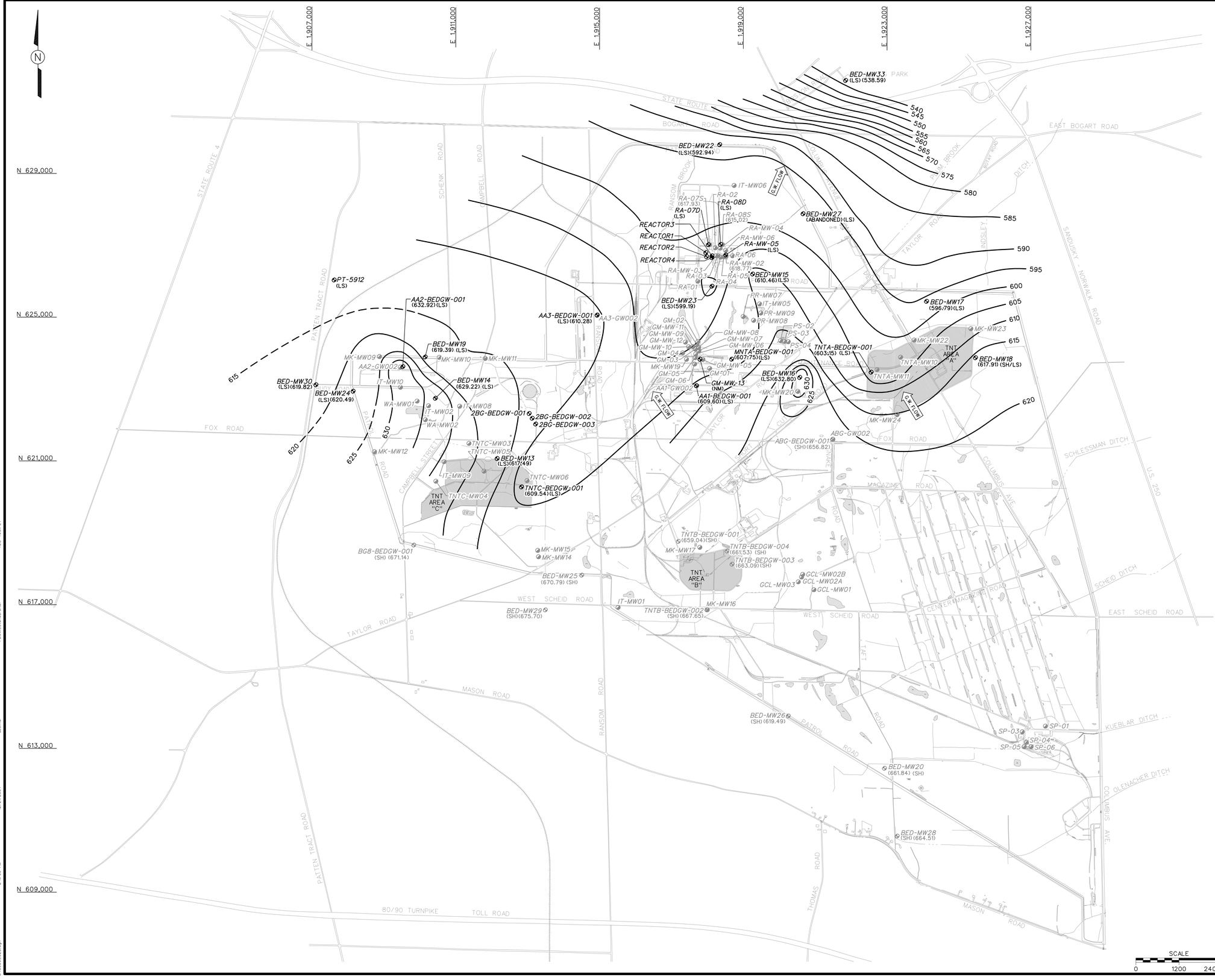


LEGEND:

ABG-GW002	OVERBURDEN/SHALE MONITORING WELL
TNTC-BEDGW-001 (LS)	BEDROCK MONITORING WELL SCREENED IN LIMESTONE
ABG-BEDGW-001 (SH)	BEDROCK MONITORING WELL SCREENED IN SHALE
	BUILDING
	RAILROAD
	SURFACE WATER
	DITCH
	FENCE (PBOW BOUNDARY)
(630.45)	GROUNDWATER ELEVATION (FT-MSL)
630	GROUNDWATER ELEVATION CONTOUR (FT-MSL) (DASHED WHERE INFERRED)
G.W. FLOW	GROUNDWATER FLOW DIRECTION
(NM)	NOT MEASURED

NOTES:

1. MONITORING WELLS PB-MW01, PB-MW02, PB-MW03, AND PB-MW04 ARE NOT SHOWN. (SURVEY COORDINATES NOT AVAILABLE).
2. MONITORING WELLS REACTOR2 AND REACTOR4 WERE NOT USED FOR GROUNDWATER ELEVATION CONTOURING.
3. TYPE OF BEDROCK MONITORING WELLS ARE SCREENED IN IS INDICATED BY (SH) - SHALE AND (LS) - LIMESTONE.
4. MONITORING WELLS WITH (SH) DESIGNATION NOT INCLUDED IN CONTOURING.
5. DASHED LINES INDICATE UNCERTAIN GROUNDWATER LEVEL ELEVATION.
6. STATIC GROUNDWATER LEVELS WERE MEASURED AUGUST 10 AND 11, 2004 UNLESS OTHERWISE INDICATED.
7. WATER LEVELS IN MONITORING WELLS 2BG-BEDGW-001, -002, AND -003 WERE NOT IN STATIC CONDITIONS, THEREFORE GROUNDWATER ELEVATIONS WERE NOT USED IN CONTOUR MAP CONSTRUCTION.
8. DEPTH TO GROUNDWATER IN WELL PT-5912 WAS MEASURED AUGUST 24, 2004, AND COMPARED TO BED-MW19 AND BED-MW30 AUGUST 10, 2004 DEPTH TO WATER MEASUREMENTS. 0.9 FEET WAS SUBTRACTED FROM THE AUGUST 24, 2004 MEASUREMENT.
9. DEPTH TO GROUNDWATER IN WELLS REACTOR1 AND REACTOR3 WERE MEASURED AUGUST 17, 2004 AND COMPARED TO RA-01 AUGUST 10, 2004 DEPTH TO WATER MEASUREMENTS. 0.6 FEET WAS ADDED TO THE AUGUST 17, 2004 MEASUREMENT.
10. WATER LEVEL ELEVATION OF TNTA-BEDGW-001 NOT USED IN CONTOUR MAP CONSTRUCTION DUE TO ERRATIC WATER LEVEL CHANGES ASSOCIATED WITH >14 FEET OF NATURAL PETROLEUM.

NO	DATE	REVISION	BY	CHKD	DSGN ENGR	ENGR	PROJ MGR	APPR

STARTING DATE	INITIATOR	CHKD	DRAWN	CHKD	PROJECT MNGR
11/18/04	D. KESSLER		D. BOMAR		S. DOWNEY

Shaw Environmental, Inc.
KNOXVILLE, TENNESSEE

2004 GROUNDWATER DATA SUMMARY AND EVALUATION REPORT FORMER PLUM BROOK ORDNANCE WORKS NASA PLUM BROOK STATION SANDUSKY, OHIO

FIGURE 6-4
DELAWARE LIMESTONE GROUNDWATER ELEVATION CONTOUR MAP (MAY 2004)

AREA	JOB NO.	DRAWING NO.	REV
SITEWIDE	843656	843656_025.DGN	

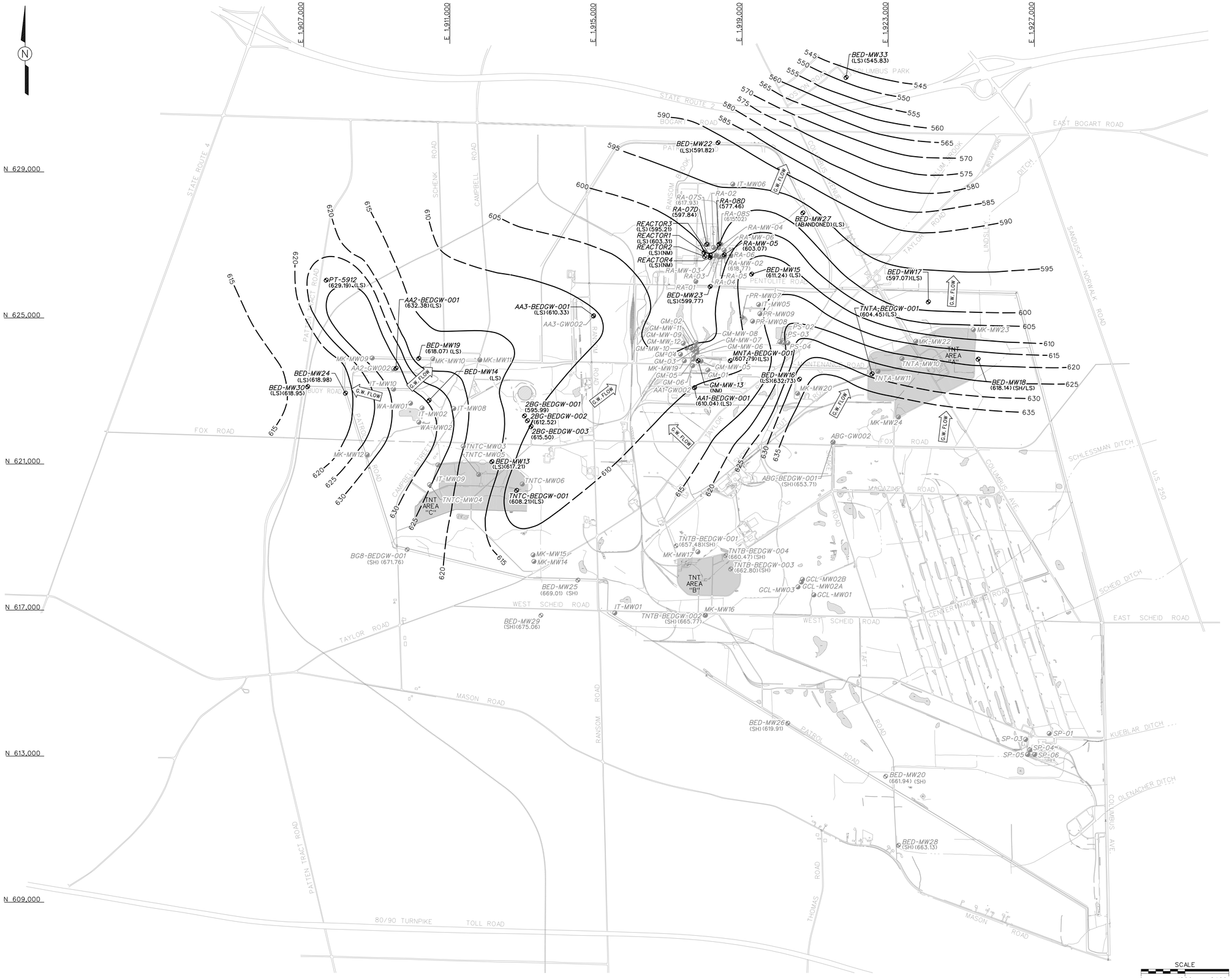
TDS 400.PLT
PBGW_standard.tbl
dbomar
12/20/2004
2:49:00 PM
843656_025.dgn
24 X 36

13 12 11 10 9 8 7 6 5 4 3 2 1

A B C D E F G H I

E 1,907,000 E 1,911,000 E 1,915,000 E 1,919,000 E 1,923,000 E 1,927,000

N 629,000 N 625,000 N 621,000 N 617,000 N 613,000 N 609,000



SCALE
0 1200 2400 FEET

LEGEND:

ABG-GW002	OVERBURDEN/SHALE MONITORING WELL
TNTC-BEDGW-001 (LS)	BEDROCK MONITORING WELL SCREENED IN LIMESTONE
ABG-BEDGW-001 (SH)	BEDROCK MONITORING WELL SCREENED IN SHALE
	BUILDING
	RAILROAD
	SURFACE WATER
	DITCH
	FENCE (PBOW BOUNDARY)
(630.45)	GROUNDWATER ELEVATION (FT-MSL)
630	GROUNDWATER ELEVATION CONTOUR (FT-MSL) (DASHED WHERE INFERRED)
G.W. FLOW	GROUNDWATER FLOW DIRECTION
(NM)	NOT MEASURED

NOTES:

1. MONITORING WELLS PB-MW01, PB-MW02, PB-MW03, AND PB-MW04 ARE NOT SHOWN. (SURVEY COORDINATES NOT AVAILABLE).
2. MONITORING WELLS REACTOR2 AND REACTOR4 WERE NOT USED FOR GROUNDWATER ELEVATION CONTOURING.
3. TYPE OF BEDROCK MONITORING WELLS ARE SCREENED IN IS INDICATED BY (SH) - SHALE AND (LS) - LIMESTONE.
4. MONITORING WELLS WITH (SH) DESIGNATION NOT INCLUDED IN CONTOURING.
5. DASHED LINES INDICATE UNCERTAIN GROUNDWATER LEVEL ELEVATION.
6. STATIC GROUNDWATER LEVELS WERE MEASURED AUGUST 10 AND 11, 2004 UNLESS OTHERWISE INDICATED.
7. WATER LEVELS IN MONITORING WELLS 2BG-BEDGW-001, -002, AND -003 WERE NOT IN STATIC CONDITIONS, THEREFORE GROUNDWATER ELEVATIONS WERE NOT USED IN CONTOUR MAP CONSTRUCTION.
8. DEPTH TO GROUNDWATER IN WELL PT-5912 WAS MEASURED AUGUST 24, 2004, AND COMPARED TO BED-MW19 AND BED-MW30 AUGUST 10, 2004 DEPTH TO WATER MEASUREMENTS. 0.9 FEET WAS SUBTRACTED FROM THE AUGUST 24, 2004 MEASUREMENT.
9. DEPTH TO GROUNDWATER IN WELLS REACTOR1 AND REACTOR3 WERE MEASURED AUGUST 17, 2004 AND COMPARED TO RA-01 AUGUST 10, 2004 DEPTH TO WATER MEASUREMENTS. 0.6 FEET WAS ADDED TO THE AUGUST 17, 2004 MEASUREMENT.
10. WATER LEVEL ELEVATION OF TNTA-BEDGW-001 NOT USED IN CONTOUR MAP CONSTRUCTION DUE TO ERRATIC WATER LEVEL CHANGES ASSOCIATED WITH >14 FEET OF NATURAL PETROLEUM.

NO	DATE	REVISION	BY	CHKD	DSGN ENGR	ENGR	PROJ MGR	APPR

STARTING DATE	INITIATOR	CHKD	DRAWN	CHKD	PROJECT MNGR
11/18/04	D. KESSLER		D. BOMAR		S. DOWNEY

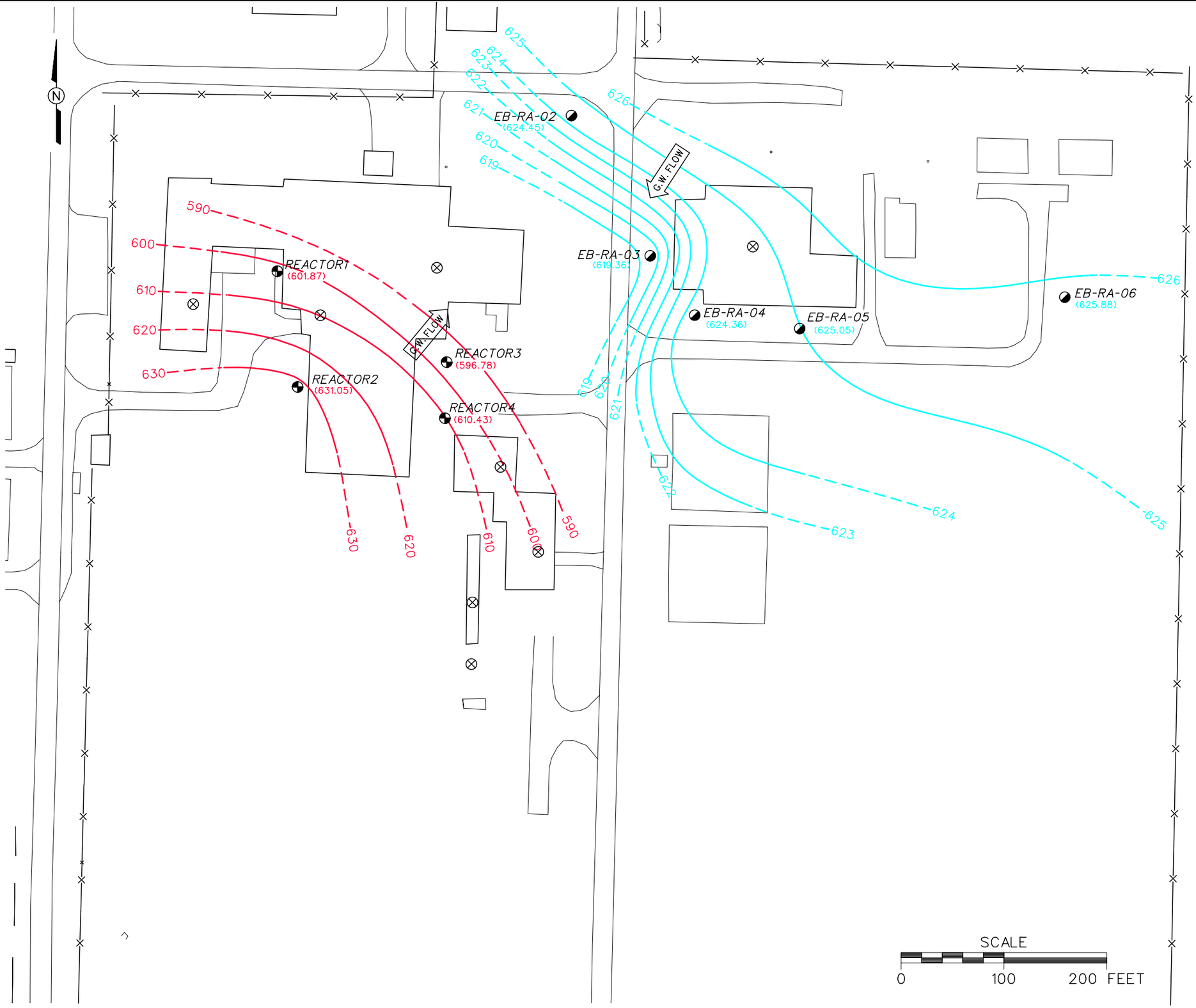
Shaw Environmental, Inc.
KNOXVILLE, TENNESSEE

2004 GROUNDWATER DATA SUMMARY AND EVALUATION REPORT FORMER PLUM BROOK ORDNANCE WORKS NASA PLUM BROOK STATION SANDUSKY, OHIO

FIGURE 6-5
DELAWARE LIMESTONE GROUNDWATER ELEVATION CONTOUR MAP (AUGUST 2004)

AREA	JOB NO.	DRAWING NO.	REV
SITEWIDE	843656	843656_011.DGN	

TDS 400.PLT
PBGW_standard.tbl
dbomar
12/20/2004
2:45:37 PM
843656_011.dgn
24 X 36



LEGEND

EB-RA-06	OVERBURDEN/SHALE MONITORING WELL LOCATION
REACTOR1	BEDROCK MONITORING WELL LOCATION
⊗	SUMP WELL
(631.05)	GROUNDWATER ELEVATION (FT-MSL) IN BEDROCK MONITORING WELLS
600	GROUNDWATER ELEVATION CONTOUR IN BEDROCK MONITORING WELLS
(625.88)	GROUNDWATER ELEVATION IN OVERBURDEN MONITORING WELLS (FT-MSL)
624	GROUNDWATER ELEVATION CONTOUR IN OVERBURDEN MONITORING WELLS (FT-MSL)
G.W. FLOW	GROUNDWATER FLOW
	BUILDINGS
	FENCE

NOTES:

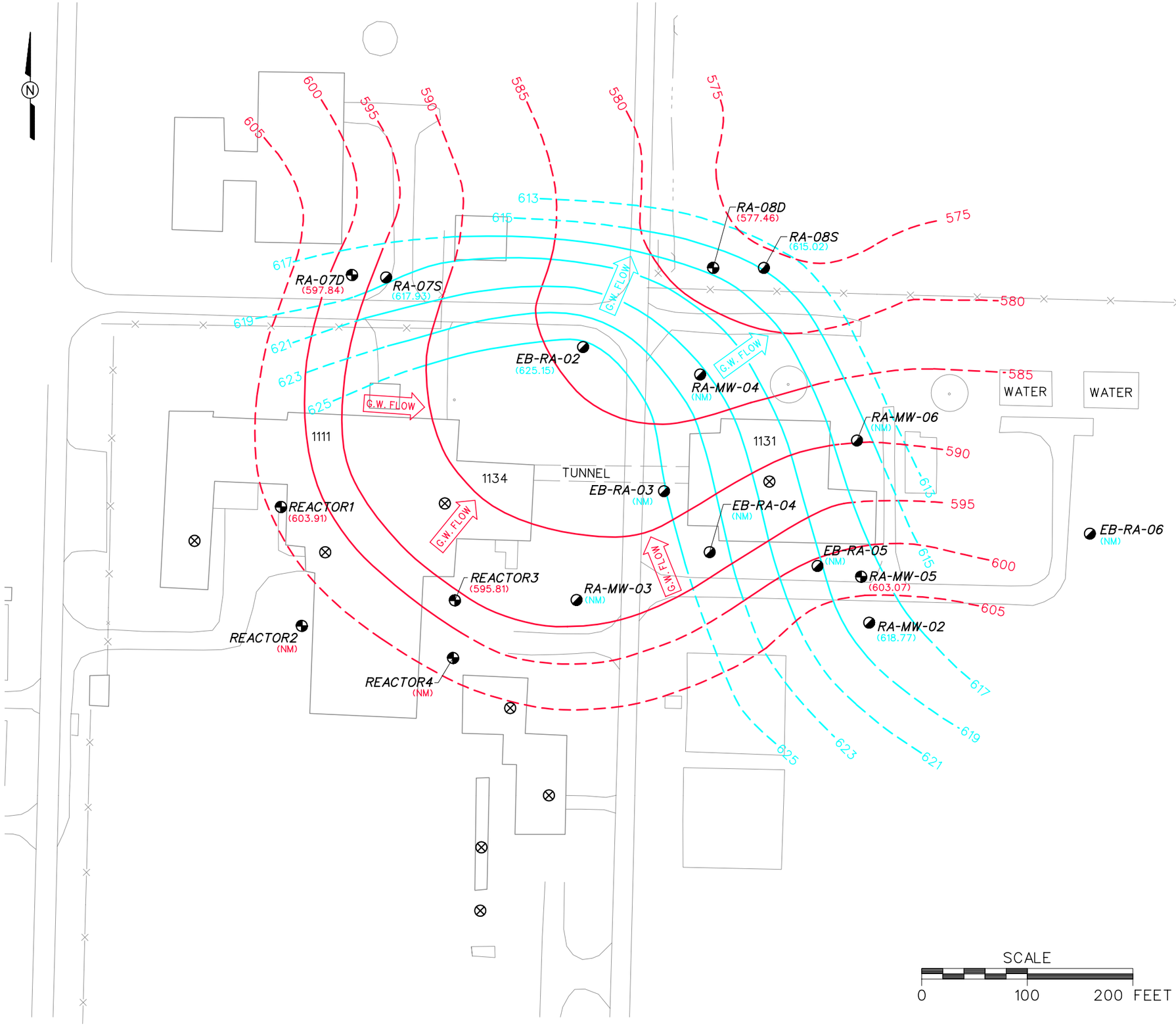
1. LOCATIONS OF SUMP WELLS ARE APPROXIMATE. SUMP WELLS HAVE NOT BEEN SURVEYED.

FIGURE 6-6
GROUNDWATER ELEVATION CONTOUR MAP REACTOR FACILITY AREA (NOVEMBER 2001)

2004 GROUNDWATER DATA SUMMARY AND EVALUATION REPORT FORMER PLUM BROOK ORDNANCE WORKS NASA PLUM BROOK STATION SANDUSKY, OHIO

Shaw® Shaw Environmental, Inc.

DWG. NO.:843656_022.dgn | PROJ. NO.: 771481
INITIATOR: D. KESSLER | PROJ. MGR.: S. DOWNEY
DRAFT. CHCK. BY: | ENGR. CHCK. BY: D. KESSLER
DATE LAST REV.: | DRAWN BY:
STARTING DATE: 11/30/04 | DRAWN BY: D. BOMAR
r2d2-color-tabloid.plt 10:30:14 AM 12/21/2004
PBOW_standard.tbl dbomar 843656_022.dgn



LEGEND

RA-06	OVERBURDEN MONITORING WELL LOCATION
REACTOR1	BEDROCK MONITORING WELL LOCATION
⊗	SUMP WELL
(603.91)	GROUNDWATER ELEVATION (FT-MSL) IN BEDROCK MONITORING WELLS
600	GROUNDWATER ELEVATION CONTOUR IN BEDROCK MONITORING WELLS
(615.02)	GROUNDWATER ELEVATION IN OVERBURDEN MONITORING WELLS (FT-MSL)
624	GROUNDWATER ELEVATION CONTOUR IN OVERBURDEN MONITORING WELLS (FT-MSL)
G.W. FLOW	GROUNDWATER FLOW
	BUILDINGS
	FENCE
(NM)	NOT MEASURED

NOTES:

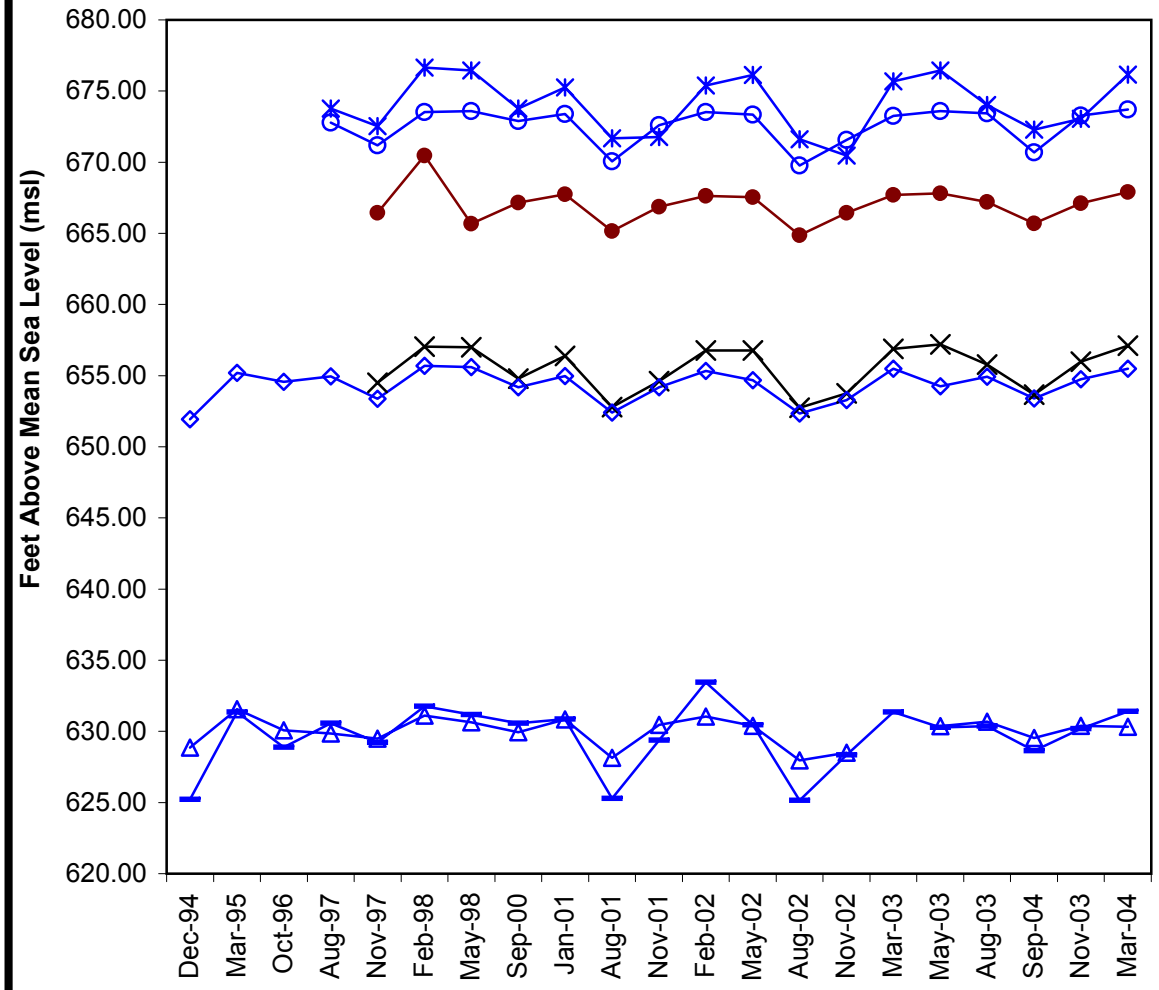
1. LOCATIONS OF SUMP WELLS ARE APPROXIMATE. SUMP WELLS HAVE NOT BEEN SURVEYED.
2. LOCATION OF RA-MW-02, -03, -04, -05, AND -06 WELLS ARE APPROXIMATE.
3. WATER LEVELS MEASURED AUGUST 17, 2004 BY NASA PERSONNEL.

FIGURE 6-7
GROUNDWATER ELEVATION CONTOUR MAP, REACTOR FACILITY AREA (AUGUST 2004)

2004 GROUNDWATER DATA SUMMARY AND EVALUATION REPORT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw® Shaw Environmental, Inc.

DWG. NO.:843656_015.dgn | PROJ. NO.: 843656
INITIATOR: D. KESSLER | PROJ. MGR.: S. DOWNEY
DRAFT. CHCK. BY: C. TUMLIN | ENGR. CHCK. BY:
REV.: | DATE LAST REV.: | DRAWN BY:
STARTING DATE: 03/08/02 | DRAWN BY:C. BENTLEY
r2d2-color-tabloid.plt 2:50:42 PM 12/20/2004
PBOW_standard.tbl dbomar 843656_015.dgn



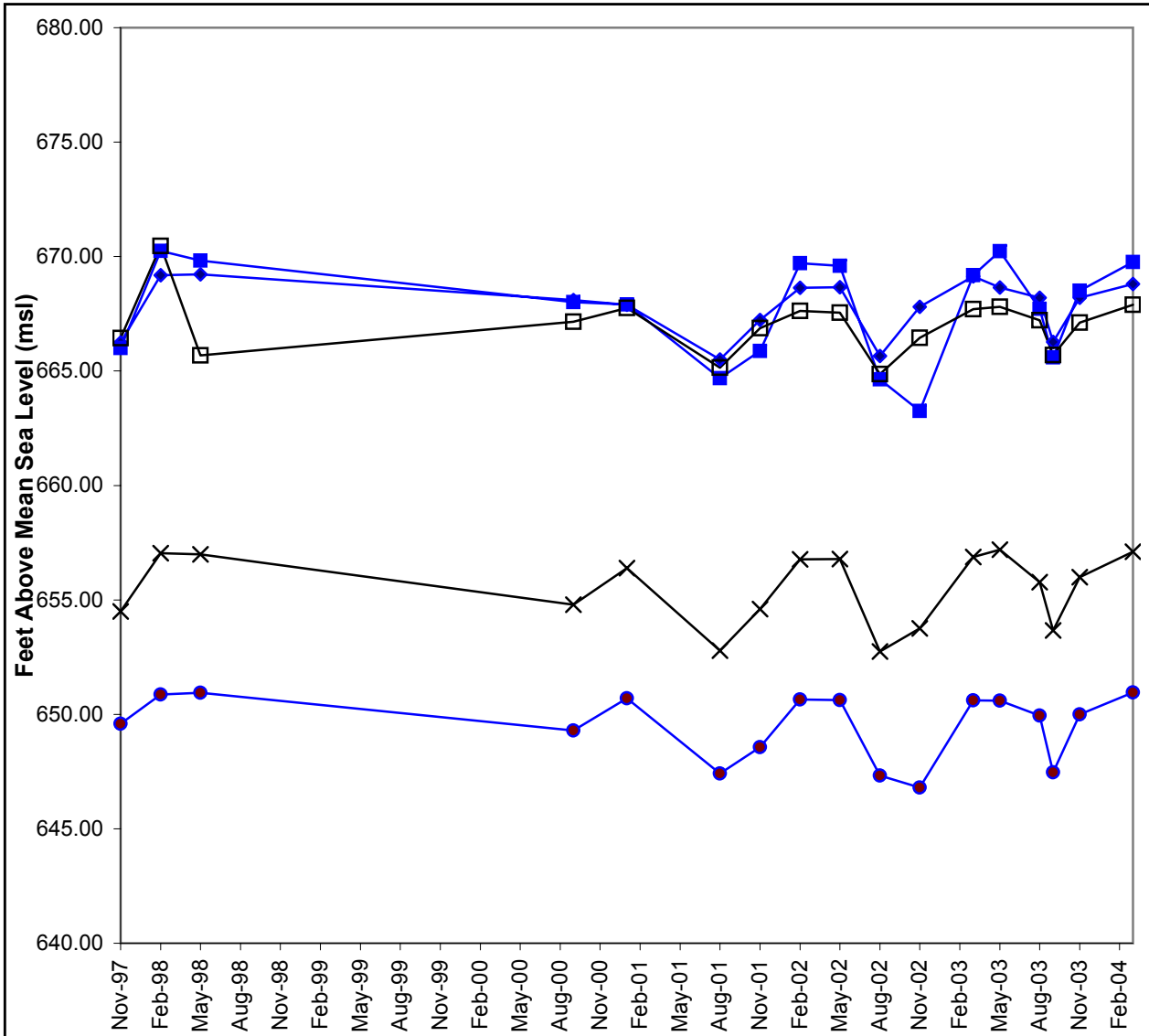
Legend:

- MK-MW14 (Overburden)
- IT-MW01 (Overburden)
- TNTB-BEDGW-002 (Ohio Shale)
- ABG-BEDGW-001 (Shale)
- TNTC-MW06 (Overburden)
- MK-MW11 (Overburden)
- MK-MW22 (Overburden)

Shaw™ Shaw Environmental, Inc.

Figure 6-8

Typical Groundwater Elevation Fluctuation, Overburden vs. Shale Wells
Former Plum Brook Ordnance Works
NASA Plum Brook Station
Sandusky, Ohio



Legend:

- MK-MW16 (Overburden)
- GCL-MW01 (Overburden)
- TNTB-BEDGW-002 (Shale)
- ABG-BEDGW-001 (Shale)
- MK-MW24 (Overburden)

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Figure 6-9

Typical Groundwater Fluctuation,
Overburden vs. Ohio Shale
Former Plum Brook Ordnance Works
NASA Plum Brook Station
Sandusky, Ohio
Ohio Shale

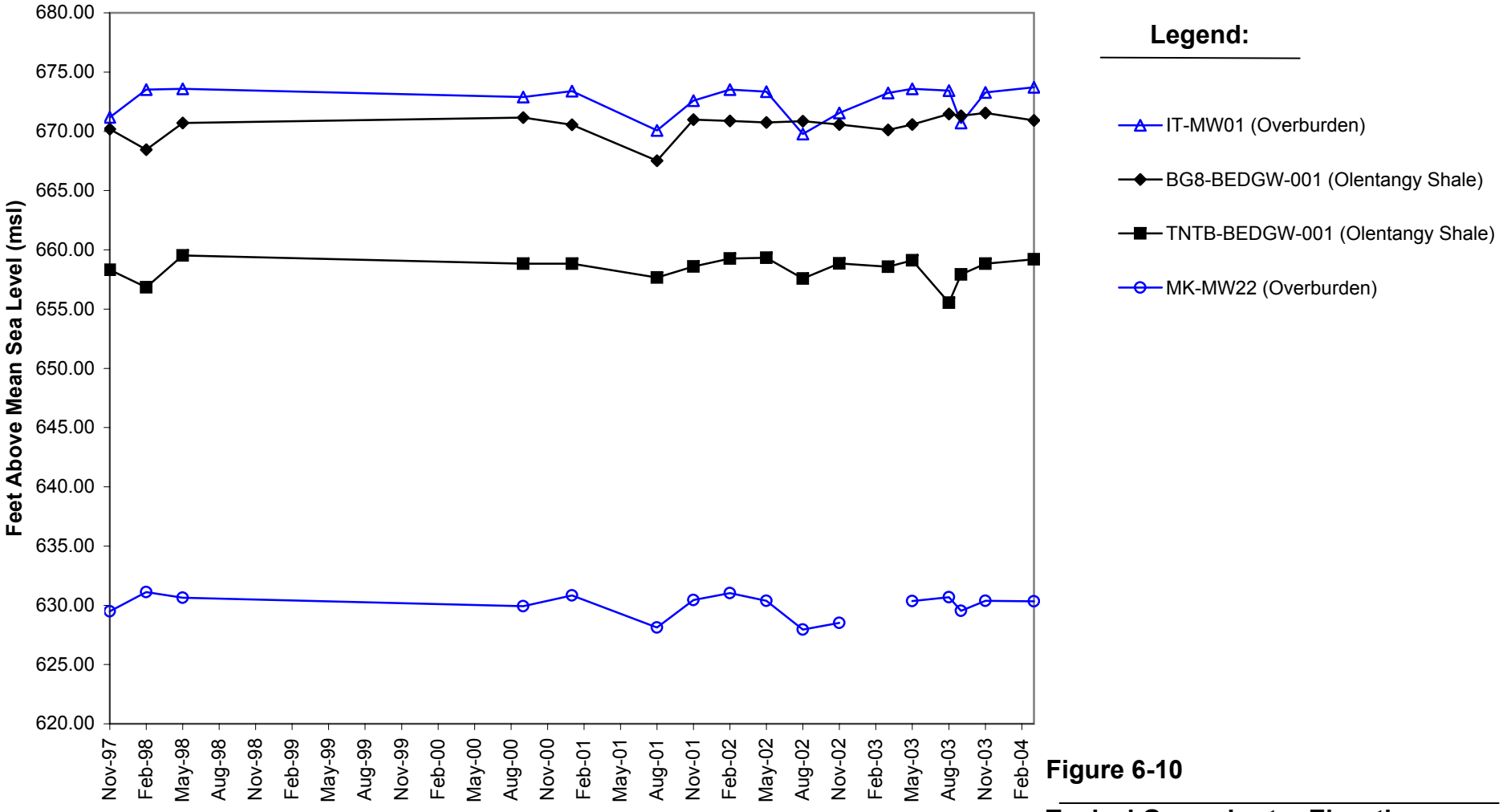
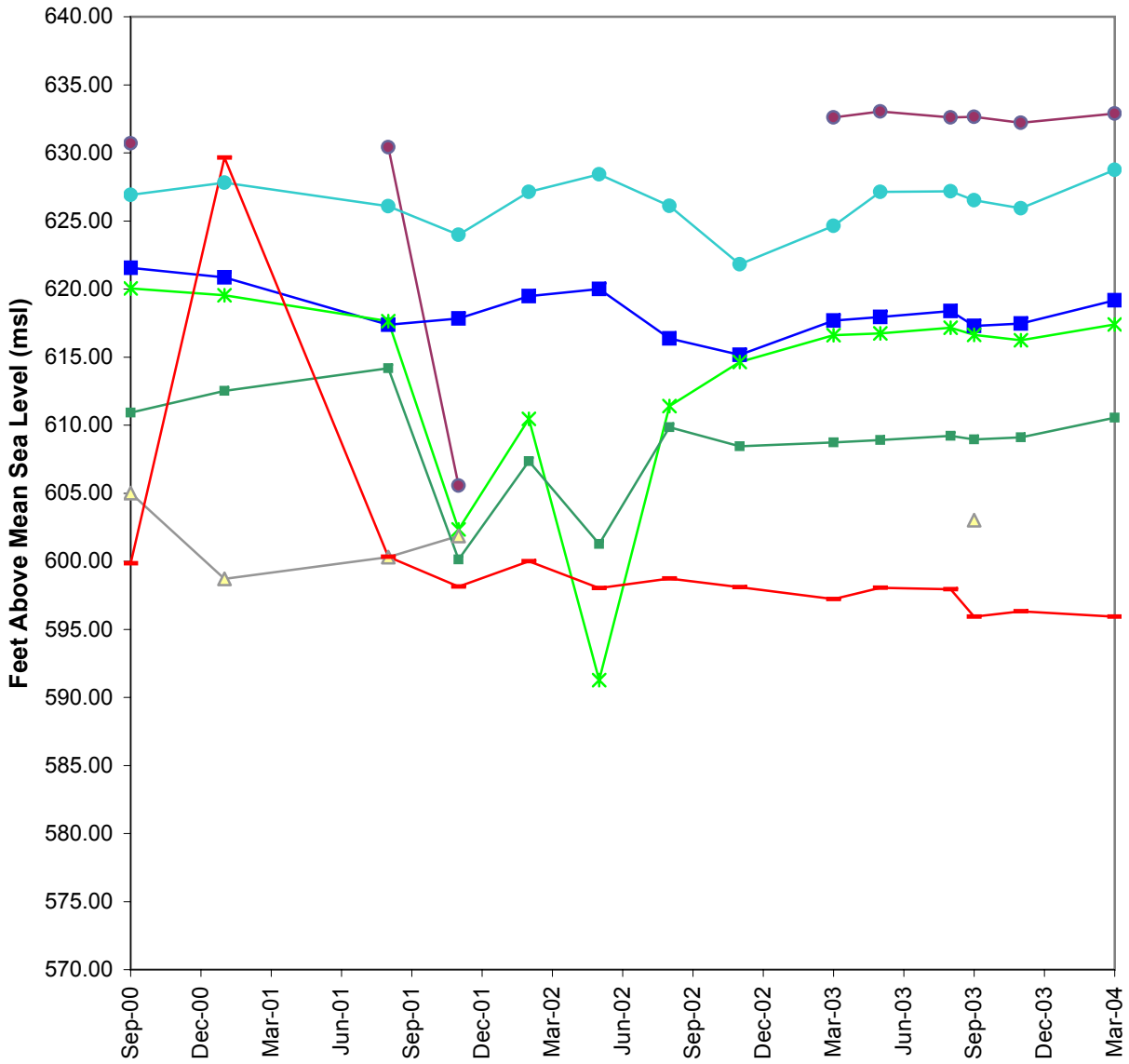


Figure 6-10

Typical Groundwater Elevation Fluctuation, Overburden/Olentangy Shale
Former Plum Brook Ordnance Works
NASA Plum Brook Station
Sandusky, Ohio

Shaw™ Shaw Environmental, Inc.



Legend:

- BED-MW16
- BED-MW14
- BED-MW19
- BED-MW13
- REACTOR1
- BED-MW15
- BED-MW17

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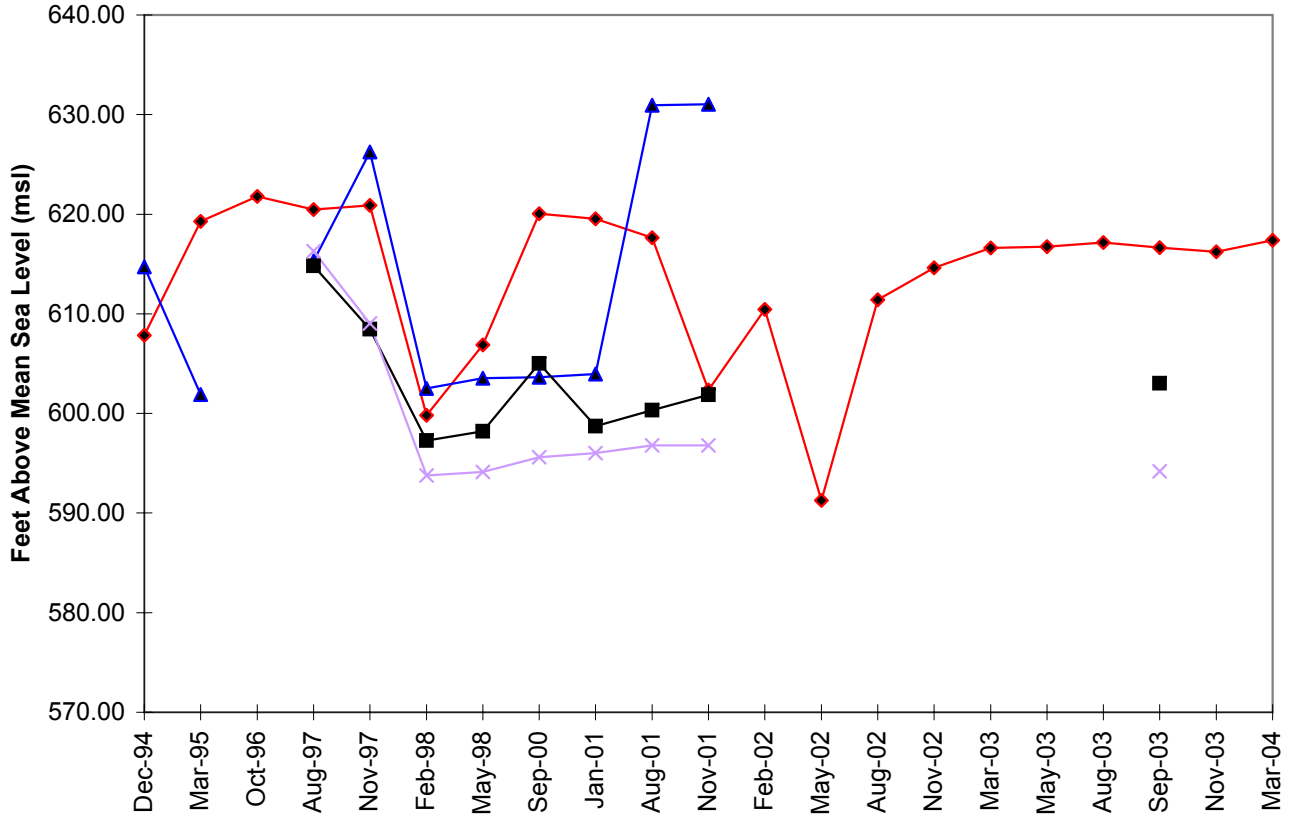
Figure 6-11

Typical Groundwater Elevation Fluctuation, Delaware Limestone
Former Plum Brook Ordnance Works
NASA Plum Brook Station
Sandusky, Ohio



Legend:

- BED-MW13
- REACTOR2
- REACTOR1
- REACTOR3

Figure 6-12

Typical Groundwater Elevation Fluctuation, Reactor Wells 1, 2, 3 and BED-MW13
Former Plum Brook Ordnance Works
NASA Plum Brook Station
Sandusky, Ohio

Shaw™ Shaw Environmental, Inc.

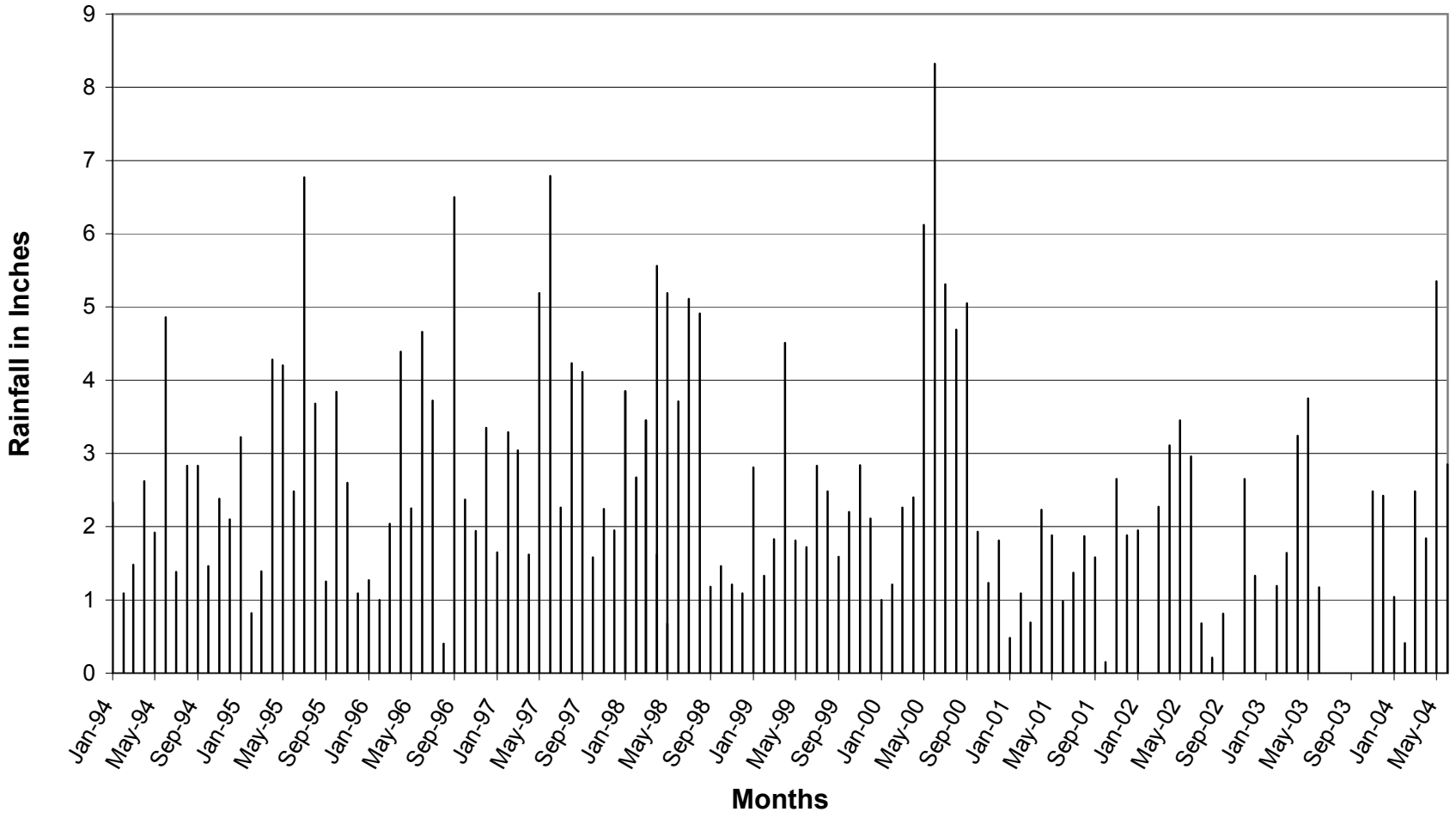


Figure 6-13

Monthly Precipitation Data,
January 1994 Through June 2004
Former Plum Brook Ordnance Works
NASA Plum Brook Station
Sandusky, Ohio

Shaw™ Shaw Environmental, Inc.

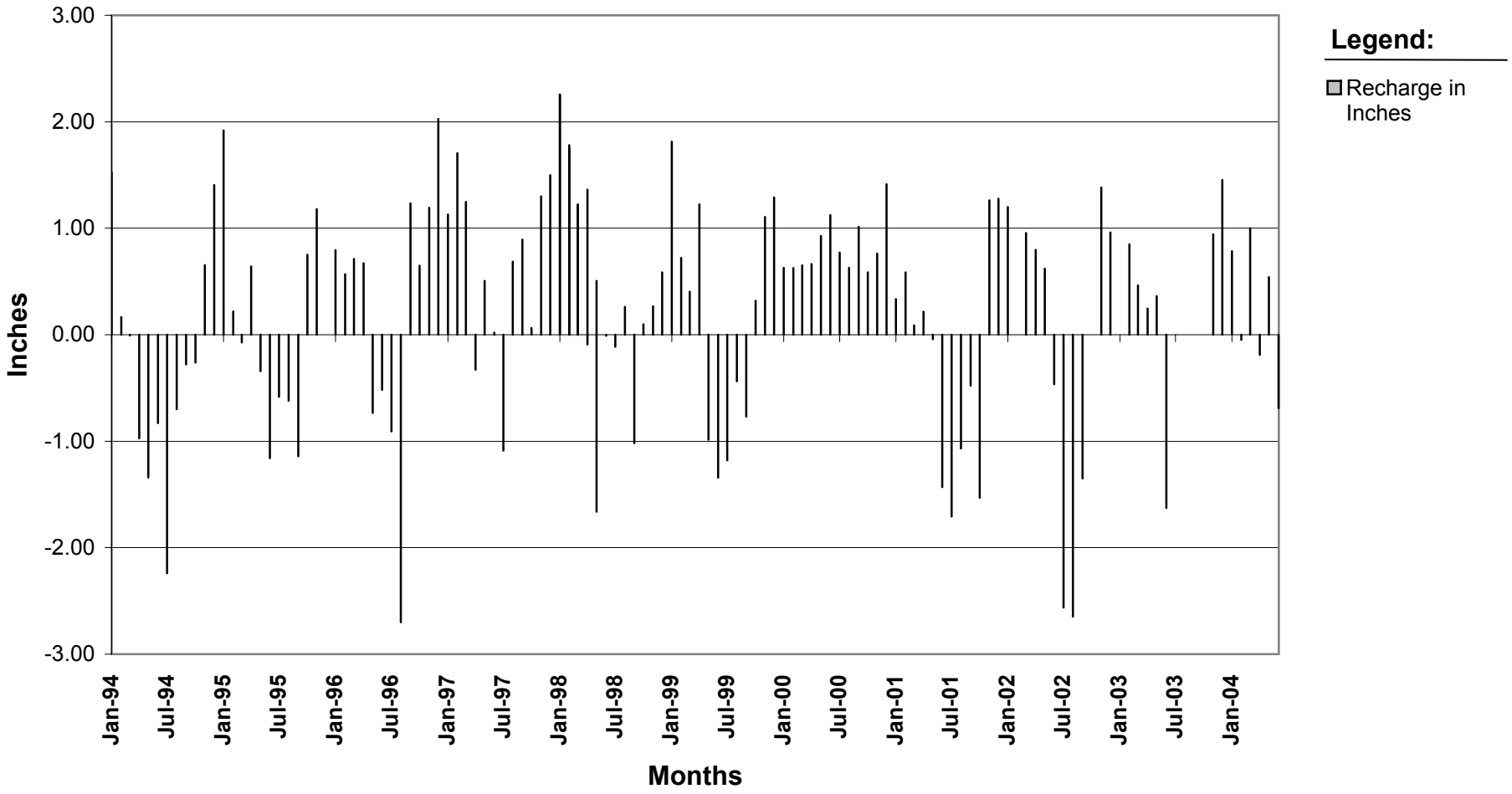
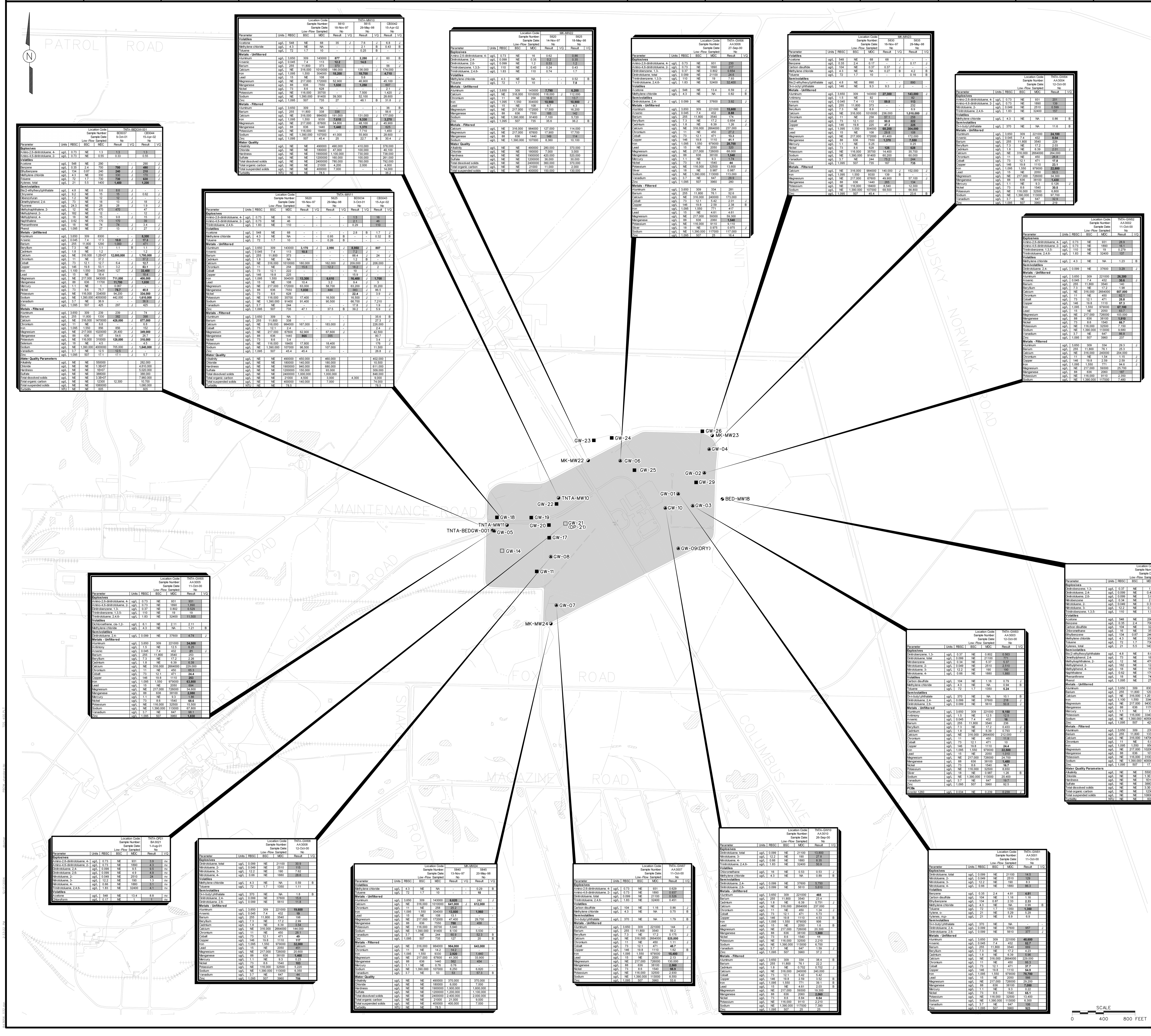


Figure 6-14

Calculated Monthly Recharge Rates at PBOW
Former Plum Brook Ordnance Works
NASA Plum Brook Station
Sandusky, Ohio

Shaw™ Shaw Environmental, Inc.



Location Code:					TNTA-MW10					
Sample Number:					5610		5615		CB3042	
Sample Date:					18-Nov-97		29-May-98		15-Apr-02	
Low-Flow Sampled:					No		No		No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ
Volatiles										
Acetone	ug/L	548	NE	68	35	J	7.6	J	6.8	J
Methylene chloride	ug/L	4.3	NE	NA	-	-	2.1	B	0.43	B
Toluene	ug/L	72	1.7	10	-	-	0.25	B	-	-
Metals - Unfiltered										
Aluminum	ug/L	3,650	309	143000	**877**	J	**2,280**	J	60	B
Arsenic	ug/L	0.045	7.4	113	**12.2**		**14.5**		-	-
Barium	ug/L	255	11,800	373	373		-	-	56	J
Calcium	ug/L	NE	316,000	1010000	186,000		136,000	J	174,000	
Iron	ug/L	1,095	1,550	304000	**18,200**		**18,700**		**4,710**	
Lead	ug/L	15	NE	108	-	-	5.6		-	-
Magnesium	ug/L	NE	217,000	172000	52,900		46,900		45,100	
Manganese	ug/L	88	636	7550	**1,530**		**1,250**		607	
Nickel	ug/L	73	8.6	628	-	-	-	-	2.1	J
Potassium	ug/L	NE	116,000	35700	-	-	7,500		1,420	J
Sodium	ug/L	NE	1,390,000	91400	39,300		52,100		28,600	
Zinc	ug/L	1,095	507	735	27		48.1	B	31.8	J
Metals - Filtered										
Aluminum	ug/L	3,650	309	NA	-	-	-	-	36	B
Barium	ug/L	255	11,800	338	338		-	-	56.6	J
Calcium	ug/L	NE	316,000	984000	191,000		131,000	J	177,000	
Iron	ug/L	1,095	1,550	9330	**7,610**		**9,330**		**3,270**	
Magnesium	ug/L	NE	217,000	67600	54,800		48,100	J	45,900	
Manganese	ug/L	88	636	1440	**1,440**		**1,370**		625	
Potassium	ug/L	NE	116,000	18400	-	-	7,710		1,450	J
Sodium	ug/L	NE	1,390,000	107000	41,000		55,900		28,600	
Zinc	ug/L	1,095	507	45.4	25		22.7	B	30.4	J
Water Quality										
Alkalinity	ug/L	NE	NE	490000	490,000		410,000		378,000	
Chloride	ug/L	NE	NE	180000	47,000		100,000		40,100	
Hardness	ug/L	NE	NE	1900000	1,100,000		730,000		738,000	
Sulfate	ug/L	NE	NE	1200000	160,000		100,000		261,000	
Total dissolved solids	ug/L	NE	NE	2400000	780,000		760,000		792,000	
Total organic carbon	ug/L	NE	NE	21000	4,200		2,000		4,000	
Total suspended solids	ug/L	NE	NE	400000	7,000		-	-	14,000	
Turbidity	NTU	NE	NE	78.5					36.2	

Location Code:					TNTA-MW11							
Sample Number:					5620		5625		BD3034		CB3043	
Sample Date:					18-Nov-97		29-May-98		3-Oct-01		15-Apr-02	
Low-Flow Sampled:					No		No		No		No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives												
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	NE	16	-	-	-	-	1.5		16	
Amino-4,6-dinitrotoluene, 2-	ug/L	0.73	NE	46					2.1		46	
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	110	-	-	-	-	0.29		110	
Volatiles												
Acetone	ug/L	548	NE	68	-	-	-	-	2.8	B	1.7	J
Methylene chloride	ug/L	4.3	NE	NA	-	-	0.95	B	-	-	0.32	B
Toluene	ug/L	72	1.7	10	-	-	0.26	B	-	-	-	-
Metals - Unfiltered												
Aluminum	ug/L	3,650	309	143000	**3,170**	J	**2,990**	J	**8,950**	J	**807**	
Arsenic	ug/L	0.045	7.4	113	**10.5**		-	-	7.2	J	-	-
Barium	ug/L	255	11,800	373	-	-	-	-	88.4	J	24	J
Cadmium	ug/L	1.8	NE	NA	-	-	-	-	1.2	B	-	-
Calcium	ug/L	NE	316,000	1010000	180,000		162,000	J	209,000	J	206,000	
Chromium	ug/L	11	NE	258	15.6		12.2		18.2	J	2	J
Cobalt	ug/L	73	12.1	222	-	-	-	-	10	J	-	-
Copper	ug/L	146	19.8	225	-	-	-	-	15.9	J	-	-
Iron	ug/L	1,095	1,550	304000	**13,300**		**6,610**		**16,400**	J	**1,700**	
Lead	ug/L	15	NE	108	10.4		3.2		9.4	J	3	
Magnesium	ug/L	NE	217,000	172000	63,000		58,700		63,200	J	35,200	
Manganese	ug/L	88	636	7550	**1,030**		444		383	J	86.5	
Nickel	ug/L	73	8.6	628	-	-	-	-	**22.4**	J	3.9	J
Potassium	ug/L	NE	116,000	35700	17,400		16,500		16,500	J	-	-
Sodium	ug/L	NE	1,390,000	91400	91,400		90,500		66,700	J	7,210	
Vanadium	ug/L	3.7	NE	244	-	-	-	-	17.8	J	1.9	J
Zinc	ug/L	1,095	507	735	47.1		37.5	B	39.2	J	5.9	J
Metals - Filtered												
Aluminum	ug/L	3,650	309	NA	-	-	-	-			35.6	B
Barium	ug/L	255	11,800	338	-	-	-	-			27.3	J
Calcium	ug/L	NE	316,000	984000	167,000		183,000	J			226,000	
Cobalt	ug/L	73	12.1	2.4	-	-	-	-			2.4	J
Magnesium	ug/L	NE	217,000	67600	62,900		67,600	J			42,500	
Manganese	ug/L	88	636	1440	**865**		355				80.7	
Nickel	ug/L	73	8.6	3.4	-	-	-	-			3.4	J
Potassium	ug/L	NE	116,000	18400	17,800		18,400				176	J
Sodium	ug/L	NE	1,390,000	107000	96,500		107,000				11,500	
Zinc	ug/L	1,095	507	45.4	45.4		-	-			26.8	J
Water Quality												
Alkalinity	ug/L	NE	NE	490000	450,000		460,000				402,000	
Chloride	ug/L	NE	NE	180000	140,000		180,000				10,500	
Hardness	ug/L	NE	NE	1900000	940,000		680,000				611,000	
Sulfate	ug/L	NE	NE	1200000	150,000		93,000				309,000	
Total dissolved solids	ug/L	NE	NE	2400000	1,000,000		1,000,000				848,000	
Total organic carbon	ug/L	NE	NE	21000	4,500		3,000		4,300		9,000	
Total suspended solids	ug/L	NE	NE	400000	140,000		7,000				74,000	
Turbidity	NTU	NE	NE	78.5							78.5	

Location Code:					MK-MW22			
Sample Number:					5820		5825	
Sample Date:					14-Nov-97		18-May-98	
Low-Flow Sampled:					No		No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ
Explosives								
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	NE	16	0.62		0.86	
Dinitrotoluene, 2,4-	ug/L	0.099	NE	0.35	0.2		0.35	
Dinitrotoluene, 2,6-	ug/L	0.099	NE	1.2	0.53		1.2	
Trinitrobenzene, 1,3,5-	ug/L	110	NE	0.43	0.24		0.43	
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	110	0.74		1.7	
Volatiles								
Methylene chloride	ug/L	4.3	NE	NA	-	-	0.52	B
Toluene	ug/L	72	1.7	10	-	-	**7.8**	
Metals - Unfiltered								
Aluminum	ug/L	3,650	309	143000	**7,790**		**6,200**	
Calcium	ug/L	NE	316,000	1010000	118,000	J	112,000	
Chromium	ug/L	11	NE	258	16.6		13.7	
Iron	ug/L	1,095	1,550	304000	**10,900**		**10,900**	J
Lead	ug/L	15	NE	108	6.7		4.3	
Magnesium	ug/L	NE	217,000	172000	17,500		16,200	
Manganese	ug/L	88	636	7550	185		142	
Sodium	ug/L	NE	1,390,000	91400	7,100		5,720	
Zinc	ug/L	1,095	507	735	35.6		36.2	B
Metals - Filtered								
Calcium	ug/L	NE	316,000	984000	127,000		114,000	
Magnesium	ug/L	NE	217,000	67600	17,900		17,700	
Manganese	ug/L	88	636	1440	149		114	
Sodium	ug/L	NE	1,390,000	107000	8,360		10,100	
Water Quality								
Alkalinity	ug/L	NE	NE	490000	280,000		370,000	
Chloride	ug/L	NE	NE	180000	7,000		3,000	
Hardness	ug/L	NE	NE	1900000	420,000		520,000	
Sulfate	ug/L	NE	NE	1200000	36,000		30,000	
Total dissolved solids	ug/L	NE	NE	2400000	360,000		370,000	
Total organic carbon	ug/L	NE	NE	21000	11,000		2,000	
Total suspended solids	ug/L	NE	NE	400000	150,000		130,000	

Location Code:					TNTA-GW06	
Sample Number:					AA3006	
Sample Date:					27-Sep-00	
Low-Flow Sampled:					No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ
Explosives						
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	NE	931	230	
Amino-4,6-dinitrotoluene, 2-	ug/L	0.73	NE	1890	217	
Dinitrobenzene, 1,3-	ug/L	0.37	NE	0.802	0.654	
Dinitrotoluene, total	ug/L	0.099	NE	21100	24.6	
Trinitrobenzene, 1,3,5-	ug/L	110	NE	19	7.93	
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	32400	32,400	
Volatiles						
Acetone	ug/L	548	NE	13.4	6.59	J
Methylene chloride	ug/L	4.3	NE	NA	0.82	B
Semivolatiles						
Dinitrotoluene, 2,4-	ug/L	0.099	NE	37600	3.92	J
Metals - Unfiltered						
Aluminum	ug/L	3,650	309	221000	**15,600**	
Arsenic	ug/L	0.045	7.4	432	**8.88**	
Barium	ug/L	255	11,800	3540	174	
Beryllium	ug/L	7.3	NE	17.2	0.854	J
Cadmium	ug/L	1.8	NE	6.39	1.26	J
Calcium	ug/L	NE	316,000	2664000	237,000	
Chromium	ug/L	11	NE	450	27.2	
Cobalt	ug/L	73	12.1	471	**13.3**	
Copper	ug/L	146	19.8	1110	**41.1**	
Iron	ug/L	1,095	1,550	979000	**28,700**	
Lead	ug/L	15	NE	2050	320	
Magnesium	ug/L	NE	217,000	726000	68,000	
Manganese	ug/L	88	636	38100	**1,540**	
Mercury	ug/L	1.1	NE	9.3	1.74	
Nickel	ug/L	73	8.6	1540	**44**	
Potassium	ug/L	NE	116,000	32500	13,600	
Silver	ug/L	18	NE	0.987	0.987	J
Sodium	ug/L	NE	1,390,000	113000	113,000	
Vanadium	ug/L	3.7	NE	647	29.9	
Zinc	ug/L	1,095	507	3960	280	
Metals - Filtered						
Aluminum	ug/L	3,650	309	334	281	
Barium	ug/L	255	11,800	76.1	52.6	
Calcium	ug/L	NE	316,000	240000	173,000	
Cobalt	ug/L	73	12.1	5.42	2.01	J
Copper	ug/L	146	19.8	2.59	2.38	B
Iron	ug/L	1,095	1,550	771	417	
Lead	ug/L	15	NE	4.61	4.61	
Magnesium	ug/L	NE	217,000	59300	59,300	
Manganese	ug/L	88	636	2060	**1,540**	
Potassium	ug/L	NE	116,000	9110	9,110	
Silver	ug/L	18	NE	0.975	0.975	J
Sodium	ug/L	NE	1,390,000	117000	117,000	
Zinc	ug/L	1,095	507	25	16.4	

Location Code:					MK-MW23			
Sample Number:					5830		5835	
Sample Date:					16-Nov-97		29-May-98	
Low-Flow Sampled:					No		No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ
Volatiles								
Acetone	ug/L	548	NE	68	68	J	-	-
Benzene	ug/L	0.35	2.4	0.17	-	-	0.17	J
Carbon disulfide	ug/L	104	NE	0.37	0.37	J	-	-
Methylene chloride	ug/L	4.3	NE	NA	0.27	B	4.2	B
Toluene	ug/L	72	1.7	10	-	-	0.16	B
Semivolatiles								
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	890	-	-	890	
Di-n-octyl phthalate	ug/L	146	NE	9.3	9.3	J	-	-
Metals - Unfiltered								
Aluminum	ug/L	3,650	309	143000	**27,300**		**143,000**	J
Antimony	ug/L	1.5	NE	82	-	-	82	
Arsenic	ug/L	0.045	7.4	113	**59.8**		**113**	
Barium	ug/L	255	11,800	373	-	-	232	
Beryllium	ug/L	7.3	NE	6.9	-	-	6.9	
Calcium	ug/L	NE	316,000	1010000	236,000		**1,010,000**	J
Chromium	ug/L	11	NE	258	57.1		258	
Cobalt	ug/L	73	12.1	222	**50.8**		**222**	
Copper	ug/L	146	19.8	225	**47.3**		**225**	
Iron	ug/L	1,095	1,550	304000	**68,200**		**304,000**	
Lead	ug/L	15	NE	108	29.8		108	
Magnesium	ug/L	NE	217,000	172000	61,400		172,000	
Manganese	ug/L	88	636	7550	**1,370**		**7,550**	
Mercury	ug/L	1.1	NE	0.25	-	-	0.25	
Nickel	ug/L	73	8.6	628	**125**		**628**	
Potassium	ug/L	NE	116,000	35700	14,400		35,700	
Sodium	ug/L	NE	1,390,000	91400	60,200		60,000	
Vanadium	ug/L	3.7	NE	244	75.2		244	
Zinc	ug/L	1,095	507	735	167		**735**	
Metals - Filtered								
Calcium	ug/L	NE	316,000	984000	140,000	J	152,000	J
Iron	ug/L	1,095	1,550	9330	139	B	-	-
Magnesium	ug/L	NE	217,000	67600	49,900		57,100	J
Manganese	ug/L	88	636	1440	265		134	
Potassium	ug/L	NE	116,000	18400	8,540		12,300	
Sodium	ug/L	NE	1,390,000	107000	68,500		66,800	
Zinc	ug/L	1,095	507	45.4	-	-	23.6	B

Location Code:					TNTA-GW04	
Sample Number:					AA3004	
Sample Date:					12-Oct-00	
Low-Flow Sampled:					No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ
Explosives						
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	NE	931	201	
Amino-4,6-dinitrotoluene, 2-	ug/L	0.73	NE	1890	139	
Nitrotoluene, 2-	ug/L	0.049	NE	2510	0.599	
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	32400	157	
Volatiles						
Methylene chloride	ug/L	4.3	NE	NA	0.86	B
Semivolatiles						
Di-n-butyl phthalate	ug/L	370	NE	NA	11.6	B
Metals - Unfiltered						
Aluminum	ug/L	3,650	309	221000	**24,100**	
Arsenic	ug/L	0.045	7.4	432	**8.04**	
Barium	ug/L	255	11,800	3540	229	
Beryllium	ug/L	7.3	NE	17.2	2.03	
Cadmium	ug/L	1.8	NE	6.39	2.01	J
Calcium	ug/L	NE	316,000	2664000	264,000	
Chromium	ug/L	11	NE	450	26.8	
Cobalt	ug/L	73	12.1	471	**17.8**	
Copper	ug/L	146	19.8	1110	**23.1**	
Iron	ug/L	1,095	1,550	979000	**22,800**	
Lead	ug/L	15	NE	2050	50.5	
Magnesium	ug/L	NE	217,000	726000	34,300	
Manganese	ug/L	88	636	38100	**1,430**	
Mercury	ug/L	1.1	NE	9.3	0.126	J
Nickel	ug/L	73	8.6	1540	**30.5**	
Potassium	ug/L	NE	116,000	32500	6,800	
Sodium	ug/L	NE	1,390,000	113000	97,700	
Vanadium	ug/L	3.7	NE	647	32.9	
Zinc	ug/L	1,095	507	3960	219	

TNTA-GW02 (AA3002, 11-Oct-00)

[illegible]	

TNTA-BEDGW-001 (BD0037, CB3044)

[illegible]	

BED-MW18

[illegible]	

TNTA-GW03

[illegible]	

TNTA-GW05 (AA3005)

[illegible]	

TNTA-DP21

[illegible]	

TNTA-GW08

[illegible]	

MK-MW24

[illegible]	

TNTA-GW07

[illegible]	

TNTA-GW10

[illegible]	

TNTA-GW01

[illegible]	

LEGEND:

- BUILDINGS
- RAILROAD
- SURFACE DRAINAGE
- SURFACE WATER
- OVERBURDEN/SHALE MONITORING WELL LOCATION
- BEDROCK MONITORING WELL LOCATION
- 2000 GROUNDWATER SAMPLING LOCATION
- 2001 DIRECT-PUSH GROUNDWATER SAMPLING LOCATION
- 2001 DIRECT-PUSH GROUNDWATER SAMPLING LOCATION (DRILLED TO REFUSAL, NO GROUNDWATER ENCOUNTERED)
- ug/L MICROGRAMS PER LITER
- nv NON VALIDATED
- NA NOT APPLICABLE, ONLY B QUALIFIED DATA DETECTED
- NE NOT ESTABLISHED (RBSCs), NOT EVALUATED (BSCs)
- NTU NEPHELOMETRIC TUBIDITY UNIT

NOTES:

1. SHADED CELL INDICATES VALUE IS GREATER THAN RBSC.
2. BOLD TEXT INDICATES VALUE IS GREATER THAN BSC.
3. RBSC VALUES REFLECT AN INCREMENTAL LIFETIME CANCER RISK (ILCR) OF 1E-6 OR A NONCANCER HAZARD QUOTIENT (HQ) OF 0.1. FOR CHEMICALS THAT EXHIBIT BOTH CANCER AND NONCANCER EFFECTS, WHICHEVER TYPE OF EFFECT IN A LOWER CONCENTRATION (USING AN ILCR OF 1E-6 AND AN HQ OF 0.1), THAT CONCENTRATION IS SELECTED AS THE RBSC.
4. BSC IS BACKGROUND SCREENING CONCENTRATION.
5. MDC IS MAXIMUM DETECTED CONCENTRATION FOR THE AOC ("B" QUALIFIED DATA NOT INCLUDED).
6. VALIDATION QUALIFIERS (VQ)
   - B - THE ANALYTE WAS NOT DETECTED SIGNIFICANTLY ABOVE THE LEVELS FOUND IN THE ASSOCIATED METHOD BLANK.
   - J - THE COMPOUND/ANALYTE WAS POSITIVELY IDENTIFIED; THE REPORTED VALUE IS AN ESTIMATED CONCENTRATION.

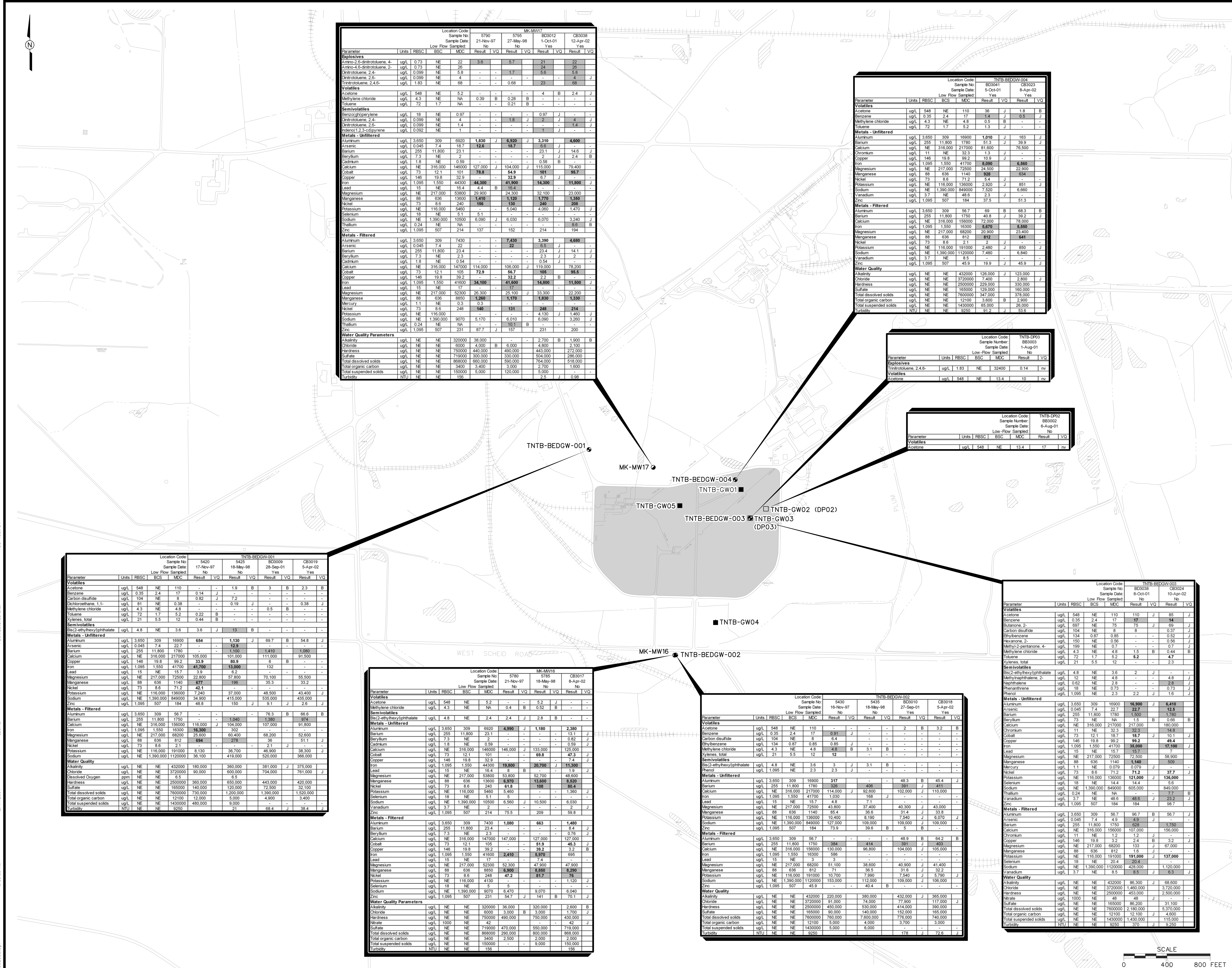
STARTING DATE 12/01/04	INITIATOR D. KESSLER	CHKD	DRAWN D. BOMAR	CHKD	PROJECT MNGR S. DOWNEY

Shaw Environmental, Inc.
KNOXVILLE, TENNESSEE

2004 GROUNDWATER DATA SUMMARY AND EVALUATION REPORT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

FIGURE 7-1
DETECTED CONSTITUENTS AT TNT AREA A ABOVE RBSCs AND/OR BSCs IN OVERBURDEN/SHALE AND BEDROCK GROUNDWATER (NOVEMBER 1997 THROUGH APRIL 2002)

AREA	JOB NO.	DRAWING NO.	REV
SITEWIDE	843656	843656_032.DGN	



				Location Code:	MK-MW17							
				Sample No:	5790		5795		BD3012		CB3038	
				Sample Date:	21-Nov-97		27-May-98		1-Oct-01		12-Apr-02	
				Low Flow Sampled:	No		No		Yes		Yes	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives												
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	NE	22	3.6		5.7		21		22	
Amino-4,6-dinitrotoluene, 2-	ug/L	0.73	NE	26					24		26	
Dinitrotoluene, 2,4-	ug/L	0.099	NE	5.8	-	-	1.7		5.6		5.8	
Dinitrotoluene, 2,6-	ug/L	0.099	NE	4	-	-	-	-	-	-	4	J
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	68	-	-	0.68		23		68	
Volatiles												
Acetone	ug/L	548	NE	5.2	-	-	-	-	4	B	2.4	J
Methylene chloride	ug/L	4.3	NE	NA	0.39	B	0.28	B	-	-	-	-
Toluene	ug/L	72	1.7	NA	-	-	0.21	B	-	-	-	-
Semivolatiles												
Benzo(ghi)perylene	ug/L	18	NE	0.97	-	-	-	-	0.97	J	-	-
Dinitrotoluene, 2,4-	ug/L	0.099	NE	4	-	-	1.8	J	2	J	4	J
Dinitrotoluene, 2,6-	ug/L	0.099	NE	1.4	-	-	-	-	-	-	1.4	J
Indeno(1,2,3-cd)pyrene	ug/L	0.092	NE	1	-	-	-	-	1	J	-	-
Metals - Unfiltered												
Aluminum	ug/L	3,650	309	6920	**1,830**	J	**6,920**	J	**3,310**		**4,600**	
Arsenic	ug/L	0.045	7.4	18.7	**12.6**		**18.7**		6.6	J	-	-
Barium	ug/L	255	11,800	23.1	-	-	-	-	23.1	J	14.6	J
Beryllium	ug/L	7.3	NE	2	-	-	-	-	2	J	2.4	B
Cadmium	ug/L	1.8	NE	0.59	-	-	-	-	0.58	B	-	-
Calcium	ug/L	NE	316,000	146000	127,000	J	104,000	J	115,000		79,400	
Cobalt	ug/L	73	12.1	101	**78.8**		**54.9**		**101**		**95.7**	
Copper	ug/L	146	19.8	32.9	-	-	**32.9**		6.7	J	-	-
Iron	ug/L	1,095	1,550	44300	**44,300**		**41,900**		**14,300**		**11,800**	J
Lead	ug/L	15	NE	16.4	4.4	B	16.4		-	-	-	-
Magnesium	ug/L	NE	217,000	53800	29,900		24,300		32,100		23,000	
Manganese	ug/L	88	636	13600	**1,410**		**1,120**		**1,770**		**1,350**	
Nickel	ug/L	73	8.6	240	**156**		**130**		**240**		**208**	
Potassium	ug/L	NE	116,000	5460	-	-	5,040		4,060	J	1,470	J
Selenium	ug/L	18	NE	5.1	5.1		-	-	-	-	-	-
Sodium	ug/L	NE	1,390,000	10500	6,090	J	6,030		6,070		3,240	J
Thallium	ug/L	0.24	NE	NA	-	-	-	-	-	-	8.6	B
Zinc	ug/L	1,095	507	214	137		152		214		194	
Metals - Filtered												
Aluminum	ug/L	3,650	309	7430	-	-	**7,430**		**3,390**		**4,680**	
Arsenic	ug/L	0.045	7.4	22	-	-	**22**		6.5	J	-	-
Barium	ug/L	255	11,800	23.4	-	-	-	-	23.4	J	14.1	J
Beryllium	ug/L	7.3	NE	2.3	-	-	-	-	2.3	J	2	J
Cadmium	ug/L	1.8	NE	0.54	-	-	-	-	0.54	J	-	-
Calcium	ug/L	NE	316,000	147000	114,000		106,000	J	119,000		78,200	
Cobalt	ug/L	73	12.1	105	**72.9**		**56.7**		**105**		**95.5**	
Copper	ug/L	146	19.8	39.2	-	-	**32.2**		2.2	B	-	-
Iron	ug/L	1,095	1,550	41600	**34,100**		**41,600**		**14,800**		**11,500**	J
Lead	ug/L	15	NE	17	-	-	17		-	-	-	-
Magnesium	ug/L	NE	217,000	52300	26,300		25,100	J	33,300		22,200	
Manganese	ug/L	88	636	8850	**1,260**		**1,170**		**1,830**		**1,330**	
Mercury	ug/L	1.1	NE	0.3	0.3		-	-	-	-	-	-
Nickel	ug/L	73	8.6	248	**140**		**131**		**248**		**214**	
Potassium	ug/L	NE	116,000	.	-	-	-	-	4,130	J	1,460	J
Sodium	ug/L	NE	1,390,000	9070	5,170		6,010		6,090		3,260	J
Thallium	ug/L	0.24	NE	NA	-	-	10.1	B	-	-	-	-
Zinc	ug/L	1,095	507	231	87.7	J	157		231		200	
Water Quality Parameters												
Alkalinity	ug/L	NE	NE	320000	38,000		-	-	2,700	B	1,900	B
Chloride	ug/L	NE	NE	6000	4,000	B	6,000		4,800		2,100	
Hardness	ug/L	NE	NE	750000	440,000		490,000		443,000		272,000	
Sulfate	ug/L	NE	NE	719000	300,000		330,000		504,000		286,000	
Total dissolved solids	ug/L	NE	NE	868000	660,000		590,000		764,000		518,000	
Total organic carbon	ug/L	NE	NE	3400	3,400		3,000		2,700		1,600	
Total suspended solids	ug/L	NE	NE	150000	5,000		120,000		5,000		-	-
Turbidity	NTU	NE	NE	156					2.5	J	0.98	

				Location Code:	TNTB-BEDGW-004			
				Sample No:	BD3041		CB3023	
				Sample Date:	5-Oct-01		8-Apr-02	
				Low Flow Sampled:	Yes		Yes	
Parameter	Units	RBSC	BCS	MDC	Result	VQ	Result	VQ
Volatiles								
Acetone	ug/L	548	NE	110	36	J	1.8	B
Benzene	ug/L	0.35	2.4	17	1.4	J	0.5	J
Methylene chloride	ug/L	4.3	NE	4.8	0.5	B	-	-
Toluene	ug/L	72	1.7	5.2	1.3	J	-	-
Metals - Unfiltered								
Aluminum	ug/L	3,650	309	16900	**1,010**	J	163	J
Barium	ug/L	255	11,800	1780	51.3	J	39.9	J
Calcium	ug/L	NE	316,000	217000	81,600		76,500	
Chromium	ug/L	11	NE	32.3	1.3	J	-	-
Copper	ug/L	146	19.8	99.2	10.9	J	-	-
Iron	ug/L	1,095	1,550	41700	**8,090**		**6,560**	
Magnesium	ug/L	NE	217,000	72500	24,500		22,900	
Manganese	ug/L	88	636	1140	**928**		634	
Nickel	ug/L	73	8.6	71.2	5.4	J	-	-
Potassium	ug/L	NE	116,000	136000	2,920	J	851	J
Sodium	ug/L	NE	1,390,000	849000	7,520		6,660	
Vanadium	ug/L	3.7	NE	48.6	2.3	J	-	-
Zinc	ug/L	1,095	507	184	37.5		51.3	
Metals - Filtered								
Aluminum	ug/L	3,650	309	56.7	69	B	68.3	B
Barium	ug/L	255	11,800	1750	40.8	J	39.2	J
Calcium	ug/L	NE	316,000	156000	72,000		78,000	
Iron	ug/L	1,095	1,550	16300	**5,670**		**5,550**	
Magnesium	ug/L	NE	217,000	68200	20,900		23,400	
Manganese	ug/L	88	636	812	**812**		**641**	
Nickel	ug/L	73	8.6	2.1	2	J	-	-
Potassium	ug/L	NE	116,000	191000	2,480	J	850	J
Sodium	ug/L	NE	1,390,000	1120000	7,480		6,840	
Vanadium	ug/L	3.7	NE	8.5	-	-	-	-
Zinc	ug/L	1,095	507	45.9	19.9	J	45.9	J
Water Quality								
Alkalinity	ug/L	NE	NE	432000	126,000	J	123,000	
Chloride	ug/L	NE	NE	3720000	7,400		2,800	J
Hardness	ug/L	NE	NE	2500000	229,000		330,000	
Sulfate	ug/L	NE	NE	165000	129,000		160,000	
Total dissolved solids	ug/L	NE	NE	7600000	347,000		378,000	
Total organic carbon	ug/L	NE	NE	12100	3,600	B	2,900	
Total suspended solids	ug/L	NE	NE	1430000	65,000		26,000	
Turbidity	NTU	NE	NE	9250	91.2	J	53.6	

				Location Code:	TNTB-DP03	
				Sample Number:	BB3003	
				Sample Date:	1-Aug-01	
				Low-Flow Sampled:	No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ
Explosives						
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	32400	0.14	nv
Volatiles						
Acetone	ug/L	548	NE	13.4	10	nv

				Location Code:	TNTB-DP02	
				Sample Number:	BB3002	
				Sample Date:	6-Aug-01	
				Low-Flow Sampled:	No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ
Volatiles						
Acetone	ug/L	548	NE	13.4	17	nv

LEGEND:

- BUILDINGS
- RAILROAD
- SURFACE DRAINAGE
- SURFACE WATER
- OVERBURDEN/SHALE MONITORING WELL LOCATION
- BEDROCK MONITORING WELL LOCATION
- 2001 DIRECT-PUSH GROUNDWATER SAMPLING LOCATION
- 2001 DIRECT-PUSH GROUNDWATER SAMPLING LOCATION (DRILLED TO REFUSAL, NO GROUNDWATER ENCOUNTERED)
- ug/L MICROGRAMS PER LITER
- nv NON VALIDATED
- NA NOT APPLICABLE, ONLY B QUALIFIED DATA DETECTED
- NE NOT ESTABLISHED (RBSCs), NOT EVALUATED (BSCs)
- NTU NEPHELOMETRIC TUBIDITY UNIT

NOTES:

1. SHADED CELL INDICATES VALUE IS GREATER THAN RBSC.
2. BOLD TEXT INDICATES VALUE IS GREATER THAN BSC.
3. RBSC VALUES REFLECT AN INCREMENTAL LIFETIME CANCER RISK (ILCR) OF 1E-6 OR A NONCANCER HAZARD QUOTIENT (HQ) OF 0.1 FOR CHEMICALS THAT EXHIBIT BOTH CANCER AND NONCANCER EFFECTS, WHICHEVER TYPE OF EFFECT IN A LOWER CONCENTRATION (USING AN ILCR OF 1E-6 AND AN HQ OF 0.1), THAT CONCENTRATION IS SELECTED AS THE RBSC.
4. BSC IS BACKGROUND SCREENING CONCENTRATION.
5. MDC IS MAXIMUM DETECTED CONCENTRATION FOR THE AOC ("B" QUALIFIED DATA NOT INCLUDED).
6. VALIDATION QUALIFIERS (VQ)
   - B - THE ANALYTE WAS NOT DETECTED SIGNIFICANTLY ABOVE THE LEVELS FOUND IN THE ASSOCIATED METHOD BLANK.
   - J - THE COMPOUND/ANALYTE WAS POSITIVELY IDENTIFIED; THE REPORTED VALUE IS AN ESTIMATED CONCENTRATION.

				Location Code:	TNTB-BEDGW-001							
				Sample No:	5420		5425		BD3009		CB3019	
				Sample Date:	17-Nov-97		18-May-98		28-Sep-01		5-Apr-02	
				Low Flow Sampled:	No		No		Yes		Yes	
Parameter	Units	RBSC	BCS	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Volatiles												
Acetone	ug/L	548	NE	110	-	-	1.9	B	3	B	2.3	B
Benzene	ug/L	0.35	2.4	17	0.14	J	-	-	-	-	-	-
Carbon disulfide	ug/L	104	NE	8	0.82	J	7.2		-	-	-	-
Dichloroethane, 1,1-	ug/L	81	NE	0.38	-	-	0.19	J	-	-	0.38	J
Methylene chloride	ug/L	4.3	NE	4.8	-	-	-	-	0.5	B	-	-
Toluene	ug/L	72	1.7	5.2	0.22	B	-	-	-	-	-	-
Xylenes, total	ug/L	21	5.5	12	0.44	B	-	-	-	-	-	-
Semivolatiles												
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	3.6	3.6	J	13	B	-	-	-	-
Metals - Unfiltered												
Aluminum	ug/L	3,650	309	16900	**654**		**1,130**	J	69.7	B	54.8	J
Arsenic	ug/L	0.045	7.4	22.7	-	-	**12.9**		-	-	-	-
Barium	ug/L	255	11,800	1780	-	-	1,100		1,410		1,080	
Calcium	ug/L	NE	316,000	217000	105,000		101,000		111,000		91,500	
Copper	ug/L	146	19.8	99.2	**33.9**		**80.9**		6	B	-	-
Iron	ug/L	1,095	1,550	41700	**41,700**		**13,000**		132		-	-
Lead	ug/L	15	NE	15.7	3.9		6.2		-	-	-	-
Magnesium	ug/L	NE	217,000	72500	22,800		57,800		70,100		55,500	
Manganese	ug/L	88	636	1140	**677**		196		35.3		33.2	
Nickel	ug/L	73	8.6	71.2	**42.1**		-	-	-	-	-	-
Potassium	ug/L	NE	116,000	136000	7,240		37,000		48,500		43,400	J
Sodium	ug/L	NE	1,390,000	849000	34,900		415,000		535,000		435,000	
Zinc	ug/L	1,095	507	184	48.8		150	J	9.1	J	2.6	J
Metals - Filtered												
Aluminum	ug/L	3,650	309	56.7	-	-	-	-	76.3	B	66.6	B
Barium	ug/L	255	11,800	1750	-	-	1,040		1,380		974	
Calcium	ug/L	NE	316,000	156000	116,000	J	104,000		107,000		91,800	
Iron	ug/L	1,095	1,550	16300	**16,300**		302		-	-	-	-
Magnesium	ug/L	NE	217,000	68200	25,600		60,400		68,200		52,600	
Manganese	ug/L	88	636	812	**694**		278		36		51.1	J
Nickel	ug/L	73	8.6	2.1	-	-	-	-	2.1	J	-	-
Potassium	ug/L	NE	116,000	191000	8,130		36,700		46,900		38,300	J
Sodium	ug/L	NE	1,390,000	1120000	36,100		419,000		520,000		366,000	
Water Quality												
Alkalinity	ug/L	NE	NE	432000	180,000		360,000		381,000	J	375,000	
Chloride	ug/L	NE	NE	3720000	90,000		600,000		704,000		761,000	J
Dissolved Oxygen	ppm	NE	NE	6.5			6.5					
Hardness	ug/L	NE	NE	2500000	360,000		650,000		443,000		420,000	
Sulfate	ug/L	NE	NE	165000	140,000		120,000		72,500		32,100	
Total dissolved solids	ug/L	NE	NE	7600000	730,000		1,200,000		1,390,000		1,520,000	
Total organic carbon	ug/L	NE	NE	12100	12,000		5,000		4,900		3,400	
Total suspended solids	ug/L	NE	NE	1430000	480,000		9,000		-	-	-	-
Turbidity	NTU	NE	NE	9250			21		68.4	J	38.4	J

				Location Code:	MK-MW16					
				Sample No:	5780		5785		CB3017	
				Sample Date:	21-Nov-97		18-May-98		8-Apr-02	
				Low Flow Sampled:	No		No		No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ
Volatiles										
Acetone	ug/L	548	NE	5.2	-	-	5.2	J	-	-
Methylene chloride	ug/L	4.3	NE	NA	0.4	B	0.52	B	-	-
Semivolatiles										
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	2.4	2.4	J	2.8	B	-	-
Metals - Unfiltered										
Aluminum	ug/L	3,650	309	6920	**4,990**	J	**1,180**		**2,380**	
Barium	ug/L	255	11,800	23.1	-	-	-	-	13.1	J
Beryllium	ug/L	7.3	NE	2	-	-	-	-	0.82	J
Cadmium	ug/L	1.8	NE	0.59	-	-	-	-	0.59	J
Calcium	ug/L	NE	316,000	146000	146,000	J	133,000		125,000	
Cobalt	ug/L	73	12.1	101	-	-	**69.8**		**47.3**	J
Copper	ug/L	146	19.8	32.9	-	-	-	-	7.4	J
Iron	ug/L	1,095	1,550	44300	**19,800**		**20,700**	J	**11,300**	
Lead	ug/L	15	NE	16.4	8	B	-	-	1.9	J
Magnesium	ug/L	NE	217,000	53800	53,800		52,700		48,600	
Manganese	ug/L	88	636	13600	**6,970**		**13,600**		**8,520**	
Nickel	ug/L	73	8.6	240	**61.8**		**108**		**80.4**	
Potassium	ug/L	NE	116,000	5460	5,460		-	-	1,360	J
Selenium	ug/L	18	NE	5.1	5		-	-	-	-
Sodium	ug/L	NE	1,390,000	10500	6,560	J	10,500		6,030	
Vanadium	ug/L	3.7	NE	2	-	-	-	-	2	J
Zinc	ug/L	1,095	507	214	75.5		209		59.8	
Metals - Filtered										
Aluminum	ug/L	3,650	309	7430	**1,080**		**663**		**1,480**	
Barium	ug/L	255	11,800	23.4	-	-	-	-	8.4	J
Beryllium	ug/L	7.3	NE	2.3	-	-	-	-	0.76	J
Calcium	ug/L	NE	316,000	147000	147,000		127,000		127,000	
Cobalt	ug/L	73	12.1	105	-	-	**51.9**		**45.3**	J
Copper	ug/L	146	19.8	39.2	-	-	**39.2**		3.2	B
Iron	ug/L	1,095	1,550	41600	**2,410**		**5,970**		695	
Lead	ug/L	15	NE	17	-	-	7.4		-	-
Magnesium	ug/L	NE	217,000	52300	52,300		47,900		47,900	
Manganese	ug/L	88	636	8850	**6,900**		**8,850**		**8,290**	
Nickel	ug/L	73	8.6	248	**47.2**		**81.7**		**76**	
Potassium	ug/L	NE	116,000	4130	-	-	-	-	1,120	J
Selenium	ug/L	18	NE	5	5		-	-	-	-
Sodium	ug/L	NE	1,390,000	9070	6,470		9,070		6,040	
Zinc	ug/L	1,095	507	231	54.7	J	141	B	70.1	J
Water Quality Parameters										
Alkalinity	ug/L	NE	NE	320000	36,000		320,000		2,600	B
Chloride	ug/L	NE	NE	6000	3,000	B	3,000		1,700	J
Hardness	ug/L	NE	NE	750000	490,000		750,000		430,000	
Nitrate	ug/L	1000	NE	42			-	-	42	J
Sulfate	ug/L	NE	NE	719000	470,000		550,000		719,000	
Total dissolved solids	ug/L	NE	NE	868000	290,000		800,000		868,000	
Total organic carbon	ug/L	NE	NE	3400	2,500		2,000		2,000	
Total suspended solids	ug/L	NE	NE	150000	-	-	9,000		150,000	
Turbidity	NTU	NE	NE	156					156	

				Location Code:	TNTB-BEDGW-002							
				Sample No:	5430		5435		BD3010		CB3018	
				Sample Date:	16-Nov-97		18-May-98		27-Sep-01		5-Apr-02	
				Low Flow Sampled:	No		No		Yes		Yes	
Parameter	Units	RBSC	BCS	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Volatiles												
Acetone	ug/L	548	NE	110	-	-	-	-	2	B	3.2	B
Benzene	ug/L	0.35	2.4	17	0.91	J	-	-	-	-	-	-
Carbon disulfide	ug/L	104	NE	8	6.4		-	-	-	-	-	-
Ethylbenzene	ug/L	134	0.87	0.85	0.85	J	-	-	-	-	-	-
Methylene chloride	ug/L	4.3	NE	4.8	4.8	B	3.1	B	-	-	-	-
Xylenes, total	ug/L	21	5.5	12	**12**		-	-	-	-	-	-
Semivolatiles												
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	3.6	3	J	3.1	B	-	-	-	-
Phenol	ug/L	1,095	NE	2.3	2.3	J	-	-	-	-	-	-
Metals - Unfiltered												
Aluminum	ug/L	3,650	309	16900	**317**		-	-	48.3	B	45.4	J
Barium	ug/L	255	11,800	1780	326		406		391	J	411	
Calcium	ug/L	NE	316,000	217000	114,000	J	92,600		102,000	J	110,000	
Iron	ug/L	1,095	1,550	41700	1,030		168	J	-	-	-	-
Lead	ug/L	15	NE	15.7	4.8		7.1		-	-	-	-
Magnesium	ug/L	NE	217,000	72500	43,800		37,400		40,300	J	43,000	
Manganese	ug/L	88	636	1140	85.4		36.6		31.4	J	33.8	
Potassium	ug/L	NE	116,000	136000	10,400		8,190		7,540	J	6,070	J
Sodium	ug/L	NE	1,390,000	849000	127,000		109,000		109,000	J	109,000	
Zinc	ug/L	1,095	507	184	73.9		39.6	B	5	B	-	-
Metals - Filtered												
Aluminum	ug/L	3,650	309	56.7	-	-	-	-	48.9	B	64.2	B
Barium	ug/L	255	11,800	1750	384		414		391	J	403	
Calcium	ug/L	NE	316,000	156000	130,000		96,800		104,000	J	105,000	
Iron	ug/L	1,095	1,550	16300	586		-	-	-	-	-	-
Lead	ug/L	15	NE	3	3		-	-	-	-	-	-
Magnesium	ug/L	NE	217,000	68200	51,100		38,600		40,900	J	41,400	
Manganese	ug/L	88	636	812	71		36.5		31.6	J	32.2	
Potassium	ug/L	NE	116,000	191000	10,700		7,990		7,540	J	5,790	J
Sodium	ug/L	NE	1,390,000	1120000	153,000		112,000		109,000	J	106,000	
Zinc	ug/L	1,095	507	45.9	-	-	40.4	B	-	-	-	-
Water Quality												
Alkalinity	ug/L	NE	NE	432000	220,000		380,000		432,000	J	365,000	
Chloride	ug/L	NE	NE	3720000	91,000		74,000		77,900		117,000	J
Hardness	ug/L	NE	NE	2500000	450,000		530,000		414,000		390,000	
Sulfate	ug/L	NE	NE	165000	90,000		140,000		152,000		165,000	
Total dissolved solids	ug/L	NE	NE	7600000	760,000		7,600,000		776,000		740,000	
Total organic carbon	ug/L	NE	NE	12100	5,000		4,000		3,700		3,000	
Total suspended solids	ug/L	NE	NE	1430000	5,000		6,000		-	-	-	-
Turbidity	NTU	NE	NE	9250					178	J	72.6	J

				Location Code:	TNTB-BEDGW-003			
				Sample No:	BD3038		CB3024	
				Sample Date:	8-Oct-01		10-Apr-02	
				Low Flow Sampled:	No		No	
Parameter	Units	RBSC	BCS	MDC	Result	VQ	Result	VQ
Volatiles								
Acetone	ug/L	548	NE	110	110	J	85	J
Benzene	ug/L	0.35	2.4	17	**17**		**14**	
Butanone, 2-	ug/L	697	NE	75	75	J	69	J
Carbon disulfide	ug/L	104	NE	8	8		0.37	J
Ethylbenzene	ug/L	134	0.87	0.85	-	-	0.52	J
Hexanone, 2-	ug/L	150	NE	0.56	-	-	0.56	J
Methyl-2-pentanone, 4-	ug/L	199	NE	0.7	-	-	0.7	J
Methylene chloride	ug/L	4.3	NE	4.8	1.5	B	0.44	B
Toluene	ug/L	72	1.7	5.2	**5.2**		**4.7**	
Xylenes, total	ug/L	21	5.5	12	-	-	2.3	
Semivolatiles								
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	3.6	2	J	-	-
Methylnaphthalene, 2-	ug/L	12	NE	4.8	-	-	4.8	J
Naphthalene	ug/L	0.62	NE	2.8	-	-	2.8	J
Phenanthrene	ug/L	18	NE	0.73	-	-	0.73	J
Phenol	ug/L	1,095	NE	2.3	2.2	J	1.6	J
Metals - Unfiltered								
Aluminum	ug/L	3,650	309	16900	**16,900**	J	**6,410**	
Arsenic	ug/L	0.045	7.4	22.7	**22.7**		**12.5**	
Barium	ug/L	255	11,800	1780	1,500		1,780	
Beryllium	ug/L	73	NE	NA	1.5	B	0.66	B
Calcium	ug/L	NE	316,000	217000	217,000		180,000	
Chromium	ug/L	11	NE	32.3	32.3		14.8	
Cobalt	ug/L	73	12.1	18.7	**18.7**	J	10.1	J
Copper	ug/L	146	19.8	99.2	**99.2**		**49.4**	
Iron	ug/L	1,095	1,550	41700	**35,000**		**17,100**	J
Lead	ug/L	15	NE	15.7	15.7		7	
Magnesium	ug/L	NE	217,000	72500	72,500		58,900	
Manganese	ug/L	88	636	1140	**1,140**		509	
Mercury	ug/L	1.1	NE	0.079	0.079	J	-	-
Nickel	ug/L	73	8.6	71.2	**71.2**		**37.7**	J
Potassium	ug/L	NE	116,000	136000	**121,000**	J	**136,000**	
Selenium	ug/L	18	NE	14.4	14.4		5.6	
Sodium	ug/L	NE	1,390,000	849000	605,000		849,000	
Thallium	ug/L	0.24	NE	NA	-	-	7.7	B
Vanadium	ug/L	3.7	NE	48.6	48.6	J	23.2	J
Zinc	ug/L	1,095	507	184	184		98.7	
Metals - Filtered								
Aluminum	ug/L	3,650	309	56.7	96.7	B	56.7	J
Arsenic	ug/L	0.045	7.4	4.9	4.9	J	-	-
Barium	ug/L	255	11,800	1750	628		1,750	
Calcium	ug/L	NE	316,000	156000	107,000		156,000	
Chromium	ug/L	11	NE	1.2	1.2	J	-	-
Copper	ug/L	146	19.8	3.2	2.4	B	3.2	J
Magnesium	ug/L	NE	217,000	68200	133	J	67,000	
Manganese	ug/L	88	636	812	1.6	J	-	-
Potassium	ug/L	NE	116,000	191000	**191,000**	J	**137,000**	
Selenium	ug/L	18	NE	20.4	20.4		-	-
Sodium	ug/L	NE	1,390,000	1120000	428,000		1,120,000	
Vanadium	ug/L	3.7	NE	8.5	8.5	J	6.3	J
Water Quality								
Alkalinity	ug/L	NE	NE	432000	86,300	J	68,600	
Chloride	ug/L	NE	NE	3720000	1,460,000		3,720,000	
Hardness	ug/L	NE	NE	2500000	453,000		2,500,000	
Nitrate	ug/L	1000	NE	48	48	J	-	-
Sulfate	ug/L	NE	NE	165000	86,200		31,100	
Total dissolved solids	ug/L	NE	NE	7600000	2,180,000		5,370,000	
Total organic carbon	ug/L	NE	NE	12100	12,100	J	4,600	
Total suspended solids	ug/L	NE	NE	1430000	1,430,000		115,000	
Turbidity	NTU	NE	NE	9250	370	J	9,250	

NO	DATE	REVISION	BY	CHKD	DSGN ENGR	ENGR	PROJ MGR	APPR

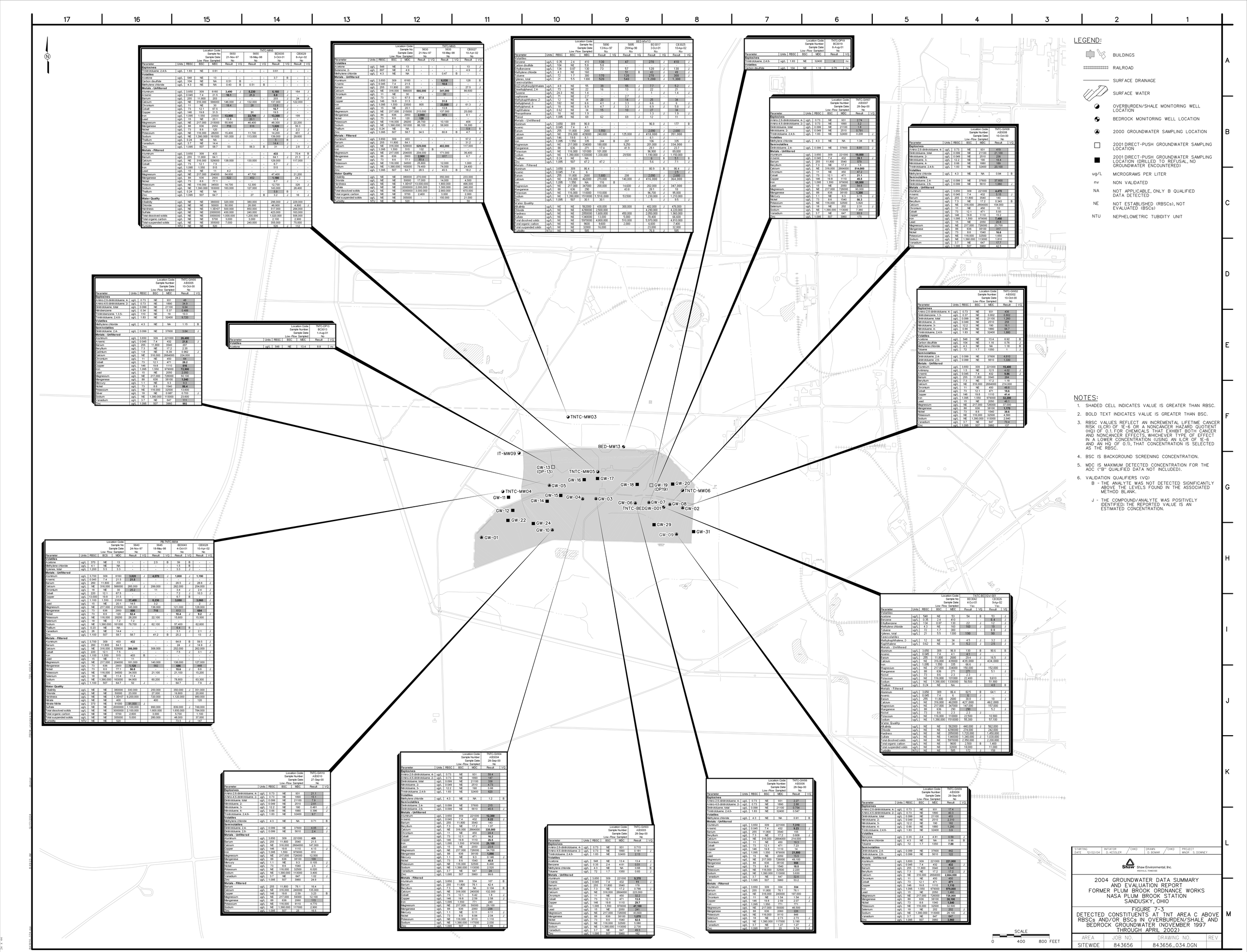
STARTING DATE 12/02/04 | INITIATOR D. KESSLER | CHKD | DRAWN D. BOMAR | CHKD | PROJECT MNGR S. DOWNEY

Shaw® Shaw Environmental, Inc.
KNOXVILLE, TENNESSEE

2004 GROUNDWATER DATA SUMMARY AND EVALUATION REPORT FORMER PLUM BROOK ORDNANCE WORKS NASA PLUM BROOK STATION SANDUSKY, OHIO

FIGURE 7-2
DETECTED CONSTITUENTS AT TNT AREA B ABOVE RBSCs AND/OR BSCs IN OVERBURDEN/SHALE AND BEDROCK GROUNDWATER (NOVEMBER 1997 THROUGH APRIL 2002)

AREA	JOB NO.	DRAWING NO.	REV
SITEWIDE	843656	843656_033.DGN	



LEGEND:

- BUILDINGS
- RAILROAD
- SURFACE DRAINAGE
- SURFACE WATER
- OVERBURDEN/SHALE MONITORING WELL LOCATION
- BEDROCK MONITORING WELL LOCATION
- 2000 GROUNDWATER SAMPLING LOCATION
- 2001 DIRECT-PUSH GROUNDWATER SAMPLING LOCATION
- 2001 DIRECT-PUSH GROUNDWATER SAMPLING LOCATION (DRILLED TO REFUSAL, NO GROUNDWATER ENCOUNTERED)
- ug/L MICROGRAMS PER LITER
- nv NON VALIDATED
- NA NOT APPLICABLE, ONLY B QUALIFIED DATA DETECTED
- NE NOT ESTABLISHED (RBSCs), NOT EVALUATED (BSCs)
- NTU NEPHELOMETRIC TUBIDITY UNIT

NOTES:

1. SHADED CELL INDICATES VALUE IS GREATER THAN RBSC.
2. BOLD TEXT INDICATES VALUE IS GREATER THAN BSC.
3. RBSC VALUES REFLECT AN INCREMENTAL LIFETIME CANCER RISK (ILCR) OF 1E-6 OR A NONCANCER HAZARD QUIENT (HQ) OF 0.1 FOR CHEMICALS THAT EXHIBIT BOTH CANCER AND NONCANCER EFFECTS, WHICHEVER TYPE OF EFFECT IN A LOWER CONCENTRATION (USING AN ILCR OF 1E-6 AND AN HQ OF 0.1), THAT CONCENTRATION IS SELECTED AS THE RBSC.
4. BSC IS BACKGROUND SCREENING CONCENTRATION.
5. MDC IS MAXIMUM DETECTED CONCENTRATION FOR THE AOC ("B" QUALIFIED DATA NOT INCLUDED).
6. VALIDATION QUALIFIERS (VQ)
   - B - THE ANALYTE WAS NOT DETECTED SIGNIFICANTLY ABOVE THE LEVELS FOUND IN THE ASSOCIATED METHOD BLANK.
   - J - THE COMPOUND/ANALYTE WAS POSITIVELY IDENTIFIED; THE REPORTED VALUE IS AN ESTIMATED CONCENTRATION.

SCALE
0 400 800 FEET

STARTING DATE	INITIATOR / CHKD	DRAWN / CHKD	PROJECT MGR
12/02/04	D. KESSLER /	D. BOMAR /	S. DOWNEY

Shaw Environmental, Inc.
NASHVILLE, TENNESSEE

2004 GROUNDWATER DATA SUMMARY AND EVALUATION REPORT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

FIGURE 7-3
DETECTED CONSTITUENTS AT TNT AREA C ABOVE RBSCs AND/OR BSCs IN OVERBURDEN/SHALE AND BEDROCK GROUNDWATER (NOVEMBER 1997 THROUGH APRIL 2002)

AREA	JOB NO.	DRAWING NO.	REV
SITEWIDE	843656	843656_034.DGN	

TNTC-MW05

Parameter	Units	RBSC	BSC	Location Code / Sample No / Sample Date / Low Flow Sampled	5650 21-Nov-97 No		5650 18-May-98 No		BD3035 3-Oct-01 No		CB3026 8-Apr-02 No	
				MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives												
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	0.61	-	-	-	-	0.61	-	-	-
Volatiles												
Acetone	ug/L	548	NE	13	-	-	-	-	3.7	B	-	-
Carbon disulfide	ug/L	104	NE	NA	0.51	B	-	-	-	-	-	-
Methylene chloride	ug/L	4.3	NE	NA	0.43	B	0.51	B	-	-	-	-
Metals - Unfiltered												
Aluminum	ug/L	3,650	309	6160	**3,490**	J	**5,230**		**6,160**	J	164	J
Arsenic	ug/L	0.045	7.4	21.5	**10.1**		**21.3**		**8.8**	J	-	-
Barium	ug/L	255	11,800	203	-	-	-	-	203	J	24	J
Calcium	ug/L	NE	316,000	566000	146,000	J	132,000		137,000	J	122,000	
Chromium	ug/L	11	NE	30	**18.4**	J	**38**		**13.5**	J	-	-
Cobalt	ug/L	73	12.1	67.5	-	-	-	-	**16.7**	J	-	-
Copper	ug/L	146	19.8	31.5	-	-	**31**		19.5	J	-	-
Iron	ug/L	1,095	1,550	23500	**13,900**		**22,700**	J	**13,300**	J	199	J
Lead	ug/L	15	NE	20.1	13.8		20.1		10.5	J	-	-
Magnesium	ug/L	NE	217,000	215000	55,900		46,400		48,300	J	22,200	
Manganese	ug/L	88	636	2950	**713**		**816**		**1,820**	J	56.3	
Nickel	ug/L	73	8.6	120	-	-	-	-	**17.2**	J	2.2	J
Potassium	ug/L	NE	116,000	28200	15,400	J	11,700		14,200	J	481	J
Sodium	ug/L	NE	1,390,000	161000	161,000	J	113,000		139,000	J	29,600	
Thallium	ug/L	0.24	NE	NA	-	-	-	-	3	B	-	-
Vanadium	ug/L	3.7	NE	14.4	-	-	-	-	**14.4**	J	-	-
Zinc	ug/L	1,095	507	58.7	53	J	58.3	B	31	J	2.8	J
Metals - Filtered												
Aluminum	ug/L	3,650	309	433	-	-	-	-	**433**	J	70.4	B
Barium	ug/L	255	11,800	64.1	-	-	-	-	64.1	J	21.3	J
Calcium	ug/L	NE	316,000	529000	138,000		130,000		129,000	J	117,000	
Cobalt	ug/L	73	12.1	7.5	-	-	-	-	6.7	J	-	-
Iron	ug/L	1,095	1,550	515	-	-	-	-	515	J	-	-
Lead	ug/L	15	NE	11	4.2	-	-	-	-	-	-	-
Magnesium	ug/L	NE	217,000	204000	51,600		47,700		47,400	J	21,200	
Manganese	ug/L	88	636	2900	**522**		**452**		**1,160**	J	24.2	
Nickel	ug/L	73	8.6	77.1	-	-	-	-	8.7	J	-	-
Potassium	ug/L	NE	116,000	34500	14,700		12,300		12,700	J	326	J
Sodium	ug/L	NE	1,390,000	163000	163,000	J	127,000		143,000	J	28,400	
Sulfate	ug/L	NE	NE	NA	-	-	-	-	**5.9**	B	-	-
Zinc	ug/L	1,095	507	64.7	-	-	27	B	3.2	J	16	J
Water Quality												
Alkalinity	ug/L	NE	NE	380000	320,000		350,000		296,000	J	229,000	
Chloride	ug/L	NE	NE	50000	50,000		26,000		46,900		4,800	J
Hardness	ug/L	NE	NE	1.3E+07	500,000		650,000		517,000		284,000	J
Sulfate	ug/L	NE	NE	2000000	430,000		240,000		423,000		163,000	
Total dissolved solids	ug/L	NE	NE	3000000	1,000,000		1,200,000		1,020,000		506,000	
Total organic carbon	ug/L	NE	NE	5700	3,000		3,000		2,100		2,900	
Total suspended solids	ug/L	NE	NE	355000	7,000		240,000		355,000		75,000	
Turbidity	NTU	NE	NE	520					520	J	112	

TNTC-MW03

Parameter	Units	RBSC	BSC	Location Code / Sample No / Sample Date / Low Flow Sampled	5630 21-Nov-97 No		5690 13-Nov-97 No		5635 18-May-98 No		CB3027 10-Apr-02 No	
				MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Volatiles												
Acetone	ug/L	548	NE	NE	13	-	-	-	-	-	13	J
Butanone, 2-	ug/L	697	NE	NE	4.9	-	-	-	-	-	4.9	J
Methylene chloride	ug/L	4.3	NE	NE	NA	-	-	-	0.47	B	0.47	B
Metals - Unfiltered												
Aluminum	ug/L	3,650	309	6160	-	-	-	-	**6,030**		128	B
Arsenic	ug/L	0.045	7.4	21.5	-	-	-	-	**18.6**		-	-
Barium	ug/L	255	11,800	203	-	-	-	-	-	-	27.5	J
Calcium	ug/L	NE	316,000	566000	**566,000**	J	**341,000**		86,600			
Chromium	ug/L	11	NE	30	-	-	-	-	**30**		-	-
Cobalt	ug/L	73	12.1	67.5	**67.5**		-	-	-	-	-	-
Copper	ug/L	146	19.8	31.5	-	-	**31.5**		-	-	-	-
Iron	ug/L	1,095	1,550	23500	805		**23,500**	J	61.3	J		
Lead	ug/L	15	NE	20.1	-	-	**13.8**		-	-	-	-
Magnesium	ug/L	NE	217,000	215000	215,000		137,000		25,000			
Manganese	ug/L	88	636	2950	**2,900**	J	**873**		8.1	J		
Nickel	ug/L	73	8.6	120	**120**		-	-	-	-	-	-
Potassium	ug/L	NE	116,000	28200	26,100		10,100		406	J		
Sodium	ug/L	NE	1,390,000	161000	86,100	J	58,900		16,300	J		
Thallium	ug/L	0.24	NE	NA	-	-	-	-	**3.9**	B		
Zinc	ug/L	1,095	507	64.7	34.5		80.8	B	4.7	J		
Metals - Filtered												
Aluminum	ug/L	3,650	309	433	-	-	-	-	-	-	57.2	J
Barium	ug/L	255	11,800	64.1	-	-	-	-	-	-	31.2	J
Calcium	ug/L	NE	316,000	529000	**529,000**		**402,000**		117,000		-	-
Iron	ug/L	1,095	1,550	515	-	-	-	-	-	-	-	-
Magnesium	ug/L	NE	217,000	204000	204,000		171,000		36,400			
Manganese	ug/L	88	636	2900	**2,900**		**617**		6.7	J		
Nickel	ug/L	73	8.6	77.1	**77.1**		-	-	-	-	-	-
Potassium	ug/L	NE	116,000	34500	25,800		12,000		1,000	J		
Sodium	ug/L	NE	1,390,000	163000	79,400	J	74,000		24,400			
Zinc	ug/L	1,095	507	64.7	28.5	J	45.5	B	18.2	J		
Water Quality												
Alkalinity	ug/L	NE	NE	380000	270,000		350,000		233,000			
Chloride	ug/L	NE	NE	50000	17,000		14,000		4,500			
Hardness	ug/L	NE	NE	NE	1.3E+07	13,000,000		1,800,000	496,000			
Sulfate	ug/L	NE	NE	2000000	2,000,000		1,300,000		248,000			
Total dissolved solids	ug/L	NE	NE	3000000	3,000,000		2,900,000		670,000			
Total organic carbon	ug/L	NE	NE	5700	2,400		3,000		2,000			
Total suspended solids	ug/L	NE	NE	355000	-	-	150,000		21,000			
Turbidity	NTU	NE	NE	520	-	-	-	-	59			

BED-MW13

Parameter	Units	RBSC	BSC	Location Code / Sample No / Sample Date / Low Flow Sampled	5690 13-Nov-97 No		5695 29-May-98 No		BD3017 3-Oct-01 No		CB3025 10-Apr-02 No	
				MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Volatiles												
Benzene	ug/L	0.35	2.4	410	**130**		**47**	-	**270**	J	**410**	J
Carbon disulfide	ug/L	104	NE	5.8	5.3	-	-	-	-	-	-	-
Ethylbenzene	ug/L	1.34	0.87	130	73		57	-	120	J	130	J
Methylene chloride	ug/L	4.3	NE	160	-	-	51	B	43	J	48	J
Toluene	ug/L	72	1.7	300	**170**		120	-	270	J	300	J
Xylenes, total	ug/L	21	5.5	1300	520		540	-	1,200	J	1,300	J
Semivolatiles												
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	55	39		55	J	7.7	J	5.2	J
Dimethylphenol, 2,4-	ug/L	73	NE	22	15		13	J	22		21	
Fluorene	ug/L	24.3	NE	14	-	-	-	-	1	J	1.4	J
Isophorone	ug/L	71	NE	27	-	-	2.7	J	-	-	-	-
Methylnaphthalene, 2-	ug/L	12	NE	34	20		14	J	25	-	34	
Methylphenol, 2-	ug/L	182	NE	6.6	4.1	J	3.3	J	6.6	J	6	J
Methylphenol, 4-	ug/L	18	NE	6.9	4.7	J	3.3	J	6.9	J	5.8	J
Naphthalene	ug/L	0.62	NE	34	15		10	J	27	-	34	
Phenanthrene	ug/L	18	NE	1.9	-	-	-	-	1.3	J	1.9	J
Phenol	ug/L	1,095	NE	69	62		69	J	12		11	
Metals - Unfiltered												
Aluminum	ug/L	3,650	309	96.8	-	-	-	-	96.8	J	177	B
Arsenic	ug/L	0.045	7.4	4.1	-	-	-	-	-	-	-	-
Barium	ug/L	255	11,800	2680	1,550		-	-	2,680	J	2,680	
Calcium	ug/L	NE	316,000	439000	240,000	J	125,000	J	418,000	J	351,000	
Copper	ug/L	146	19.8	6.3	-	-	-	-	6.3	-	-	-
Iron	ug/L	1,095	1,550	335	244	B	207	-	516	-	335	J
Magnesium	ug/L	NE	217,000	334000	180,000		9,250	-	201,000	J	334,000	
Manganese	ug/L	88	636	271	174		41.9	-	29.1	J	23.7	
Potassium	ug/L	NE	116,000	101000	101,000		-	-	96,900	J	89,000	
Sodium	ug/L	NE	1,390,000	1330000	1,330,000		29,500	-	1,190,000	J	1,150,000	
Thallium	ug/L	0.24	NE	NA	-	-	-	-	6	B	5.1	B
Zinc	ug/L	1,095	507	47.3	47.2	-	-	-	5.6	J	7.1	J
Metals - Filtered												
Aluminum	ug/L	3,650	309	86.4	-	-	-	-	80.3	B	86.4	J
Arsenic	ug/L	0.045	7.4	6	-	-	-	-	-	-	2.5	J
Barium	ug/L	255	11,800	2680	1,600		208	-	2,090	J	2,680	
Calcium	ug/L	NE	316,000	462000	270,000		140,000	J	416,000	J	364,000	
Iron	ug/L	1,095	1,550	116	116	B	-	-	-	-	-	-
Magnesium	ug/L	NE	217,000	347000	200,000		14,600	J	202,000	J	347,000	
Manganese	ug/L	88	636	290	-	-	43.6	-	28.1	J	19	
Potassium	ug/L	NE	116,000	110000	110,000		-	-	96,700	J	95,000	
Sodium	ug/L	NE	1,390,000	1510000	1,510,000		53,500	-	1,230,000	J	1,210,000	
Zinc	ug/L	1,095	507	30.1	30.1	-	-	-	9.5	J	9.5	J
Water Quality												
Alkalinity	ug/L	NE	NE	562000	430,000		300,000	J	402,000	J	476,000	
Chloride	ug/L	NE	NE	4290000	1,500,000		450,000	J	4,290,000	J	4,220,000	
Hardness	ug/L	NE	NE	5990000	1,500,000		450,000	J	4,290,000	J	4,220,000	
Sulfate	ug/L	NE	NE	1340000	1,000,000		5,000	J	784,000	J	862,000	
Total dissolved solids	ug/L	NE	NE	5970000	4,800,000		510,000	J	5,970,000	J	4,810,000	
Total organic carbon	ug/L	NE	NE	9600	9,600		2,000	J	6,600	J	7,400	
Total suspended solids	ug/L	NE	NE	30000	16,000		-	-	21,000	J	32,000	
Turbidity	NTU	NE	NE	595	-	-	-	-	76.8		595	

TNTC-MW07

Parameter	Units	RBSC	BSC	Location Code / Sample No / Sample Date / Low Flow Sampled	A83007 28-Sep-00 No	
				MDC	Result	VQ
Explosives						
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	32400	4	nv
Volatiles						
Carbon disulfide	ug/L	104	NE	1.18	0.75	nv

TNTC-GW08

Parameter	Units	RBSC	BSC	Location Code / Sample No / Sample Date / Low Flow Sampled	A83008 10-Oct-00 No	
				MDC	Result	VQ
Explosives						
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	NE	931	**419**	
Dinitrotoluene, total	ug/L	0.099	NE	21100	**21,100**	J
Nitrotoluene, 2-	ug/L	0.049	NE	2510	236	
Nitrotoluene, 3-	ug/L	12.2	NE	190	18.4	
Nitrotoluene, 4-	ug/L	0.66	NE	1880	189	
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	32400	**20,100**	
Volatiles						
Methylene chloride	ug/L	4.3	NE	NA	0.94	B
Semivolatiles						
Dinitrotoluene, 2,4-	ug/L	0.099	NE	37600	**37,600**	
Dinitrotoluene, 2,6-	ug/L	0.099	NE	5610	**1,960**	J
Metals - Unfiltered						
Aluminum	ug/L	3,650	309	221000	**4,470**	
Arsenic	ug/L	0.045	7.4	432	**8.15**	J
Barium	ug/L	255	11,800	3540	140	
Beryllium	ug/L	7.3	NE	17.2	0.345	B
Calcium	ug/L	NE	316,000	2664000	154,000	
Chromium	ug/L	11	NE	450	10	
Cobalt	ug/L	73	12.1	471	5.93	
Copper	ug/L	146	19.8	1110	15.2	
Iron	ug/L	1,095	1,550	979000	**7,460**	
Lead	ug/L	15	NE	2050	20.8	
Magnesium	ug/L	NE	217,000	726000	20,700	
Manganese	ug/L	88	636	38100	317	
Nickel	ug/L	73	8.6	1540	**16.6**	
Potassium	ug/L	NE	116,000	32500	1,650	
Sodium	ug/L	NE	1,390,000	113000	1,810	
Vanadium	ug/L	3.7	NE	647	37.7	
Zinc	ug/L	1,095	507	3960	42.5	

TNTC-GW02

Parameter	Units	RBSC	BSC	Location Code / Sample Number / Sample Date / Low-Flow Sampled	A83002 10-Oct-00 No	
				MDC	Result	VQ
Explosives						
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	NE	931	**436**	
Dinitrotoluene, 1,3-	ug/L	0.37	NE	0.802	0.802	
Dinitrotoluene, total	ug/L	0.099	NE	21100	**1,260**	
Nitrotoluene, 2-	ug/L	0.049	NE	2510	258	
Nitrotoluene, 3-	ug/L	12.2	NE	190	16.1	
Nitrotoluene, 4-	ug/L	0.66	NE	1880	**94.7**	
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	32400	**1,880**	
Volatiles						
Acetone	ug/L	548	NE	13.4	6.92	B
Carbon disulfide	ug/L	104	NE	1.18	0.75	J
Methylene chloride	ug/L	4.3	NE	NA	1.18	B
Toluene	ug/L	72	1.7	1300	1	J
Semivolatiles						
Dinitrotoluene, 2,4-	ug/L	0.099	NE	37600	**4,610**	
Dinitrotoluene, 2,6-	ug/L	0.099	NE	5610	**1,330**	
Metals - Unfiltered						
Aluminum	ug/L	3,650	309	221000	**15,400**	
Antimony	ug/L	1.5	NE	12.5	4.92	J
Arsenic	ug/L	0.045	7.4	432	**9.86**	J
Barium	ug/L	255	11,800	3540	264	
Beryllium	ug/L	7.3	NE	17.2	1.18	
Calcium	ug/L	NE	316,000	2664000	214,000	
Chromium	ug/L	11	NE	450	**48.6**	
Cobalt	ug/L	73	12.1	471	**15.6**	
Copper	ug/L	146	19.8	1110	**41.4**	
Iron	ug/L	1,095	1,550	979000	**52,200**	
Lead	ug/L	15	NE	2050	**46.1**	
Magnesium	ug/L	NE	217,000	726000	37,000	
Manganese	ug/L	88	636	38100	**1,170**	
Nickel	ug/L	73	8.6	1540	**38.6**	
Potassium	ug/L	NE	116,000	32500	4,560	
Sodium	ug/L	NE	1,390,000	113000	2,640	
Vanadium	ug/L	3.7	NE	647	**70.4**	
Zinc	ug/L	1,095	507	3960	127	

TNTC-GW01

Parameter	Units	RBSC	BSC	Location Code / Sample No / Sample Date / Low Flow Sampled	A83001 28-Sep-00 No	
				MDC	Result	VQ
Explosives						
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	NE	931	**2,270**	
Amino-4,6-dinitrotoluene, 2-	ug/L	0.73	NE	1890	**2,880**	
Dinitrotoluene, total	ug/L	0.099	NE	21100	**9,754**	
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	32400	**3,540**	
Volatiles						
Methylene chloride	ug/L	4.3	NE	NA	0.91	B
Metals - Unfiltered						
Aluminum	ug/L	3,650	309	221000	**7,310**	
Arsenic	ug/L	0.045	7.4	432	**9.23**	J
Barium	ug/L	255	11,800	3540	155	
Beryllium	ug/L	7.3	NE	17.2	0.608	J
Calcium	ug/L	NE	NE	316,000	2664000	214,000
Chromium	ug/L	11	NE	450	**19.3**	
Cobalt	ug/L	73	12.1	471	7.23	
Copper	ug/L	146	19.8	1110	14	
Iron	ug/L	1,095	1,550	979000	**21,900**	
Lead	ug/L	15	NE	2050	**15.5**	
Magnesium	ug/L	NE	NE	217,000	726000	49,100
Manganese	ug/L	88	636	38100	**958**	
Nickel	ug/L	73	8.6	1540	**15.5**	
Potassium	ug/L	NE	NE	116,000	32500	5,820
Sodium	ug/L	NE	NE	1,390,000	113000	3,630
Vanadium	ug/L	3.7	NE	647	**32.6**	
Zinc	ug/L	1,095	507	3960	53.2	
Metals - Filtered						
Aluminum	ug/L	3,650	309	334	**334**	
Barium	ug/L	255	11,800	76.1	76.1	
Calcium	ug/L	NE	NE	316,000	240000	197,000
Chromium	ug/L	11	NE	1.54	1.54	J
Copper	ug/L	146	19.8	2.59	2.07	J
Iron	ug/L	1,095	1,550	774	771	
Magnesium	ug/L	NE	NE	217,000	55300	46,500
Manganese	ug/L	88	636	2060	**226**	
Potassium	ug/L	NE	NE	116,000	9110	848
Selenium	ug/L	18	NE	2.73	2.73	J
Sodium	ug/L	NE	NE	1,390,000	117000	3,190
Vanadium	ug/L	3.7	NE	647	1.27	J
Zinc	ug/L	1,095	507	28	5.74	J

TNTC-BEDGW-001

Parameter	Units	RBSC	BSC	Location Code / Sample No / Sample Date / Low Flow Sampled	BD3042 4-Oct-01 Yes		CB3026 9-Apr-02 Yes	
				MDC	Result	VQ	Result	VQ
Volatiles								
Acetone	ug/L	548	NE	53	54	B	53	J
Benzene	ug/L	0.35	2.4	410	-	-	8.4	J
Ethylbenzene	ug/L	1.34	0.87	130	22	J	12	J
Methylene chloride	ug/L	4.3	NE	160	19	J	19	J
Toluene	ug/L	72	1.7	300	-	-	8.8	J
Xylenes, total	ug/L	21	5.5	1300	**150**		**90**	
Semivolatiles								
Methylnaphthalene, 2-	ug/L	12	NE	34	4.5	J	3.2	J
Naphthalene	ug/L	0.62	NE	34	5.2	J	2.5	J
Metals - Unfiltered								
Aluminum	ug/L	3,650	309	96.8	130	B	90.6	B
Arsenic	ug/L	0.045	7.4	4.1	4.1	J	-	-
Barium	ug/L	255	11,800	2680	29.4	J	18.5	J
Calcium	ug/L	NE	316,000	439000	439,000		434,000	
Iron	ug/L	1,095	1,550	335	66.6	J	-	-
Magnesium	ug/L	NE	217,000	334000	150,000		152,000	
Manganese	ug/L	88	636	271	**271**		5.1	J
Nickel	ug/L	73	8.6	120	2.3	J	-	-
Potassium	ug/L	NE	116,000	101000	22,400		9,610	
Sodium	ug/L	NE	1,390,000	1330000	54,500		51,900	
Thallium	ug/L	0.24	NE	NA	-	-	**4.8**	B
Metals - Filtered								
Aluminum	ug/L	3,650	309	86.4	82.5	B	64.1	J
Arsenic	ug/L	0.045	7.4	6	6	J	-	-
Barium	ug/L	255	11,800	2680	30.8	J	18	J
Calcium	ug/L	NE	316,000	462000	427,000		462,000	
Magnesium	ug/L	NE	217,000	347000	147,000		157,000	
Manganese	ug/L	88	636	290	**290**		5.2	J
Nickel	ug/L	73	8.6	2.3	2.3	J	-	-
Potassium	ug/L	NE	116,000	110000	22,500		10,900	
Sodium	ug/L	NE	1,390,000	1510000	55,300		57,100	
Water Quality								
Alkalinity	ug/L	NE	NE	562000	440,000	J	562,000	
Chloride	ug/L	NE	NE	4290000	274,000		242,000	
Hardness	ug/L	NE	NE	5990000	1,720,000		1,450,000	
Sulfate	ug/L	NE	NE	1340000	1,340,000	J	1,030,000	
Total dissolved solids	ug/L	NE	NE	5970000	2,250,000		2,200,000	
Total organic carbon	ug/L	NE	NE	9600	2,500	B	1,400	
Total suspended solids	ug/L	NE	NE	30000	18,000		11,000	
Turbidity	NTU	NE	NE	595	172	J	156	

TNTC-GW09

Parameter	Units	RBSC	BSC	Location Code / Sample Number / Sample Date / Low-Flow Sampled	A83009 29-Sep-00 No	
				MDC	Result	VQ
Explosives						
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	NE	931	**17.4**	
Amino-4,6-dinitrotoluene, 2-	ug/L	0.73	NE	1890	**40.3**	
Dinitrotoluene, total	ug/L	0.099	NE	21100	**453**	
Nitrotoluene, 2-	ug/L	0.049	NE	2510	**2,310**	
Nitrotoluene, 3-	ug/L	12.2	NE	190	**182**	
Nitrotoluene, 4-	ug/L	0.66	NE	1880	**1,290**	
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	32400	**3,110**	
Volatiles						
Benzene	ug/L	0.35	2.4	4.81	**0.59**	J
Methylene chloride	ug/L	4.3	NE	NA	0.96	B
Toluene	ug/L	72	1.7	1300	**7.88**	J
Semivolatiles						
Dinitrotoluene, 2,4-	ug/L	0.099	NE	37600	**442**	
Dinitrotoluene, 2,6-	ug/L	0.099	NE	5610	**122**	
Metals - Unfiltered						
Aluminum	ug/L	3,650	309	221000	**221,000**	
Arsenic	ug/L	0.045	7.4	432	**432**	J
Barium	ug/L	255	11,800	3540	**3,540**	
Beryllium	ug/L	7.3	NE	17.2	**17.2**	J
Calcium	ug/L	NE	316,000	2664000	**2,664,000**	
Chromium	ug/L	11	NE	450	**450**	
Cobalt	ug/L	73	12.1	471	**471**	
Copper	ug/L	146	19.8	1110	**1,110**	
Iron	ug/L	1,095	1,550	979000	**979,000**	
Lead	ug/L	15	NE	2050	**1,480**	
Magnesium	ug/L	NE	217,000	726000	**726,000**	
Manganese	ug/L	88	636	38100	**38,100**	
Nickel	ug/L	73	8.6	1540	**1,540**	
Potassium	ug/L	NE	116,000	32500	**32,500**	
Selenium	ug/L	18	NE	202	**202**	J
Sodium	ug/L	NE	1,390,000	1130000	**29,100**	J
Vanadium	ug/L	3.7	NE	647	**647**	
Zinc	ug/L	1,095	507	3960	**3,960**	

TNTC-GW10

Parameter	Units	RBSC	BSC	Location Code / Sample Number / Sample Date / Low-Flow Sampled	A83010 27-Sep-00 No	
				MDC	Result	VQ
Explosives						
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	NE	931	**21.1**	
Amino-4,6-dinitrot

Location Code:	WA-RP-DP09
Sample No.:	8450
Sample Date:	16-Jun-98
Low-Flow Sampled:	No

Parameter	Units	RBSC	BSC	MDC	Result	VQ
Explosives						
Dinitrobenzene, 1,3-	ug/L	0.37	NE	4800	8.6	
Dinitrotoluene, 2,4-	ug/L	0.099	NE	6800	28	
Dinitrotoluene, 2,6-	ug/L	0.099	NE	400	2.7	
Trinitrobenzene, 1,3,5-	ug/L	110	NE	680	9.4	
Volatiles						
Tetrachloroethene	ug/L	0.104	NE	0.26	0.15	J
Semivolatiles						
Dinitro-2-methylphenol, 4,6-	ug/L	0.37	NE	2300	24	J
Dinitrotoluene, 2,4-	ug/L	0.099	NE	5200	60	
Dinitrotoluene, 2,6-	ug/L	0.099	NE	550	6.3	J
Nitroaniline, 3-	ug/L	3.2	NE	88	5.1	J
Nitrophenol, 4-	ug/L	4.9	NE	290	2.4	J
Metals - Unfiltered						
Aluminum	ug/L	3,650	309	280000	**11,100**	
Arsenic	ug/L	0.045	7.4	1780	**15.2**	
Calcium	ug/L	NE	316,000	2680000	220,000	
Iron	ug/L	1,095	1,550	679000	**25,500**	
Lead	ug/L	15	NE	459	11.8	
Magnesium	ug/L	NE	217,000	651000	**219,000**	
Manganese	ug/L	88	636	55100	**8,610**	
Sodium	ug/L	NE	1,390,000	9410000	44,300	
Metals - Filtered						
Calcium	ug/L	NE	316,000	780000	237,000	
Iron	ug/L	1,095	1,550	13300	120	
Lead	ug/L	15	NE	459	31.5	
Magnesium	ug/L	NE	217,000	348000	**227,000**	
Manganese	ug/L	88	636	62400	**8,480**	
Sodium	ug/L	NE	1,390,000	1.3E+07	44,800	
Water Quality Parameters						
Alkalinity	ug/L	NE	NE	1500000	1,000,000	
Hardness	ug/L	NE	NE	3400000	1,400,000	
Sulfate	ug/L	NE	NE	1E+07	305,000	
Total dissolved solids	ug/L	NE	NE	2.2E+07	1,710,000	
Total organic carbon	ug/L	NE	NE	6600000	32,000	
Total suspended solids	ug/L	NE	NE	110000	85,000	

Location Code:	WA-RP-DP08
Sample No.:	8410
Sample Date:	16-Jun-98
Low-Flow Sampled:	No

Parameter	Units	RBSC	BSC	MDC	Result	VQ
Explosives						
Dinitrobenzene, 1,3-	ug/L	0.37	NE	4800	0.74	
Dinitrotoluene, 2,4-	ug/L	0.099	NE	6800	2.3	
Dinitrotoluene, 2,6-	ug/L	0.099	NE	400	0.28	
Volatiles						
Acetone	ug/L	548	NE	20	3.3	B
Carbon disulfide	ug/L	104	NE	0.26	0.15	J
Tetrachloroethene	ug/L	0.104	NE	0.26	0.2	J
Toluene	ug/L	72	1.7	1.9	0.17	B

Location Code:	WA-RP-DP12
Sample No.:	8570
Sample Date:	15-Jun-98
Low-Flow Sampled:	No

Parameter	Units	RBSC	BSC	MDC	Result	VQ
Explosives						
Dinitrobenzene, 1,3-	ug/L	0.37	NE	4800	0.69	
Dinitrotoluene, 2,4-	ug/L	0.099	NE	6800	2	
Dinitrotoluene, 2,6-	ug/L	0.099	NE	400	0.28	
Volatiles						
Acetone	ug/L	548	NE	20	2.4	B
Toluene	ug/L	72	1.7	1.9	0.14	B

Location Code:	WA-RP-DP13
Sample No.:	8610
Sample Date:	15-Jun-98
Low-Flow Sampled:	No

Parameter	Units	RBSC	BSC	MDC	Result	VQ
Explosives						
Dinitrobenzene, 1,3-	ug/L	0.37	NE	4800	270	
Dinitrotoluene, 2,4-	ug/L	0.099	NE	6800	950	
Trinitrobenzene, 1,3,5-	ug/L	110	NE	680	680	
Volatiles						
Acetone	ug/L	548	NE	20	1.5	B
Ethylbenzene	ug/L	134	0.87	0.19	0.19	J
Toluene	ug/L	72	1.7	1.9	0.53	B
Semivolatiles						
Dinitrotoluene, 2,4-	ug/L	0.099	NE	9200	660	
Dinitrotoluene, 2,6-	ug/L	0.099	NE	550	56	J
Nitroaniline, 3-	ug/L	3.2	NE	88	15	J
Metals - Unfiltered						
Aluminum	ug/L	3,650	309	280000	**77,200**	
Arsenic	ug/L	0.045	7.4	1780	**1,780**	
Calcium	ug/L	NE	316,000	2680000	315,000	
Chromium	ug/L	11	NE	561	127	
Iron	ug/L	1,095	1,550	679000	**153,000**	
Lead	ug/L	15	NE	459	**420**	
Magnesium	ug/L	NE	217,000	651000	84,200	
Manganese	ug/L	88	636	55100	**12,600**	
Mercury	ug/L	1.1	NE	0.65	0.65	
Selenium	ug/L	18	NE	1760	1,760	
Sodium	ug/L	NE	1,390,000	9410000	187,000	
Thallium	ug/L	0.24	NE	1770	1,770	
Zinc	ug/L	1,095	507	2010	397	
Metals - Filtered						
Calcium	ug/L	NE	316,000	780000	156,000	
Manganese	ug/L	88	636	62400	**7,870**	
Sodium	ug/L	NE	1,390,000	1.3E+07	192,000	
Water Quality Parameters						
Alkalinity	ug/L	NE	NE	1500000	643,000	
Hardness	ug/L	NE	NE	3400000	960,000	
Nitrate	ug/L	1000	NE	460000	1,800	
Sulfate	ug/L	NE	NE	1E+07	278,000	
Total dissolved solids	ug/L	NE	NE	2.2E+07	1,260,000	
Total organic carbon	ug/L	NE	NE	6600000	36,600	
Total suspended solids	ug/L	NE	NE	110000	15,000	

Location Code:	WA-RP-DP19
Sample No.:	8850
Sample Date:	26-Jun-98
Low-Flow Sampled:	No

Parameter	Units	RBSC	BSC	MDC	Result	VQ
Explosives						
Dinitrobenzene, 1,3-	ug/L	0.37	NE	4800	0.24	
Volatiles						
Acetone	ug/L	548	NE	20	10	B
Butanone, 2-	ug/L	697	NE	24	1.8	J
Carbon disulfide	ug/L	104	NE	0.26	0.18	J

Location Code:	WA-RP-DP01
Sample No.:	8130
Sample Date:	25-Jun-98
Low-Flow Sampled:	No

Parameter	Units	RBSC	BSC	MDC	Result	VQ
Volatiles						
Acetone	ug/L	548	NE	20	4.3	B

Location Code:	WA-RP-DP06
Sample No.:	8330
Sample Date:	23-Jun-98
Low-Flow Sampled:	No

Parameter	Units	RBSC	BSC	MDC	Result	VQ
Explosives						
Dinitrobenzene, 1,3-	ug/L	0.37	NE	4800	0.2	
Volatiles						
Acetone	ug/L	548	NE	20	2.5	B

Location Code:	WA-RP-DP04
Sample No.:	8250/8250B
Sample Date:	24-Jun-98
Low-Flow Sampled:	No

Parameter	Units	RBSC	BSC	MDC	Result	VQ
Volatiles						
Acetone	ug/L	548	NE	20	2.4	B
Semivolatiles						
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	10	5.1	B
Nitroaniline, 3-	ug/L	3.2	NE	88	3.2	J
Metals - Unfiltered						
Aluminum	ug/L	3,650	309	280000	**1,240**	
Calcium	ug/L	NE	316,000	2680000	**569,000**	
Iron	ug/L	1,095	1,550	679000	**3,660**	
Magnesium	ug/L	NE	217,000	651000	**234,000**	J
Manganese	ug/L	88	636	55100	**1,410**	
Potassium	ug/L	NE	116,000	33100	17,400	
Sodium	ug/L	NE	1,390,000	9410000	81,800	
Zinc	ug/L	1,095	507	2010	22.1	
Metals - Filtered						
Calcium	ug/L	NE	316,000	780000	**549,000**	
Magnesium	ug/L	NE	217,000	348000	**242,000**	J
Manganese	ug/L	88	636	62400	**1,480**	
Potassium	ug/L	NE	116,000	18200	18,200	
Sodium	ug/L	NE	1,390,000	1.3E+07	114,000	

Location Code:	WA-RP-DP07
Sample No.:	8370
Sample Date:	26-Jun-98
Low-Flow Sampled:	No

Parameter	Units	RBSC	BSC	MDC	Result	VQ
Volatiles						
Acetone	ug/L	548	NE	20	7.2	B
Toluene	ug/L	72	1.7	1.9	0.34	B
Metals - Unfiltered						
Aluminum	ug/L	3,650	309	280000	**51,100**	
Barium	ug/L	255	11,800	1680	248	
Calcium	ug/L	NE	316,000	2680000	**644,000**	
Chromium	ug/L	11	NE	561	**61.8**	
Cobalt	ug/L	73	12.1	5610	**68.4**	
Copper	ug/L	146	19.8	2800	**126**	
Iron	ug/L	1,095	1,550	679000	**123,000**	
Magnesium	ug/L	NE	217,000	651000	109,000	J
Manganese	ug/L	88	636	55100	**3,310**	
Nickel	ug/L	73	8.6	5040	**220**	
Potassium	ug/L	NE	116,000	33100	17,100	
Sodium	ug/L	NE	1,390,000	9410000	182,000	
Vanadium	ug/L	3.7	NE	1000	**125**	
Zinc	ug/L	1,095	507	2010	411	
Metals - Filtered						
Calcium	ug/L	NE	316,000	780000	**364,000**	
Magnesium	ug/L	NE	217,000	348000	71,400	J
Manganese	ug/L	88	636	62400	**482**	
Potassium	ug/L	NE	116,000	18200	6,170	
Sodium	ug/L	NE	1,390,000	1.3E+07	181,000	

Location Code:	WA-RP-DP11
Sample No.:	8430
Sample Date:	26-Jun-98
Low-Flow Sampled:	No

Parameter	Units	RBSC	BSC	MDC	Result	VQ
Explosives						
Trinitrobenzene, 1,3,5-	ug/L	110	NE	680	7.2	
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	7.1	7.1	
Volatiles						
Acetone	ug/L	548	NE	20	4.9	B
Benzene	ug/L	0.35	2.4	0.15	0.13	J
Toluene	ug/L	72	1.7	1.9	0.57	B
Trichloroethene	ug/L	0.028	NE	0.43	0.16	B
Semivolatiles						
Dinitrotoluene, 2,4-	ug/L	0.099	NE	9200	1.8	J
Nitroaniline, 3-	ug/L	3.2	NE	88	2.1	J
Metals - Unfiltered						
Aluminum	ug/L	3,650	309	280000	**69,700**	
Arsenic	ug/L	0.045	7.4	1780	**56.2**	
Barium	ug/L	255	11,800	1680	598	
Calcium	ug/L	NE	316,000	2680000	**982,000**	
Chromium	ug/L	11	NE	561	**90.9**	
Cobalt	ug/L	73	12.1	5610	**81.2**	
Copper	ug/L	146	19.8	2800	**214**	
Iron	ug/L	1,095	1,550	679000	**137,000**	
Lead	ug/L	15	NE	459	**50.3**	
Magnesium	ug/L	NE	217,000	651000	**242,000**	J
Manganese	ug/L	88	636	55100	**4,640**	
Mercury	ug/L	1.1	NE	0.65	0.24	
Nickel	ug/L	73	8.6	5040	**249**	
Potassium	ug/L	NE	116,000	33100	20,500	
Sodium	ug/L	NE	1,390,000	9410000	503,000	
Vanadium	ug/L	3.7	NE	1000	**161**	
Zinc	ug/L	1,095	507	2010	467	
Metals - Filtered						
Calcium	ug/L	NE	316,000	780000	**395,000**	
Copper	ug/L	146	19.8	3260	**67**	
Iron	ug/L	1,095	1,550	15300	121	
Magnesium	ug/L	NE	217,000	348000	80,100	J
Manganese	ug/L	88	636	62400	**1,070**	
Nickel	ug/L	73	8.6	5820	**62**	
Potassium	ug/L	NE	116,000	18200	10,200	
Sodium	ug/L	NE	1,390,000	1.3E+07	614,000	

Location Code:	WA-RP-DP17
Sample No.:	8770
Sample Date:	25-Jun-98
Low-Flow Sampled:	No

Parameter	Units	RBSC	BSC	MDC	Result	VQ
Explosives						
Dinitrotoluene, 2,4-	ug/L	0.099	NE	6800	22	
Trinitrobenzene, 1,3,5-	ug/L	110	NE	680	32	
Volatiles						
Acetone	ug/L	548	NE	20	1.6	B
Toluene	ug/L	72	1.7	1.9	0.16	B
Semivolatiles						
Dinitrotoluene, 2,4-	ug/L	0.099	NE	9200	52	J
Dinitrotoluene, 2,6-	ug/L	0.099	NE	550	18	J
Nitroaniline, 3-	ug/L	3.2	NE	88	49	J
Metals - Unfiltered						
Aluminum	ug/L	3,650	309	280000	**38,800**	
Barium	ug/L	255	11,800	1680	217	
Calcium	ug/L	NE	316,000	2680000	**666,000**	
Chromium	ug/L	11	NE	561	**56.7**	
Cobalt	ug/L	73	12.1	5610	**173**	
Copper	ug/L	146	19.8	2800	**163**	
Iron	ug/L	1,095	1,550	679000	**72,000**	
Lead	ug/L	15	NE	459	28.9	
Magnesium	ug/L	NE	217,000	651000	178,000	J
Manganese	ug/L	88	636	55100	**2,470**	
Mercury	ug/L	1.1	NE	0.65	0.25	
Nickel	ug/L	73	8.6	5040	**134**	
Potassium	ug/L	NE	116,000	33100	7,640	
Sodium	ug/L	NE	1,390,000	9410000	1,060,000	
Vanadium	ug/L	3.7	NE	1000	**113**	
Zinc	ug/L	1,095	507	2010	265	
Metals - Filtered						
Aluminum	ug/L	3,650	309	1350	**1,350**	
Calcium	ug/L	NE	316,000	780000	301,000	
Chromium	ug/L	11	NE	495	32.9	
Cobalt	ug/L	73	12.1	6660	**142**	
Copper	ug/L	146	19.8	3260	**54.6**	
Iron	ug/L	1,095	1,550	15300	**2,000**	
Magnesium	ug/L	NE	217,000	348000	145,000	J
Manganese	ug/L	88	636	62400	**891**	
Sodium	ug/L	NE	1,390,000	1.3E+07	993,000	

Location Code:	WA-RP-DP16
Sample No.:	8730
Sample Date:	25-Jun-98
Low-Flow Sampled:	No

Parameter	Units	RBSC	BSC	MDC	Result	VQ
Explosives						
Trinitrobenzene, 1,3,5-	ug/L	110	NE	680	40	
Volatiles						
Acetone	ug/L	548	NE	20	1.6	B
Toluene	ug/L	72	1.7	1.9	0.26	B
Semivolatiles						
Dinitrotoluene, 2,4-	ug/L	0.099	NE	9200	60	J
Dinitrotoluene, 2,6-	ug/L	0.099	NE	550	15	J
Nitroaniline, 3-	ug/L	3.2	NE	88	43	J
Metals - Unfiltered						
Aluminum	ug/L	3,650	309	280000	**200,000**	
Antimony	ug/L	1.5	NE	118	106	
Arsenic	ug/L	0.045	7.4	1780	**111**	
Barium	ug/L	255	11,800	1680	773	
Beryllium	ug/L	7.3	NE	9.5	**9.5**	
Calcium	ug/L	NE	316,000	2680000	**2,680,000**	
Chromium	ug/L	11	NE	561	**295**	
Cobalt	ug/L	73	12.1	5610	**264**	
Copper	ug/L	146	19.8	2800	**654**	
Iron	ug/L	1,095	1,550	679000	**339,000**	
Lead	ug/L	15	NE	459	**137**	
Magnesium	ug/L	NE	217,000	651000	**651,000**	J
Manganese	ug/L	88	636	55100	**9,280**	
Mercury	ug/L	1.1	NE	0.65	0.47	
Nickel	ug/L	73	8.6	5040	**515**	
Potassium	ug/L	NE	116,000	33100	33,100	
Sodium	ug/L	NE	1,390,000	9410000	907,000	
Vanadium	ug/L	3.7	NE	1000	**381**	
Zinc	ug/L	1,095	507	2010	**1,260**	
Metals - Filtered						
Aluminum	ug/L	3,650	309	1350	203	
Antimony	ug/L	1.5	NE	46	**46**	
Calcium	ug/L	NE	316,000	780000	**735,000**	
Cobalt	ug/L	73	12.1	6660	**162**	
Copper	ug/L	146	19.8	3260	**117**	
Iron	ug/L	1,095	1,550	15300	177	
Magnesium	ug/L	NE	217,000	348000	193,000	J
Manganese	ug/L	88	636	62400	**535**	
Nickel	ug/L	73	8.6	5820	**46.3**	
Sodium	ug/L	NE	1,390,000	1.3E+07	1,040,000	
Zinc	ug/L	1,095	507	1100	33.2	

Location Code:	WA-RP-DP15
Sample No.:	8690
Sample Date:	26-Jun-98
Low-Flow Sampled:	No

Parameter	Units	RBSC	BSC	MDC	Result	VQ
Explosives						
Dinitrotoluene, 2,4-	ug/L	0.099	NE	6800	1.1	
Volatiles						
Acetone	ug/L	548	NE	20	9.6	B
Butanone, 2-	ug/L	697	NE	24	1.2	J
Toluene	ug/L	72	1.7	1.9	0.15	B

IT-MW10
DP05
DP08
DP12
BED-MW14
DP19
DP01
DP06
WA-MW01
DP09
DP13
DP15
IT-MW02
DP20
IT-MW08
DP02
DP16
DP03
DP10
WA-MW02
DP17
DP04
DP07
DP11
DP14
DP18

SCALE
0 400 800 FEET

LEGEND:

- BUILDINGS
- RAILROAD
- SURFACE DRAINAGE
- SURFACE WATER
- OVERBURDEN/SHALE MONITORING WELL LOCATION
- BEDROCK MONITORING WELL LOCATION
- DIRECT-PUSH GROUNDWATER SAMPLING LOCATION
- ug/L MICROGRAMS PER LITER
- nv NON VALIDATED
- NA NOT APPLICABLE, ONLY B QUALIFIED DATA DETECTED
- NE NOT ESTABLISHED (RBSCs), NOT EVALUATED (BSCs)
- NTU NEPHELOMETRIC TUBIDITY UNIT

NOTES:

1. SHADED CELL INDICATES VALUE IS GREATER THAN RBSC.
2. BOLD TEXT INDICATES VALUE IS GREATER THAN BSC.
3. RBSC VALUES REFLECT AN INCREMENTAL LIFETIME CANCER RISK (ILCR) OF 1E-6 OR A NONCANCER HAZARD QUOTIENT (HQ) OF 0.1 FOR CHEMICALS THAT EXHIBIT BOTH CANCER AND NONCANCER EFFECTS, WHICHEVER TYPE OF EFFECT IN A LOWER CONCENTRATION (USING AN ILCR OF 1E-6 AND AN HQ OF 0.1), THAT CONCENTRATION IS SELECTED AS THE RBSC.
4. BSC IS BACKGROUND SCREENING CONCENTRATION.
5. MDC IS MAXIMUM DETECTED CONCENTRATION FOR THE AOC ("B" QUALIFIED DATA NOT INCLUDED).
6. VALIDATION QUALIFIERS (VQ)
   - B - THE ANALYTE WAS NOT DETECTED SIGNIFICANTLY ABOVE THE LEVELS FOUND IN THE ASSOCIATED METHOD BLANK.
   - J - THE COMPOUND/ANALYTE WAS POSITIVELY IDENTIFIED; THE REPORTED VALUE IS AN ESTIMATED CONCENTRATION.

STARTING DATE	INITIATOR	CHKD	DRAWN	CHKD	PROJECT MNGR
12/02/04	D. KESSLER		D. BOMAR		S. DOWNEY

Shaw Environmental, Inc.
NASHVILLE, TENNESSEE

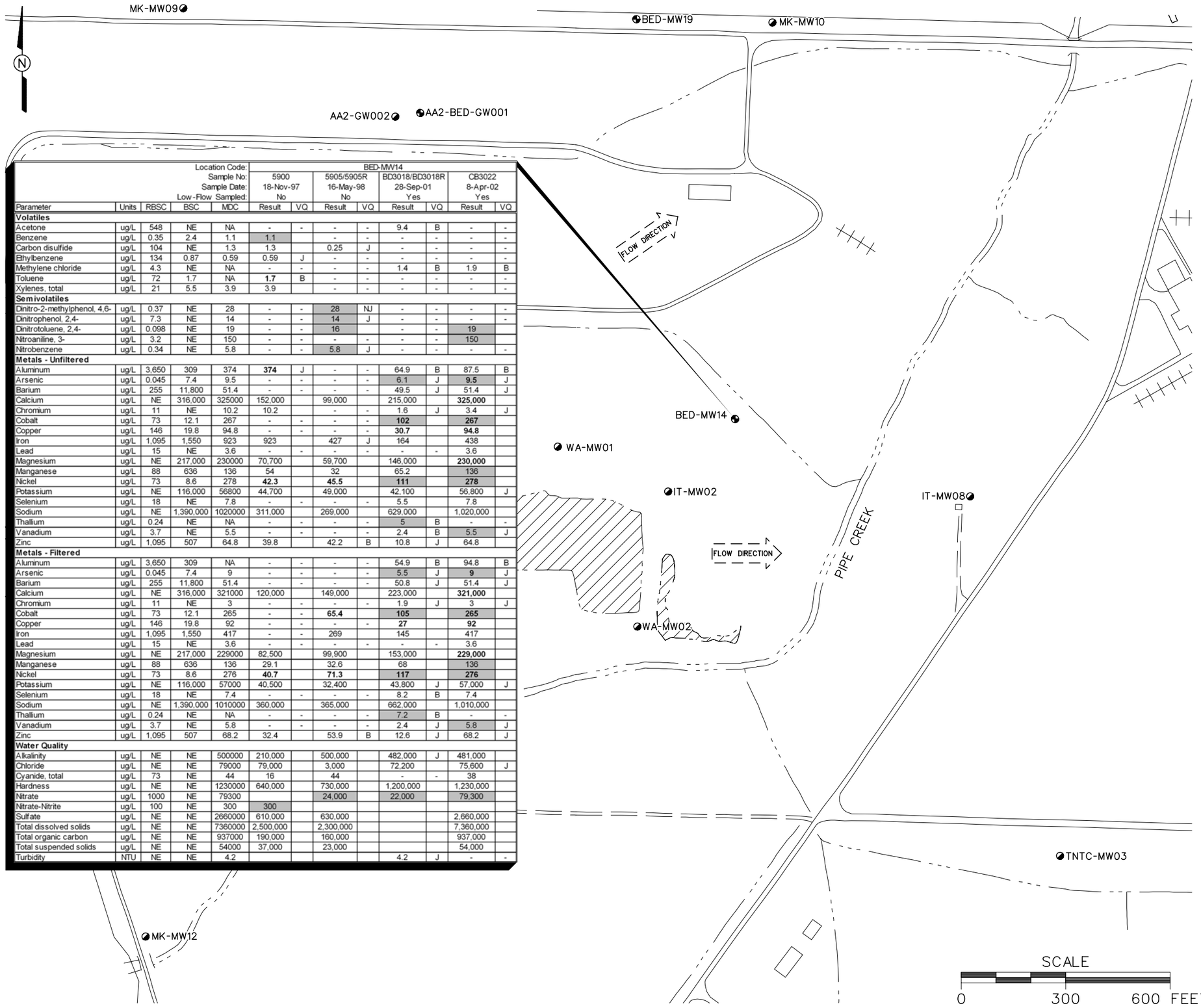
2004 GROUNDWATER DATA SUMMARY AND EVALUATION REPORT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

FIGURE 7-4
DETECTED CONSTITUENTS AT WEST AREA RED WATER PONDS ABOVE RBSCs AND/OR BSCs IN OVERBURDEN/SHALE GROUNDWATER (JUNE1998)

AREA	JOB NO.	DRAWING NO.	REV
SITEWIDE	843656	843656_035.DGN	

					Location Code:		BED-MW14					
					Sample No:		5900		5905/5905R		BD3018/BD3018R	
					Sample Date:		18-Nov-97		16-May-98		28-Sep-01	
					Low-Flow Sampled:		No		No		Yes	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Volatiles												
Acetone	ug/L	548	NE	NA	-	-	-	-	9.4	B	-	-
Benzene	ug/L	0.35	2.4	1.1	1.1		-	-	-	-	-	-
Carbon disulfide	ug/L	104	NE	1.3	1.3		0.25	J	-	-	-	-
Ethylbenzene	ug/L	134	0.87	0.59	0.59	J	-	-	-	-	-	-
Methylene chloride	ug/L	4.3	NE	NA	-	-	-	-	1.4	B	1.9	B
Toluene	ug/L	72	1.7	NA	**1.7**	B	-	-	-	-	-	-
Xylenes, total	ug/L	21	5.5	3.9	3.9		-	-	-	-	-	-
Semivolatiles												
Dinitro-2-methylphenol, 4,6-	ug/L	0.37	NE	28	-	-	28	NJ	-	-	-	-
Dinitrophenol, 2,4-	ug/L	7.3	NE	14	-	-	14	J	-	-	-	-
Dinitrotoluene, 2,4-	ug/L	0.098	NE	19	-	-	16		-	-	19	
Nitroaniline, 3-	ug/L	3.2	NE	150	-	-	-	-	-	-	150	
Nitrobenzene	ug/L	0.34	NE	5.8	-	-	5.8	J	-	-	-	-
Metals - Unfiltered												
Aluminum	ug/L	3,650	309	374	**374**	J	-	-	64.9	B	87.5	B
Arsenic	ug/L	0.045	7.4	9.5	-	-	-	-	6.1	J	**9.5**	J
Barium	ug/L	255	11,800	51.4	-	-	-	-	49.5	J	51.4	J
Calcium	ug/L	NE	316,000	325000	152,000		99,000		215,000		**325,000**	
Chromium	ug/L	11	NE	10.2	10.2		-	-	1.6	J	3.4	J
Cobalt	ug/L	73	12.1	267	-	-	-	-	**102**		**267**	
Copper	ug/L	146	19.8	94.8	-	-	-	-	**30.7**		**94.8**	
Iron	ug/L	1,095	1,550	923	923		427	J	164		438	
Lead	ug/L	15	NE	3.6	-	-	-	-	-	-	3.6	
Magnesium	ug/L	NE	217,000	230000	70,700		59,700		146,000		**230,000**	
Manganese	ug/L	88	636	136	54		32		65.2		136	
Nickel	ug/L	73	8.6	278	**42.3**		**45.5**		**111**		**278**	
Potassium	ug/L	NE	116,000	56800	44,700		49,000		42,100		56,800	J
Selenium	ug/L	18	NE	7.8	-	-	-	-	5.5		7.8	
Sodium	ug/L	NE	1,390,000	1020000	311,000		269,000		629,000		1,020,000	
Thallium	ug/L	0.24	NE	NA	-	-	-	-	5	B	-	-
Vanadium	ug/L	3.7	NE	5.5	-	-	-	-	2.4	B	5.5	J
Zinc	ug/L	1,095	507	64.8	39.8		42.2	B	10.8	J	64.8	
Metals - Filtered												
Aluminum	ug/L	3,650	309	NA	-	-	-	-	54.9	B	94.8	B
Arsenic	ug/L	0.045	7.4	9	-	-	-	-	5.5	J	**9**	J
Barium	ug/L	255	11,800	51.4	-	-	-	-	50.8	J	51.4	J
Calcium	ug/L	NE	316,000	321000	120,000		149,000		223,000		**321,000**	
Chromium	ug/L	11	NE	3	-	-	-	-	1.9	J	3	J
Cobalt	ug/L	73	12.1	265	-	-	**65.4**		**105**		**265**	
Copper	ug/L	146	19.8	92	-	-	-	-	**27**		**92**	
Iron	ug/L	1,095	1,550	417	-	-	269		145		417	
Lead	ug/L	15	NE	3.6	-	-	-	-	-	-	3.6	
Magnesium	ug/L	NE	217,000	229000	82,500		99,900		153,000		**229,000**	
Manganese	ug/L	88	636	136	29.1		32.6		68		136	
Nickel	ug/L	73	8.6	276	**40.7**		**71.3**		**117**		**276**	
Potassium	ug/L	NE	116,000	57000	40,500		32,400		43,800	J	57,000	J
Selenium	ug/L	18	NE	7.4	-	-	-	-	8.2	B	7.4	
Sodium	ug/L	NE	1,390,000	1010000	360,000		365,000		662,000		1,010,000	
Thallium	ug/L	0.24	NE	NA	-	-	-	-	7.2	B	-	-
Vanadium	ug/L	3.7	NE	5.8	-	-	-	-	2.4	J	5.8	J
Zinc	ug/L	1,095	507	68.2	32.4		53.9	B	12.6	J	68.2	J
Water Quality												
Alkalinity	ug/L	NE	NE	500000	210,000		500,000		482,000	J	481,000	
Chloride	ug/L	NE	NE	79000	79,000		3,000		72,200		75,600	J
Cyanide, total	ug/L	73	NE	44	16		44		-	-	38	
Hardness	ug/L	NE	NE	1230000	640,000		730,000		1,200,000		1,230,000	
Nitrate	ug/L	1000	NE	79300			24,000		22,000		79,300	
Nitrate-Nitrite	ug/L	100	NE	300	300							
Sulfate	ug/L	NE	NE	2660000	610,000		630,000				2,660,000	
Total dissolved solids	ug/L	NE	NE	7360000	2,500,000		2,300,000				7,360,000	
Total organic carbon	ug/L	NE	NE	937000	190,000		160,000				937,000	
Total suspended solids	ug/L	NE	NE	54000	37,000		23,000				54,000	
Turbidity	NTU	NE	NE	4.2					4.2	J	-	-

					Location Code:		BED-MW14	
					Sample No:		CB3022	
					Sample Date:		8-Apr-02	
					Low-Flow Sampled:		Yes	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ
Volatiles								
Acetone	ug/L	548	NE	NA	-	-	-	-
Benzene	ug/L	0.35	2.4	1.1	-	-	-	-
Carbon disulfide	ug/L	104	NE	1.3	-	-	-	-
Ethylbenzene	ug/L	134	0.87	0.59	-	-	-	-
Methylene chloride	ug/L	4.3	NE	NA	1.9	B	-	-
Toluene	ug/L	72	1.7	NA	-	-	-	-
Xylenes, total	ug/L	21	5.5	3.9	-	-	-	-
Semivolatiles								
Dinitro-2-methylphenol, 4,6-	ug/L	0.37	NE	28	-	-	-	-
Dinitrophenol, 2,4-	ug/L	7.3	NE	14	-	-	-	-
Dinitrotoluene, 2,4-	ug/L	0.098	NE	19	19			
Nitroaniline, 3-	ug/L	3.2	NE	150	150			
Nitrobenzene	ug/L	0.34	NE	5.8	-	-	-	-
Metals - Unfiltered								
Aluminum	ug/L	3,650	309	374	87.5	B	-	-
Arsenic	ug/L	0.045	7.4	9.5	**9.5**	J	-	-
Barium	ug/L	255	11,800	51.4	51.4	J	-	-
Calcium	ug/L	NE	316,000	325000	**325,000**		-	-
Chromium	ug/L	11	NE	10.2	3.4	J	-	-
Cobalt	ug/L	73	12.1	267	**267**		-	-
Copper	ug/L	146	19.8	94.8	**94.8**		-	-
Iron	ug/L	1,095	1,550	923	438		-	-
Lead	ug/L	15	NE	3.6	3.6		-	-
Magnesium	ug/L	NE	217,000	230000	**230,000**		-	-
Manganese	ug/L	88	636	136	136		-	-
Nickel	ug/L	73	8.6	278	**278**		-	-
Potassium	ug/L	NE	116,000	56800	56,800	J	-	-
Selenium	ug/L	18	NE	7.8	7.8		-	-
Sodium	ug/L	NE	1,390,000	1020000	1,020,000		-	-
Thallium	ug/L	0.24	NE	NA	-	-	-	-
Vanadium	ug/L	3.7	NE	5.5	5.5	J	-	-
Zinc	ug/L	1,095	507	64.8	64.8		-	-
Metals - Filtered								
Aluminum	ug/L	3,650	309	NA	94.8	B	-	-
Arsenic	ug/L	0.045	7.4	9	**9**	J	-	-
Barium	ug/L	255	11,800	51.4	51.4	J	-	-
Calcium	ug/L	NE	316,000	321000	**321,000**		-	-
Chromium	ug/L	11	NE	3	3	J	-	-
Cobalt	ug/L	73	12.1	265	**265**		-	-
Copper	ug/L	146	19.8	92	**92**		-	-
Iron	ug/L	1,095	1,550	417	417		-	-
Lead	ug/L	15	NE	3.6	3.6		-	-
Magnesium	ug/L	NE	217,000	229000	**229,000**		-	-
Manganese	ug/L	88	636	136	136		-	-
Nickel	ug/L	73	8.6	276	**276**		-	-
Potassium	ug/L	NE	116,000	57000	57,000	J	-	-
Selenium	ug/L	18	NE	7.4	7.4		-	-
Sodium	ug/L	NE	1,390,000	1010000	1,010,000		-	-
Thallium	ug/L	0.24	NE	NA	-	-	-	-
Vanadium	ug/L	3.7	NE	5.8	5.8	J	-	-
Zinc	ug/L	1,095	507	68.2	68.2	J	-	-
Water Quality								
Alkalinity	ug/L	NE	NE	500000	481,000		-	-
Chloride	ug/L	NE	NE	79000	75,600	J	-	-
Cyanide, total	ug/L	73	NE	44	38		-	-
Hardness	ug/L	NE	NE	1230000	1,230,000		-	-
Nitrate	ug/L	1000	NE	79300	79,300		-	-
Nitrate-Nitrite	ug/L	100	NE	300			-	-
Sulfate	ug/L	NE	NE	2660000	2,660,000		-	-
Total dissolved solids	ug/L	NE	NE	7360000	7,360,000		-	-
Total organic carbon	ug/L	NE	NE	937000	937,000		-	-
Total suspended solids	ug/L	NE	NE	54000	54,000		-	-
Turbidity	NTU	NE	NE	4.2	-	-	-	-



LEGEND

IT-MW02	OVERBURDEN/SHALE MONITORING WELL LOCATION
BED-MW14	BEDROCK MONITORING WELL LOCATION
	BUILDINGS
	RAILROAD
	SURFACE WATER
	DITCH
	FENCE
FLOW DIRECTION	BEDROCK GROUNDWATER FLOW DIRECTION (AUGUST 2004)
ug/L	MICROGRAMS PER LITER
nv	NON VALIDATED
NA	NOT APPLICABLE, ONLY B QUALIFIED DATA DETECTED
NE	NOT ESTABLISHED (RBSCs), NOT EVALUATED (BSCs)
NTU	NEPHELOMETRIC TUBIDITY UNIT

NOTES:

1. SHADED CELL INDICATES VALUE IS GREATER THAN RBSC.
2. BOLD TEXT INDICATES VALUE IS GREATER THAN BSC.
3. RBSC VALUES REFLECT AN INCREMENTAL LIFETIME CANCER RISK (ILCR) OF 1E-6 OR A NONCANCER HAZARD QUOTIENT (HQ) OF 0.1. FOR CHEMICALS THAT EXHIBIT BOTH CANCER AND NONCANCER EFFECTS, WHICHEVER TYPE OF EFFECT IN A LOWER CONCENTRATION (USING AN ILCR OF 1E-6 AND AN HQ OF 0.1), THAT CONCENTRATION IS SELECTED AS THE RBSC.
4. BSC IS BACKGROUND SCREENING CONCENTRATION.
5. MDC IS MAXIMUM DETECTED CONCENTRATION FOR THE AOC ("B" QUALIFIED DATA NOT INCLUDED).
6. VALIDATION QUALIFIERS (VQ)
   - B - THE ANALYTE WAS NOT DETECTED SIGNIFICANTLY ABOVE THE LEVELS FOUND IN THE ASSOCIATED METHOD BLANK.
   - J - THE COMPOUND/ANALYTE WAS POSITIVELY IDENTIFIED; THE REPORTED VALUE IS AN ESTIMATED CONCENTRATION.

FIGURE 7-5
DETECTED CONSTITUENTS AT WEST AREA RED WATER PONDS ABOVE RBSCs AND/OR BSCs IN BEDROCK GROUNDWATER (NOVEMBER 1997 THROUGH APRIL 2002)

2004 GROUNDWATER DATA SUMMARY AND EVALUATION REPORT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw® Shaw Environmental, Inc.

DWG. NO.:843656_036.dgn | PROJ. NO.: 843656
INITIATOR: D. KESSLER | PROJ. MGR.: S. DOWNEY
DRAFT. CHCK. BY: | ENGR. CHCK. BY: D. KESSLER
DATE LAST REV.: | DRAWN BY:
STARTING DATE: 12/02/04 | DRAWN BY: D. BOMAR
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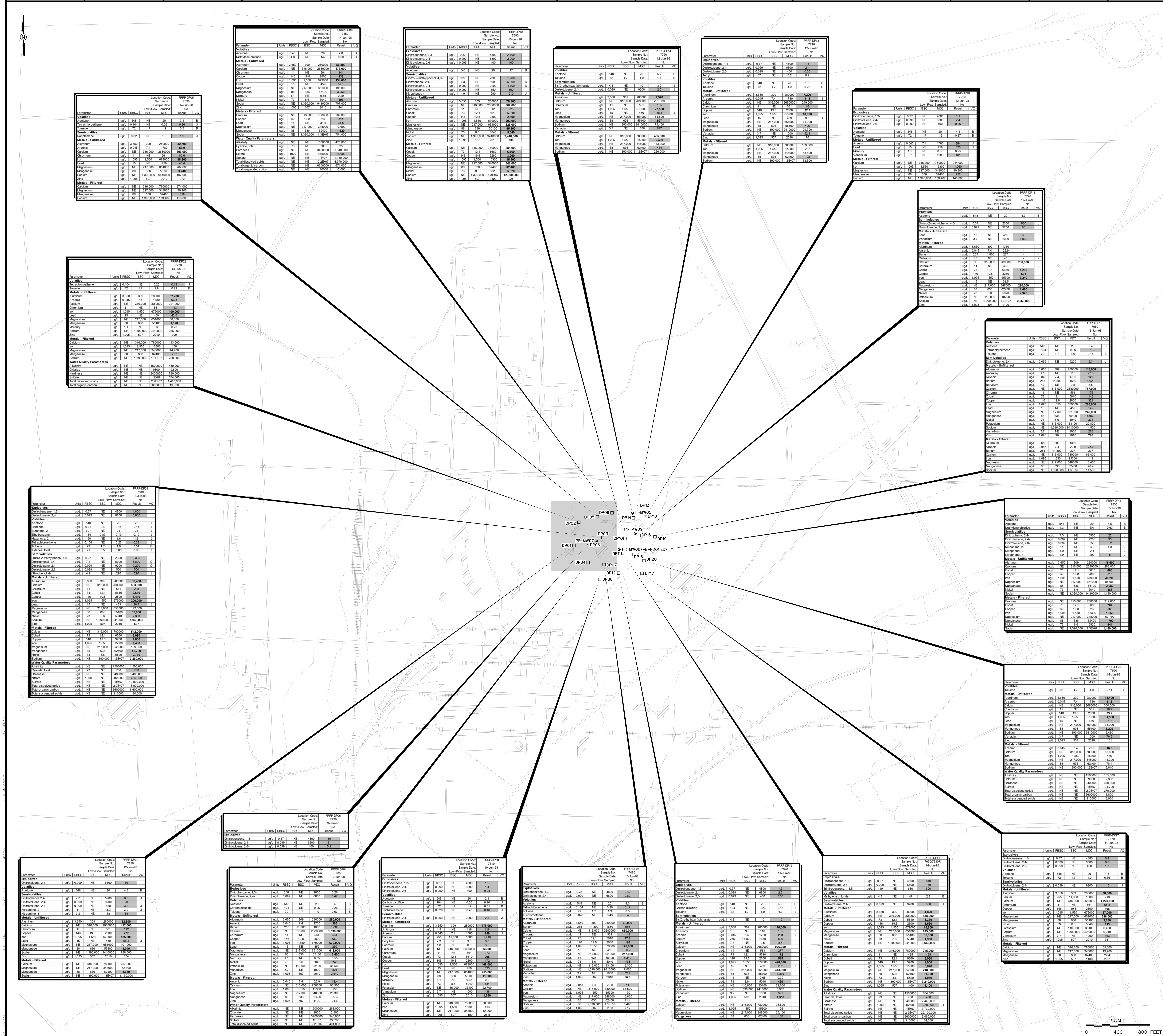
PBOW_standard.tbl dbomar
843656_036.dgn



Location Code: PRRP-DP05
Sample No.: 7390
Sample Date: 14-Jun-98
Low-Flow Sampled: No

Parameter	Units	RBSC	BSC	MDC	Result	VQ
Volatiles						
Acetone	ug/L	548	NE	20	3.1	B
Tetrachloroethene	ug/L	0.104	NE	0.26	0.26	J
Toluene	ug/L	72	1.7	1.9	0.3	B
Semivolatiles						
Naphthalene	ug/L	0.62	NE	1.9	1.9	J
Metals - Unfiltered						
Aluminum	ug/L	3,650	309	280000	**32,700**	
Arsenic	ug/L	0.045	7.4	1780	**53.9**	
Calcium	ug/L	NE	316,000	2680000	**606,000**	
Chromium	ug/L	11	NE	561	82.6	
Iron	ug/L	1,095	1,550	679000	**98,200**	
Lead	ug/L	15	NE	459	48.4	
Magnesium	ug/L	NE	217,000	651000	204,000	
Manganese	ug/L	88	636	55100	**3,240**	
Sodium	ug/L	NE	1,390,000	9410000	107,000	
Zinc	ug/L	1,095	507	2010	279	
Metals - Filtered						
Calcium	ug/L	NE	316,000	780000	274,000	
Magnesium	ug/L	NE	217,000	348000	96,100	
Manganese	ug/L	88	636	62400	**818**	
Sodium	ug/L	NE	1,390,000	1.3E+07	119,000	

Location Code: PRRP-DP09
Sample No.: 7550
Sample Date: 14-Jun-98
Low-Flow Sampled: No

Parameter	Units	RBSC	BSC	MDC	Result	VQ
Volatiles						
Acetone	ug/L	548	NE	20	2.8	B
Methylene chloride	ug/L	4.3	NE	NA	0.59	B
Metals - Unfiltered						
Aluminum	ug/L	3,650	309	280000	**56,800**	
Calcium	ug/L	NE	316,000	2680000	**873,000**	
Chromium	ug/L	11	NE	561	141	
Copper	ug/L	146	19.8	2800	**438**	
Iron	ug/L	1,095	1,550	679000	**134,000**	
Lead	ug/L	15	NE	459	67.1	
Magnesium	ug/L	NE	217,000	651000	195,000	
Manganese	ug/L	88	636	55100	**4,050**	
Mercury	ug/L	1.1	NE	0.65	0.29	
Nickel	ug/L	73	8.6	5040	**407**	
Sodium	ug/L	NE	1,390,000	9410000	707,000	
Zinc	ug/L	1,095	507	2010	441	
Metals - Filtered						
Calcium	ug/L	NE	316,000	780000	269,000	
Copper	ug/L	146	19.8	3260	**311**	
Lead	ug/L	15	NE	31.5	31.5	
Magnesium	ug/L	NE	217,000	348000	73,600	
Manganese	ug/L	88	636	62400	**1,120**	
Sodium	ug/L	NE	1,390,000	1.3E+07	754,000	
Water Quality Parameters						
Alkalinity	ug/L	NE	NE	1500000	476,000	
Cyanide, total	ug/L	73	NE	780	23	
Hardness	ug/L	NE	NE	3400000	1,640,000	
Nitrate	ug/L	1000	NE	465000	16,900	
Sulfate	ug/L	NE	NE	1E+07	1,150,000	
Total dissolved solids	ug/L	NE	NE	2.2E+07	4,370,000	
Total organic carbon	ug/L	NE	NE	6600000	671,000	
Total suspended solids	ug/L	NE	NE	110000	12,000	

Location Code: PRRP-DP10
Sample No.: 7590
Sample Date: 10-Jun-98
Low-Flow Sampled: No

Parameter	Units	RBSC	BSC	MDC	Result	VQ
Explosives						
Dinitrobenzene, 1,3-	ug/L	0.37	NE	4800	2,100	
Dinitrotoluene, 2,4-	ug/L	0.099	NE	6800	2,200	
Dinitrotoluene, 2,6-	ug/L	0.099	NE	400	400	
Volatiles						
Acetone	ug/L	548	NE	20	17	B
Semivolatiles						
Dinitro-2-methylphenol, 4,6-	ug/L	0.37	NE	2300	1,700	
Dinitrophenol, 2,4-	ug/L	7.3	NE	5900	5,900	D
Dinitrotoluene, 2,4-	ug/L	0.099	NE	9200	4,100	D
Dinitrotoluene, 2,6-	ug/L	0.099	NE	550	390	
Nitrophenol, 4-	ug/L	4.9	NE	290	210	J
Metals - Unfiltered						
Aluminum	ug/L	3,650	309	280000	**78,300**	
Calcium	ug/L	NE	316,000	2680000	**662,000**	
Chromium	ug/L	11	NE	561	223	
Cobalt	ug/L	73	12.1	5610	**5,610**	
Copper	ug/L	146	19.8	2800	**2,800**	
Iron	ug/L	1,095	1,550	679000	**202,000**	
Magnesium	ug/L	NE	217,000	651000	**326,000**	
Manganese	ug/L	88	636	55100	**55,100**	
Nickel	ug/L	73	8.6	5040	**5,040**	
Sodium	ug/L	NE	1,390,000	9410000	**9,410,000**	
Zinc	ug/L	1,095	507	2010	**736**	
Metals - Filtered						
Calcium	ug/L	NE	316,000	780000	**681,000**	
Cobalt	ug/L	73	12.1	6660	**6,660**	
Copper	ug/L	146	19.8	3260	**3,260**	
Iron	ug/L	1,095	1,550	15300	**15,300**	
Magnesium	ug/L	NE	217,000	348000	**348,000**	
Manganese	ug/L	88	636	62400	**62,400**	
Nickel	ug/L	73	8.6	5820	**5,820**	
Sodium	ug/L	NE	1,390,000	1.3E+07	**12,600,000**	
Zinc	ug/L	1,095	507	1100	225	

Location Code: PRRP-DP14
Sample No.: 7750
Sample Date: 12-Jun-98
Low-Flow Sampled: No

Parameter	Units	RBSC	BSC	MDC	Result	VQ
Volatiles						
Acetone	ug/L	548	NE	20	5.7	B
Toluene	ug/L	72	1.7	1.9	1.1	B
Semivolatiles						
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	10	3.2	J
Dinitrotoluene, 2,4-	ug/L	0.099	NE	9200	2.5	J
Metals - Unfiltered						
Aluminum	ug/L	3,650	309	280000	**7,970**	
Calcium	ug/L	NE	316,000	2680000	281,000	
Chromium	ug/L	11	NE	561	105	
Iron	ug/L	1,095	1,550	679000	**27,500**	
Lead	ug/L	15	NE	459	38.1	J
Magnesium	ug/L	NE	217,000	651000	83,800	
Manganese	ug/L	88	636	55100	**927**	
Sodium	ug/L	NE	1,390,000	9410000	79,400	
Vanadium	ug/L	3.7	NE	1000	877	
Metals - Filtered						
Calcium	ug/L	NE	316,000	780000	**405,000**	
Iron	ug/L	1,095	1,550	15300	**2,400**	
Magnesium	ug/L	NE	217,000	348000	143,000	
Manganese	ug/L	88	636	62400	454	
Sodium	ug/L	NE	1,390,000	1.3E+07	256,000	

Location Code: PRRP-DP13
Sample No.: 7710
Sample Date: 12-Jun-98
Low-Flow Sampled: No

Parameter	Units	RBSC	BSC	MDC	Result	VQ
Explosives						
Dinitrobenzene, 1,3-	ug/L	0.37	NE	4800	1.6	
Dinitrotoluene, 2,4-	ug/L	0.099	NE	6800	2.4	
Dinitrotoluene, 2,6-	ug/L	0.099	NE	400	0.36	
Tetryl	ug/L	37	NE	0.2	0.2	
Volatiles						
Acetone	ug/L	548	NE	20	1.5	B
Toluene	ug/L	72	1.7	1.9	0.26	B
Metals - Unfiltered						
Aluminum	ug/L	3,650	309	280000	**7,220**	
Arsenic	ug/L	0.045	7.4	1780	**11.1**	J
Calcium	ug/L	NE	316,000	2680000	249,000	
Chromium	ug/L	11	NE	561	16	
Copper	ug/L	146	19.8	2800	**27.7**	
Iron	ug/L	1,095	1,550	679000	**18,800**	
Lead	ug/L	15	NE	459	9.5	J
Magnesium	ug/L	NE	217,000	651000	71,900	
Manganese	ug/L	88	636	55100	496	
Sodium	ug/L	NE	1,390,000	9410000	29,700	
Vanadium	ug/L	3.7	NE	1000	52.3	
Zinc	ug/L	1,095	507	2010	76	
Metals - Filtered						
Calcium	ug/L	NE	316,000	780000	189,000	
Iron	ug/L	1,095	1,550	15300	237	
Magnesium	ug/L	NE	217,000	348000	53,800	
Manganese	ug/L	88	636	62400	108	
Sodium	ug/L	NE	1,390,000	1.3E+07	33,500	

Location Code: PRRP-DP18
Sample No.: 7910
Sample Date: 12-Jun-98
Low-Flow Sampled: No

Parameter	Units	RBSC	BSC	MDC	Result	VQ
Explosives						
Dinitrobenzene, 1,3-	ug/L	0.37	NE	4800	1.1	
Dinitrotoluene, 2,4-	ug/L	0.099	NE	6800	2.4	
Dinitrotoluene, 2,6-	ug/L	0.099	NE	400	0.36	
Volatiles						
Acetone	ug/L	548	NE	20	4.4	B
Toluene	ug/L	72	1.7	1.9	0.37	B
Metals - Unfiltered						
Arsenic	ug/L	0.045	7.4	1780	**584**	J
Lead	ug/L	15	NE	459	320	J
Mercury	ug/L	1.1	NE	0.65	0.25	
Vanadium	ug/L	3.7	NE	1000	101	
Metals - Filtered						
Calcium	ug/L	NE	316,000	780000	244,000	
Iron	ug/L	1,095	1,550	15300	1,260	
Magnesium	ug/L	NE	217,000	348000	80,300	
Manganese	ug/L	88	636	62400	252	
Sodium	ug/L	NE	1,390,000	1.3E+07	140,000	

Location Code: PRRP-DP15
Sample No.: 7790
Sample Date: 12-Jun-98
Low-Flow Sampled: No

Parameter	Units	RBSC	BSC	MDC	Result	VQ
Volatiles						
Acetone	ug/L	548	NE	20	4.3	B
Semivolatiles						
Dinitro-2-methylphenol, 4,6-	ug/L	0.37	NE	2300	830	J
Dinitrotoluene, 2,4-	ug/L	0.099	NE	9200	80	J
Metals - Unfiltered						
Lead	ug/L	15	NE	459	33	J
Vanadium	ug/L	3.7	NE	1000	1,000	
Metals - Filtered						
Aluminum	ug/L	3,650	309	1350	-	-
Arsenic	ug/L	0.045	7.4	22.9	-	-
Barium	ug/L	255	11,800	237	-	-
Cadmium	ug/L	1.8	NE	46	-	-
Calcium	ug/L	NE	316,000	780000	**780,000**	
Chromium	ug/L	11	NE	495	-	-
Cobalt	ug/L	73	12.1	6660	**1,290**	
Copper	ug/L	146	19.8	3260	**531**	
Iron	ug/L	1,095	1,550	15300	**3,240**	
Lead	ug/L	15	NE	31.5	-	-
Magnesium	ug/L	NE	217,000	348000	**260,000**	
Manganese	ug/L	88	636	62400	**1,460**	
Nickel	ug/L	73	8.6	5820	**2,370**	
Potassium	ug/L	NE	116,000	18200	-	-
Sodium	ug/L	NE	1,390,000	1.3E+07	**2,560,000**	
Zinc	ug/L	1,095	507	1100	-	-

Location Code: PRRP-DP02
Sample No.: 7270
Sample Date: 14-Jun-98
Low-Flow Sampled: No

Parameter	Units	RBSC	BSC	MDC	Result	VQ
Volatiles						
Tetrachloroethene	ug/L	0.104	NE	0.26	0.14	J
Toluene	ug/L	72	1.7	1.9	0.22	B
Metals - Unfiltered						
Aluminum	ug/L	3,650	309	280000	**52,200**	
Arsenic	ug/L	0.045	7.4	1780	**63.3**	
Calcium	ug/L	NE	316,000	2680000	221,000	
Chromium	ug/L	11	NE	561	113	
Iron	ug/L	1,095	1,550	679000	**100,000**	
Lead	ug/L	15	NE	459	42.6	
Magnesium	ug/L	NE	217,000	651000	66,300	
Manganese	ug/L	88	636	55100	**1,120**	
Mercury	ug/L	1.1	NE	0.65	0.23	
Sodium	ug/L	NE	1,390,000	9410000	266,000	
Zinc	ug/L	1,095	507	2010	299	
Metals - Filtered						
Calcium	ug/L	NE	316,000	780000	193,000	
Iron	ug/L	1,095	1,550	15300	150	
Magnesium	ug/L	NE	217,000	348000	44,400	
Manganese	ug/L	88	636	62400	257	
Sodium	ug/L	NE	1,390,000	1.3E+07	288,000	
Water Quality Parameters						
Alkalinity	ug/L	NE	NE	1500000	450,000	
Chloride	ug/L	NE	NE	9800	9,800	
Hardness	ug/L	NE	NE	3400000	780,000	
Sulfate	ug/L	NE	NE	1E+07	574,000	
Total dissolved solids	ug/L	NE	NE	2.2E+07	1,410,000	
Total organic carbon	ug/L	NE	NE	6600000	19,300	

Location Code: PRRP-DP19
Sample No.: 7950
Sample Date: 13-Jun-98
Low-Flow Sampled: No

Parameter	Units	RBSC	BSC	MDC	Result	VQ
Volatiles						
Acetone	ug/L	548	NE	20	5.4	B
Tetrachloroethene	ug/L	0.104	NE	0.26	0.13	J
Toluene	ug/L	72	1.7	1.9	0.15	B
Semivolatiles						
Dinitrotoluene, 2,4-	ug/L	0.099	NE	9200	2.3	J
Metals - Unfiltered						
Aluminum	ug/L	3,650	309	280000	**118,000**	
Antimony	ug/L	1.5	NE	118	77.8	J
Arsenic	ug/L	0.045	7.4	1780	**122**	J
Barium	ug/L	255	11,800	1680	1,020	
Beryllium	ug/L	7.3	NE	9.5	5.5	
Calcium	ug/L	NE	316,000	2680000	**787,000**	
Chromium	ug/L	11	NE	561	176	
Cobalt	ug/L	73	12.1	5610	**140**	
Copper	ug/L	146	19.8	2800	**334**	
Iron	ug/L	1,095	1,550	679000	**266,000**	
Lead	ug/L	15	NE	459	142	J
Magnesium	ug/L	NE	217,000	651000	**240,000**	
Manganese	ug/L	88	636	55100	**5,940**	
Nickel	ug/L	73	8.6	5040	**338**	
Potassium	ug/L	NE	116,000	33100	20,800	
Sodium	ug/L	NE	1,390,000	9410000	14,500	
Vanadium	ug/L	3.7	NE	1000	288	
Zinc	ug/L	1,095	507	2010	**799**	
Metals - Filtered						
Aluminum	ug/L	3,650	309	1350	-	-
Arsenic	ug/L	0.045	7.4	22.9	**22.9**	
Barium	ug/L	255	11,800	237	237	
Calcium	ug/L	NE	316,000	780000	63,400	
Iron	ug/L	1,095	1,550	15300	119	
Magnesium	ug/L	NE	217,000	348000	16,400	
Manganese	ug/L	88	636	62400	28.4	
Sodium	ug/L	NE	1,390,000	1.3E+07	11,500	

Location Code: PRRP-DP16
Sample No.: 7830
Sample Date: 13-Jun-98
Low-Flow Sampled: No

Parameter	Units	RBSC	BSC	MDC	Result	VQ
Volatiles						
Acetone	ug/L	548	NE	20	4.6	B
Methylene chloride	ug/L	4.3	NE	NA	0.63	B
Semivolatiles						
Dinitrophenol, 2,4-	ug/L	7.3	NE	5900	22	J
Dinitrotoluene, 2,4-	ug/L	0.099	NE	9200	35	
Dinitrotoluene, 2,6-	ug/L	0.099	NE	550	6.2	J
Nitroaniline, 2-	ug/L	11	NE	3.2	1.3	J
Nitrophenol, 2-	ug/L	4.9	NE	2.1	2.1	J
Nitrophenol, 4-	ug/L	4.9	NE	290	5	J
Metals - Unfiltered						
Aluminum	ug/L	3,650	309	280000	**15,500**	
Calcium	ug/L	NE	316,000	2680000	283,000	
Cobalt	ug/L	73	12.1	5610	**668**	
Copper	ug/L	146	19.8	2800	**510**	
Iron	ug/L	1,095	1,550	679000	**40,200**	
Magnesium	ug/L	NE	217,000	651000	88,000	
Manganese	ug/L	88	636	55100	**2,080**	
Nickel	ug/L	73	8.6	5040	**468**	
Sodium	ug/L	NE	1,390,000	9410000	1,180,000	
Metals - Filtered						
Calcium	ug/L	NE	316,000	780000	212,000	
Cobalt	ug/L	73	12.1	6660	**784**	
Copper	ug/L	146	19.8	3260	**568**	
Iron	ug/L	1,095	1,550	15300	**1,950**	
Magnesium	ug/L	NE	217,000	348000	67,700	
Manganese	ug/L	88	636	62400	**1,700**	
Nickel	ug/L	73	8.6	5820	**441**	
Sodium	ug/L	NE	1,390,000	1.3E+07	**1,450,000**	

Location Code: PRRP-DP03
Sample No.: 7310
Sample Date: 8-Jun-98
Low-Flow Sampled: No

Parameter	Units	RBSC	BSC	MDC	Result	VQ
Explosives						
Dinitrobenzene, 1,3-	ug/L	0.37	NE	4800	4,800	
Dinitrotoluene, 2,4-	ug/L	0.099	NE	6800	6,800	
Volatiles						
Acetone	ug/L	548	NE	20	20	J
Benzene	ug/L	0.35	2.4	0.15	0.14	J
Butanone, 2-	ug/L	697	NE	24	24	J
Ethylbenzene	ug/L	134	0.87	0.19	0.19	J
Hexanone, 2-	ug/L	150	NE	1.8	1.8	J
Tetrachloroethene	ug/L	0.104	NE	0.26	0.22	J
Toluene	ug/L	72	1.7	1.9	0.51	B
Xylenes, total	ug/L	21	5.5	0.88	0.88	J
Semivolatiles						
Dinitro-2-methylphenol, 4,6-	ug/L	0.37	NE	2300	2,300	
Dinitrophenol, 2,4-	ug/L	7.3	NE	5900	5,800	D
Dinitrotoluene, 2,4-	ug/L	0.099	NE	9200	9,200	D
Dinitrotoluene, 2,6-	ug/L	0.099	NE	550	550	
Nitrophenol, 4-	ug/L	4.9	NE	290	290	J
Metals - Unfiltered						
Aluminum	ug/L	3,650	309	280000	**88,400**	
Calcium	ug/L	NE	316,000	2680000	**683,000**	
Chromium	ug/L	11	NE	561	208	
Cobalt	ug/L	73	12.1	5610	**2,610**	
Copper	ug/L	146	19.8	2800	**1,410**	
Iron	ug/L	1,095	1,550	679000	**200,000**	
Lead	ug/L	15	NE	459	96.7	J
Magnesium	ug/L	NE	217,000	651000	172,000	
Manganese	ug/L	88	636	55100	**39,600**	
Nickel	ug/L	73	8.6	5040	**2,380**	
Sodium	ug/L	NE	1,390,000	9410000	**5,930,000**	
Zinc	ug/L	1,095	507	2010	**597**	
Metals - Filtered						
Calcium	ug/L	NE	316,000	780000	**542,000**	
Cobalt	ug/L	73	12.1	6660	**3,090**	
Copper	ug/L	146	19.8	3260	**1,600**	
Iron	ug/L	1,095	1,550	15300	**7,480**	
Magnesium	ug/L	NE	217,000	348000	139,000	
Manganese	ug/L	88	636	62400	**42,700**	
Nickel	ug/L	73	8.6	5820	**2,760**	
Sodium	ug/L	NE	1,390,000	1.3E+07	**7,260,000**	
Water Quality Parameters						
Alkalinity	ug/L	NE	NE	1500000	1,500,000	
Cyanide, total	ug/L	73	NE	780	780	
Hardness	ug/L	NE	NE	3400000	3,400,000	
Nitrate	ug/L	1000	NE	465000	465,000	
Sulfate	ug/L	NE	NE	1E+07	10,000,000	
Total dissolved solids	ug/L	NE	NE	2.2E+07	15,000,000	
Total organic carbon	ug/L	NE	NE	6600000	6,600,000	
Total suspended solids	ug/L	NE	NE	110000	110,000	

Location Code: PRRP-DP20
Sample No.: 7990
Sample Date: 14-Jun-98
Low-Flow Sampled: No

Parameter	Units	RBSC	BSC	MDC	Result	VQ
Volatiles						
Toluene	ug/L	72	1.7	1.9	0.14	B
Metals - Unfiltered						
Aluminum	ug/L	3,650	309	280000	**13,400**	
Arsenic	ug/L	0.045	7.4	1780	**31.3**	
Calcium	ug/L	NE	316,000	2680000	300,000	
Chromium	ug/L	11	NE	561	26.9	
Copper	ug/L	146	19.8	2800	**33.2**	
Iron	ug/L	1,095	1,550	679000	**31,500**	
Lead	ug/L	15	NE	459	21.6	
Magnesium	ug/L	NE	217,000	651000	75,900	
Manganese	ug/L	88	636	55100	**1,220**	
Sodium	ug/L	NE	1,390,000	9410000	6,480	
Vanadium	ug/L	3.7	NE	1000	76.5	
Zinc	ug/L	1,095	507	2010	151	
Metals - Filtered						
Arsenic	ug/L	0.045	7.4	22.9	**16.9**	
Calcium	ug/L	NE	316,000	780000	58,800	
Iron	ug/L	1,095	1,550	15300	456	
Magnesium	ug/L	NE	217,000	348000	14,300	
Manganese	ug/L	88	636	62400	78.4	
Sodium	ug/L	NE	1,390,000	1.3E+07	6,810	
Water Quality Parameters						
Alkalinity	ug/L	NE	NE	1500000	155,000	
Chloride	ug/L	NE	NE	9800	2,300	
Hardness	ug/L	NE	NE	3400000	670,000	
Sulfate	ug/L	NE	NE	1E+07	24,700	
Total dissolved solids	ug/L	NE	NE	2.2E+07	276,000	
Total organic carbon	ug/L	NE	NE	6600000	1,800	
Total suspended solids	ug/L	NE	NE	110000	6,000	

Location Code: PRRP-DP06
Sample No.: 7430
Sample Date: 9-Jun-98
Low-Flow Sampled: No

Parameter	Units	RBSC	BSC	MDC	Result	VQ
Explosives						
Dinitrobenzene, 1,3-	ug/L	0.37	NE	4800	10	
Dinitrotoluene, 2,4-	ug/L	0.099	NE	6800	31	
Dinitrotoluene, 2,6-	ug/L	0.099	NE	400	5.1	

Location Code: PRRP-DP01
Sample No.: 7230
Sample Date: 12-Jun-98
Low-Flow Sampled: No

Parameter	Units	RBSC	BSC	MDC	Result	VQ
Explosives						
Dinitrotoluene, 2,4-	ug/L	0.099	NE	6800	10	
Volatiles						
Acetone	ug/L	548	NE	20	4.3	B
Semivolatiles						
Dinitrophenol, 2,4-	ug/L	7.3	NE	5900	8.3	J
Dinitrotoluene, 2,4-	ug/L	0.099	NE	9200	20	
Dinitrotoluene, 2,6-	ug/L	0.099	NE	550	3.3	J
Nitroaniline, 2-	ug/L	11	NE	3.2	3.2	J
Nitroaniline, 3-	ug/L	3.2	NE	88	88	
Metals - Unfiltered						
Aluminum	ug/L	3,650	309	280000	**52,900**	
Calcium	ug/L	NE	316,000	2680000	**432,000**	
Chromium	ug/L	11	NE	561	112	
Copper	ug/L	146	19.8	2800	**277**	
Iron	ug/L	1,095	1,550	679000	**125,000**	
Lead	ug/L	15	NE	459	58.3	J
Magnesium	ug/L	NE	217,000	651000	101,000	
Manganese	ug/L	88	636	55100	**4,040**	
Sodium	ug/L	NE	1,390,000	9410000	788,000	
Zinc	ug/L	1,095	507	2010	374	
Metals - Filtered						
Calcium	ug/L	NE	316,000	780000	207,000	
Magnesium	ug/L	NE	217,000	348000	52,800	
Manganese	ug/L	88	636	62400	**1,680**	
Sodium	ug/L	NE	1,390,000	1.3E+07	1,130,000	

Location Code: PRRP-DP04
Sample No.: 7350
Sample Date: 9-Jun-98
Low-Flow Sampled: No

Parameter	Units	RBSC	BSC	MDC	Result	VQ
Explosives						
Dinitrobenzene, 1,3-	ug/L	0.37	NE	4800	0.28	
Dinitrotoluene, 2,4-	ug/L	0.099	NE	6800	0.47	
Volatiles						
Acetone	ug/L	548	NE	20	4	B
Carbon disulfide	ug/L	104	NE	0.26	0.26	J
Toluene	ug/L	72	1.7	1.9	0.63	B
Metals - Unfiltered						
Aluminum	ug/L	3,650	309	280000	**280,000**	
Arsenic	ug/L	0.045	7.4	1780	**305**	J
Barium	ug/L	255	11,800	1680	1,680	
Calcium	ug/L	NE	316,000	2680000	**1,530,000**	
Chromium	ug/L	11	NE	561	561	
Copper	ug/L	146	19.8	2800	**669**	
Iron	ug/L	1,095	1,550	679000	**679,000**	
Lead	ug/L	15	NE	459	292	J
Magnesium	ug/L	NE	217,000	651000	**616,000**	
Manganese	ug/L	88	636	55100	**12,400**	
Mercury	ug/L	1.1	NE	0.65	0.55	
Nickel	ug/L	73	8.6	5040	**740**	
Potassium	ug/L	NE	116,000	33100	31,500	
Vanadium	ug/L	3.7	NE	1000	821	
Zinc	ug/L	1,095	507	2010	**2,010**	
Metals - Filtered						
Arsenic	ug/L	0.045	7.4	22.9	**13.4**	
Calcium	ug/L	NE	316,000	780000	90,900	
Iron	ug/L	1,095	1,550	15300	166	
Magnesium	ug/L	NE	217,000	348000	25,300	
Manganese	ug/L	88	636	62400	39.3	
Zinc	ug/L	1,095	507	1100	21.6	
Water Quality Parameters						
Alkalinity	ug/L	NE	NE	1500000	263,000	
Chloride	ug/L	NE	NE	9800	2,300	
Hardness	ug/L	NE	NE	3400000	940,000	
Sulfate	ug/L	NE	NE	1E+07	22,700	
Total dissolved solids	ug/L	NE	NE	2.2E+07	401,000	

Location Code: PRRP-DP08
Sample No.: 7510
Sample Date: 10-Jun-98
Low-Flow Sampled: No

Parameter	Units	RBSC	BSC	MDC	Result	VQ
Explosives						
Dinitrobenzene, 1,3-	ug/L	0.37	NE	4800	1.2	
Dinitrotoluene, 2,4-	ug/L	0.099	NE	6800	1.4	
Dinitrotoluene, 2,6-	ug/L	0.099	NE	400	0.28	
Volatiles						
Acetone	ug/L	548	NE	20	2.1	B
Carbon disulfide	ug/L	104	NE	0.26	0.16	J
Toluene	ug/L	72	1.7	1.9	0.51	B
Trichloroethene	ug/L	0.028	NE	0.43	0.16	J
Semivolatiles						
Dinitrotoluene, 2,4-	ug/L	0.099	NE	9200	2.8	J
Metals - Unfiltered						
Aluminum	ug/L	3,650	309	280000	**178,000**	
Antimony	ug/L	1.5	NE	118	118	J
Arsenic	ug/L	0.045	7.4	1780	**259**	J
Barium	ug/L	255	11,800	1680	1,210	
Beryllium	ug/L	7.3	NE	9.5	8.8	
Cadmium	ug/L	1.8	NE	6.5	6.5	
Calcium	ug/L	NE	316,000	2680000	**863,000**	
Chromium	ug/L	11	NE	561	273	
Cobalt	ug/L	73	12.1	5610	**208**	
Copper	ug/L	146	19.8	2800	**472**	
Iron	ug/L	1,095	1,550	679000	**468,000**	
Lead	ug/L	15	NE	459	323	J
Magnesium	ug/L	NE	217,000	651000	**253,000**	
Manganese	ug/L	88	636	55100	**11,800**	
Mercury	ug/L	1.1	NE	0.65	0.2	
Nickel	ug/L	73	8.6	5040	**521**	
Potassium	ug/L	NE	116,000	33100	22,700	
Vanadium	ug/L	3.7	NE	1000	438	
Zinc	ug/L	1,095	507	2010	**1,550**	
Metals - Filtered						
Calcium	ug/L	NE	316,000	780000	58,000	
Iron	ug/L	1,095	1,550	15300	116	
Magnesium	ug/L	NE	217,000	348000	12,900	
Zinc	ug/L	1,095	507	1100	26.5	

Location Code: PRRP-DP07
Sample No.: 7470
Sample Date: 10-Jun-98
Low-Flow Sampled: No

Parameter	Units	RBSC	BSC	MDC	Result	VQ
Explosives						
Dinitrobenzene, 1,3-	ug/L	0.37	NE	4800	0.42	
Dinitrotoluene, 2,4-	ug/L	0.099	NE	6800	0.82	
Volatiles						
Acetone	ug/L	548	NE	20	4.3	B
Tetrachloroethene	ug/L	0.104	NE	0.26	0.17	J
Toluene	ug/L	72	1.7	1.9	0.3	B
Trichloroethene	ug/L	0.028	NE	0.43	0.43	J
Metals - Unfiltered						
Aluminum	ug/L	3,650	309	280000	**69,000**	
Barium	ug/L	255	11,800	1680	556	
Calcium	ug/L	NE	316,000	2680000	**650,000**	
Chromium	ug/L	11	NE	561	114	
Cobalt	ug/L	73	12.1	5610	**77.6**	
Copper	ug/L	146	19.8	2800	**194**	
Iron	ug/L	1,095	1,550	679000	**176,000**	
Lead	ug/L	15	NE	459	86.2	J
Magnesium	ug/L	NE	217,000	651000	**217,000**	
Manganese	ug/L	88	636	55100	**4,310**	
Nickel	ug/L	73	8.6	5040	**191**	
Potassium	ug/L	NE	116,000	33100	12,300	
Sodium	ug/L	NE	1,390,000	9410000	7,060	
Vanadium	ug/L	3.7	NE	1000	212	
Zinc	ug/L	1,095	507	2010	**525**	
Metals - Filtered						
Arsenic	ug/L	0.045	7.4	22.9	**11**	
Calcium	ug/L	NE	316,000	780000	66,500	
Iron	ug/L	1,095	1,550	15300	190	
Magnesium	ug/L	NE	217,000	348000	15,800	
Manganese	ug/L	88	636	62400	71.4	
Sodium	ug/L	NE	1,390,000	1.3E+07	5,490	
Zinc	ug/L	1,095	507	1100	77.7	

Location Code: PRRP-DP12
Sample No.: 7670
Sample Date: 11-Jun-98
Low-Flow Sampled: No

Parameter	Units	RBSC	BSC	MDC	Result	VQ
Explosives						
Dinitrobenzene, 1,3-	ug/L	0.37	NE	4800	1.3	
Dinitrotoluene, 2,4-	ug/L	0.099	NE	6800	2.3	
Dinitrotoluene, 2,6-	ug/L	0.099	NE	400	0.35	
Volatiles						
Acetone	ug/L	548	NE	20	5.9	B
Carbon disulfide	ug/L	104	NE	0.26	0.16	J
Toluene	ug/L	72	1.7	1.9	**1.9**	J
Semivolatiles						
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	10	10	
Metals - Unfiltered						
Aluminum	ug/L	3,650	309	280000	**170,000**	
Antimony	ug/L	1.5	NE	118	105	J
Arsenic	ug/L	0.045	7.4	1780	**238**	J
Barium	ug/L	255	11,800	1680	896	
Beryllium	ug/L	7.3	NE	9.5	8.5	
Calcium	ug/L	NE	316,000	2680000	**926,000**	
Chromium	ug/L	11	NE	561	277	
Cobalt	ug/L	73	12.1	5610	**172**	
Copper	ug/L	146	19.8	2800	**515**	
Iron	ug/L	1,095	1,550	679000	**426,000**	
Lead	ug/L	15	NE	459	202	J
Magnesium	ug/L	NE	217,000	651000	**313,000**	
Manganese	ug/L	88	636	55100	**6,460**	
Mercury	ug/L	1.1	NE	0.65	0.32	
Nickel	ug/L	73	8.6	5040	**490**	
Potassium	ug/L	NE	116,000	33100	21,600	
Sodium	ug/L	NE	1,390,000	9410000	5,960	
Vanadium	ug/L	3.7	NE	1000	391	
Zinc	ug/L	1,095	507	2010	**1,350**	
Metals - Filtered						
Calcium	ug/L	NE	316,000	780000	98,800	
Iron	ug/L	1,095	1,550	15300	125	
Magnesium	ug/L	NE	217,000	348000	25,100	
Manganese	ug/L	88	636	62400	150	

Location Code: PRRP-DP11
Sample No.: 7630/7630R
Sample Date: 14-Jun-98
Low-Flow Sampled: No

Parameter	Units	RBSC	BSC	MDC	Result	VQ
Explosives						
Dinitrobenzene, 1,3-	ug/L	0.37	NE	4800	840	
Dinitrotoluene, 2,4-	ug/L	0.099	NE	6800	150	
Trinitrobenzene, 1,3,5-	ug/L	110	NE	680	600	
Volatiles						
Methylene chloride	ug/L	4.3	NE	NA	2.2	B
Semivolatiles						
Dinitrotoluene, 2,4-	ug/L	0.099	NE	9200	380	J
Metals - Unfiltered						
Aluminum	ug/L	3,650	309	280000	**4,820**	
Calcium	ug/L	NE	316,000	2680000	**848,000**	
Cobalt	ug/L	73	12.1	5610	**3,360**	
Copper	ug/L	146	19.8	2800	**1,530**	
Iron	ug/L	1,095	1,550	679000	**15,500**	
Magnesium	ug/L	NE	217,000	651000	**249,000**	
Manganese	ug/L	88	636	55100	**35,300**	
Nickel	ug/L	73	8.6	5040	**1,950**	
Sodium	ug/L	NE	1,390,000	9410000	**3,640,000**	
Metals - Filtered						
Calcium	ug/L	NE	316,000	780000	**745,000**	
Chromium	ug/L	11	NE	495	495	
Cobalt	ug/L	73	12.1	6660	**3,030**	
Copper	ug/L	146	19.8	3260	**2,000**	
Iron	ug/L	1,095	1,550	15300	**5,870**	
Magnesium	ug/L	NE	217,000	348000	**218,000**	
Manganese	ug/L	88	636	62400	**31,300**	
Nickel	ug/L	73	8.6	5820	**1,970**	
Sodium	ug/L	NE	1,390,000	1.3E+07	**3,210,000**	
Zinc	ug/L	1,095	507	1100	**1,100**	
Water Quality Parameters						
Alkalinity	ug/L	NE	NE	1500000	864,000	
Cyanide, total	ug/L	73	NE	780	400	
Hardness	ug/L	NE	NE	3400000	2,440,000	
Nitrate	ug/L	1000	NE	465000	350,000	J
Sulfate	ug/L	NE	NE	1E+07	3,730,000	
Total dissolved solids	ug/L	NE	NE	2.2E+07	22,100,000	
Total organic carbon	ug/L	NE	NE	6600000	3,060,000	
Total suspended solids	ug/L	NE	NE	110000	34,000	

Location Code: PRRP-DP17
Sample No.: 7870
Sample Date: 11-Jun-98
Low-Flow Sampled: No

Parameter	Units	RBSC	BSC	MDC	Result	VQ
Explosives						
Dinitrobenzene, 1,3-	ug/L	0.37	NE	4800	6.4	
Dinitrotoluene, 2,4-	ug/L	0.099	NE	6800	8.9	
Dinitrotoluene, 2,6-	ug/L	0.099	NE	400	1.7	
Volatiles						
Acetone	ug/L	548	NE	20	1.5	B
Toluene	ug/L	72	1.7	1.9	0.56	B
Semivolatiles						
Dinitrotoluene, 2,4-	ug/L	0.099	NE	9200	1.5	J
Metals - Unfiltered						
Aluminum	ug/L	3,650	309	280000	**38,600**	
Barium	ug/L	255	11,800	1680	218	
Calcium	ug/L	NE	316,000	2680000	**1,270,000**	
Chromium	ug/L	11	NE	561	65.8	
Copper	ug/L	146	19.8	2800	**106**	
Iron	ug/L	1,095	1,550	679000	**87,000**	
Magnesium	ug/L	NE	217,000	651000	**286,000**	
Manganese	ug/L	88	636	55100	**3,280**	
Nickel	ug/L	73	8.6	5040	**113**	
Potassium	ug/L	NE	116,000	33100	6,430	
Sodium	ug/L	NE	1,390,000	9410000	6,010	
Vanadium	ug/L	3.7	NE	1000	163	
Zinc	ug/L	1,095	507	2010	341	
Metals - Filtered						
Calcium	ug/L	NE	316,000	780000	55,000	
Magnesium	ug/L	NE	217,000	348000	13,200	
Manganese	ug/L	88	636	62400	22.4	
Zinc	ug/L	1,095	507	1100	28.7	

LEGEND:

- BUILDINGS
- RAILROAD
- SURFACE DRAINAGE
- SURFACE WATER
- OVERBURDEN/SHALE MONITORING WELL LOCATION
- DIRECT-PUSH GROUNDWATER SAMPLING LOCATION
- ug/L — MICROGRAMS PER LITER
- nv — NON VALIDATED
- NA — NOT APPLICABLE, ONLY B QUALIFIED DATA DETECTED
- NE — NOT ESTABLISHED (RBSCs), NOT EVALUATED (BSCs)
- NTU — NEPHELOMETRIC TUBIDITY UNIT

NOTES:

1. SHADED CELL INDICATES VALUE IS GREATER THAN RBSC.
2. BOLD TEXT INDICATES VALUE IS GREATER THAN BSC.
3. RBSC VALUES REFLECT AN INCREMENTAL LIFETIME CANCER RISK (ILCR) OF 1E-6 OR A NONCANCER HAZARD QUOTIENT (HQ) OF 0.1. FOR CHEMICALS THAT EXHIBIT BOTH CANCER AND NONCANCER EFFECTS, WHICHEVER TYPE OF EFFECT IN A LOWER CONCENTRATION (USING AN ILCR OF 1E-6 AND AN HQ OF 0.1), THAT CONCENTRATION IS SELECTED AS THE RBSC.
4. BSC IS BACKGROUND SCREENING CONCENTRATION.
5. MDC IS MAXIMUM DETECTED CONCENTRATION FOR THE AOC ("B" QUALIFIED DATA NOT INCLUDED).
6. VALIDATION QUALIFIERS (VQ)
   - B - THE ANALYTE WAS NOT DETECTED SIGNIFICANTLY ABOVE THE LEVELS FOUND IN THE ASSOCIATED METHOD BLANK.
   - J - THE COMPOUND/ANALYTE WAS POSITIVELY IDENTIFIED; THE REPORTED VALUE IS AN ESTIMATED CONCENTRATION.

STARTING DATE	INITIATOR	CHKD	DRAWN	CHKD	PROJECT MNGR
12/03/04	D. KESSLER		D. BOMAR		S. DOWNEY

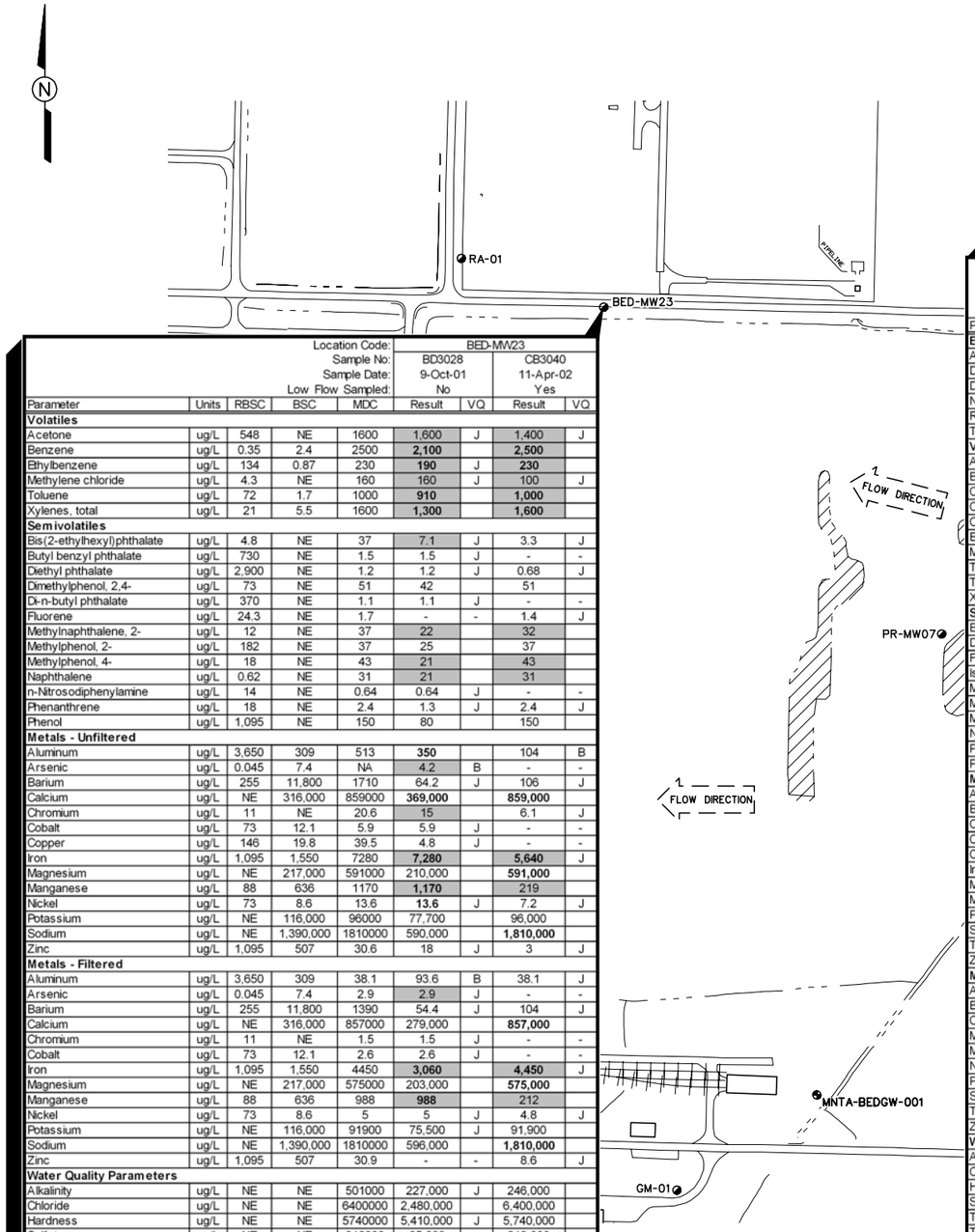
Shaw Environmental, Inc.
KNOXVILLE, TENNESSEE

2004 GROUNDWATER DATA SUMMARY AND EVALUATION REPORT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

FIGURE 7-6
DETECTED CONSTITUENTS AT PENTOLITE ROAD RED WATER PONDS ABOVE RBSCs AND/OR BSCs IN OVERBURDEN/SHALE GROUNDWATER (JUNE 1998)

AREA	JOB NO.	DRAWING NO.	REV.
SITEWIDE	843656	843656_037.DGN	

843656_037.dgn 4:48:21 PM 12/20/2004 dbomar PBOW_standard.tbl



					Location Code:	BED-MW23		
					Sample No:	BD3028		CB3040
					Sample Date:	9-Oct-01		11-Apr-02
					Low Flow Sampled:	No		Yes
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ
Volatiles								
Acetone	ug/L	548	NE	1600	1,600	J	1,400	J
Benzene	ug/L	0.35	2.4	2500	**2,100**		**2,500**	
Ethylbenzene	ug/L	134	0.87	230	**190**	J	**230**	
Methylene chloride	ug/L	4.3	NE	160	160	J	100	J
Toluene	ug/L	72	1.7	1000	**910**		**1,000**	
Xylenes, total	ug/L	21	5.5	1600	**1,300**		**1,600**	
Semivolatiles								
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	37	7.1	J	3.3	J
Butyl benzyl phthalate	ug/L	730	NE	1.5	1.5	J	-	-
Diethyl phthalate	ug/L	2,900	NE	1.2	1.2	J	0.68	J
Dimethylphenol, 2,4-	ug/L	73	NE	51	42		51	
Di-n-butyl phthalate	ug/L	370	NE	1.1	1.1	J	-	-
Fluorene	ug/L	24.3	NE	1.7	-	-	1.4	J
Methylnaphthalene, 2-	ug/L	12	NE	37	22		32	
Methylphenol, 2-	ug/L	182	NE	37	25		37	
Methylphenol, 4-	ug/L	18	NE	43	21		43	
Naphthalene	ug/L	0.62	NE	31	21		31	
n-Nitrosodiphenylamine	ug/L	14	NE	0.64	0.64	J	-	-
Phenanthrene	ug/L	18	NE	2.4	1.3	J	2.4	J
Phenol	ug/L	1,095	NE	150	80		150	
Metals - Unfiltered								
Aluminum	ug/L	3,650	309	513	**350**		104	B
Arsenic	ug/L	0.045	7.4	NA	4.2	B	-	-
Barium	ug/L	255	11,800	1710	64.2	J	106	J
Calcium	ug/L	NE	316,000	859000	**369,000**		**859,000**	
Chromium	ug/L	11	NE	20.6	15		6.1	J
Cobalt	ug/L	73	12.1	5.9	5.9	J	-	-
Copper	ug/L	146	19.8	39.5	4.8	J	-	-
Iron	ug/L	1,095	1,550	7280	**7,280**		**5,640**	J
Magnesium	ug/L	NE	217,000	591000	210,000		**591,000**	
Manganese	ug/L	88	636	1170	**1,170**		219	
Nickel	ug/L	73	8.6	13.6	**13.6**	J	7.2	J
Potassium	ug/L	NE	116,000	96000	77,700		96,000	
Sodium	ug/L	NE	1,390,000	1810000	590,000		**1,810,000**	
Zinc	ug/L	1,095	507	30.6	18	J	3	J
Metals - Filtered								
Aluminum	ug/L	3,650	309	38.1	93.6	B	38.1	J
Arsenic	ug/L	0.045	7.4	2.9	2.9	J	-	-
Barium	ug/L	255	11,800	1390	54.4	J	104	J
Calcium	ug/L	NE	316,000	857000	279,000		**857,000**	
Chromium	ug/L	11	NE	1.5	1.5	J	-	-
Cobalt	ug/L	73	12.1	2.6	2.6	J	-	-
Iron	ug/L	1,095	1,550	4450	**3,060**		**4,450**	J
Magnesium	ug/L	NE	217,000	575000	203,000		**575,000**	
Manganese	ug/L	88	636	988	**988**		212	
Nickel	ug/L	73	8.6	5	5	J	4.8	J
Potassium	ug/L	NE	116,000	91900	75,500	J	91,900	
Sodium	ug/L	NE	1,390,000	1810000	596,000		**1,810,000**	
Zinc	ug/L	1,095	507	30.9	-	-	8.6	J
Water Quality Parameters								
Alkalinity	ug/L	NE	NE	501000	227,000	J	246,000	
Chloride	ug/L	NE	NE	6400000	2,480,000		6,400,000	
Hardness	ug/L	NE	NE	5740000	5,410,000	J	5,740,000	
Sulfate	ug/L	NE	NE	218000	85,800		218,000	
Total dissolved solids	ug/L	NE	NE	1.3E+07	3,080,000		12,500,000	
Total organic carbon	ug/L	NE	NE	13000	6,200		6,400	
Total suspended solids	ug/L	NE	NE	1660000	292,000		1,660,000	
Turbidity	NTU	NE	NE	6500	324		6,500	

					Location Code:	BED-MW15							
					Sample No:	5910		5915		BD3019		CB3041	
					Sample Date:	18-Nov-97		28-May-98		9-Oct-01		15-Apr-02	
					Low Flow Sampled:	No		No		No		No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	
Explosives													
Amino-2,6-dinitrotoluene, 4-	ug/L	0.73	NE	0.97	-	-	-	-	-	-	0.97		
Dinitrotoluene, 2,4-	ug/L	0.099	NE	0.89	-	-	0.89		-	-	-	-	
Dinitrotoluene, 2,6-	ug/L	0.099	NE	0.89	-	-	0.89		-	-	-	-	
Nitrobenzene	ug/L	0.34	NE	0.35	-	-	-	-	-	-	0.35		
RDX	ug/L	0.61	NE	0.51	-	-	-	-	-	-	0.51		
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	1.6	-	-	-	-	1.6		1.3		
Volatiles													
Acetone	ug/L	548	NE	1600	-	-	-	-	170	J	87	J	
Benzene	ug/L	0.35	2.4	2500	**570**		**780**		**670**		**600**		
Carbon disulfide	ug/L	104	NE	3.1	-	-	-	-	-	-	3.1	J	
Chlorobenzene	ug/L	10.6	NE	5.5	-	-	5.5	J	-	-	-	-	
Chloroform	ug/L	0.17	NE	NA	8.4	B	-	-	-	-	-	-	
Ethylbenzene	ug/L	134	0.87	230	**130**		**140**		**150**	J	**130**		
Methylene chloride	ug/L	4.3	NE	160	31	B	83	B	120	J	31	J	
Toluene	ug/L	72	1.7	1000	**490**		**550**		**630**		**460**		
Trichloroethane, 1,1,2-	ug/L	0.2	NE	4.9	-	-	4.9	J	-	-	-	-	
Xylenes, total	ug/L	21	5.5	1600	**920**		**880**		**1,000**		**880**		
Semivolatiles													
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	37	37		28	B	2.2	J	1.8	J	
Dimethylphenol, 2,4-	ug/L	73	NE	51	6.7	J	10		5.6	J	6.8	J	
Fluorene	ug/L	24.3	NE	1.7	1.7	J	-	-	-	-	-	-	
Isophorone	ug/L	71	NE	4.2	4.2	J	3.8	J	-	-	-	-	
Methylnaphthalene, 2-	ug/L	12	NE	37	31		37		25		27		
Methylphenol, 2-	ug/L	182	NE	37	3	J	6.7	J	3.3	J	3.9	J	
Methylphenol, 4-	ug/L	18	NE	43	3.9	J	7.7	J	4.2	J	5.6	J	
Naphthalene	ug/L	0.62	NE	31	22		31		24		25		
Phenanthrene	ug/L	18	NE	2.4	2.2	J	2	J	0.98	J	1.3	J	
Phenol	ug/L	1,095	NE	150	18		32		12		15		
Metals - Unfiltered													
Aluminum	ug/L	3,650	309	513	-	-	**513**	J	51.1	B	74.8	B	
Barium	ug/L	255	11,800	1710	605		1,710		481		856		
Calcium	ug/L	NE	316,000	859000	280,000		**662,000**	J	199,000		287,000		
Chromium	ug/L	11	NE	20.6	-	-	20.6		-	-	-	-	
Copper	ug/L	146	19.8	39.5	-	-	**39.5**		-	-	-	-	
Iron	ug/L	1,095	1,550	7280	930		**4,810**		-	-	142		
Magnesium	ug/L	NE	217,000	591000	177,000		**259,000**		169,000		**234,000**		
Manganese	ug/L	88	636	1170	26.3		139		5.6	J	7	J	
Potassium	ug/L	NE	116,000	96000	58,800		62,500		62,100		75,100	J	
Sodium	ug/L	NE	1,390,000	1810000	559,000		811,000		566,000		705,000		
Thallium	ug/L	0.24	NE	50.8	-	-	50.8		-	-	-	-	
Zinc	ug/L	1,095	507	30.6	30.6		105	B	-	-	-	-	
Metals - Filtered													
Aluminum	ug/L	3,650	309	38.1	-	-	-	-	64.5	B	52.4	B	
Barium	ug/L	255	11,800	1390	555		1,390		484		855		
Calcium	ug/L	NE	316,000	857000	245,000	J	**390,000**	J	199,000		286,000		
Magnesium	ug/L	NE	217,000	575000	182,000		**299,000**	J	171,000		**236,000**		
Manganese	ug/L	88	636	988	-	-	-	-	5.2	J	6.3	J	
Nickel	ug/L	73	8.6	5	-	-	-	-	2.4	J	-	-	
Potassium	ug/L	NE	116,000	91900	61,100		74,800		62,200		75,900	J	
Sodium	ug/L	NE	1,390,000	1810000	582,000		1,010,000		572,000		716,000		
Thallium	ug/L	0.24	NE	62.2	-	-	62.2		-	-	-	-	
Zinc	ug/L	1,095	507	30.9	30.9		47.3	B	-	-	9.4	J	
Water Quality Parameters													
Alkalinity	ug/L	NE	NE	501000	85,000		500,000		382,000	J	501,000		
Chloride	ug/L	NE	NE	6400000	1,400,000		2,200,000		1,910,000		2,100,000		
Hardness	ug/L	NE	NE	5740000	1,500,000		1,800,000		855,000		1,490,000		
Sulfate	ug/L	NE	NE	218000	-	-	82,000		89,200		103,000		
Total dissolved solids	ug/L	NE	NE	1.3E+07	3,200,000		3,800,000		2,570,000		3,720,000		
Total organic carbon	ug/L	NE	NE	13000	11,000		13,000		8,400		6,500		
Total suspended solids	ug/L	NE	NE	1660000	7,000		13,000		-	-	25,000		
Turbidity	NTU	NE	NE	6500					203		140		

LEGEND:

IT-MW05	OVERBURDEN/SHALE MONITORING WELL LOCATION
BED-MW15	BEDROCK MONITORING WELL LOCATION
	BUILDINGS
	RAILROAD
	SURFACE WATER
	DITCH
	FENCE
FLOW DIRECTION	BEDROCK GROUNDWATER FLOW DIRECTION (AUGUST 2004)
ug/L	MICROGRAMS PER LITER
nv	NON VALIDATED
NA	NOT APPLICABLE, ONLY B QUALIFIED DATA DETECTED
NE	NOT ESTABLISHED (RBSCs), NOT EVALUATED (BSCs)
NTU	NEPHELOMETRIC TUBIDITY UNIT

NOTES:

1. SHADED CELL INDICATES VALUE IS GREATER THAN RBSC.
2. BOLD TEXT INDICATES VALUE IS GREATER THAN BSC.
3. RBSC VALUES REFLECT AN INCREMENTAL LIFETIME CANCER RISK (ILCR) OF 1E-6 OR A NONCANCER HAZARD QUOTIENT (HQ) OF 0.1. FOR CHEMICALS THAT EXHIBIT BOTH CANCER AND NONCANCER EFFECTS, WHICHEVER TYPE OF EFFECT IN A LOWER CONCENTRATION (USING AN ILCR OF 1E-6 AND AN HQ OF 0.1), THAT CONCENTRATION IS SELECTED AS THE RBSC.
4. BSC IS BACKGROUND SCREENING CONCENTRATION.
5. MDC IS MAXIMUM DETECTED CONCENTRATION FOR THE AOC ("B" QUALIFIED DATA NOT INCLUDED).
6. VALIDATION QUALIFIERS (VQ)
   - B - THE ANALYTE WAS NOT DETECTED SIGNIFICANTLY ABOVE THE LEVELS FOUND IN THE ASSOCIATED METHOD BLANK.
   - J - THE COMPOUND/ANALYTE WAS POSITIVELY IDENTIFIED; THE REPORTED VALUE IS AN ESTIMATED CONCENTRATION.

FIGURE 7-7
DETECTED CONSTITUENTS AT PENTOLITE ROAD RED WATER PONDS ABOVE RBSCs AND/OR BSCs IN BEDROCKGROUNDWATER (NOVEMBER 1997 THROUGH APRIL 2002)

2004 GROUNDWATER DATA SUMMARY AND EVALUATION REPORT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

SCALE
0 400 800 FEET

Shaw™ Shaw Environmental, Inc.

DWG. NO.:843656_038.dgn PROJ. NO.: 771481
INITIATOR: D. KESSLER PROJ. MGR.: S. DOWNEY
DRAFT. CHCK. BY: C. TUMLIN ENGR. CHCK. BY: D. KESSLER
LAST REV.: BY:
STARTING DATE: 08/12/02 DRAWN BY: B. VANDERGRIFF
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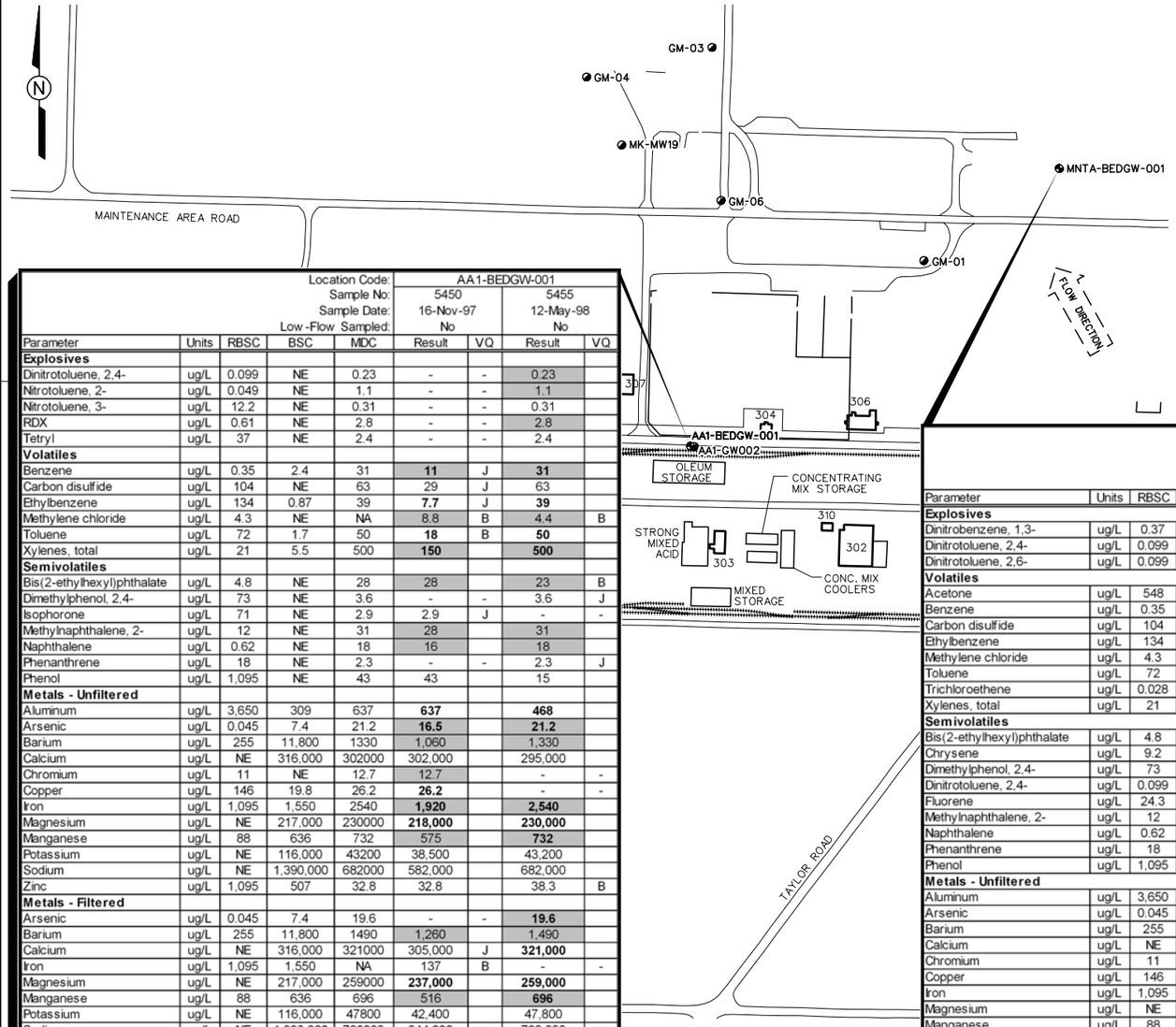
PBOW_standard.tbl dbomar 843656_038.dgn



			Location Code:	AA1-BEDGW-001			
			Sample No:	5450		5455	
			Sample Date:	16-Nov-97		12-May-98	
			Low-Flow Sampled:	No		No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ
Explosives								
Dinitrotoluene, 2,4-	ug/L	0.099	NE	0.23	-	-	0.23	
Nitrotoluene, 2-	ug/L	0.049	NE	1.1	-	-	1.1	
Nitrotoluene, 3-	ug/L	12.2	NE	0.31	-	-	0.31	
RDX	ug/L	0.61	NE	2.8	-	-	2.8	
Tetryl	ug/L	37	NE	2.4	-	-	2.4	
Volatiles								
Benzene	ug/L	0.35	2.4	31	**11**	J	**31**	
Carbon disulfide	ug/L	104	NE	63	29	J	63	
Ethylbenzene	ug/L	134	0.87	39	**7.7**	J	**39**	
Methylene chloride	ug/L	4.3	NE	NA	8.8	B	4.4	B
Toluene	ug/L	72	1.7	50	**18**	B	**50**	
Xylenes, total	ug/L	21	5.5	500	**150**		**500**	
Semivolatiles								
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	28	28		23	B
Dimethylphenol, 2,4-	ug/L	73	NE	3.6	-	-	3.6	J
Isophorone	ug/L	71	NE	2.9	2.9	J	-	-
Methylnaphthalene, 2-	ug/L	12	NE	31	28		31	
Naphthalene	ug/L	0.62	NE	18	16		18	
Phenanthrene	ug/L	18	NE	2.3	-	-	2.3	J
Phenol	ug/L	1,095	NE	43	43		15	
Metals - Unfiltered								
Aluminum	ug/L	3,650	309	637	**637**		**468**	
Arsenic	ug/L	0.045	7.4	21.2	**16.5**		**21.2**	
Barium	ug/L	255	11,800	1330	1,060		1,330	
Calcium	ug/L	NE	316,000	302000	302,000		295,000	
Chromium	ug/L	11	NE	12.7	12.7		-	-
Copper	ug/L	146	19.8	26.2	**26.2**		-	-
Iron	ug/L	1,095	1,550	2540	**1,920**		**2,540**	
Magnesium	ug/L	NE	217,000	230000	**218,000**		**230,000**	
Manganese	ug/L	88	636	732	575		**732**	
Potassium	ug/L	NE	116,000	43200	38,500		43,200	
Sodium	ug/L	NE	1,390,000	682000	582,000		682,000	
Zinc	ug/L	1,095	507	32.8	32.8		38.3	B
Metals - Filtered								
Arsenic	ug/L	0.045	7.4	19.6	-	-	**19.6**	
Barium	ug/L	255	11,800	1490	1,260		1,490	
Calcium	ug/L	NE	316,000	321000	305,000	J	**321,000**	
Iron	ug/L	1,095	1,550	NA	137	B	-	-
Magnesium	ug/L	NE	217,000	259000	**237,000**		**259,000**	
Manganese	ug/L	88	636	696	516		**696**	
Potassium	ug/L	NE	116,000	47800	42,400		47,800	
Sodium	ug/L	NE	1,390,000	786000	644,000		786,000	
Zinc	ug/L	1,095	507	105	105		66.3	B
Water Quality								
Alkalinity	ug/L	NE	NE	900000	830,000		900,000	
Chloride	ug/L	NE	NE	3000000	1,900,000		3,000,000	J
Hardness	ug/L	NE	NE	2000000	1,800,000		2,000,000	
Sulfate	ug/L	NE	NE	40000	7,000		40,000	J
Total dissolved solids	ug/L	NE	NE	3600000	3,600,000		730,000	
Total organic carbon	ug/L	NE	NE	16000	16,000		11,000	J
Total suspended solids	ug/L	NE	NE	330000	6,000		330,000	

			Location Code:	MNTA-BEDGW-001							
			Sample No:	5440		5445		BD3008		CB3039	
			Sample Date:	20-Nov-97		28-May-98		3-Oct-01		12-Apr-02	
			Low-Flow Sampled:	No		No		Yes		No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives												
Dinitrobenzene, 1,3-	ug/L	0.37	NE	0.86	-	-	0.86		-	-	-	-
Dinitrotoluene, 2,4-	ug/L	0.099	NE	2	-	-	2		-	-	-	-
Dinitrotoluene, 2,6-	ug/L	0.099	NE	0.34	-	-	0.34		-	-	-	-
Volatiles												
Acetone	ug/L	548	NE	140	-	-	-	-	-	-	140	J
Benzene	ug/L	0.35	2.4	110	-	-	**19**		**110**	J	**36**	J
Carbon disulfide	ug/L	104	NE	21	3.7	J	21		-	-	-	-
Ethylbenzene	ug/L	134	0.87	61	-	-	**7.7**		**61**	J	**25**	J
Methylene chloride	ug/L	4.3	NE	200	5.1	B	2.6	B	200	J	110	J
Toluene	ug/L	72	1.7	140	-	-	**18**		**140**	J	**40**	J
Trichloroethene	ug/L	0.028	NE	18	-	-	-	-	-	-	18	J
Xylenes, total	ug/L	21	5.5	490	**8.2**	B	**150**		**490**		**310**	
Semivolatiles												
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	5	3.9	J	6.5	B	5	J	0.91	J
Chrysene	ug/L	9.2	NE	0.8	-	-	-	-	0.8	J	0.54	J
Dimethylphenol, 2,4-	ug/L	73	NE	1.8	1.7	J	1.8	J	-	-	-	-
Dinitrotoluene, 2,4-	ug/L	0.099	NE	1.3	-	-	1.3	J	-	-	-	-
Fluorene	ug/L	24.3	NE	1.6	-	-	-	-	1.6	J	1.2	J
Methylnaphthalene, 2-	ug/L	12	NE	23	1.9	J	1.2	J	21		23	
Naphthalene	ug/L	0.62	NE	16	2.3	J	-	-	11		16	
Phenanthrene	ug/L	18	NE	2.8	-	-	-	-	2.8	J	1.9	J
Phenol	ug/L	1,095	NE	17	17		11		-	-	-	-
Metals - Unfiltered												
Aluminum	ug/L	3,650	309	119	249	B	-	-	119	J	129	B
Arsenic	ug/L	0.045	7.4	2.9	-	-	-	-	2.9	J	-	-
Barium	ug/L	255	11,800	457	424		457		381		388	
Calcium	ug/L	NE	316,000	441000	**336,000**	J	**441,000**	J	299,000		305,000	
Chromium	ug/L	11	NE	2.9	-	-	-	-	2.9	J	-	-
Copper	ug/L	146	19.8	24.3	-	-	-	-	**24.3**	J	-	-
Iron	ug/L	1,095	1,550	6400	**6,400**		481		978		376	J
Magnesium	ug/L	NE	217,000	317000	**235,000**		**317,000**		**224,000**		**236,000**	
Manganese	ug/L	88	636	849	**849**		181		**641**		388	
Potassium	ug/L	NE	116,000	98800	58,800		60,900		98,800	J	92,000	
Sodium	ug/L	NE	1,390,000	1330000	1,140,000	J	1,320,000		1,330,000		1,210,000	
Thallium	ug/L	0.24	NE	NA	-	-	-	-	5.4	B	8.7	B
Vanadium	ug/L	3.7	NE	NA	-	-	-	-	2.1	B	-	-
Zinc	ug/L	1,095	507	16.2	34.4	B	68	B	16.2	J	12.9	J
Metals - Filtered												
Aluminum	ug/L	3,650	309	51.1	-	-	-	-	86	B	51.1	J
Barium	ug/L	255	11,800	596	449		596		387		398	
Calcium	ug/L	NE	316,000	483000	**358,000**		**483,000**	J	298,000		**316,000**	
Iron	ug/L	1,095	1,550	NA	298	B	-	-	-	-	-	-
Magnesium	ug/L	NE	217,000	345000	**254,000**		**345,000**	J	**227,000**		**239,000**	
Manganese	ug/L	88	636	899	**899**		183		621		380	
Potassium	ug/L	NE	116,000	97200	63,500		65,800		97,200		96,300	
Sodium	ug/L	NE	1,390,000	1520000	1,190,000		**1,520,000**		1,350,000		1,280,000	
Thallium	ug/L	0.24	NE	NA	-	-	-	-	4.8	B	-	-
Zinc	ug/L	1,095	507	24.8	24.8	J	32.8	B	-	-	2.6	J
Water Quality Parameters												
Alkalinity	ug/L	NE	NE	691000	670,000		-	-	630,000	J	691,000	
Chloride	ug/L	NE	NE	4130000	55,000		3,800,000		4,130,000		3,480,000	
Hardness	ug/L	NE	NE	2100000	2,000,000		2,100,000		1,660,000		1,580,000	
Sulfate	ug/L	NE	NE	64000	62,000		64,000		-	-	1,400	J
Total dissolved solids	ug/L	NE	NE	7200000	5,300,000		7,200,000		5,860,000		6,010,000	
Total organic carbon	ug/L	NE	NE	11000	11,000		7,000		3,900		5,900	
Total suspended solids	ug/L	NE	NE	79000	4,000		29,000		79,000		24,000	
Turbidity	NTU	NE	NE	392					392	J	277	

SCALE

0 400 800 FEET

LEGEND:

MK-MW19	OVERBURDEN/SHALE MONITORING WELL LOCATION
AA1-BEDGW-001	BEDROCK MONITORING WELL LOCATION
	BUILDINGS
	RAILROAD
	SURFACE WATER
	DITCH
	FENCE
FLOW DIRECTION	BEDROCK GROUNDWATER FLOW DIRECTION (AUGUST 2004)
ug/L	MICROGRAMS PER LITER
nv	NON VALIDATED
NA	NOT APPLICABLE, ONLY B QUALIFIED DATA DETECTED
NE	NOT ESTABLISHED (RBSCs), NOT EVALUATED (BSCs)
NTU	NEPHELOMETRIC TUBIDITY UNIT

NOTES:

1. SHADED CELL INDICATES VALUE IS GREATER THAN RBSC.
2. BOLD TEXT INDICATES VALUE IS GREATER THAN BSC.
3. RBSC VALUES REFLECT AN INCREMENTAL LIFETIME CANCER RISK (ILCR) OF 1E-6 OR A NONCANCER HAZARD QUOTIENT (HQ) OF 0.1. FOR CHEMICALS THAT EXHIBIT BOTH CANCER AND NONCANCER EFFECTS, WHICHEVER TYPE OF EFFECT IN A LOWER CONCENTRATION (USING AN ILCR OF 1E-6 AND AN HQ OF 0.1), THAT CONCENTRATION IS SELECTED AS THE RBSC.
4. BSC IS BACKGROUND SCREENING CONCENTRATION.
5. MDC IS MAXIMUM DETECTED CONCENTRATION FOR THE AOC ("B" QUALIFIED DATA NOT INCLUDED).
6. VALIDATION QUALIFIERS (VQ)
   - B - THE ANALYTE WAS NOT DETECTED SIGNIFICANTLY ABOVE THE LEVELS FOUND IN THE ASSOCIATED METHOD BLANK.
   - J - THE COMPOUND/ANALYTE WAS POSITIVELY IDENTIFIED; THE REPORTED VALUE IS AN ESTIMATED CONCENTRATION.

FIGURE 7-8

DETECTED CONSTITUENTS AT ACID AREA NO. 1/MAINTENANCE SHOP AREA ABOVE RBSCs AND/OR BSCs IN BEDROCK GROUNDWATER (NOVEMBER 1997 THROUGH APRIL 2002)

2004 GROUNDWATER DATA SUMMARY AND EVALUATION REPORT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw™ Shaw Environmental, Inc.

DWG. NO.:843656_039.dgn | PROJ. NO.: 771481
INITIATOR: D. KESSLER | DATE LAST REV.:
PROJ. MGR.: S. DOWNEY | DRAWN BY:
DRAFT. CHCK. BY: C. TUMLIN | STARTING DATE: 08/12/02
ENGR. CHCK. BY: D. KESSLER | DRAWN BY: B. VANDERGRIFF
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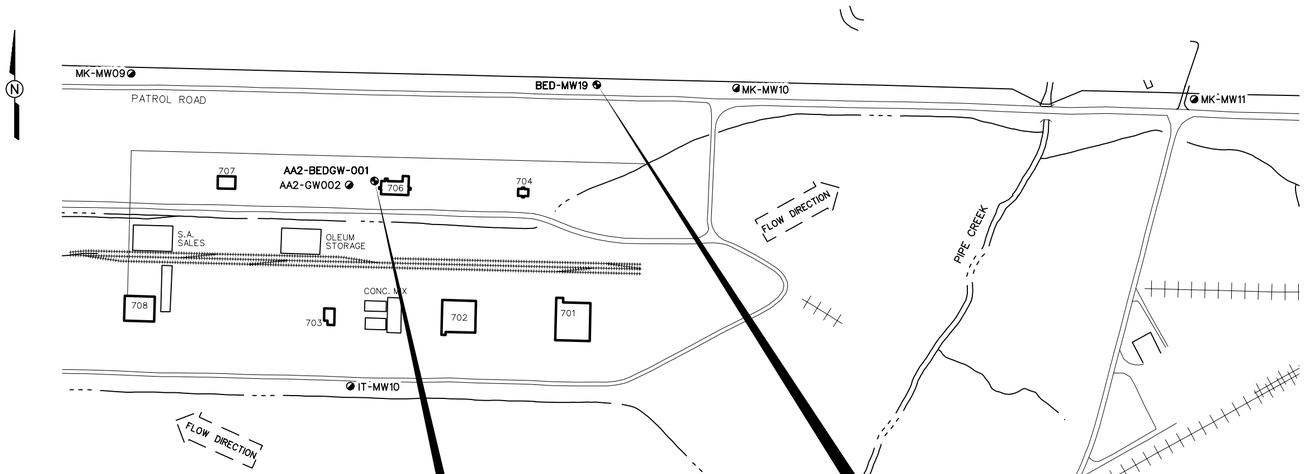
STARTING DATE: 02DEC04 | INITIATOR: D. KESSLER | TECH. REVIEW: D. KESSLER | DWG. NO.: 843656_040.dgn
DRAWN BY: C. TUMLIN | CADD REVIEW: C.BENTLEY | PROJ. MGR.: S. DOWNEY | PROJ. NO.: 771481



					Location Code:		AA2-BEDGW-001					
					Sample No:		5460		5465		BD3004	
					Sample Date:		20-Nov-97		12-May-98		8-Oct-01	
					Low-Flow Sampled:		No		No		Yes	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives												
Dinitrobenzene, 1,3-	ug/L	0.37	NE	0.81	-	-	0.81		-	-	-	-
Dinitrotoluene, 2,4-	ug/L	0.099	NE	2.5	-	-	2.5		-	-	-	-
Dinitrotoluene, 2,6-	ug/L	0.099	NE	1.2	-	-	1.2		-	-	-	-
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	1.6	-	-	-	-	1.6		-	-
Volatiles												
Acetone	ug/L	548	NE	68	-	-	41	J	54	B	-	-
Benzene	ug/L	0.35	2.4	130	**33**		**130**		**45**	J	**4.8**	J
Butanone, 2-	ug/L	697	NE	18	-	-	18	J	-	-	-	-
Carbon disulfide	ug/L	104	NE	6.9	5.5	J	1.7	J	-	-	0.84	J
Chlorobenzene	ug/L	10.6	NE	21	21	J	-	-	-	-	-	-
Chloromethane	ug/L	16	NE	30	-	-	10		30	J	-	-
Ethylbenzene	ug/L	134	0.87	64	**23**	J	**43**		**64**	J	**13**	
Methylene chloride	ug/L	4.3	NE	100	7.4	B	3.2	B	100	J	3.9	J
Toluene	ug/L	72	1.7	21	**32**	B	**20**		-	-	**2.2**	J
Xylenes, total	ug/L	21	5.5	360	**200**		**220**		**360**		**98**	
Semivolatiles												
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	9.7	-	-	5.6	B	-	-	2	J
Dimethylphenol, 2,4-	ug/L	73	NE	8.6	1.3	J	8.6	J	2.5	J	1.8	J
Methylnaphthalene, 2-	ug/L	12	NE	12	1.3	J	5.6	J	9.8	J	3.2	J
Methylphenol, 2-	ug/L	182	NE	1.6	-	-	1.6	J	-	-	-	-
Methylphenol, 4-	ug/L	18	NE	1.6	-	-	1.6	J	-	-	-	-
Naphthalene	ug/L	0.62	NE	12	-	-	8.1	J	12		2.5	J
Phenol	ug/L	1,095	NE	74	-	-	74		2.2	J	-	-
Metals - Unfiltered												
Aluminum	ug/L	3,650	309	10200	**1,060**	J	**10,200**		**1,170**	J	195	B
Arsenic	ug/L	0.045	7.4	34.2	-	-	**34.2**		**9.1**	J	6.6	J
Barium	ug/L	255	11,800	1800	220		645		843		368	
Calcium	ug/L	NE	316,000	1970000	186,000	J	**1,970,000**		81,800		99,400	
Chromium	ug/L	11	NE	307	-	-	307		2.4	J	1.3	J
Cobalt	ug/L	73	12.1	63.3	-	-	**63.3**		5.9	J	9.2	J
Copper	ug/L	146	19.8	99	-	-	**62.7**		3.6	B	-	-
Iron	ug/L	1,095	1,550	51600	**5,240**		**51,600**		**7,210**		**2,020**	J
Lead	ug/L	15	NE	38.6	6.5	B	38.6		-	-	-	-
Magnesium	ug/L	NE	217,000	132000	56,900		132,000		60,000		58,000	
Manganese	ug/L	88	636	5130	522		**5,130**		**1,030**		228	
Nickel	ug/L	73	8.6	238	-	-	**238**		3.7	J	4	J
Potassium	ug/L	NE	116,000	49500	29,100		34,200		30,100	J	28,900	
Sodium	ug/L	NE	1,390,000	132000	99,100	J	124,000		132,000		100,000	
Thallium	ug/L	0.24	NE	NA	-	-	-	-	5.3	B	5.2	B
Vanadium	ug/L	3.7	NE	108	-	-	108		-	-	-	-
Zinc	ug/L	1,095	507	144	55		137	B	10.2	J	6.2	J
Metals - Filtered												
Aluminum	ug/L	3,650	309	45.2	-	-	-	-	75.6	B	42.6	J
Arsenic	ug/L	0.045	7.4	9	-	-	-	-	3.7	J	**9**	J
Barium	ug/L	255	11,800	1740	212		279		724		336	
Beryllium	ug/L	7.3	NE	NA	-	-	-	-	0.56	B	-	-
Calcium	ug/L	NE	316,000	220000	88,600		70,400		59,300		89,900	
Cobalt	ug/L	73	12.1	3.4	-	-	-	-	-	-	3.4	J
Iron	ug/L	1,095	1,550	1300	106	B	-	-	1,300		124	J
Magnesium	ug/L	NE	217,000	81000	54,800		54,300		54,600		57,100	
Manganese	ug/L	88	636	995	351		**995**		**946**		207	
Nickel	ug/L	73	8.6	7.9	-	-	-	-	-	-	-	-
Potassium	ug/L	NE	116,000	46200	30,000		31,200		27,500	J	29,600	
Sodium	ug/L	NE	1,390,000	127000	104,000		124,000		127,000		103,000	
Zinc	ug/L	1,095	507	66.2	66.2	J	29.1	B	7.1	J	5	J
Water Quality												
Alkalinity	ug/L	NE	NE	1050000	510,000		600,000		552,000	J	586,000	
Chloride	ug/L	NE	NE	396000	47,000		53,000	J	68,100		56,000	
Hardness	ug/L	NE	NE	1700000	700,000		860,000		360,000		700,000	
Sulfate	ug/L	NE	NE	70000	48,000		70,000	J	31,700		32,700	
Total dissolved solids	ug/L	NE	NE	1200000	750,000		310,000		716,000		712,000	
Total organic carbon	ug/L	NE	NE	16000	7,400		6,000	J	3,100		3,100	
Total suspended solids	ug/L	NE	NE	199000	4,000		-	-	113,000		22,000	
Turbidity	NTU	NE	NE	662					313	J	137	

					Location Code:		BED-MW19									
					Sample No:		5950		5955		BD3025		CB3013		DF3001		DH3001	
					Sample Date:		14-Nov-97		16-May-98		4-Oct-01		4-Apr-02		5-May-04		25-Aug-04	
					Low-Flow Sampled:		No		No		Yes		Yes		Yes		Yes	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																		
Dinitrobenzene, 1,3-	ug/L	0.37	NE	0.81	0.22		-	-	-	-	-	-	-	-	-	-	-	-
Nitrobenzene	ug/L	0.34	NE	0.32	0.32		-	-	-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 3-	ug/L	12.2	NE	0.62	-	-	0.62		-	-	-	-	-	-	-	-	-	-
RDX	ug/L	0.61	NE	0.17	-	-	-	-	-	-	-	-	0.17	J	-	-	-	-
Volatiles																		
Acetone	ug/L	548	NE	68	68	J	-	-	66	B	-	-	220	B	-	-		
Benzene	ug/L	0.35	2.4	130	**11**		1.9	J	**46**		**42**	J	**18**	J	**28**			
Bromomethane	ug/L	0.87	NE	7.9	-	-	-	-	7.9	J	-	-	-	-	-	-		
Carbon disulfide	ug/L	104	NE	6.9	2		6.9		-	-	-	-	3.2	J	1.7	J		
Chlorobenzene	ug/L	10.6	NE	21	-	-	-	-	-	-	-	-	2.2	J	-	-		
Ethylbenzene	ug/L	134	0.87	64	**5.1**		**1.2**	J	**17**	J	**16**	J	**6.8**	J	**8.8**			
Methylene chloride	ug/L	4.3	NE	100	-	-	2.3	B	30	J	9.7	J	7.3	J	-	-		
Toluene	ug/L	72	1.7	21	**8.9**		1.5	B	**21**	J	**18**	J	**8**	J	**11**			
Xylenes, total	ug/L	21	5.5	360	**38**		**10**		**180**		**170**		**66**		**95**			
Semivolatiles																		
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	9.7	5.8	J	24	B	-	-	9.7	J	-	-	-	-		
Methylnaphthalene, 2-	ug/L	12	NE	12	3.3	J	1.5	J	12		10		5.2	J	11			
Naphthalene	ug/L	0.62	NE	12	2.1	J	-	-	8.6	J	6.1	J	3.7	J	7	J		
Phenanthrene	ug/L	18	NE	0.89	-	-	-	-	0.82	J	0.74	J	-	-	0.89	J		
Phenol	ug/L	1,095	NE	74	55		-	-	1.2	J	-	-	-	-	-	-		
Metals - Unfiltered																		
Aluminum	ug/L	3,650	309	10200	-	-	-	-	94.8	B	56.2	J	61.7	J	67.3	B		
Barium	ug/L	255	11,800	1800	1,520		1,800		1,060		892		1,120		1,190			
Calcium	ug/L	NE	316,000	1970000	255,000	J	171,000		221,000		121,000		184,000		185,000			
Chromium	ug/L	11	NE	307	10		-	-	1.2	J	-	-	-	-	-	-		
Copper	ug/L	146	19.8	99	**61.7**		-	-	**99**		15.6	J	**52.2**		**31.5**			
Iron	ug/L	1,095	1,550	51600	376	B	141	J	149		-	-	-	-	-	-		
Lead	ug/L	15	NE	38.6	6.8		-	-	-	-	-	-	-	-	-	-		
Magnesium	ug/L	NE	217,000	132000	57,200		80,000		66,200		41,900		44,600		36,300			
Manganese	ug/L	88	636	5130	30.4		-	-	2.2	J	2.2	J	-	-	2	J		
Nickel	ug/L	73	8.6	238	-	-	-	-	**13.8**	J	3.5	J	**9.2**	J	4.9	B		
Potassium	ug/L	NE	116,000	49500	49,500		26,000		43,800		41,500	J	36,500	J	38,900			
Sodium	ug/L	NE	1,390,000	132000	120,000		129,000		75,400		88,400		74,300	J	80,500			
Thallium	ug/L	0.24	NE	NA	-	-	-	-	-	-	-	-	5.1	B	-	-		
Zinc	ug/L	1,095	507	144	62.3		29.5	B	144		31.3		65.9		96.6			
Metals - Filtered																		
Aluminum	ug/L	3,650	309	45.2	-	-	-	-	86	B	66.6	B	45.2	J	50.3	B		
Barium	ug/L	255	11,800	1740	1,520		1,740		1,080		852		1,050		1,140			
Beryllium	ug/L	7.3	NE	NA	-	-	-	-	-	-	-	-	-	-	-	-		
Calcium	ug/L	NE	316,000	220000	220,000		162,000		202,000		109,000		170,000		181,000			
Copper	ug/L	146	19.8	13	-	-	-	-	-	-	-	-	-	-	13	J		
Magnesium	ug/L	NE	217,000	81000	65,100		77,900		81,000		44,000		44,800		36,500			
Manganese	ug/L	88	636	995	-	-	16.3		4	J	2.5	J	2.2	J	2.8	J		
Nickel	ug/L	73	8.6	7.9	-	-	-	-	7.9	J	4.3	J	7.9	J	5.1	B		
Potassium	ug/L	NE	116,000	46200	46,200		24,800		42,100		42,900	J	36,500	J	39,300	J		
Selenium	ug/L	18	NE	1.8	-	-	-	-	-	-	-	-	2.6	B	1.8	J		
Sodium	ug/L	NE	1,390,000	127000	125,000		127,000		94,900		92,900		75,400	J	80,800			
Thallium	ug/L	0.24	NE	2.6	-	-	-	-	-	-	-	-	4.4	B	2.6	J		
Zinc	ug/L	1,095	507	66.2	57.4		24.4	B	5.2	J	3.1	J	-	-	43.6			
Water Quality																		
Alkalinity	ug/L	NE	NE	1050000	310,000		750,000		707,000	J	302,000		1,050,000	J	634,000			
Chloride	ug/L	NE	NE	396000	330,000		280,000		248,000	J	373,000	J	229,000		396,000			
Cyanide, total	ug/L	73	NE	16	-	-	16		-	-	-	-						
Hardness	ug/L	NE	NE	1700000	1,700,000		750,000		905,000		424,000		662,000		584,000			
Sulfate	ug/L	NE	NE	70000	14,000		49,000		27,700	J	32,200		21,000		29,500			
Total dissolved solids	ug/L	NE	NE	1200000	1,200,000		590,000		1,110,000		651,000		887,000		836,000			
Total organic carbon	ug/L	NE	NE	16000	16,000		9,000		8,600		5,900		5,600		5,600			
Total suspended solids	ug/L	NE	NE	199000	41,000		5,000		199,000		44,000		32,000		79,000			
Turbidity	NTU	NE	NE	662					662	J	164		220		118			

LEGEND

MK-MW10	OVERBURDEN/SHALE MONITORING WELL LOCATION
AA2-BEDGW-001	BEDROCK MONITORING WELL LOCATION
	BUILDINGS
	AREA OF STORAGE TANKS
	RAILROAD
	ABANDONED RAILROAD
	SURFACE WATER
	DITCH
	FENCE
	NATURAL GAS
FLOW DIRECTION	BEDROCK GROUNDWATER FLOW DIRECTION (AUGUST 2004)
ug/L	MICROGRAMS PER LITER
nv	NON VALIDATED
NA	NOT APPLICABLE, ONLY B QUALIFIED DATA DETECTED
NE	NOT ESTABLISHED (RBSCs), NOT EVALUATED (BSCs)
NTU	NEPHELOMETRIC TUBIDITY UNIT

NOTES:

1. SHADED CELL INDICATES VALUE IS GREATER THAN RBSC.
2. BOLD TEXT INDICATES VALUE IS GREATER THAN BSC.
3. RBSC VALUES REFLECT AN INCREMENTAL LIFETIME CANCER RISK (ILCR) OF 1E-6 OR A NONCANCER HAZARD QUOTIENT (HQ) OF 0.1. FOR CHEMICALS THAT EXHIBIT BOTH CANCER AND NONCANCER EFFECTS, WHICHEVER TYPE OF EFFECT IN A LOWER CONCENTRATION (USING AN ILCR OF 1E-6 AND AN HQ OF 0.1), THAT CONCENTRATION IS SELECTED AS THE RBSC.
4. BSC IS BACKGROUND SCREENING CONCENTRATION.
5. MDC IS MAXIMUM DETECTED CONCENTRATION FOR THE AOC ("B" QUALIFIED DATA NOT INCLUDED).
6. VALIDATION QUALIFIERS (VQ)
   - B - THE ANALYTE WAS NOT DETECTED SIGNIFICANTLY ABOVE THE LEVELS FOUND IN THE ASSOCIATED METHOD BLANK.
   - J - THE COMPOUND/ANALYTE WAS POSITIVELY IDENTIFIED; THE REPORTED VALUE IS AN ESTIMATED CONCENTRATION.

FIGURE 7-9
DETECTED CONSTITUENTS AT ACID AREA NO. 2 ABOVE RBSCs AND/OR BSCs IN BEDROCK WELLS (NOVEMBER 1997 THROUGH APRIL 2002)

2004 GROUNDWATER DATA SUMMARY AND EVALUATION REPORT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

SCALE
0 300 600 FEET

Shaw™ Shaw Environmental, Inc.

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PROJ. MGR.: S. DOWNEY
INITIATOR: D. KESSLER
CADD REVIEW: C.BENTLEY
STARTING DATE: 02DEC04
DRAWN BY: C. TUMLIN
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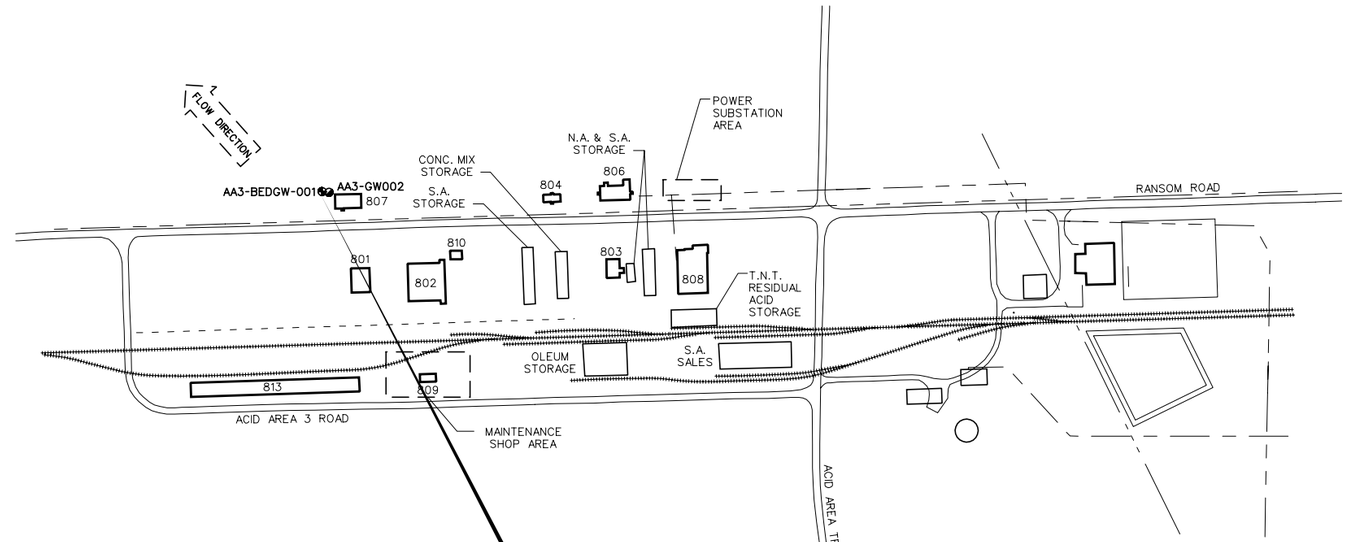


					Location Code:		AA3-BEDGW-001					
					Sample No:		5470		5475		BD3005		CB3033	
					Sample Date:		19-Nov-97		14-May-98		27-Sep-01		10-Apr-02	
					Low-Flow Sampled:		No		No		Yes		Yes	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Volatiles												
Acetone	ug/L	548	NE	36	36	J	-	-	22	B	-	-
Benzene	ug/L	0.35	2.4	11	-	-	-	-	**11**		**8**	J
Carbon disulfide	ug/L	104	NE	4.2	4.2	J	-	-	-	-	-	-
Ethylbenzene	ug/L	134	0.87	4.6	-	-	-	-	**4**	J	**4.6**	J
Methylene chloride	ug/L	4.3	NE	9.2	2.1	B	160	B	2.2	B	9.2	J
Toluene	ug/L	72	1.7	12	-	-	**29**	B	**11**		**12**	J
Xylenes, total	ug/L	21	5.5	31	-	-	-	-	**28**		**31**	
Semivolatiles												
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	5.8	5.8	J	-	-	-	-	-	-
Naphthalene	ug/L	0.62	NE	0.7	-	-	-	-	-	-	0.7	J
Phenol	ug/L	1,095	NE	3.1	3.1	J	-	-	-	-	-	-
Metals - Unfiltered												
Aluminum	ug/L	3,650	309	397	-	-	**397**		59.6	B	104	B
Barium	ug/L	255	11,800	102	-	-	-	-	102	J	80.2	J
Calcium	ug/L	NE	316,000	189000	189,000		131,000		122,000	J	104,000	
Chromium	ug/L	11	NE	NA	-	-	-	-	1.6	B	-	-
Iron	ug/L	1,095	1,550	450	168	B	450		126		118	J
Magnesium	ug/L	NE	217,000	108000	108,000		76,800		80,700		69,300	
Manganese	ug/L	88	636	83.8	74.6		83.8		28.7		20.7	
Potassium	ug/L	NE	116,000	49600	49,600		38,500		43,900		40,400	
Sodium	ug/L	NE	1,390,000	368000	368,000		282,000		293,000		237,000	
Thallium	ug/L	0.24	NE	NA	-	-	10.1	B	-	-	6.9	B
Zinc	ug/L	1,095	507	29.2	29.2		67.6	B	-	-	-	-
Metals - Filtered												
Aluminum	ug/L	3,650	309	49.2	-	-	-	-	50.2	B	49.2	J
Barium	ug/L	255	11,800	99.5	-	-	-	-	99.5	J	78.1	J
Calcium	ug/L	NE	316,000	160000	160,000		143,000		122,000		104,000	
Magnesium	ug/L	NE	217,000	96300	96,300		89,400		80,900		67,100	
Manganese	ug/L	88	636	57.6	57.6		51.3		23.9		17	
Potassium	ug/L	NE	116,000	44700	44,700		43,800		43,100		40,000	
Sodium	ug/L	NE	1,390,000	331000	331,000		321,000		293,000		237,000	
Thallium	ug/L	0.24	NE	NA	-	-	-	-	6.4	B	-	-
Zinc	ug/L	1,095	507	23	23		42.8	B	-	-	-	-
Water Quality												
Alkalinity	ug/L	NE	NE	790000	670,000		790,000		750,000	J	650,000	
Chloride	ug/L	NE	NE	860000	790,000		860,000	J	451,000		369,000	
Hardness	ug/L	NE	NE	1.3E+07	13,000,000		860,000		630,000		480,000	
Sulfate	ug/L	NE	NE	31100	-	-	8,000	J	31,100		-	-
Total dissolved solids	ug/L	NE	NE	1900000	1,900,000		1,800,000		1,440,000		1,200,000	
Total organic carbon	ug/L	NE	NE	5300	5,300	J	2,000	J	840	J	1,000	
Total suspended solids	ug/L	NE	NE	54000	38,000		54,000		-	-	16,000	
Turbidity	NTU	NE	NE	179					179	J	118	

LEGEND

AA3-GW002	OVERBURDEN/SHALE MONITORING WELL LOCATION
AA3-BEDGW-001	BEDROCK MONITORING WELL LOCATION
	BUILDINGS
	AREA OF STORAGE TANKS
	RAILROAD
	ABANDONED RAILROAD
	SURFACE WATER
	DITCH
	FENCE
	NATURAL GAS
	RAW WATER
	EVAPORATOR LINES
	FORMER SEWER LINE
1 FLOW DIRECTION	BEDROCK GROUNDWATER FLOW DIRECTION (AUGUST 2004)
ug/L	MICROGRAMS PER LITER
nv	NON VALIDATED
NA	NOT APPLICABLE, ONLY B QUALIFIED DATA DETECTED
NE	NOT ESTABLISHED (RBSCs), NOT EVALUATED (BSCs)
NTU	NEPHELOMETRIC TUBIDITY UNIT

NOTES:

1. SHADED CELL INDICATES VALUE IS GREATER THAN RBSC.
2. BOLD TEXT INDICATES VALUE IS GREATER THAN BSC.
3. RBSC VALUES REFLECT AN INCREMENTAL LIFETIME CANCER RISK (ILCR) OF 1E-6 OR A NONCANCER HAZARD QUOTIENT (HQ) OF 0.1. FOR CHEMICALS THAT EXHIBIT BOTH CANCER AND NONCANCER EFFECTS, WHICHEVER TYPE OF EFFECT IN A LOWER CONCENTRATION (USING AN ILCR OF 1E-6 AND AN HQ OF 0.1), THAT CONCENTRATION IS SELECTED AS THE RBSC.
4. BSC IS BACKGROUND SCREENING CONCENTRATION.
5. MDC IS MAXIMUM DETECTED CONCENTRATION FOR THE AOC ("B" QUALIFIED DATA NOT INCLUDED).
6. VALIDATION QUALIFIERS (VQ)
   - B - THE ANALYTE WAS NOT DETECTED SIGNIFICANTLY ABOVE THE LEVELS FOUND IN THE ASSOCIATED METHOD BLANK.
   - J - THE COMPOUND/ANALYTE WAS POSITIVELY IDENTIFIED; THE REPORTED VALUE IS AN ESTIMATED CONCENTRATION.

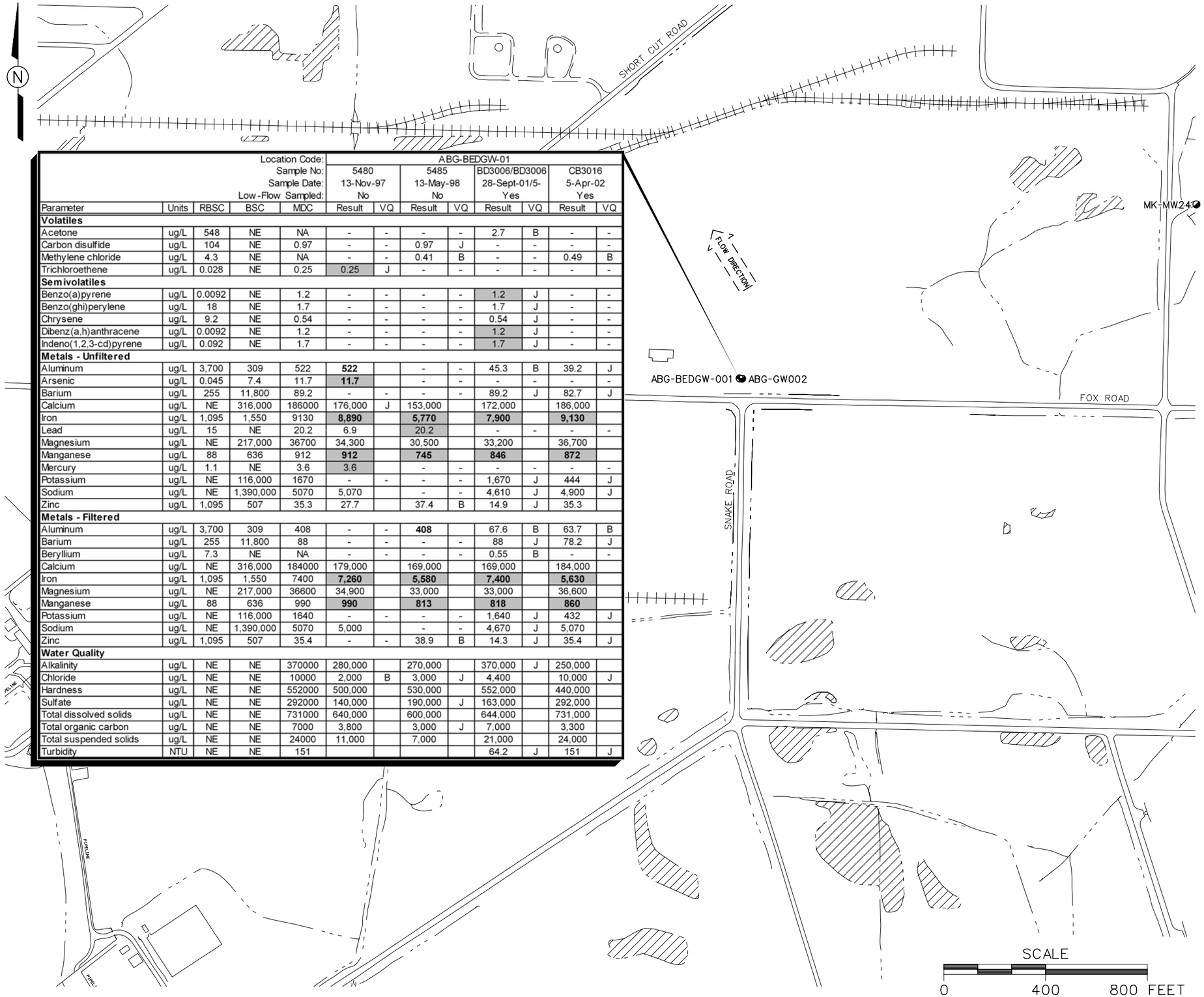
SCALE
0 400 800 FEET

FIGURE 7-10
DETECTED CONSTITUENTS AT ACID AREA NO. 3 ABOVE RBSCs AND/OR BSCs IN BEDROCK GROUNDWATER (NOVEMBER 1997 THROUGH APRIL 2002)

2004 GROUNDWATER DATA SUMMARY AND EVALUATION REPORT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw™ Shaw Environmental, Inc.

			Location Code:	ABG-BEDGW-01							
			Sample No:	5480		5485		BD3006/BD3006		CB3016	
			Sample Date:	13-Nov-97		13-May-98		28-Sept-01/5-		5-Apr-02	
			Low-Flow Sampled:	No		No		Yes		Yes	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Volatiles												
Acetone	ug/L	548	NE	NA	-	-	-	-	2.7	B	-	-
Carbon disulfide	ug/L	104	NE	0.97	-	-	0.97	J	-	-	-	-
Methylene chloride	ug/L	4.3	NE	NA	-	-	0.41	B	-	-	0.49	B
Trichloroethene	ug/L	0.028	NE	0.25	0.25	J	-	-	-	-	-	-
Semivolatiles												
Benzo(a)pyrene	ug/L	0.0092	NE	1.2	-	-	-	-	1.2	J	-	-
Benzo(ghi)perylene	ug/L	18	NE	1.7	-	-	-	-	1.7	J	-	-
Chrysene	ug/L	9.2	NE	0.54	-	-	-	-	0.54	J	-	-
Dibenz(a,h)anthracene	ug/L	0.0092	NE	1.2	-	-	-	-	1.2	J	-	-
Indeno(1,2,3-cd)pyrene	ug/L	0.092	NE	1.7	-	-	-	-	1.7	J	-	-
Metals - Unfiltered												
Aluminum	ug/L	3,700	309	522	**522**		-	-	45.3	B	39.2	J
Arsenic	ug/L	0.045	7.4	11.7	**11.7**		-	-	-	-	-	-
Barium	ug/L	255	11,800	89.2	-	-	-	-	89.2	J	82.7	J
Calcium	ug/L	NE	316,000	186000	176,000	J	153,000		172,000		186,000	
Iron	ug/L	1,095	1,550	9130	**8,890**		**5,770**		**7,900**		**9,130**	
Lead	ug/L	15	NE	20.2	6.9		20.2		-	-	-	-
Magnesium	ug/L	NE	217,000	36700	34,300		30,500		33,200		36,700	
Manganese	ug/L	88	636	912	**912**		**745**		**846**		**872**	
Mercury	ug/L	1.1	NE	3.6	3.6		-	-	-	-	-	-
Potassium	ug/L	NE	116,000	1670	-	-	-	-	1,670	J	444	J
Sodium	ug/L	NE	1,390,000	5070	5,070		-	-	4,610	J	4,900	J
Zinc	ug/L	1,095	507	35.3	27.7		37.4	B	14.9	J	35.3	
Metals - Filtered												
Aluminum	ug/L	3,700	309	408	-	-	**408**		67.6	B	63.7	B
Barium	ug/L	255	11,800	88	-	-	-	-	88	J	78.2	J
Beryllium	ug/L	7.3	NE	NA	-	-	-	-	0.55	B	-	-
Calcium	ug/L	NE	316,000	184000	179,000		169,000		169,000		184,000	
Iron	ug/L	1,095	1,550	7400	**7,260**		**5,580**		**7,400**		**5,630**	
Magnesium	ug/L	NE	217,000	36600	34,900		33,000		33,000		36,600	
Manganese	ug/L	88	636	990	**990**		**813**		**818**		**860**	
Potassium	ug/L	NE	116,000	1640	-	-	-	-	1,640	J	432	J
Sodium	ug/L	NE	1,390,000	5070	5,000		-	-	4,670	J	5,070	
Zinc	ug/L	1,095	507	35.4	-	-	38.9	B	14.3	J	35.4	J
Water Quality												
Alkalinity	ug/L	NE	NE	370000	280,000		270,000		370,000	J	250,000	
Chloride	ug/L	NE	NE	10000	2,000	B	3,000	J	4,400		10,000	J
Hardness	ug/L	NE	NE	552000	500,000		530,000		552,000		440,000	
Sulfate	ug/L	NE	NE	292000	140,000		190,000	J	163,000		292,000	
Total dissolved solids	ug/L	NE	NE	731000	640,000		600,000		644,000		731,000	
Total organic carbon	ug/L	NE	NE	7000	3,800		3,000	J	7,000		3,300	
Total suspended solids	ug/L	NE	NE	24000	11,000		7,000		21,000		24,000	
Turbidity	NTU	NE	NE	151					64.2	J	151	J



LEGEND

ABG-GW002	OVERBURDEN/SHALE MONITORING WELL LOCATION
ABG-BEDGW-001	BEDROCK MONITORING WELL LOCATION
	BUILDINGS
	RAILROAD
	SURFACE WATER
	DITCH
FLOW DIRECTION	BEDROCK GROUNDWATER FLOW DIRECTION (AUGUST 2004)
ug/L	MICROGRAMS PER LITER
nv	NON VALIDATED
NA	NOT APPLICABLE, ONLY B QUALIFIED DATA DETECTED
NE	NOT ESTABLISHED (RBSCs), NOT EVALUATED (BSCs)
NTU	NEPHELOMETRIC TUBIDITY UNIT

NOTES:

1. SHADED CELL INDICATES VALUE IS GREATER THAN RBSC.
2. BOLD TEXT INDICATES VALUE IS GREATER THAN BSC.
3. RBSC VALUES REFLECT AN INCREMENTAL LIFETIME CANCER RISK (ILCR) OF 1E-6 OR A NONCANCER HAZARD QUOTIENT (HQ) OF 0.1. FOR CHEMICALS THAT EXHIBIT BOTH CANCER AND NONCANCER EFFECTS, WHICHEVER TYPE OF EFFECT IN A LOWER CONCENTRATION (USING AN ILCR OF 1E-6 AND AN HQ OF 0.1), THAT CONCENTRATION IS SELECTED AS THE RBSC.
4. BSC IS BACKGROUND SCREENING CONCENTRATION.
5. MDC IS MAXIMUM DETECTED CONCENTRATION FOR THE AOC ("B" QUALIFIED DATA NOT INCLUDED).
6. VALIDATION QUALIFIERS (VQ)
   - B - THE ANALYTE WAS NOT DETECTED SIGNIFICANTLY ABOVE THE LEVELS FOUND IN THE ASSOCIATED METHOD BLANK.
   - J - THE COMPOUND/ANALYTE WAS POSITIVELY IDENTIFIED; THE REPORTED VALUE IS AN ESTIMATED CONCENTRATION.

FIGURE 7-11

DETECTED CONSTITUENTS AT ADDITIONAL BURNING GROUND AREA ABOVE RBSCs AND/OR BSCs IN OVERBURDEN/SHALE GROUNDWATER (NOVEMBER 1997 THROUGH APRIL 2002)

2004 GROUNDWATER DATA SUMMARY AND EVALUATION REPORT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw™ Shaw Environmental, Inc.

DWG. NO.: 843656_042.dgn
PROJ. NO.: 833886
TECH. REVIEW: D. KESSLER
PROJ. MGR.: S. DOWNEY
INITIATOR: D. KESSLER
CADD REVIEW: C.BENTLEY
STARTING DATE: 02DEC04
DRAWN BY: C. TUMLIN

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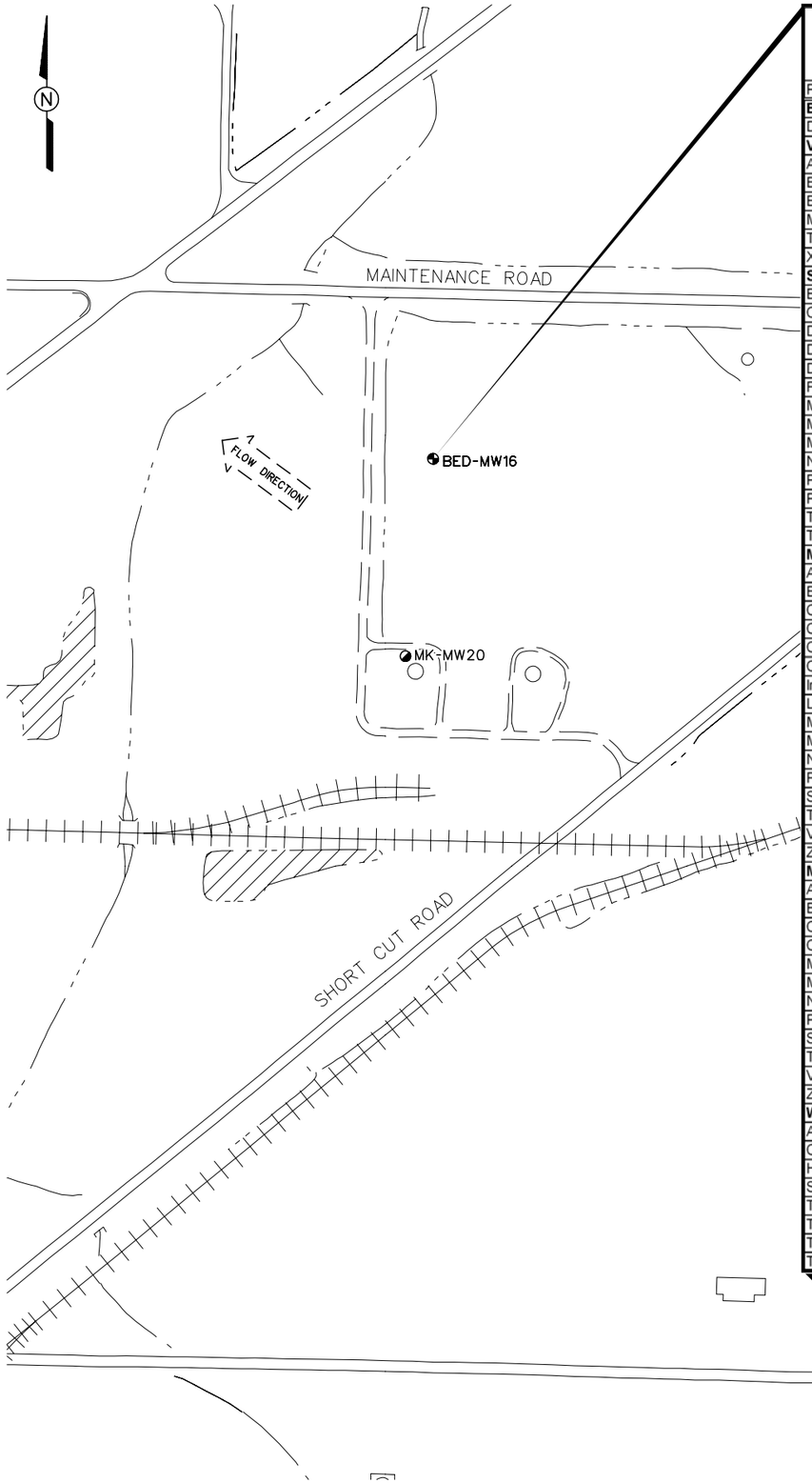

					Location Code:		BED-MW16					
					Sample No:		5920		5925		BD3020		CB3037	
					Sample Date:		24-Nov-97		1-Jun-98		10-Oct-01		11-Apr-02	
					Low-Flow Sampled:		No		No		No		No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives												
Dinitrotoluene, 2,6-	ug/L	0.099	NE	11	-	-	-	-	-	-	11	
Volatiles												
Acetone	ug/L	548	NE	930	-	-	-	-	930	J	60	J
Benzene	ug/L	0.35	2.4	800	**490**		**450**	J	**800**	J	**150**	J
Ethylbenzene	ug/L	134	0.87	200	**130**		**140**	J	**200**	J	**40**	J
Methylene chloride	ug/L	4.3	NE	52	8.8	B	100	B	52	J	11	J
Toluene	ug/L	72	1.7	590	**390**		**350**	J	**590**	J	**150**	J
Xylenes, total	ug/L	21	5.5	1500	**1,100**		**1,000**	J	**1,500**		**610**	
Semivolatiles												
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	920	920	J	4.9	B	2.4	J	2.1	J
Chrysene	ug/L	9.2	NE	0.87	-	-	-	-	0.87	J	-	-
Dibenzofuran	ug/L	1.2	NE	1.2	-	-	-	-	1.2	J	-	-
Dichlorobenzene, 1,3-	ug/L	18.3	NE	4.4	-	-	4.4	J	-	-	-	-
Dimethylphenol, 2,4-	ug/L	73	NE	13	-	-	-	-	3	J	13	
Fluorene	ug/L	24.3	NE	2.8	-	-	-	-	2.8	J	1.8	J
Methylnaphthalene, 2-	ug/L	12	NE	64	-	-	-	-	64		24	
Methylphenol, 2-	ug/L	182	NE	1.6	-	-	-	-	1.6	J	0.88	J
Methylphenol, 4-	ug/L	18	NE	1.7	-	-	-	-	1.7	J	-	-
Naphthalene	ug/L	0.62	NE	52	-	-	-	-	52		5	J
Phenanthrene	ug/L	18	NE	5.1	-	-	-	-	5.1	J	2.6	J
Phenol	ug/L	1,095	NE	4.6	-	-	-	-	4.6	J	1	J
Trichlorobenzene, 1,2,4-	ug/L	0.72	NE	1.6	-	-	1.6	J	-	-	-	-
Trichlorophenol, 2,4,5-	ug/L	365	NE	35	-	-	35		-	-	-	-
Metals - Unfiltered												
Aluminum	ug/L	3,650	309	11000	**502**	J	**11,000**		36.2	B	85.3	B
Barium	ug/L	255	11,800	612	463		612		147	J	19.2	J
Calcium	ug/L	NE	316,000	2880000	**875,000**	J	**2,880,000**		**645,000**	J	**318,000**	
Chromium	ug/L	11	NE	105	24.4		105		-	-	-	-
Cobalt	ug/L	73	12.1	2.4	-	-	-	-	2.4	J	-	-
Copper	ug/L	146	19.8	84.9	-	-	**84.9**		-	-	-	-
Iron	ug/L	1,095	1,550	45900	1,140		**45,900**		73.2	J	-	-
Lead	ug/L	15	NE	40.4	-	-	40.4		-	-	-	-
Magnesium	ug/L	NE	217,000	105000	6,190		105,000		303	J	31,700	
Manganese	ug/L	88	636	2200	133		**2,200**		2.9	J	17	
Nickel	ug/L	73	8.6	54.7	-	-	**54.7**		**10.8**	J	3.2	J
Potassium	ug/L	NE	116,000	26400	26,400		22,800		18,600	J	4,420	J
Sodium	ug/L	NE	1,390,000	88200	73,200	J	46,600		88,200	J	30,100	
Thallium	ug/L	0.24	NE	101	-	-	101		-	-	5.9	B
Vanadium	ug/L	3.7	NE	126	64.7		126		-	-	-	-
Zinc	ug/L	1,095	507	235	30		235		-	-	-	-
Metals - Filtered												
Aluminum	ug/L	3,650	309	NA	-	-	-	-	55.2	B	61.4	B
Barium	ug/L	255	11,800	523	389		523		143	J	18.4	J
Calcium	ug/L	NE	316,000	949000	**915,000**		**949,000**		**644,000**	J	**330,000**	
Chromium	ug/L	11	NE	14.8	13.6		14.8		-	-	-	-
Magnesium	ug/L	NE	217,000	32000	-	-	-	-	43.9	B	32,000	
Manganese	ug/L	88	636	6.8	-	-	-	-	-	-	6.8	J
Nickel	ug/L	73	8.6	10.2	-	-	-	-	**10.2**	J	-	-
Potassium	ug/L	NE	116,000	24900	24,900		23,500		17,800	J	4,700	J
Sodium	ug/L	NE	1,390,000	85600	68,600		57,200		85,600	J	31,700	
Thallium	ug/L	0.24	NE	53.1	-	-	53.1		6.4	B	6.2	B
Vanadium	ug/L	3.7	NE	58.3	58.3		50.6		-	-	-	-
Zinc	ug/L	1,095	507	365	-	-	-	-	4.2	J	365	
Water Quality												
Alkalinity	ug/L	NE	NE	1700000	1,600,000		1,700,000		1,060,000	J		
Chloride	ug/L	NE	NE	370000	88,000		140,000		370,000		75,900	
Hardness	ug/L	NE	NE	5300000	5,300,000		2,000,000		1,650,000		700,000	
Sulfate	ug/L	NE	NE	734000	150,000		37,000		212,000		734,000	
Total dissolved solids	ug/L	NE	NE	6400000	6,400,000		4,000,000		1,950,000		1,450,000	
Total organic carbon	ug/L	NE	NE	14000	8,400		14,000		6,800		5,500	
Total suspended solids	ug/L	NE	NE	330000	7,000		330,000		12,000		14,000	
Turbidity	NTU	NE	NE	8					3.6		8	

LEGEND:

MK-MW20	OVERBURDEN/SHALE MONITORING WELL LOCATION
BED-MW16	BEDROCK MONITORING WELL LOCATION
	BUILDINGS
	RAILROAD
	SURFACE WATER
	DITCH
FLOW DIRECTION	BEDROCK GROUNDWATER FLOW DIRECTION (AUGUST 2004)
ug/L	MICROGRAMS PER LITER
nv	NON VALIDATED
NA	NOT APPLICABLE, ONLY B QUALIFIED DATA DETECTED
NE	NOT ESTABLISHED (RBSCs), NOT EVALUATED (BSCs)
NTU	NEPHELOMETRIC TUBIDITY UNIT

NOTES:

1. SHADED CELL INDICATES VALUE IS GREATER THAN RBSC.
2. BOLD TEXT INDICATES VALUE IS GREATER THAN BSC.
3. RBSC VALUES REFLECT AN INCREMENTAL LIFETIME CANCER RISK (ILCR) OF 1E-6 OR A NONCANCER HAZARD QUOTIENT (HQ) OF 0.1. FOR CHEMICALS THAT EXHIBIT BOTH CANCER AND NONCANCER EFFECTS, WHICHEVER TYPE OF EFFECT IN A LOWER CONCENTRATION (USING AN ILCR OF 1E-6 AND AN HQ OF 0.1), THAT CONCENTRATION IS SELECTED AS THE RBSC.
4. BSC IS BACKGROUND SCREENING CONCENTRATION.
5. MDC IS MAXIMUM DETECTED CONCENTRATION FOR THE AOC ("B" QUALIFIED DATA NOT INCLUDED).
6. VALIDATION QUALIFIERS (VQ)
   - B - THE ANALYTE WAS NOT DETECTED SIGNIFICANTLY ABOVE THE LEVELS FOUND IN THE ASSOCIATED METHOD BLANK.
   - J - THE COMPOUND/ANALYTE WAS POSITIVELY IDENTIFIED; THE REPORTED VALUE IS AN ESTIMATED CONCENTRATION.

FIGURE 7-12

DETECTED CONSTITUENTS AT UPPER TOLUENE TANKS AREA ABOVE RBSCs AND/OR BSCs IN BEDROCK GROUNDWATER (NOVEMBER 1997 THROUGH APRIL 2002)

2004 GROUNDWATER DATA SUMMARY AND EVALUATION REPORT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw™ Shaw Environmental, Inc.

DWG. NO.: 843656_043.dgn | PROJ. NO.: 833886
INITIATOR: D. KESSLER | PROJ. MGR.: S. DOWNEY
DRAFT. CHCK. BY: C.BENTLEY | ENGR. CHCK. BY: D. KESSLER
DATE LAST REV.: | DRAWN BY:
STARTING DATE: 02DEC04 | DRAWN BY: C.E.TUMLIN
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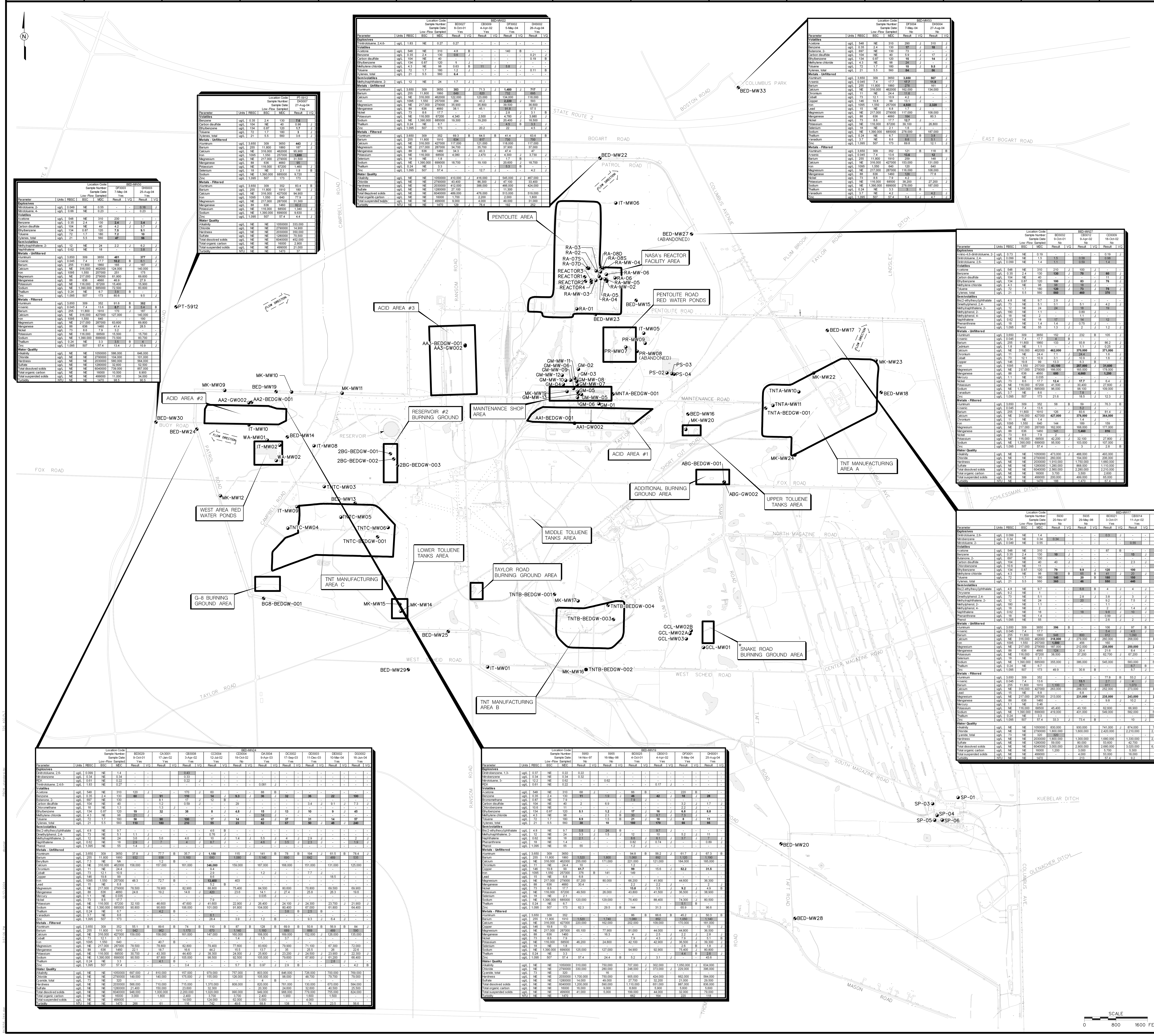


				Location Code:	BED-MW30			
				Sample Number:	DF3003		DH3003	
				Sample Date:	7-May-04		25-Aug-04	
				Low-Flow Sampled:	Yes		Yes	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ
Explosives								
Nitrotoluene, 2-	ug/L	0.049	NE	0.55	-	-	0.16	J
Nitrotoluene, 4-	ug/L	0.66	NE	0.23	-	-	0.23	
Volatiles								
Acetone	ug/L	548	NE	310	230		-	-
Benzene	ug/L	0.35	2.4	130	**2.4**	J	**3.4**	J
Carbon disulfide	ug/L	104	NE	40	4.2	J	3.7	J
Ethylbenzene	ug/L	134	0.87	120	**7.5**		**9.1**	
Toluene	ug/L	72	1.7	180	**7.2**		**10**	
Xylenes, total	ug/L	21	5.5	560	**47**		**56**	
Semivolatiles								
Methylnaphthalene, 2-	ug/L	12	NE	24	2.2	J	6.2	J
Naphthalene	ug/L	0.62	NE	18	-	-	3.8	J
Metals - Unfiltered								
Aluminum	ug/L	3,650	309	3650	**481**		**377**	J
Arsenic	ug/L	0.045	7.4	17.7	**10.2**	B	6.1	J
Barium	ug/L	255	11,800	1860	165	J	187	J
Calcium	ug/L	NE	316,000	462000	124,000		140,000	
Iron	ug/L	1095	1,550	257000	251		175	
Magnesium	ug/L	NE	217,000	279000	61,900		69,600	
Manganese	ug/L	88	636	4660	46.9		27.9	
Potassium	ug/L	NE	116,000	67200	15,400		15,900	
Sodium	ug/L	NE	1,390,000	685000	72,500		83,600	
Thallium	ug/L	0.24	NE	6.7	3.9	B	-	-
Zinc	ug/L	1,095	507	173	80.6		9.5	J
Metals - Filtered								
Aluminum	ug/L	3,650	309	352	91.6	B	**352**	
Arsenic	ug/L	0.045	7.4	13.6	**8.7**	B	5.4	B
Barium	ug/L	255	11,800	1910	170	J	187	J
Calcium	ug/L	NE	316,000	427000	127,000		140,000	
Iron	ug/L	1095	1,550	640	-	-	190	
Magnesium	ug/L	NE	217,000	287000	63,600		69,800	
Manganese	ug/L	88	636	1460	41.4		28.5	
Nickel	ug/L	73	8.6	7.9	3.2	J	-	-
Potassium	ug/L	NE	116,000	68500	15,500		15,700	J
Sodium	ug/L	NE	1,390,000	699000	73,500		83,700	
Thallium	ug/L	0.24	NE	3.3	3.5	B	4	J
Zinc	ug/L	1,095	507	57.4	13.4	J	10.9	J
Water Quality								
Alkalinity	ug/L	NE	NE	1050000	586,000		646,000	
Chloride	ug/L	NE	NE	2790000	104,000		101,000	
Hardness	ug/L	NE	NE	2030000	580,000		564,000	
Sulfate	ug/L	NE	NE	1280000	32,600		52,500	
Total dissolved solids	ug/L	NE	NE	6040000	739,000		857,000	
Total organic carbon	ug/L	NE	NE	16000	10,500		8,900	
Total suspended solids	ug/L	NE	NE	499000	11,000		34,000	
Turbidity	NTU	NE	NE	1470	98.5		90.5	

				Location Code:	PT-5912	
				Sample Number:	DH3007	
				Sample Date:	27-Aug-04	
				Low-Flow Sampled:	Yes	
Parameter	Units	RBSC	BSC	MDC	Result	VQ
Volatiles						
Benzene	ug/L	0.35	2.4	130	**7.6**	
Carbon disulfide	ug/L	104	NE	40	0.96	J
Ethylbenzene	ug/L	134	0.87	120	**1.7**	J
Toluene	ug/L	72	1.7	180	**3**	J
Xylenes, total	ug/L	21	5.5	560	3.6	J
Metals - Unfiltered						
Aluminum	ug/L	3,650	309	3650	**443**	J
Barium	ug/L	255	11,800	1860	187	J
Calcium	ug/L	NE	316,000	462000	95,900	
Iron	ug/L	1095	1,550	257000	**1,680**	
Magnesium	ug/L	NE	217,000	279000	31,500	
Manganese	ug/L	88	636	4660	95	
Potassium	ug/L	NE	116,000	67200	1,460	J
Selenium	ug/L	18	NE	2.1	1.8	B
Sodium	ug/L	NE	1,390,000	685000	9,720	
Zinc	ug/L	1,095	507	173	173	
Metals - Filtered						
Aluminum	ug/L	3,650	309	352	83.4	B
Barium	ug/L	255	11,800	1910	180	J
Calcium	ug/L	NE	316,000	427000	94,900	
Iron	ug/L	1095	1,550	640	77.9	J
Magnesium	ug/L	NE	217,000	287000	31,300	
Manganese	ug/L	88	636	1460	92.2	
Potassium	ug/L	NE	116,000	68500	1,340	J
Sodium	ug/L	NE	1,390,000	699000	9,630	
Zinc	ug/L	1,095	507	57.4	4.4	J
Water Quality						
Alkalinity	ug/L	NE	NE	1050000	333,000	
Chloride	ug/L	NE	NE	2790000	14,900	
Hardness	ug/L	NE	NE	2030000	350,000	
Sulfate	ug/L	NE	NE	1280000	70,500	
Total dissolved solids	ug/L	NE	NE	6040000	452,000	
Total organic carbon	ug/L	NE	NE	16000	2,900	
Total suspended solids	ug/L	NE	NE	499000	21,000	
Turbidity	NTU	NE	NE	1470	37	

				Location Code:	BED-MW22							
				Sample Number:	BD3027		CB3009		DF3002		DH3002	
				Sample Date:	8-Oct-01		4-Apr-02		5-May-04		26-Aug-04	
				Low-Flow Sampled:	Yes		Yes		Yes		Yes	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives												
Trinitrotoluene, 2,4,6-	ug/L	1.83	NE	0.27	0.27		-	-	-	-	-	-
Volatiles												
Acetone	ug/L	548	NE	310	4.8	B	-	-	140	B	-	-
Benzene	ug/L	0.35	2.4	130	0.6	J	-	-	-	-	0.21	J
Carbon disulfide	ug/L	104	NE	40	-	-	-	-	-	-	0.19	B
Ethylbenzene	ug/L	134	0.87	120	**1**	J	-	-	-	-	-	-
Methylene chloride	ug/L	4.3	NE	98	0.63	B	11	J	5.8	J	-	-
Toluene	ug/L	72	1.7	180	1.2	J	-	-	-	-	0.11	B
Xylenes, total	ug/L	21	5.5	560	**6.4**		-	-	-	-	-	-
Semivolatiles												
Methylnaphthalene, 2-	ug/L	12	NE	24	1.7	J	-	-	-	-	-	-
Metals - Unfiltered												
Aluminum	ug/L	3,650	309	3650	**353**	J	71.3	J	**1,480**	J	**717**	J
Barium	ug/L	255	11,800	1860	649		620		732		695	
Calcium	ug/L	NE	316,000	462000	122,000		123,000		134,000		118,000	
Iron	ug/L	1095	1,550	257000	284		43.2	J	**2,220**	J	593	
Magnesium	ug/L	NE	217,000	279000	35,900		35,800		39,500		36,600	
Manganese	ug/L	88	636	4660	38.1		45.1		91.8		57.5	
Nickel	ug/L	73	8.6	17.7	-	-	-	-	2.8	J	3.1	B
Potassium	ug/L	NE	116,000	67200	4,340	J	2,500	J	4,780	J	3,980	J
Sodium	ug/L	NE	1,390,000	685000	19,300		19,200		20,400	J	18,500	
Thallium	ug/L	0.24	NE	6.7	-	-	-	-	4.5	B	3.3	J
Zinc	ug/L	1,095	507	173	-	-	20.2		22		4.5	J
Metals - Filtered												
Aluminum	ug/L	3,650	309	352	69.3	B	64.5	B	41.4	J	63.6	B
Barium	ug/L	255	11,800	1910	634		617		730		700	
Calcium	ug/L	NE	316,000	427000	117,000		121,000		118,000		117,000	
Magnesium	ug/L	NE	217,000	287000	34,700		35,700		37,900		37,000	
Manganese	ug/L	88	636	1460	34.3		43.3		47.4		47	
Potassium	ug/L	NE	116,000	68500	4,080	J	2,470	J	4,300	J	3,730	J
Selenium	ug/L	18	NE	1.8	-	-	-	-	1.7	B	-	-
Sodium	ug/L	NE	1,390,000	699000	18,700		19,100		20,600	J	18,700	
Thallium	ug/L	0.24	NE	3.3	-	-	-	-	5.3	B	-	-
Zinc	ug/L	1,095	507	57.4	-	-	12.7	J	-	-	4.2	J
Water Quality												
Alkalinity	ug/L	NE	NE	1050000	410,000	J	416,000		545,000	J	467,000	
Chloride	ug/L	NE	NE	2790000	43,400		86,300	J	47,100		33,400	
Hardness	ug/L	NE	NE	2030000	412,000		388,000		466,000		424,000	
Sulfate	ug/L	NE	NE	1280000	27,100		-	-	11,300		-	-
Total dissolved solids	ug/L	NE	NE	6040000	489,000		476,000		513,000		519,000	
Total organic carbon	ug/L	NE	NE	16000	1,700		2,200		2,000		1,800	
Total suspended solids	ug/L	NE	NE	499000	9,000		4,000		49,000		31,000	
Turbidity	NTU	NE	NE	1470	129	J	76.4		192		252	

				Location Code:	BED-MW33			
				Sample Number:	DF3004		DH3004	
				Sample Date:	7-May-04		27-Aug-04	
				Low-Flow Sampled:	No		No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ
Volatiles								
Acetone	ug/L	548	NE	310	290	J	310	J
Benzene	ug/L	0.35	2.4	130	**17**	J	**18**	J
Butanone, 2-	ug/L	697	NE	130	73	J	-	-
Carbon disulfide	ug/L	104	NE	40	5.9	J	17	J
Ethylbenzene	ug/L	134	0.87	120	**15**	J	**14**	J
Methylene chloride	ug/L	4.3	NE	98	24	J	-	-
Toluene	ug/L	72	1.7	180	**15**	J	**9.5**	J
Xylenes, total	ug/L	21	5.5	560	**84**		**56**	
Metals - Unfiltered								
Aluminum	ug/L	3,650	309	3650	**3,650**		**567**	J
Arsenic	ug/L	0.045	7.4	17.7	**17.7**		**11.9**	
Barium	ug/L	255	11,800	1860	278		161	J
Calcium	ug/L	NE	316,000	462000	162,000		134,000	
Chromium	ug/L	11	NE	24.4	11.6		-	-
Cobalt	ug/L	73	12.1	10.9	4.2	J	-	-
Copper	ug/L	146	19.8	99	13.1	J	-	-
Iron	ug/L	1095	1,550	257000	**4,920**		**2,320**	
Lead	ug/L	15	NE	6.8	1.7	J	-	-
Magnesium	ug/L	NE	217,000	279000	117,000		108,000	
Manganese	ug/L	88	636	4660	164		80.3	
Nickel	ug/L	73	8.6	17.7	**12.7**	J	-	-
Potassium	ug/L	NE	116,000	67200	39,100		26,800	
Selenium	ug/L	18	NE	2.1	1.6	J	-	-
Sodium	ug/L	NE	1,390,000	685000	278,000		187,000	
Thallium	ug/L	0.24	NE	6.7	3	B	3.8	J
Vanadium	ug/L	3.7	NE	8.6	8.6	J	5.1	J
Zinc	ug/L	1,095	507	173	69.8		12.1	J
Metals - Filtered								
Aluminum	ug/L	3,650	309	352	121	B	118	B
Arsenic	ug/L	0.045	7.4	13.6	**13.6**		**12**	
Barium	ug/L	255	11,800	1910	259		148	J
Calcium	ug/L	NE	316,000	427000	153,000		131,000	
Iron	ug/L	1095	1,550	640	120		640	
Magnesium	ug/L	NE	217,000	287000	116,000		108,000	
Manganese	ug/L	88	636	1460	129		77.8	
Nickel	ug/L	73	8.6	7.9	4.2	J	-	-
Potassium	ug/L	NE	116,000	68500	38,200		27,200	J
Sodium	ug/L	NE	1,390,000	699000	278,000		187,000	
Thallium	ug/L	0.24	NE	3.3	3	B	-	-
Vanadium	ug/L	3.7	NE	4.2	-	-	4.2	J
Zinc	ug/L	1,095	507	57.4	5.4	J	4.7	J

				Location Code:	BED-MW27					
				Sample Number:	BD3032		CB3012		CD3009	
				Sample Date:	9-Oct-01		9-Apr-02		18-Oct-02	
				Low-Flow Sampled:	No		No		No	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ
Explosives										
Amino-4,6-dinitrotoluene, 2-	ug/L	0.73	NE	0.19	-	-	-	-	0.19	J
Dinitrotoluene, 2,4-	ug/L	0.099	NE	1.5	1.5		0.58		0.98	
Dinitrotoluene, 2,6-	ug/L	0.099	NE	1.4	1.1		0.59		1.4	
Volatiles										
Acetone	ug/L	548	NE	310	210	J	100	J	-	-
Benzene	ug/L	0.35	2.4	130	**130**	J	**70**	J	**60**	J
Carbon disulfide	ug/L	104	NE	40	-	-	-	-	11	J
Ethylbenzene	ug/L	134	0.87	120	**100**	J	**83**	J	**76**	J
Methylene chloride	ug/L	4.3	NE	98	98	J	18	J	-	-
Toluene	ug/L	72	1.7	180	**120**	J	**73**	J	**75**	J
Xylenes, total	ug/L	21	5.5	560	**560**		**460**		**370**	
Semivolatiles										
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	9.7	2.9	J	-	-	-	-
Dimethylphenol, 2,4-	ug/L	73	NE	5.1	3.1	J	5.1	J	4.2	J
Methylnaphthalene, 2-	ug/L	12	NE	24	24		18		19	
Methylphenol, 2-	ug/L	180	NE	1.1	-	-	0.89	J	-	-
Methylphenol, 4-	ug/L	18	NE	2	-	-	1.1	J	-	-
Naphthalene	ug/L	0.62	NE	18	17		14		12	
Phenanthrene	ug/L	18	NE	1.4	1.4	J	0.75	J	-	-
Phenol	ug/L	1,095	NE	55	1.3	J	2	J	1.2	J
Metals - Unfiltered										
Aluminum	ug/L	3,650	309	3650	152	J	232	B	105	J
Arsenic	ug/L	0.045	7.4	17.7	4	B	-	-	-	-
Barium	ug/L	255	11,800	1860	133	J	93.8	J	86.2	J
Cadmium	ug/L	1.8	NE	1.1	-	-	1.1	J	0.25	J
Calcium	ug/L	NE	316,000	462000	**462,000**		**370,000**		**371,000**	
Chromium	ug/L	11	NE	24.4	7.1	J	24.4		1.6	J
Cobalt	ug/L	73	12.1	10.9	3.1	J	10.9	J	1.6	J
Copper	ug/L	146	19.8	99	13.3	J	6.3	B	-	-
Iron	ug/L	1095	1,550	257000	**43,100**		**257,000**	J	**31,600**	
Magnesium	ug/L	NE	217,000	279000	166,000		165,000		178,000	
Manganese	ug/L	88	636	4660	**680**		**4,660**		**1,250**	
Mercury	ug/L	1.1	NE	0.035	-	-	-	-	-	-
Nickel	ug/L	73	8.6	17.7	**12.4**	J	**17.7**	J	6.4	J
Potassium	ug/L	NE	116,000	67200	41,500		30,400		27,600	J
Sodium	ug/L	NE	1,390,000	685000	96,000		98,100		109,000	
Vanadium	ug/L	3.7	NE	8.6	-	-	7.8	J	-	-
Zinc	ug/L	1,095	507	173	21.6		18.5	J	12.3	J
Metals - Filtered										
Aluminum	ug/L	3,650	309	352	58	B	59	J	76.3	B
Arsenic	ug/L	0.045	7.4	13.6	-	-	5.2	J	-	-
Barium	ug/L	255	11,800	1910	126	J	83.6	J	81.4	J
Calcium	ug/L	NE	316,000	427000	**427,000**		**378,000**		**364,000**	
Chromium	ug/L	11	NE	1.4	-	-	1.4	J	-	-
Iron	ug/L	1095	1,550	640	144		189	J	159	
Magnesium	ug/L	NE	217,000	287000	162,000		168,000		177,000	
Manganese	ug/L	88	636	1460	141		**1,460**		**816**	
Nickel	ug/L	73	8.6	7.9	2	J	-	-	-	-
Potassium	ug/L	NE	116,000	68500	42,200	J	32,100		27,800	J
Sodium	ug/L	NE	1,390,000	699000	95,500		103,000		107,000	
Zinc	ug/L	1,095	507	57.4	-	-	3	J	2.8	B
Water Quality										
Alkalinity	ug/L	NE	NE	1050000	473,000	J	488,000		493,000	
Chloride	ug/L	NE	NE	2790000	260,000		194,000		206,000	
Hardness	ug/L	NE	NE	2030000	1,910,000		1,750,000		1,660,000	
Sulfate	ug/L	NE	NE	1280000	1,280,000		868,000		1,110,000	
Total dissolved solids	ug/L	NE	NE	6040000	2,560,000		2,280,000		2,210,000	
Total organic carbon	ug/L	NE	NE	16000	3,700		3,500		2,600	
Total suspended solids	ug/L	NE	NE	499000	200,000		499,000		65,000	
Turbidity	NTU	NE	NE	1470	188		1,470		67.4	

				Location Code:	BED-MW17											
				Sample Number:	5930		5935		BD3021		CB3014		DF3000		DH3000	
				Sample Date:	20-Nov-97		29-May-98		3-Oct-01		11-Apr-02		6-May-04		26-Aug-04	
				Low-Flow Sampled:	No		No		Yes		Yes		Yes		Yes	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																
Dinitrotoluene, 2,6-	ug/L	0.099	NE	1.4	-	-	-	-	0.3	J	-	-	-	-	-	-
Nitrobenzene	ug/L	0.34	NE	0.34	0.34		-	-	-	-	-	-	-	-	-	-
Nitrotoluene, 2-	ug/L	0.049	NE	0.55	-	-	-	-	-	-	0.55		-	-	-	-
Volatiles																
Acetone	ug/L	548	NE	310	-	-	-	-	87	B	-	-	1,300	B	-	-
Benzene	ug/L	0.35	2.4	130	**10**	J	-	-	-	-	**13**	J	**15**	J	**13**	J
Butanone, 2-	ug/L	697	NE	130	-	-	-	-	-	-	-	-	130	J	-	-
Carbon disulfide	ug/L	104	NE	40	40	J	-	-	-	-	2.3	J	-	-	8.9	J
Chlorobenzene	ug/L	10.6	NE	11	-	-	-	-	-	-	-	-	11	J	-	-
Ethylbenzene	ug/L	134	0.87	120	**79**		**9.9**	J	**120**		**100**		**86**	J	**62**	
Methylene chloride	ug/L	4.3	NE	98	18	B	65	B	41	J	20	J	34	J	-	-
Toluene	ug/L	72	1.7	180	**140**		**20**	B	**180**		**150**		**120**		**98**	
Xylenes, total	ug/L	21	5.5	560	**360**		**46**		**550**		**440**		**390**		**280**	
Semivolatiles																
Bis(2-ethylhexyl)phthalate	ug/L	4.8	NE	9.7	-	-	6.8	B	4	J	4	J	2.3	J	-	-
Chrysene	ug/L	9.2	NE	1	-	-	-	-	-	-	-	-	1	J	-	-
Dimethylphenol, 2,4-	ug/L	73	NE	5.1	-	-	2.8	J	3.8	J	3	J	-	-	-	-
Methylnaphthalene, 2-	ug/L	12	NE	24	-	-	20		9.2	J	7.5	J	7.7	J	12	
Methylphenol, 2-	ug/L	180	NE	1.1	-	-	-	-	1.1	J	-	-	-	-	-	-
Methylphenol, 4-	ug/L	18	NE	2	-	-	-	-	2	J	1.4	J	-	-	-	-
Naphthalene	ug/L	0.62	NE	18	-	-	18		9.8	J	10	J	8	J	13	
Phenanthrene	ug/L	18	NE	1.4	-	-	-	-	0.99	J	-	-	0.85	J	1.2	J
Phenol	ug/L	1,095	NE	55	-	-	-	-	2.6	J	2	J	2.2	J	2.6	J
Metals - Unfiltered																
Aluminum	ug/L	3,650	309	3650	**396**	B	-	-	106	J	97	B	122	J	136	B
Arsenic	ug/L	0.045	7.4	17.7	-	-	-	-	5.4	J	4.5	J	4	B	-	-
Barium	ug/L	255	11,800	1860	948		800		912		1,090		1,860		1,790	
Calcium	ug/L	NE	316,000	462000	**318,000**	J	279,000	J	260,000		268,000		**316,000**		312,000	
Iron	ug/L	1095	1,550	257000	**1,580**		456		160		-	-	-	-	-	-
Magnesium	ug/L	NE	217,000	279000	187,000		212,000		**230,000**		**250,000**		**277,000**		**279,000**	
Manganese	ug/L	88	636	4660	124		20.4		21.6		8.4	J	4.7	B	6.3	J
Potassium	ug/L	NE	116,000	67200	38,500		37,200		62,700	J	67,200		64,400	J	67,000	
Selenium	ug/L	18	NE	2.1	-	-	-	-	-	-	-	-	-	-	2.1	B
Sodium	ug/L	NE	1,390,000	685000	355,000	j	386,000		545,000		583,000		662,000		685,000	
Thallium	ug/L	0.24	NE	6.7	-	-	-	-	-	-	6.7	B	-	-	-	-
Zinc	ug/L	1,095	507	173	49.9		30.8	B	-	-	5.7	J	24.7	J	11.5	J
Metals - Filtered																
Aluminum	ug/L	3,650	309	352	-	-	-	-	77.8	B	53.2	J	82.4	B	95.3	B
Arsenic	ug/L	0.045	7.4	13.6	-	-	**13.1**		2.7	J	4	J	3.8	B	-	-
Barium	ug/L	255	11,800	1910	1,100		871		911		1,070		1,910		1,810	
Calcium	ug/L	NE	316,000	427000	263,000		289,000	J	252,000		273,000		**326,000**		**316,000**	
Lead	ug/L	15	NE	6.8	-	-	6.8		-	-	-	-	-	-	-	-
Magnesium	ug/L	NE	217,000	287000	213,000		**231,000**	J	**235,000**		**243,000**		**287,000**		**284,000**	
Manganese	ug/L	88	636	1460	-	-	-	-	9.8	J	10.2	J	4.4	B	5	J
Mercury	ug/L	1.1	NE	0.46	-	-	-	-	-	-	-	-	0.46		-	-
Potassium	ug/L	NE	116,000	68500	45,400		43,100		62,600		66,900		66,700	J	68,500	J
Sodium	ug/L	NE	1,390,000	699000	419,000		431,000		549,000		582,000		684,000		699,000	
Thallium	ug/L	0.24	NE	3.3	-	-	-	-	-	-	-	-	2.9	B	3.3	J
Zinc	ug/L	1,095	507	57.4	33.3	J	73.4	B	-	-	10	J	8.1	J	6.1	J
Water Quality																
Alkalinity	ug/L	NE	NE	1050000	830,000		930,000		741,000	J	874,000		789,000		855,000	
Chloride	ug/L	NE	NE	2790000	1,800,000		1,600,000		2,420,000		2,210,000		2,460,000		2,790,000	
Cyanide, total	ug/L	73	NE	320	320		-	-	-	-	-	-	-	-	-	-
Hardness	ug/L	NE	NE	2030000	1,800,000		1,300,000		1,680,000		1,330,000		2,030,000		1,940,000	
Sulfate	ug/L	NE	NE	1280000	59,000		80,000		53,600		42,700		-	-	-	-
Total dissolved solids	ug/L	NE	NE	6040000	3,000,000		2,900,000		2,680,000		3,020,000		6,040,000		4,690,000	
Total organic carbon	ug/L	NE	NE	16000	1,200		3,000		5,700		5,300		6,400		1,000	
Total suspended solids	ug/L	NE	NE	499000	-	-	4,000		53,000		18,000		9,000		22,000	
Turbidity	NTU	NE	NE	1470			213		57.4	J	9.2		6.3		36.4	

Location Code:	BED-MW24	[illegible]
[illegible]	[illegible]	[illegible]

Location Code:	BED-MW16	[illegible]
[illegible]	[illegible]	[illegible]

LEGEND:

- OVERBURDEN/SHALE MONITORING WELL LOCATION
- BEDROCK MONITORING WELL LOCATION
- AREA OF CONCERN
- POND
- CREEK, DITCH, CONVEYANCE
- RAILROAD
- ROAD
- FENCE
- FLOW DIRECTION — BEDROCK GROUNDWATER FLOW DIRECTION (AUGUST 2004)

ug/L — MICROGRAMS PER LITER
nv — NON VALIDATED
NA — NOT APPLICABLE, ONLY B QUALIFIED DATA DETECTED
NE — NOT ESTABLISHED (RBSCs), NOT EVALUATED (BSCs)
NTU — NEPHELOMETRIC TUBIDITY UNIT

NOTES:

1. SHADED CELL INDICATES VALUE IS GREATER THAN RBSC.
2. BOLD TEXT INDICATES VALUE IS GREATER THAN BSC.
3. RBSC VALUES REFLECT AN INCREMENTAL LIFETIME CANCER RISK (ILCR) OF 1E-6 OR A NONCANCER HAZARD QUOTIENT (HQ) OF 0.1. FOR CHEMICALS THAT EXHIBIT BOTH CANCER AND NONCANCER EFFECTS, WHICHEVER TYPE OF EFFECT IN A LOWER CONCENTRATION (USING AN ILCR OF 1E-6 AND AN HQ OF 0.1), THAT CONCENTRATION IS SELECTED AS THE RBSC.
4. BSC IS BACKGROUND SCREENING CONCENTRATION.
5. MDC IS MAXIMUM DETECTED CONCENTRATION FOR THE AOC ("B" QUALIFIED DATA NOT INCLUDED).
6. VALIDATION QUALIFIERS (VQ)
   B - THE ANALYTE WAS NOT DETECTED SIGNIFICANTLY ABOVE THE LEVELS FOUND IN THE ASSOCIATED METHOD BLANK.
   J - THE COMPOUND/ANALYTE WAS POSITIVELY IDENTIFIED; THE REPORTED VALUE IS AN ESTIMATED CONCENTRATION.
7. *SNAKE ROAD BURNING GROUND AREA WAS ALSO REFERRED TO AS "SNAKE ROAD BURN PIT", "SCHEID ROAD BURNING GROUNDS", AND "DISPOSAL AREA THREE".
8. AREAS OF CONCERN NOT SHOWN ARE:
   RESERVOIR #1
   WASTE WATER DISPOSAL PLANT #1
   WASTE WATER DISPOSAL PLANT #2
   POWER HOUSE #2 ASH PIT
9. REACTOR FACILITY CONSTRUCTED BY NASA POST WWII AND IS IDENTIFIED FOR LOCATION PURPOSES ONLY.

SCALE
0 800 1600 FEET

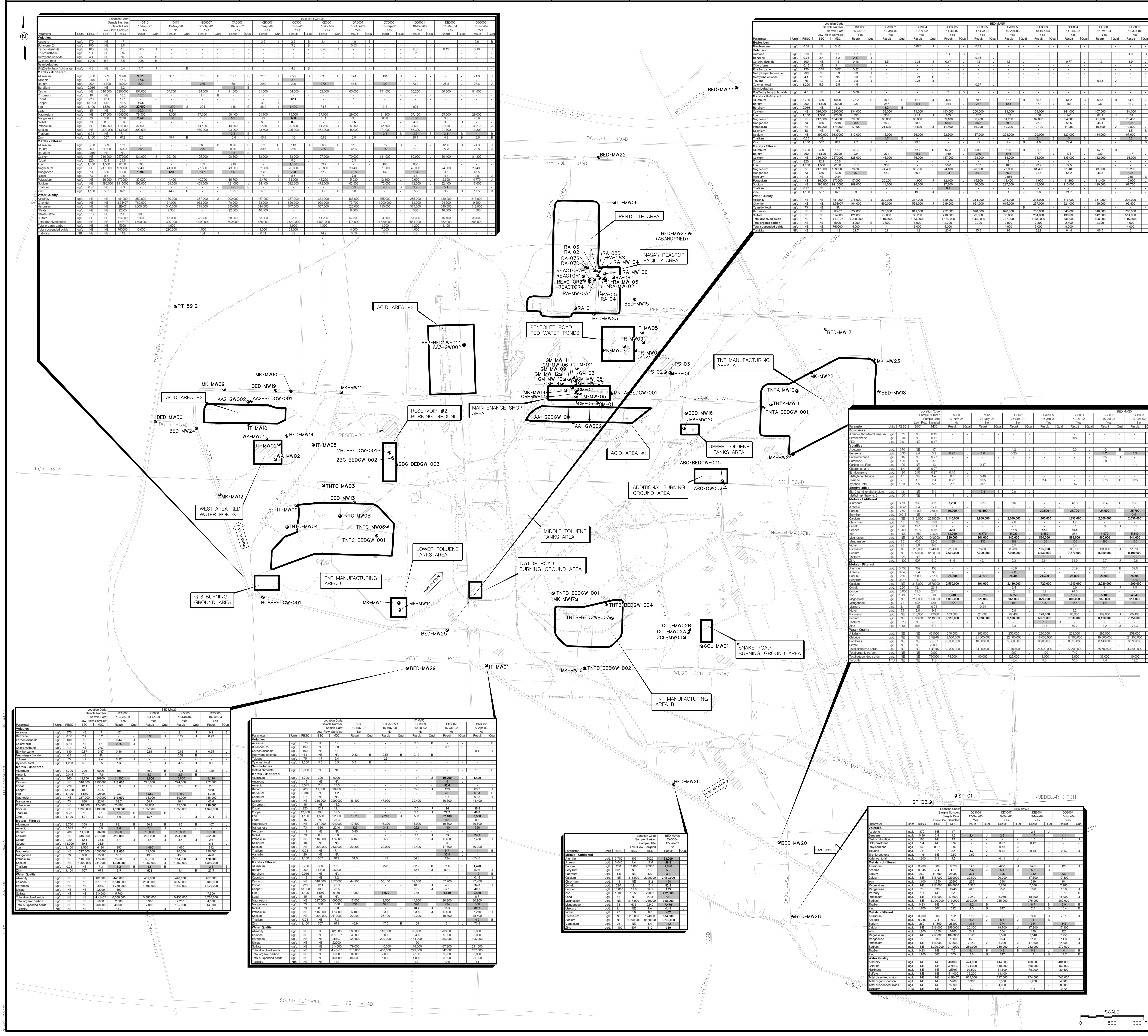
STARTING DATE 02DEC04	INITIATOR D.KESSLER	CHKD KESSLER	DRAWN D.HALL	CHKD	PROJECT MNGR S.DOWNEY

Shaw Environmental, Inc.
KNOXVILLE, TENNESSEE

2004 GROUNDWATER DATA SUMMARY AND EVALUATION REPORT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

FIGURE 7-13
DETECTED CONSTITUENTS AT DOWNGRADIENT AREAS ABOVE RBSCs AND/OR BSCs IN BEDROCK GROUNDWATER (NOVEMBER 1997 THROUGH APRIL 2002)

AREA	JOB NO.	DRAWING NO.	REV
SITEWIDE	843656	843656_044.DGN	



LEGEND:

- OVERBURDEN/SHALE MONITORING WELL LOCATION
- BEDROCK MONITORING WELL LOCATION
- AREA OF CONCERN
- POND
- CREEK, DITCH, CONVEYANCE
- RAILROAD
- ROAD
- FENCE
- FLOW DIRECTION — OVERBURDEN/SHALE GROUNDWATER FLOW DIRECTION (AUGUST 2004)

ug/L	MICROGRAMS PER LITER
nv	NON VALIDATED
NA	NOT APPLICABLE, ONLY B QUALIFIED DATA DETECTED
NE	NOT ESTABLISHED (RBSCs), NOT EVALUATED (BSCs)
NTU	NEPHELOMETRIC TUBIDITY UNIT

NOTES:

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2. BOLD TEXT INDICATES VALUE IS GREATER THAN BSC.
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4. BSC IS BACKGROUND SCREENING CONCENTRATION.
5. MDC IS MAXIMUM DETECTED CONCENTRATION FOR THE AOC ("B" QUALIFIED DATA NOT INCLUDED).
6. VALIDATION QUALIFIERS (VQ)
   - B - THE ANALYTE WAS NOT DETECTED SIGNIFICANTLY ABOVE THE LEVELS FOUND IN THE ASSOCIATED METHOD BLANK.
   - J - THE COMPOUND/ANALYTE WAS POSITIVELY IDENTIFIED; THE REPORTED VALUE IS AN ESTIMATED CONCENTRATION.
7. *SNAKE ROAD BURNING GROUND AREA WAS ALSO REFERRED TO AS "SNAKE ROAD BURN PIT", "SCHEID ROAD BURNING GROUNDS", AND "DISPOSAL AREA THREE".
8. AREAS OF CONCERN NOT SHOWN ARE:

   RESERVOIR #1
   WASTE WATER DISPOSAL PLANT #1
   WASTE WATER DISPOSAL PLANT #2
   POWER HOUSE #2 ASH PIT
9. REACTOR FACILITY CONSTRUCTED BY NASA POST WWII AND IS IDENTIFIED FOR LOCATION PURPOSES ONLY.

STARTING DATE 05/07/99	INITIATOR D.KESSLER	CHKD KESSLER	DRAWN D.HALL	CHKD	PROJECT MNGR S.DOWNEY

Shaw™ Shaw Environmental, Inc.
KNOXVILLE, TENNESSEE

2004 GROUNDWATER DATA SUMMARY AND EVALUATION REPORT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

FIGURE 7-14
DETECTED CONSTITUENTS AT BACKGROUND AREAS IN OVERBURDEN/SHALE GROUNDWATER (NOVEMBER 1997 THROUGH APRIL 2002)

AREA	JOB NO.	DRAWING NO.	REV
SITEWIDE	843656	843656_045.DGN	

2004 Groundwater Data Summary and Evaluation Report

Former Plum Brook Ordnance Works Sandusky, Ohio

Volume 1, Part 2 of 2

Appendices

Prepared for:

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Prepared by:

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Knoxville, Tennessee 37923

Shaw Project No. 843656

Revision 1

April 2005

List of Appendices

Appendix A – Groundwater Sample Collection Logs
Appendix B – Soil Boring and Monitoring Well HTRW Drill Logs/Well Construction Diagrams
Appendix C – Photographs
Appendix D – Well Development Logs
Appendix E – Hydraulic Conductivity Data
Appendix F – Land Survey Data
Appendix G - IDW Waste Manifests (August 2003 – August 2004)
Appendix H – Data Validation Summaries
Appendix I – Chemical Analytical Data Summary
Appendix J – Detected Hits Summary Excluding "B" Qualifiers
Appendix K – Data Quality Evaluations
Appendix L - Chains-of-Custody
Appendix M – Methods Related to the Evaluation of Background
Appendix N – Teleconference Notes on BTEX in Quarry/E-Mail Message on Active Oil/Gas Field
Appendix O – Recharge Calculations
Appendix P – Comments and Responses

APPENDIX A

GROUNDWATER SAMPLE COLLECTION LOGS

2002 DOWNGRADIENT WELL BED-MW27 GROUNDWATER SAMPLING

(PRIOR TO ABANDONMENT)

INTERNATIONAL TECHNOLOGY CORPORATION

Sample Collection Log

Project: 833886 PLUM BROOK ORDNANCE WK

Manager: Steve Downey

PB10 1802 STL N

RFA / COC Number: PB10 1802 STL K

Location Code: **PB-BED-MW27**
Sample Number: **CD3009**
Sample Name: **PBOW-02-GW-PB-BED-MW27-CD3009**
Sampling Method: **LF**
Sample Type: **GW** *Sample Purpose:* **REG**

Collection Date: 10/18/02
Collection Time: 0820
Start Depth: 87.6
End Depth: 89
Sample Matrix: **WATER**
Sample Team: DK/JW

QC Partners:
(TB) CD5006 (ER) — (FB) —

ERPIMS Values:
Sacode:
Lot Control#:

Analytical Suite	Flt	Frtn	Qty	Size	Units	Type
METALS3-W-F	Y	A	1	~~500~~ 250	mL	HDPE
METALS3-W	N	B	1	~~500~~ 250	mL	HDPE
EXPLOSIVES	N	C	1	1	L	Amb. Glass
VOLATILES3	N	D	3	40	mL	GVIAL,SEP
SEMIVOLATILES3	N	E	2	1	L	Amb. Glass
TOC	N	F	2	40	mL	GVIAL,SEP
CYANIDE	N	G	1	~~500~~ 100	mL	HDPE
ALKALINITY	N	H	1	1	L	HDPE
CHLORIDE	N	H	1	1	L	HDPE
NITRATE-W	N	H	1	1	L	HDPE
SULFATE	N	H	1	1	L	HDPE
TDS	N	H	1	1	L	HDPE
TSS	N	H	1	1	L	HDPE
TURB 180.1	N	H	1	1	L	HDPE
HARDNESS	N	I	1	~~500~~ 250	mL	HDPE

10/15/02 - DTW = 48.04' DTP = 47.54'
Bailed dry.
Removed 60 gals.

0800
10/18/02 DTW = 87.6 Ft
water column = 18.4 Ft

10/15/02 TD = 106.05 Ft

Comments: Depth to water = 48.04 Ft Depth to product = 47.54 Ft. (0.5 Ft/6 inches). Product brown/weathered natural petroleum.

Sketch Location:

Logged BY / Date: David Kessler 10/15/02 *Reviewed BY / Date:* David Kessler 10/18/02

INTERNATIONAL TECHNOLOGY CORPORATION

Sample Collection Log

Project: 833886 **PLUM BROOK ORDNANCE WK**

Manager: Steve Downey

Location Code: CD 3009

Sample Number: PB-BED-MW27

10/15/02 DTW = 48.04 Ft. TD = 106.00 Ft. Depth to product = 47.54 Ft

- Began bailing gw at with dedicated 3" PVC bailer.
- Removed 60 gals

10/15/02 DTW - 87.6

PURGE RECORD:

Initial	Time(24hr)	Depth to Water (ft)	Eh (mV)	pH (SU)	Conductivity (mS/cm)	Turbidity (NTU)	Diss Oxygen (ppm)	Temperature (C)	Purge Volume (gal)
Sample:									

No Readings Taken

Logged BY / Date: David Kreuh 10/15/02 *Reviewed BY / Date:* David Kreuh 10/1

GROUNDWATER SAMPLING FORM

IT CORPORATION
A Member of The IT Group

Project Number: 833886 ~~825635~~
Project Name: PBOW Groundwater
Investigation Site: Downgradient
RFA/COC Number: PB 10 1802 STL K/N

Collection Date: 10/18/02
Collection Time: 0820
Sample Filtered (Yes / No): yes
Weather/Temp: cloudy, cold (45°)

Form Completed By: D. Kessler
Sampler(s): D. Kessler / J. Hofer
Reviewed By: D. Kessler

Sample Number: PBOW-02-GW-

MONITORING WELL INFORMATION [use top of casing (TOC) for all measurements]

Well Number: PB-DED-MW27
Well Secure (Yes / No): yes
Well Labeled (Yes / No): yes
Well Condition: good
Screen Height: open hole
Casing Type: —

Outside Casing Dia. (in): Borehole 6"
Depth to Product (ft): 47.54
Total Well Depth (ft): 106.00
Depth to Water (ft): 48.04
Water Column (ft): 57.96
Elev. Ref. for Water Level:

Odor: strong H_2S, Petroleum
Vapor Monitor Type: PID / VRAE
- Vapor Monitor S/N: H842641 / H845141 - Findley
- Reading (ppm): 162 / LEL = >50 H_2S = >50 CO = 4.0 O_2 = 19.6
Remarks:

MONITORING WELL PURGE CALCULATIONS AND PURGE RECORD

Volume of Water in Casing: Gallons/foot = 0.041 x d^2, where d is casing diameter in inches = (0.041 x (6)^2) = 1.48 gal/ft
Well Volume (gallons) = Water Column (ft) x Gal/ft = 57.96 ft x 1.48 Gal/ft = 85.78 gallons

Volume of Water in Filter Pack: Gallons/foot = 0.041 x (D^2 - d^2), where D is total borehole dia. in inches & d is casing dia. in inches = 0.041 x (Open Borehole)^2) = _____ gal/ft
Filter Pack Volume (gal) = ((Screen Height + lesser of 2 ft or water column) x gal/ft) x porosity (0.3) = ((Screen Height _____ ft + _____ ft) x _____ gal/ft) x 0.3 = _____ gallons

Purge Well Volume: ~~Purge Well Volume = Filter Pack~~ Volume + Well Volume = _____ gal + _____ gal = _____ gal

1 x Purge Well Volume (gal.)	2 x Purge Well Volume (gal.)	3 x Purge Well Volume (gal.)	4 x Purge Well Volume (gal.)	5 x Purge Well Volume (gal.)
85.78	171.56	257.34	343.12	428.90

Purge Cycle	Time (24 hr)	Depth to Water	Conductivity	pH	Eh	Temperature	Turbidity	Diss. O_2	Purge Volume
Units:		Feet	umhos/cm	Standard Units	ppm	°F	NTU	ppm	gallons
Purge Vol 1									
Purge Vol 2		Water quality readings not recorded due to 0.5 ft product							
Purge Vol 3									
Purge Vol 4		and black, oily water (would contaminate Horiba)							
Purge Vol 5									
SAMPLE									

SAMPLE ANALYTICAL INFORMATION

Requested Analysis	Method	Sample Container(s)	Requested Analysis	Method	Sample Container(s)	Requested Analysis	Method	Sample Container(s)
Nitroaromatics	Mod. 8330	2 - 1 Liter Amber Glass	Dissolved TAL Metals	3005A/6010B / 7470A	1 - 500 mL HDPE	Chloride	325.3	1 - 1 Liter HDPE See Note A
TCL Volatile Organics	5030 / 8260B	3 - 40 mL Glass Vials	Total Cyanide	9010A/9012	1 - 1 Liter HDPE	Sulfate	375.3	A. Sample for alkalinity, chloride, sulfate, TSS. TDS, and turbidity combined in one 1-liter HDPE container.
TCL SVOCs	3510C / 8270C	2 - 1 Liter Amber Glass	Total Organic Carbon	9060	1 - 250 mL Amber Glass	Tot. Suspended Solids	160.2	
Total TAL Metals	3005A/6010B / 7470A	1 - 500 mL HDPE	Nitrate	353.2		Total Dissolved Solids	160.1	
Hardness	130.2		Alkalinity	310.1	1 - 1 Liter HDPE See Note A	Turbidity	180.1	

MAY 2002 DOWNGRADIENT GROUNDWATER SAMPLING

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Sample Collection Log

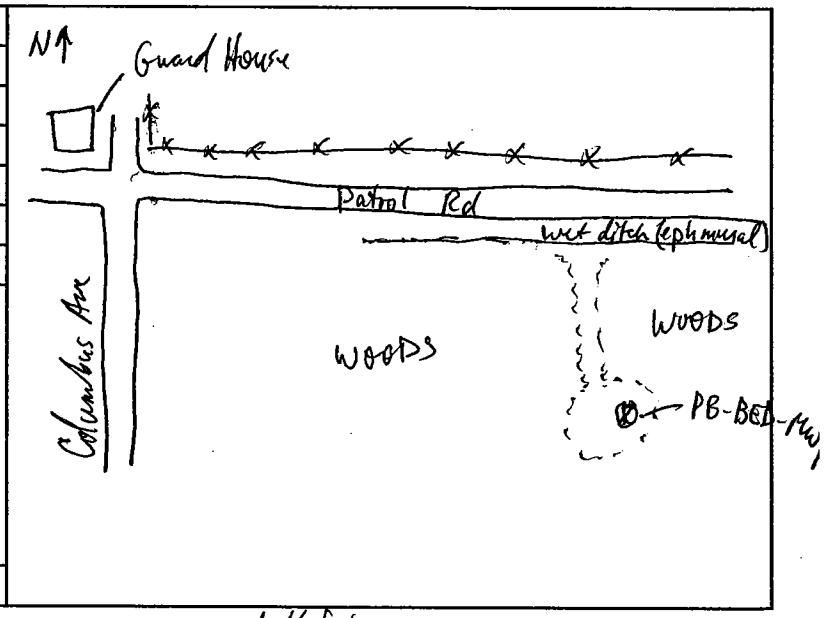
Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	**PB-BED-MW17**	Collection Date:	5/6/04
Sample Number:	**DF3000**	Collection Time:	~~1525~~ 1525
Sample Name:	**PBOW-04-PB-BED-MW17-DF3000**	Start Depth:	39.0
Sampling Method:	**Low Flow**	End Depth:	39.5
Sample Type:	**GW**	Sample Matrix:	**WATER**
Sample Purpose:	**REG**	Sample Team:	**Kessler/Ward**

Analytical Suite	Containers
FILTERED METALS	1 - 250 mL HDPE
TOTAL METALS	1 - 250 mL HDPE
EXPLOSIVES	1 - 1 L Amb. Glass
VOLATILES	3 - 40 mL Vial
SEMIVOLATILES	2 - 1 L Amb. Glass
TOC	2 - 40 mL Vial
CYANIDE	1 - 1 L HDPE
ALKALINITY	1 - 1 L HDPE
CHLORIDE	
NITRATE	
SULFATE	
TDS	
TSS	
TURBIDITY	
HARDNESS	1 - 250 mL HDPE

Sketch Location



Comments: Water violently gurgling/bubbling in well. Recorded depth first ~~bit~~ of splash on indicator to measure depth to water

Removed 2.2 gal

Logged by/Date: David Kessler 5/6/04 Reviewed by/Date: David Kessler 5/6/04

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GROUNDWATER PURGE FORM

Location Code: **PB-BED-MW17**

Sample Number: **DF3000**

Pump at 39'
Static ~ 31.40' water column ~ 33.0'
cpm 4 10 5 20psi

Static	Water Quality Parameter Measurements								
Date/ Time 5/6/04	DTW (ft. BTOC)	Purge Rate (mL/min)	Cumulative Volume Purged (L)	Temp. (degree C)	Conductivity (umhos/cm)	pH (std. units)	Eh (mv)	DO (mg/L)	Turbidity (NTU)
1425	31.45	300	0	15.49	7.103	6.77	-370.0	4.50	54.6
1430	31.53	210	500 ml	14.77	7.108	6.77	-358.0	6.18	26.0
1435	31.80	170	~~470~~	14.64	7.106	6.80	-355.0	8.75	6.0
1440	32.20	170	~~840~~	14.39	7.120	6.80	-354.7	10.18	6.8
1445	32.30	150	~~950~~ 1 gal	14.50	7.130	6.82	-355.1	11.36	9.1
1450	32.41?	170		14.30	7.126	6.85	-354.6	11.89	9.7
1455	32.47?	170		13.96	7.147	6.86	-356.8	12.38	26.4
1500	32.38?	170	1.4 gal	13.78	7.153	6.87	-357.8	12.67	35.6
1505	32.71?	170		13.45	7.140	6.88	-357.2	13.05	41.2
1510	33.00?	160	1.8 gal	13.44	7.144	6.88	-357.1	13.15	19.2
1515	33.20?	160	2 gal	13.44	7.145	6.88	-357.6	13.35	8.5
1520	33.08?	160	2.1	13.48	7.146	6.88	-358.4	13.45	20.8
1525	Collected Sample								

Abbreviations: BTOC - Below top of casing; DTW - Depth to water; mL - milliliter; L - Liter

Water in well bubbling/gurgling violently. Air bubbles in flow thru cell each cycle (large/many).

GROUNDWATER SAMPLING FORM

Shaw®

Project Number: 843635
Project Name: PBOW
Investigation Site: Downgradient
RFA/COC Number: PB050604STL-NC-KN

Collection Date: 5/6/04
Collection Time: 1525
Sample Filtered (Yes/No): Yes; Metals
Weather/Temp: Sunny, hot (75°), breezy

Form Completed By: David Kessler
Sampler(s): D. Kessler, G. Ward
Reviewed By: David Kessler

Sample Name: PBOW-04-PB-BED-MW17-GW-DF3000

MONITORING WELL INFORMATION [use top of casing (TOC) for all measurements]

Well Number: MW17	Outside Casing Dia. (in): 3"	Odor: Very Strong H_2S
Well Secure (Yes / No): Yes	Depth to Product (ft): NA	Vapor Monitor Type: PID / LEL
Well Labeled (Yes / No): Yes	Total Well Depth (ft): ~~65.8'~~ 64.4'	Vapor Monitor S/N: H844306 / 83371 Five-Star Passport
Well Condition: Good	Depth to Water (ft): 31.40'	Reading (ppm): LEL = >100 % O_2 = 18.6 %
Top of Screen: 19.4'	Water Column: 33.0'	PID = 157.4 C = 0 ppm H_2S = >200 ppm
Screen Height: 45'	Top of Filter Pack: NA	Depth Pump Set: 39'
Casing Type: Open hole	Pump Type: Bladder	Pump Settings: psi – 40, Refill – 10, Discharge - 5
		Remarks:

MONITORING WELL PURGE CALCULATIONS

Volume of Water in Casing: Gallons/foot = 0.041 x d^2, where d is casing diameter in inches = (0.041 x (_____)^2) = _____ gal/ft

Well Volume (gallons) = Water Column (ft) x Gal/ft = _____ ft x _____ Gal/ft = _____ gallons

Volume of Water in Filter Pack: Gallons/foot = 0.041 x (D^2-d^2), where D is total borehole dia. in inches & d is casing dia. in inches = 0.041 x ((_____)^2 – (_____)^2) = _____ gal/ft

Filter Pack Volume (gal) = ((Screen Height + Sand Above Set or Water Column) x gal/ft) x porosity (0.3) = ((Screen Height _____ ft + _____ ft) x _____ gal/ft) x 0.3 = _____ gallons

Purge Well Volume: Purge Well Volume – Filter Pack Volume + Well Volume = _____ gal + _____ gal = _____ gal

1 x Purge Well Volume (gal.)	2 x Purge Well Volume (gal.)	3 x Purge Well Volume (gal.)	4 x Purge Well Volume (gal.)	5 x Purge Well Volume (gal.)
~~8.058~~ DKK	~~11.16~~ DKK	~~16.74~~ DKK		

LOW-FLOW TUBING PURGE CALCULATIONS (3 tubing/pump volumes required for PBOW)

Volume of Water in Tubing: 1/4" ID Tubing = 0.01 Liters/ft. 3/8" ID Tubing = 0.02 Liters/ft. 2" Bladder Pump Volume = 0.3 Liters Tubing Length = 45 ft.

Tubing Volume (Liters) = ([Tubing Liters/ft. x Tubing length] + Pump volume) x 3 = ([0.01 L/ft x 45 ft] + 0.3 L) x 3 = 2.25 L

Total Volume Purged: 8.3 L Liters to gallons = L x 0.26gal/L 2.2 gal

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Sample Collection Log

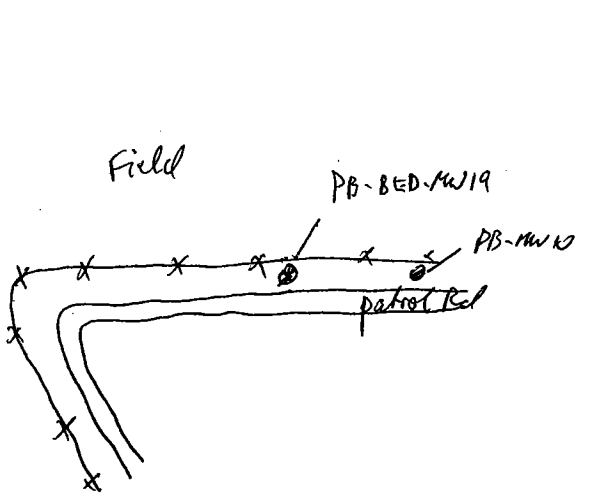
Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	**PB-BED-MW19**	Collection Date:	5/5/04
Sample Number:	**DF3001**	Collection Time:	0930
Sample Name:	**PBOW-04-PB-BED-MW19-DF3001**	Start Depth:	32'
Sampling Method:	**Low Flow**	End Depth:	32.5'
Sample Type:	**GW**	Sample Matrix:	**WATER**
Sample Purpose:	**REG**	Sample Team:	**Kessler/Ward**

Analytical Suite	Containers
FILTERED METALS	1 - 250 mL HDPE
TOTAL METALS	1 - 250 mL HDPE
EXPLOSIVES	1 - 1 L Amb. Glass
VOLATILES	3 - 40 mL Vial
SEMIVOLATILES	2 - 1 L Amb. Glass
TOC	2 - 40 mL Vial
CYANIDE	1 - 1 L HDPE
ALKALINITY	1 - 1 L HDPE
CHLORIDE	
NITRATE	
SULFATE	
TDS	
TSS	
TURBIDITY	
HARDNESS	1 - 250 mL HDPE

Sketch Location



Comments: Removed @ 4.5 gal 5/4/04
Removed 1.3 gal 5/5/04 for sample collection

Logged by/Date: David Kessler 5/4/04
Greg Ward 5/4/04-5/5/04

Reviewed by/Date: David Kessler 5/5/04

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GROUNDWATER PURGE FORM

Location Code: **PB-BED-MW19**

Sample Number: **DF3001**

Water Quality Parameter Measurements									
Date/ Time	DTW (ft. BTOC)	Purge Rate (mL/min)	Cumulative Volume Purged (L)	Temp. (degree C)	Conductivity (~~umhos/cm~~ mS/cm)	pH (std. units)	Eh (mv)	DO (mg/L)	Turbidity (NTU)
5/4/04									
14:45	23.04	250 mL/min	250	12.15	6.396	12.32	-122.5	2.68	12.8
14.50	23.92	250 mL	1,250	12.11	6.278	12.33	-152.2	2.00	14.8
14.55	24.22	250	2,500	12.21	6.149	12.32	-165.3	1.61	12.6
15.00	24.41	250	3,750	12.12	5.981	12.32	-180.5	1.13	16.2
1505	24.60	250	5.000	12.14	5.579	12.29	-200.9	0.63	29.7
1510	25.2	250	6.250	11.37	3.305	12.12	-245.9	0.17	111.2
1515	25.8	500	8.750	11.46	1.686	11.75	-257.4	0.12	132.5
1520	26.4	500	11.250	11.52	1.037	8.85	-303.2	0.10	37.0
1525	26.4	500	11.250	11.44	1.239	7.00	-341.2	2.14	146.7
15:04	Static 22.96								
0835	23.33	200	11,450	11.09	1.465	6.94	-364.9	0.65	95.6
0840	23.46	200	12.450	11.52	1.541	6.69	-363.7	0.01	25.3
0845	23.52	100	12.950	11.96	1.555	6.64	-361.0	2.33	15.3
0850	23.60	100	13.450	11.93	1.563	6.67	-364.6	4.99	16.9
0855	23.60	100	13.950	11.93	1.565	6.71	-365.7	6.65	23.8
0900	23.60	100	14.450	12.18	1.562	6.72	-363.7	2.49	22.6
0905	23.60	100	14.950	12.32	1.563	6.73	-366.8	8.18	13.3
0910	23.60	100	15.450	12.45	1.561	6.74	-367.4	8.41	11.3
0915	23.60	100	15.950	12.74	1.559	6.75	-363.8	8.96	14.0
0920	23.60	100	16.450	12.52	1.565	6.75	-366.0	9.51	12.6
0925	23.60	100	16.950	12.42	1.566	6.76	-366.2	9.57	14.9
0930 Collected Sample									

Abbreviations: BTOC - Below top of casing; DTW - Depth to water; mL - milliliter; L - Liter

GROUNDWATER SAMPLING FORM

Shaw®

Project Number: 843635
Project Name: PBOW
Investigation Site: Downgradient
RFA/COC Number: PB050504STL<K NC

Collection Date: 5/5/04
Collection Time: 0930
Sample Filtered (Yes/No): Yes; Metals
Weather/Temp: cloudy, cool (50°)

Form Completed By: David Kessler
Sampler(s): D. Kessler, G. Ward
Reviewed By: David Kessler

Sample Name: PBOW-04-PB-BED-MW19-GW-DF3001

MONITORING WELL INFORMATION [use top of casing (TOC) for all measurements]

Well Number: MW19	**Outside Casing Dia. (in):** 2"	**Odor:** None
Well Secure (Yes / No): Yes	**Depth to Product (ft):** NA	**Vapor Monitor Type:** PID / LEL {From Findlay
Well Labeled (Yes / No): Yes	**Total Well Depth (ft):** 52.2' 5/4/04 5/5/04	**Vapor Monitor S/N:** H844306 183371 FiveStar-Passport
Well Condition: Good	**Depth to Water (ft):** 23.04 (2") 22.95	**Reading (ppm):** LEL = 0 % O_2 = 21.0 %
Top of Screen: 24.5' bgs	**Water Column:** 29.16'	PID = 1.2 ppm C = 0 ppm H_2S = 0 ppm
Screen Height: 25'	**Top of Filter Pack:** ~ 22.5' bgs	**Depth Pump Set:** 32'
Casing Type: PVC	**Pump Type:** Bladder	**Pump Settings:** psi – 20, Refill – 10, Discharge - 5
		Remarks: 25' screen discharge ~ 90-100 ml/min

MONITORING WELL PURGE CALCULATIONS

Volume of Water in Casing: Gallons/foot = 0.041 x d^2, where d is casing diameter in inches = (0.041 x (2)^2) = 0.164 gal/ft

Well Volume (gallons) = Water Column (ft) x Gal/ft = 29.16 ft x 0.164 Gal/ft = 4.78 gallons

Volume of Water in Filter Pack: Gallons/foot = 0.041 x (D^2-d^2), where D is total borehole dia. in inches & d is casing dia. in inches = 0.041 x ((6)^2 – (2)^2) = 1.31 gal/ft

Filter Pack Volume (gal) = ((Screen Height + Sand Above Set or Water Column) x gal/ft) x porosity (0.3) = ((Screen Height 25 ft + 2 ft) x 1.31 gal/ft) x 0.3 = 10.6 gallons

Purge Well Volume: Purge Well Volume – Filter Pack Volume + Well Volume = 10.6 gal + 4.78 gal = 15.39 gal

1 x Purge Well Volume (gal.)	2 x Purge Well Volume (gal.)	3 x Purge Well Volume (gal.)	4 x Purge Well Volume (gal.)	5 x Purge Well Volume (gal.)
15.39	30.78	46.17	61.56	76.95

LOW-FLOW TUBING PURGE CALCULATIONS (3 tubing/pump volumes required for PBOW)

Volume of Water in Tubing: 1/4" ID Tubing = 0.01 Liters/ft. 3/8" ID Tubing = 0.02 Liters/ft. 2" Bladder Pump Volume = 0.3 Liters Tubing Length = 42 ft.

Tubing Volume (Liters) = ([Tubing Liters/ft. x Tubing length] + Pump volume) x 3 = ([0.01 L/ft x 42 ft] + 0.3 L) x 3 = 2.16 L

Total Volume Purged: 2.4 L Liters to gallons = L x 0.26gal/L must pump 0.64 gal

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Sample Collection Log

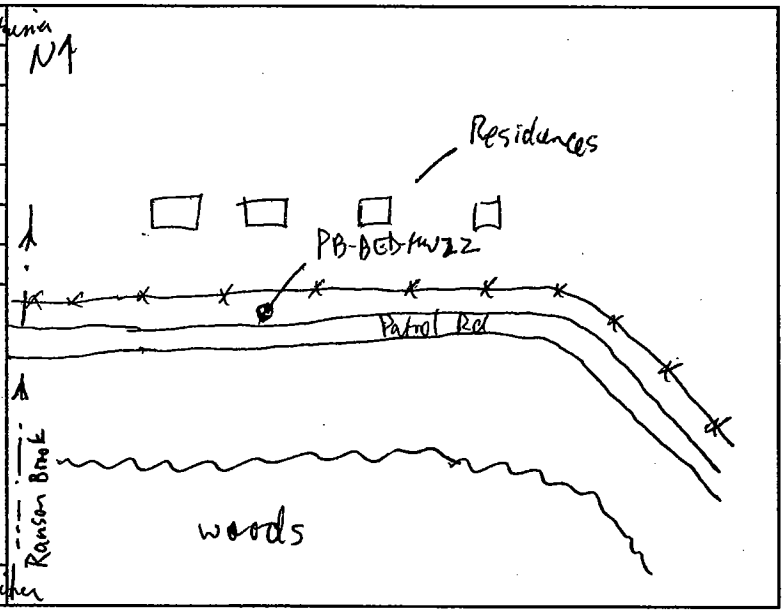
Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	**PB-BED-MW22**	Collection Date:	5/5/04
Sample Number:	**DF3002**	Collection Time:	1530
Sample Name:	**PBOW-04-PB-BED-MW22-DF3002**	Start Depth:	35.0'
Sampling Method:	**Low Flow**	End Depth:	35.5'
Sample Type:	**GW**	Sample Matrix:	**WATER**
Sample Purpose:	**REG**	Sample Team:	**Kessler/Ward**

Analytical Suite	Containers (in 1L container)
FILTERED METALS	1 - 250 mL HDPE
TOTAL METALS	1 - 250 mL HDPE
EXPLOSIVES	1 - 1 L Amb. Glass
VOLATILES	3 - 40 mL Vial
SEMIVOLATILES	2 - 1 L Amb. Glass
TOC	2 - 40 mL Vial
CYANIDE	1 - 1 L HDPE
ALKALINITY	1 - 1 L HDPE
CHLORIDE	
NITRATE	
SULFATE	
TDS	
TSS	
TURBIDITY	
HARDNESS	1 - 250 mL HDPE (in 1L container)

Sketch Location



Comments: Removed 2.8 gallons

Logged by/Date: David Kessler 5/5/04
~~Kw~~ Gerard 5.5.04

Reviewed by/Date: David Kessler 5/5/04

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Sample Collection Log

Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	**PB-BED-MW22**	Collection Date:	5/5/04
Sample Number:	**DF3002-MS**	Collection Time:	1530
Sample Name:	**PBOW-04-PB-BED-MW22-DF3002-MS**	Start Depth:	35
Sampling Method:	**Low Flow**	End Depth:	35.5
Sample Type:	**GW**	Sample Matrix:	**WATER**
Sample Purpose:	**MS**	Sample Team:	**Kessler/Ward**

Analytical Suite	Containers	Sketch Location
FILTERED METALS	1 - 250 mL HDPE	See sample# DF3002 for location information.
TOTAL METALS	1 - 250 mL HDPE	
EXPLOSIVES	1 - 1 L Amb. Glass	
VOLATILES	3 - 40 mL Vial	
SEMIVOLATILES	2 - 1 L Amb. Glass	
TOC	2 - 40 mL Vial	
CYANIDE	1 - 1 L HDPE	
ALKALINITY	1 - 1 L HDPE	
CHLORIDE		
NITRATE		
SULFATE		
TDS		
TSS		
TURBIDITY		
HARDNESS	1 - 250 mL HDPE	

Comments: See sample# DF3002 for purge and location information.

Logged by/Date: 5.5.04 Reviewed by/Date: David Kessler 5/5/04

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Sample Collection Log

Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	**PB-BED-MW22**	Collection Date:	5/5/04
Sample Number:	**DF3002-MSD**	Collection Time:	1530
Sample Name:	**PBOW-04-PB-BED-MW22-DF3002-MSD**	Start Depth:	35
Sampling Method:	**Low Flow**	End Depth:	35.5'
Sample Type:	**GW**	Sample Matrix:	**WATER**
Sample Purpose:	**MSD**	Sample Team:	**Kessler/Ward**

Analytical Suite	Containers	Sketch Location
FILTERED METALS	1 - 250 mL HDPE	See sample# DF3002 for location information.
TOTAL METALS	1 - 250 mL HDPE	
EXPLOSIVES	1 - 1 L Amb. Glass	
VOLATILES	3 - 40 mL Vial	
SEMIVOLATILES	2 - 1 L Amb. Glass	
TOC	2 - 40 mL Vial	
CYANIDE	1 - 1 L HDPE	
ALKALINITY	1 - 1 L HDPE	
CHLORIDE		
NITRATE		
SULFATE		
TDS		
TSS		
TURBIDITY		
HARDNESS	1 - 250 mL HDPE	

Comments: See sample# DF3002 for purge and location information.

Logged by/Date: Kward 5-5-04

Reviewed by/Date: David Kessler 5/5/04

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GROUNDWATER PURGE FORM

Location Code: **PB-BED-MW22**

Sample Number: **DF3002**

Water Quality Parameter Measurements									
Date/ Time 5-5-04	DTW (ft. BTOC)	Purge Rate (mL/min)	Cumulative Volume Purged (L)	Temp. (degree C)	Conductivity (umhos/cm)	pH (std. units)	Eh (mv)	DO (mg/L)	Turbidity (NTU)
1400	30.85	300	1.300	14.55	0.966	6.83	-327.9	2.49	176.5
1405	30.65	200	2.300	15.34	0.953	6.75	-331.0	0.43	206.9
1410	30.60	200	3.300	16.34	0.950	6.74	-333.1	0.33	139.4
1415	30.61	200	4.300	16.51	0.949	6.74	-332.8	0.35	156.8
1420	30.58	200	5.300	16.65	0.951	6.73	-333.0	0.41	145.2
1425	30.61	~~200~~ 120	6.300	17.03	0.951	6.72	-334.0	0.62	138.4
1430	30.58	~~200~~ 100	7.300	17.27	0.951	6.71	-331.0	0.94	129.6
1435	30.60	~~200~~ 90	8.300	17.29	0.952	6.70	-330.0	1.42	123.4
1440	30.61	~~200~~ 75	9.300	17.54	0.954	6.70	-329.7	2.30	110.9
1445	30.59	~~200~~ 75	10.300	17.55	0.954	6.69	-329.2	2.61	107.7
1450	30.61	~~200~~ 75	11.300						
1455	30.40	200		14.64	0.948	6.69	-324.9	3.96	74.2
1500	30.41	200		14.50	0.944	6.68	-325.0	4.15	58.1
1505				14.05	0.940	6.68	-326.7	4.48	51.7
1510				13.92	0.938	6.67	-328.8	5.00	56.1
1515				14.12	0.941	6.68	-327.2	5.30	60.6
1530	30.80			13.86	0.935	6.67	-327.7	5.37	68.0
	~~30.86~~		2.8 gal	~~13.95~~					

Removed ~2.8 gallons

Collected sample 1530

DKK

Abbreviations: BTOC - Below top of casing; DTW - Depth to water; mL - milliliter; L - Liter

GROUNDWATER SAMPLING FORM

Shaw®

Project Number: 843635
Project Name: PBOW
Investigation Site: Downgradient
RFA/COC Number: PB050504F STL KN STL NC ACC

Collection Date: 5/5/04
Collection Time: 1530
Sample Filtered (Yes/No): Yes; Metals
Weather/Temp: Sunny (65°), breezy

Form Completed By: David Kessler
Sampler(s): D. Kessler, G. Ward
Reviewed By: David Kessler

Sample Name: PBOW-04-PB-BED-MW22-GW-DF30002

MONITORING WELL INFORMATION [use top of casing (TOC) for all measurements]

Well Number: MW22	**Outside Casing Dia. (in):** 2"	**Odor:** H_2S - Strong (very)
Well Secure (Yes / No): Yes	**Depth to Product (ft):** NA	**Vapor Monitor Type:** PID / LEL
Well Labeled (Yes / No): Yes	**Total Well Depth (ft):** 42'	**Vapor Monitor S/N:** H844306 185371 Five Star Passport
Well Condition: Good	**Depth to Water (ft):** 37.88'	**Reading (ppm):** LEL = >100 % O_2 = 14 %
Top of Screen: 27'	**Water Column:** 11.60'	PID = 16.4 C = 0 ppm H_2S = >200 ppm
Screen Height: 15'	**Top of Filter Pack:** 25'	**Depth Pump Set:** 35' CPM 4, 10 5
Casing Type: PVC	**Pump Type:** Bladder	**Pump Settings:** psi – 20, Refill – ~~25~~, Discharge ~~28~~ DKK
		Remarks: Definite H_2S Vapors visible when cap removed New Well cap working well.

MONITORING WELL PURGE CALCULATIONS

Volume of Water in Casing: Gallons/foot = 0.041 x d^2, where d is casing diameter in inches = (0.041 x (_____)^2) = _____ gal/ft

Well Volume (gallons) = Water Column (ft) x Gal/ft = _____ ft x _____ Gal/ft = _____ gallons

Volume of Water in Filter Pack: Gallons/foot = 0.041 x (D^2-d^2), where D is total borehole dia. in inches & d is casing dia. in inches = 0.041 x ((_____)^2 – (_____)^2) = _____ gal/ft

Filter Pack Volume (gal) = ((Screen Height + Sand Above Set or Water Column) x gal/ft) x porosity (0.3) = ((Screen Height _____ ft + _____ ft) x _____ gal/ft) x 0.3 = _____ gallons

Purge Well Volume: Purge Well Volume – Filter Pack Volume + Well Volume = _____ gal + _____ gal = _____ gal

1 x Purge Well Volume (gal.)	~~2 x~~ Purge Well Volume (gal.)	3 x Purge Well Volume (gal.)	4 x Purge Well Volume (gal.)	5 x Purge Well Volume (gal.)

LOW-FLOW TUBING PURGE CALCULATIONS (3 tubing/pump volumes required for PBOW)

Volume of Water in Tubing: 1/4" ID Tubing = 0.01 Liters/ft. 3/8" ID Tubing = 0.02 Liters/ft. 2" Bladder Pump Volume = 0.3 Liters Tubing Length = ____ ft.

Tubing Volume (Liters) = ([Tubing Liters/ft. x Tubing length] + Pump volume) x 3 = ([0.01 L/ft x 45 ft] + 0.3 L) x 3 = 2.25 L

Total Volume Purged: 2.25 L Liters to gallons = L x 0.26gal/L = 0.59 gal

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Sample Collection Log

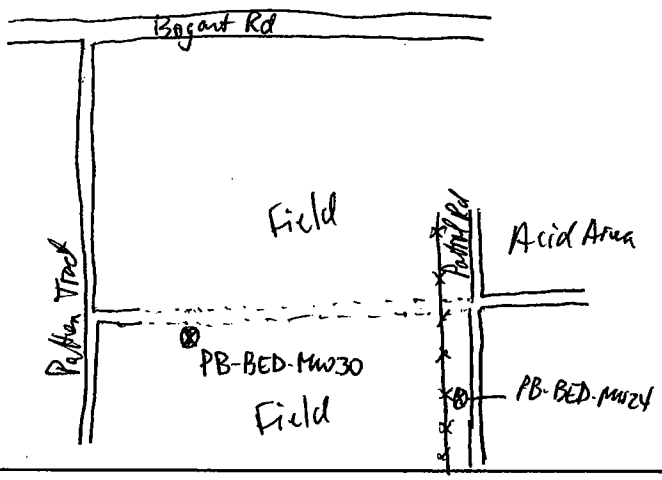
Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	**PB-BED-MW30**	Collection Date:	5/7/04
Sample Number:	**DF3003**	Collection Time:	1010
Sample Name:	**PBOW-04-PB-BED-MW30-DF3003**	Start Depth:	46.0
Sampling Method:	**Low Flow**	End Depth:	46.3
Sample Type:	**GW**	Sample Matrix:	**WATER**
Sample Purpose:	**REG**	Sample Team:	**Kessler/Ward**

Analytical Suite	Containers
FILTERED METALS	1 - 250 mL HDPE
TOTAL METALS	1 - 250 mL HDPE
EXPLOSIVES	1 - 1 L Amb. Glass
VOLATILES	3 - 40 mL Vial
SEMIVOLATILES	2 - 1 L Amb. Glass
TOC	2 - 40 mL Vial
CYANIDE	1 - 1 L HDPE
ALKALINITY	1 - 1 L HDPE
CHLORIDE	
NITRATE	
SULFATE	
TDS	
TSS	
TURBIDITY	
HARDNESS	1 - 250 mL HDPE

Sketch Location



Comments: Removed 1.5 gal. Samples placed on ice

Logged by/Date: David Kessler 5/7/04 Reviewed by/Date: David Kessler 5/7/04

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GROUNDWATER PURGE FORM

Location Code: **PB-BED-MW30**

Sample Number: **DF3003**

Water Quality Parameter Measurements									
Date/ Time 5/7/04	DTW (ft. BTOC)	Purge Rate (mL/min)	Cumulative Volume Purged (L)	Temp. (degree C)	Conductivity (umhos/cm)	pH (std. units)	Eh (mv)	DO (mg/L)	Turbidity (NTU)
0920	26.72	110	200 ml	11.81	1.360	6.94	-290.8	1.55	53.6
0925	26.75	100		11.79	1.358	6.91	-294.0	1.06	48.1
0930	26.72	100		11.83	1.357	6.93	-296.4	0.97	42.7
0935	26.75	100		11.88	1.358	6.97	-298.0	0.61	39.8
0940	26.79	100		11.73	1.361	7.00	-299.4	0.50	35.5
0945	26.78	100		11.65	1.363	7.00	-298.1	0.45	32.4
0950	26.83	130		11.53	1.370	7.01	-298.9	0.44	30.5
0955	26.81	130	1 gal	11.55	1.369	7.04	-299.2	0.40	27.8
1000	26.82	130		11.75	1.365	7.04	-300.2	0.33	25.9
1005	26.79	130		11.89	1.368	7.06	-299.5	0.31	22.7
1010	26.82	130	1.5 gal	11.63	1.371	7.09	-300.1	0.29	23.2
	Collected Sample								

Abbreviations: BTOC - Below top of casing; DTW - Depth to water; mL - milliliter; L - Liter

GROUNDWATER SAMPLING FORM

Shaw®

Project Number: 843635
Project Name: PBOW
Investigation Site: Downgradient
RFA/COC Number: PB050704STL-NC-K

Collection Date: 5/7/04
Collection Time: 1010
Sample Filtered (Yes/No): Yes; Metals
Weather/Temp: Cloudy, wet, sprinkles

Form Completed By: David Kessler
Sampler(s): D. Kessler, G. Ward
Reviewed By: David Keasler

Sample Name: PBOW-04-PB-BED-MW30-GW-DF3003

MONITORING WELL INFORMATION [use top of casing (TOC) for all measurements]

Well Number: MW30	Outside Casing Dia. (in): 2"	Odor:
Well Secure (Yes / No): Yes	Depth to Product (ft): NA	Vapor Monitor Type: PID / LEL } From Findley
Well Labeled (Yes / No): Yes	Total Well Depth (ft): 54.53'	Vapor Monitor S/N: H844306, 183371 5 Star - Passport
Well Condition: Good	Depth to Water (ft): ~~36.48~~ 26.48 Ft	Reading (ppm): LEL = 54 % O_2 = 20.8 %
Top of Screen: 39.53'	Water Column: 28.05 Ft	PID=14.7 C = 10 ppm H_2S= 0 ppm
Screen Height: 15'	Top of Filter Pack: 39'	Depth Pump Set: 46 Ft (Bottom-inlet)
Casing Type: PVC	Pump Type: Bladder	Pump Settings: psi -28, Refill -10, Discharge - 5
		Remarks: CPM 4

MONITORING WELL PURGE CALCULATIONS

Volume of Water in Casing: Gallons/foot = 0.041 x d^2, where d is casing diameter in inches = (0.041 x (2)^2) = 0.164 gal/ft

Well Volume (gallons) = Water Column (ft) x Gal/ft = _____ ft x _____ Gal/ft = _____ gallons

Volume of Water in Filter Pack: Gallons/foot = 0.041 x (D^2-d^2), where D is total borehole dia. in inches & d is casing dia. in inches = 0.041 x ((_____)^2 – (_____)^2) = _____ gal/ft

Filter Pack Volume (gal) = ((Screen Height + Sand Above Set or Water Column) x gal/ft) x porosity (0.3) = ((Screen Height _____ ft + _____ ft) x _____ gal/ft) x 0.3 = _____ gallons

LOW-FLOW

Purge Well Volume: Purge Well Volume – Filter Pack Volume + Well Volume = _____ gal + _____ gal = _____ gal

1 x Purge Well Volume (gal.)	~~2 x~~ Purge Well Volume (gal.)	3 x Purge Well Volume (gal.)	4 x Purge Well Volume (gal.)	5 x Purge Well Volume (gal.)

LOW-FLOW TUBING PURGE CALCULATIONS (3 tubing/pump volumes required for PBOW)

Volume of Water in Tubing: 1/4" ID Tubing = 0.01 Liters/ft. 3/8" ID Tubing = 0.02 Liters/ft. 2" Bladder Pump Volume = 0.3 Liters Tubing Length = 49 ft.

Tubing Volume (Liters) = ([Tubing Liters/ft. x Tubing length] + Pump volume) x 3 = ([~~0.01~~ 0.01 L/ft x 49 ft] + 0.3 L) x 3 = 2.39 L = 0.62 gal

Total Volume Purged: 5.7 L Liters to gallons = L x 0.26gal/L = Removed 1.5 gal

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Sample Collection Log

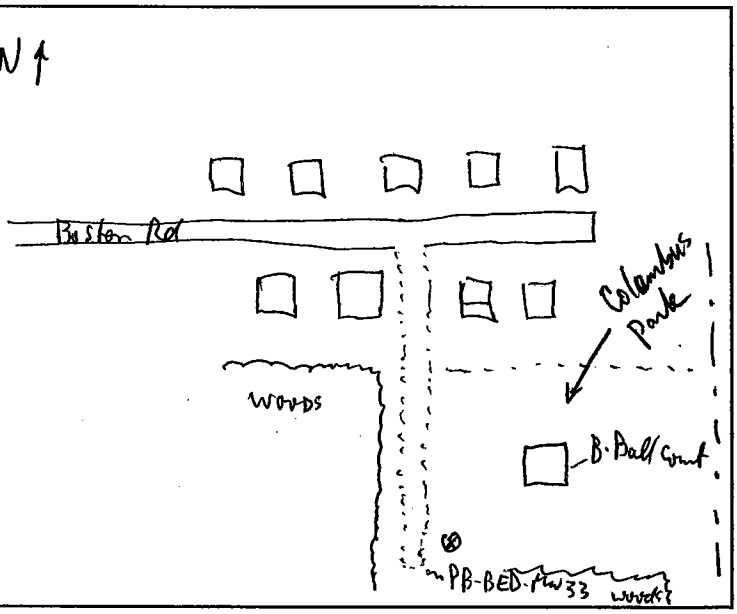
Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	**PB-BED-MW33**	Collection Date:	5/7/04
Sample Number:	**DF3004**	Collection Time:	1150
Sample Name:	**PBOW-04-PB-BED-MW33-DF3004**	Start Depth:	81
Sampling Method:	**Low Flow**	End Depth:	84
Sample Type:	**GW**	Sample Matrix:	**WATER**
Sample Purpose:	**REG**	Sample Team:	**Kessler/Ward**

Analytical Suite	Containers
FILTERED METALS	1 - 250 mL HDPE
TOTAL METALS	1 - 250 mL HDPE
EXPLOSIVES	1 - 1 L Amb. Glass
VOLATILES	2 - 40 mL Vial
~~SEMIVOLATILES~~	~~2 - 1 L Amb. Glass~~ DKK
~~TOC~~	~~2 - 40 mL Vial~~ DKK
~~CYANIDE~~	~~1 - 1 L HDPE~~ DKK
~~ALKALINITY~~	
~~CHLORIDE~~	
~~NITRATE~~	
~~SULFATE~~	~~1 - 1 L HDPE~~ DKK
~~TDS~~	
~~TSS~~	
~~TURBIDITY~~	
~~HARDNESS~~	~~1 - 250 mL HDPE~~ DKK

Sketch Location



Comments: 5/4/04 Static = ~~78~~ 73.86'
1115 Bailed dry to = 82.60'
5/7/04 1130 Static = 81.13 ft
Filtered dissolved metals with hand pump using 0.45 micro filter. - Bailed/Purged Dry - 2.8 gal.

Logged by/Date: David Kessler 5/6/04 Reviewed by/Date: David Kessler 5/6/04

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GROUNDWATER PURGE FORM

5/6/04 → Attempted low flow.
Pump set at 80 Ft (Top)
Pumping from 81.5 Ft Bottom of pump.

Location Code: **PB-BED-MW33**

Sample Number: **DF3004**

Water Quality Parameter Measurements									
Date/ Time	DTW (ft. BTOC) static 75.78	Purge Rate (mL/min)	Cumulative Volume Purged (L)	Temp. (degree C)	Conductivity (umhos/cm)	pH (std. units)	Eh (mv)	DO (mg/L)	Turbidity (NTU)
5/6/04									
0945	75.95	100	0	14.54	3.231	6.96	-152.5	2.33	41.8
0950	76.10	100		14.97	3.208	6.95	-163.6	1.57	56.2
0955 (reduced rate)	76.15	50	.5 gal	15.48	3.201	6.95	-164.0	1.31	42.9
1000	76.23	150		16.33	3.208	6.96	-163.8	1.20	51.0
1000	76.50	~~100~~ 50	0.75 gal	16.45	3.225	6.96	-167.5	1.11	46.2
1010	76.70	50	0.8 gal	16.79	3.213	6.97	-153.1	0.96	47.9
1020 (ramped up)	78.95	400		13.85	3.255	7.05	-174.4	0.77	88.8
1025	79.10	400	1.8 gal	12.38	3.243	7.04	-202.2	0.50	66.0
1030	80.10	400	2 gal	13.49	3.256	7.11	-185.1	0.34	20.4
1035	80.25		2.2 gal	13.84	3.263	7.13	-184.1	0.33	22.1
1045	80.40	0	2.3 gal	16.64	3.284	7.10	-166.8	0.28	19.5
1115	82.60		2.8 gal						
Collected sample 5/7/04 1150. Recorded no sample water quality readings due to insufficient water.									

Abbreviations: BTOC - Below top of casing; DTW - Depth to water; mL - milliliter; L - Liter

Collected sample w/ Teflon bailer 5/7/04 1150. Collected only
- Nitroaromatics (1@1L), Dissolved metals (1@250ml), Total metals (1@250ml), 2@40ml volatiles
- Recorded no sample water quality readings.

GROUNDWATER SAMPLING FORM

Shaw®

Project Number: 843635 **Collection Date:** 5/7/04 **Form Completed By:** D. Kessler

Project Name: PBOW **Collection Time:** 1150 **Sampler(s):** D. Kessler, G. Ward

Investigation Site: Downgradient **Sample Filtered (Yes/No):** Yes; Metals

RFA/COC Number: PB050704STL-K **Weather/Temp:** slight rain, warm(70°) **Reviewed By:** David Kessler

Sample Name: PBOW-04-PB-BED-MW33-GW-DF3004

MONITORING WELL INFORMATION [use top of casing (TOC) for all measurements]

Well Number: MW33	**Outside Casing Dia. (in):** 2"	**Odor:** None
Well Secure (Yes / No): Yes	**Depth to Product (ft):** NA	**Vapor Monitor Type:** PID / LEL } From Findlay
Well Labeled (Yes / No): Yes	**Total Well Depth (ft):** ~~80.5'~~ 88.5 (TD = measured 83.95')	**Vapor Monitor S/N:** H844306 / 833771 FireStar-Passport
Well Condition: Good	**Depth to Water (ft):** 73.86	**Reading (ppm):** LEL = 12 % O_2 = 20.9 %
Top of Screen: 68.5'	**Water Column:** 10.09	PID = 15.3 C = 0 ppm H_2S = 0.0 ppm
Screen Height: 20'	**Top of Filter Pack:** 65.5'	**Depth Pump Set:** Bottom 81.5', Top = 80' (pumping from 81.5')
Casing Type: PVC	**Pump Type:** Bladder	**Pump Settings:** psi – , Refill – , Discharge -
		Remarks: CPM2 Rotor 23.0 Disch = 7, Throttled varied 40-65 Attempted controls ↑

MONITORING WELL PURGE CALCULATIONS

Volume of Water in Casing: Gallons/foot = 0.041 x d^2, where d is casing diameter in inches = (0.041 x (2)^2) = 0.164 gal/ft

Well Volume (gallons) = Water Column (ft) x Gal/ft = 10.09 ft x 0.164 Gal/ft = 1.65 gallons

Volume of Water in Filter Pack: Gallons/foot = 0.041 x (D^2-d^2), where D is total borehole dia. in inches & d is casing dia. in inches = 0.041 x ((5)^2 – (2)^2) = 0.86 gal/ft

Filter Pack Volume (gal) = ((Screen Height + Sand Above Set or Water Column) x gal/ft) x porosity (0.3) = ((Screen Height 10.09 ft + 0 ft) x 0.86 gal/ft) x 0.3 = 2.60 gallons

Purge Well Volume: Purge Well Volume – Filter Pack Volume + Well Volume = 2.60 gal + 1.65 gal = 4.25 gal

1 x Purge Well Volume (gal.)	2 x Purge Well Volume (gal.)	3 x Purge Well Volume (gal.)	4 x Purge Well Volume (gal.)	5 x Purge Well Volume (gal.)
4.25	8.50	12.75	17	21.25

LOW-FLOW TUBING PURGE CALCULATIONS (3 tubing/pump volumes required for PBOW)

Volume of Water in Tubing: 1/4" ID Tubing = 0.01 Liters/ft. 3/8" ID Tubing = 0.02 Liters/ft. ~~2" Bladder Pump Volume = 0.3 Liters~~ Tubing Length = 90 ft.

Tubing Volume (Liters) = ([Tubing Liters/ft. x Tubing length] ~~+ Pump volume~~) x 3 = ([0.01 L/ft x ____ ft] + 0.3 L) x 3 = _____ L

Total Volume Purged: _____ L Liters to gallons = L x 0.26gal/L

Removed 2.8 gal total

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Sample Collection Log

Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	**PB-BED-MW22**	Collection Date:	5/5/04
Sample Number:	**DF3005**	Collection Time:	1530
Sample Name:	**PBOW-04-PB-BED-MW22-DF3005**	Start Depth:	35
Sampling Method:	**Low Flow**	End Depth:	35.5
Sample Type:	**GW**	Sample Matrix:	**WATER**
Sample Purpose:	**FD**	Sample Team:	**Kessler/Ward**

Analytical Suite	Containers	Sketch Location
FILTERED METALS	1 - 250 mL HDPE	See sample# DF3002 for location information.
TOTAL METALS	1 - 250 mL HDPE — in 1 @ 1 container	
EXPLOSIVES	1 - 1 L Amb. Glass	
VOLATILES	3 - 40 mL Vial	
SEMIVOLATILES	2 - 1 L Amb. Glass	

Comments: See sample# DF3002 for purge and location information.

Logged by/Date: Gerard 5.5.04

Reviewed by/Date: David Kessler 5/5/04

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Sample Collection Log

Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	**PB-BED-MW22**	Collection Date:	5/5/04
Sample Number:	**DF3006**	Collection Time:	1530
Sample Name:	**PBOW-04-PB-BED-MW22-DF3006**	Start Depth:	35'
Sampling Method:	**Low Flow**	End Depth:	35.5'
Sample Type:	**GW**	Sample Matrix:	**WATER**
Sample Purpose:	**FS**	Sample Team:	**Kessler/Ward**

Analytical Suite	Containers	Sketch Location
FILTERED METALS	1 - 250 mL HDPE	See sample# DF3002 for location information.
TOTAL METALS	1 - 250 mL HDPE	
EXPLOSIVES	1 - 1 L Amb. Glass	
VOLATILES	3 - 40 mL Vial	
SEMIVOLATILES	2 - 1 L Amb. Glass	

Comments: See sample# DF3002 for purge and location information.

Logged by/Date: [signature] 5.5.04

Reviewed by/Date: David Kessler 5/5/04

JUNE 2004 BACKGROUND BEDROCK GROUNDWATER SAMPLING (10TH QUARTER)

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Sample Collection Log

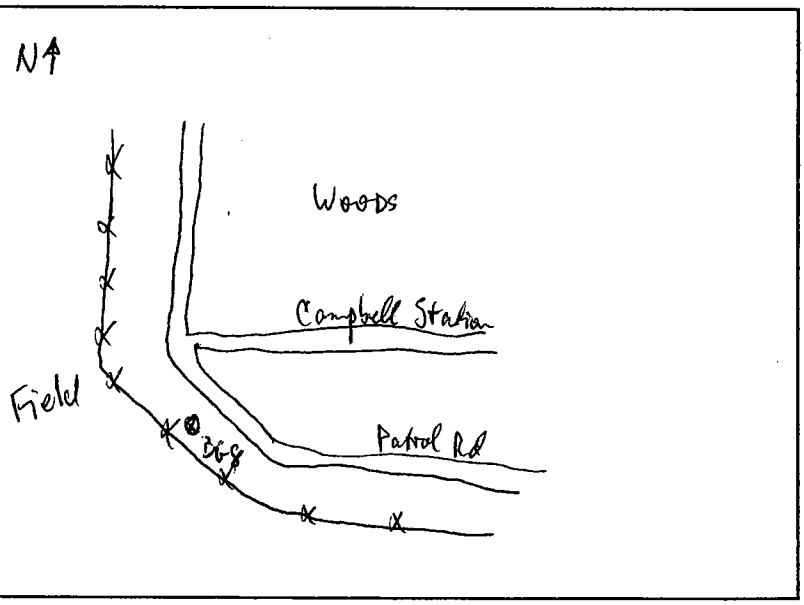
Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	**IT-BG8-BEDGW-001**	Collection Date:	6/16/04 ~~6/09/04~~
Sample Number:	**DG3000**	Collection Time:	1600
Sample Name:	**PBOW-04-IT-BG8-BEDGW-001-DG3000**	Start Depth:	14.0'
Sampling Method:	**Low Flow**	End Depth:	14.1'
Sample Type:	**GW**	Sample Matrix:	**WATER**
Sample Purpose:	**REG**	Sample Team:	**Kessler/Ward**

Analytical Suite	Containers
FILTERED METALS	1 - ~~250~~ 125 mL HDPE
TOTAL METALS	1 - ~~250~~ 125 mL HDPE
EXPLOSIVES	1 - 1 L Amb. Glass
VOLATILES	3 - 40 mL Vial
SEMIVOLATILES	2 - 1 L Amb. Glass
TOC	2 - 40 mL Vial
CYANIDE	1 - 1 L HDPE
ALKALINITY	1 - 1 L HDPE
CHLORIDE	
NITRATE	
SULFATE	
TDS	
TSS	
TURBIDITY	
HARDNESS	1 - 250 mL HDPE

Sketch Location



Comments: Removed 1.8 gal

Logged by/Date: [signature] 6-16-04

Reviewed by/Date: David Kessler 6/16/04

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GROUNDWATER PURGE FORM

Location Code: **IT-BG8-BEDGW-001**

Sample Number: **DG3000**

Pump set at 14 Ft.
DTW = Static = 5.25'

Water Quality Parameter Measurements									
Date/ Time 6-16-04	DTW (ft. BTOC)	Purge Rate (mL/min)	Cumulative Volume Purged (L)	Temp. (degree C)	Conductivity (umhos/cm)	pH (std. units)	Eh (mv)	DO (mg/L)	Turbidity (NTU)
15:15	5.36	190	1.0	17.50	0.638	7.11	-84.0	1.96	0.0
15:20	5.35	190	1.950	16.34	0.644	7.11	-88.1	1.55	0.0
15:25	5.36	190	2.900	16.29	0.646	7.13	-95.0	1.11	0.0
15:30	5.36	190	3.850	15.95	0.647	7.14	-98.9	1.28	0.0
15:35	5.35	190	4.800	15.80	0.648	7.15	-100.6	1.20	0.0
15:40	5.36	190	5.750	15.77	0.649	7.15	-101.0	1.17	0.0
15:45	5.36	190	6.700	15.83	0.648	7.16	-102.5	1.10	0.0
15:50	5.36	190	7.650	15.82	0.648	7.16	-102.8	1.90	0.0
15:55	5.36	190	8.600	15.81	0.649	7.17	-102.9	1.89	0.0
16:00	5.36	190	9.550	15.82	0.648	7.18	-102.8	1.90	0.0
1600 Collected Sample									

Abbreviations: BTOC - Below top of casing; DTW - Depth to water; mL - milliliter; L - Liter

GROUNDWATER SAMPLING FORM

Shaw®

Project Number: 843635
Project Name: PBOW
Investigation Site: Background
RFA/COC Number: RD061604STL-K

Collection Date: 6/16/04
Collection Time: 1600
Sample Filtered (Yes/No): Yes; Metals
Weather/Temp: Cloudy, sprinkles, hot (85°)

Form Completed By: David Kessler
Sampler(s): D. Kessler, ~~Z. Parham~~ G. Ward
Reviewed By: David Kessler

Sample Name: PBOW-04-IT-BG8-BEDGW-001-DG3000

MONITORING WELL INFORMATION [use top of casing (TOC) for all measurements]

Well Number: DEDGW-001	Outside Casing Dia. (in): 2"	Odor: None
Well Secure (Yes / No): Yes	Depth to Product (ft): NA	Vapor Monitor Type: PID / LEL - From Findlay
Well Labeled (Yes / No): Yes	Total Well Depth (ft): 20'	Vapor Monitor S/N: 82383 / 35175
Well Condition: Good	Depth to Water (ft): 5.25	Reading (ppm): LEL = 0.0% O_2 = 20.8 %
Top of Screen: 5'	Water Column: 14.75 Ft	PID = 0.0 C = 0 ppm H_2S = 0.0 ppm
Screen Height: 15'	Top of Filter Pack: 5'	Depth Pump Set: ~~32~~ 14'
Casing Type: PVC	Pump Type: Bladder	Pump Settings: psi – ~~8~~ 7, Refill – 10, Discharge - 5
		Remarks: 7 psi

MONITORING WELL PURGE CALCULATIONS

Volume of Water in Casing: Gallons/foot = 0.041 x d^2, where d is casing diameter in inches = (0.041 x (_____)^2) = _____ gal/ft

Well Volume (gallons) = Water Column (ft) x Gal/ft = _____ ft x _____ Gal/ft = _____ gallons

Volume of Water in Filter Pack: Gallons/foot = 0.041 x (D^2-d^2), where D is total borehole dia. in inches & d is casing dia. in inches = 0.041 x ((_____)^2 – (_____)^2) = _____ gal/ft

Filter Pack Volume (gal) = ((Screen Height + Sand Above Set or Water Column) x gal/ft) x porosity (0.3) = ((Screen Height _____ ft + _____ ft) x _____ gal/ft) x 0.3 = _____ gallons

Purge Well Volume: Purge Well Volume – Filter Pack Volume + Well Volume = _____ gal + _____ gal = _____ gal

1 x Purge Well Volume (gal.)	2 x Purge Well Volume (gal.)	3 x Purge Well Volume (gal.)	4 x Purge Well Volume (gal.)	5 x Purge Well Volume (gal.)

LOW-FLOW TUBING PURGE CALCULATIONS (3 tubing/pump volumes required for PBOW)

Volume of Water in Tubing: 1/4" ID Tubing = 0.01 Liters/ft. 3/8" ID Tubing = 0.02 Liters/ft. 2" Bladder Pump Volume = 0.3 Liters Tubing Length = 20 ft.

Tubing Volume (Liters) = ([Tubing Liters/ft. x Tubing length] + Pump volume) x 3 = ([0.02 L/ft x 20 ft] + 0.3 L) x 3 = 2.1 L = 0.55 gal

Total Volume Purged: 9.6 L Liters to gallons = L x 0.26gal/L

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Sample Collection Log

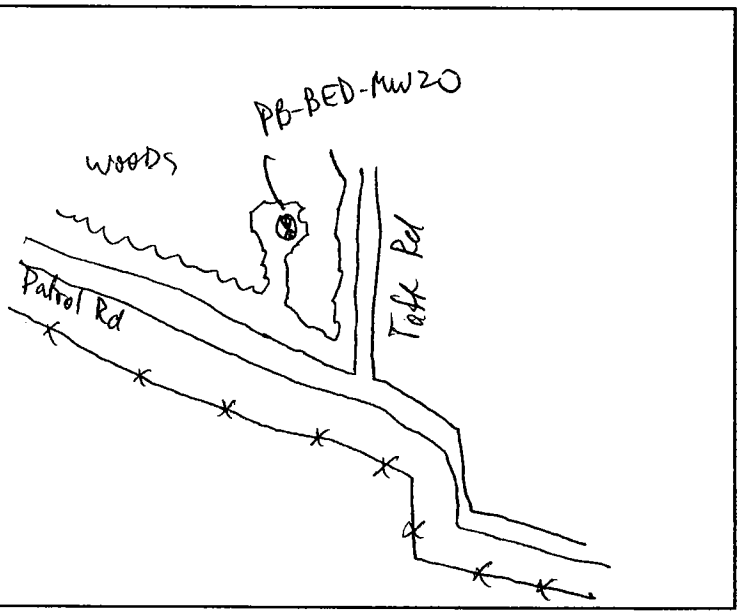
Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	**PB-BED-MW20**	Collection Date:	6/17/04
Sample Number:	**DG3001**	Collection Time:	1515
Sample Name:	**PBOW-04-PB-BED-MW20-DG3001**	Start Depth:	32.0
Sampling Method:	**Low Flow**	End Depth:	32.1
Sample Type:	**GW**	Sample Matrix:	**WATER**
Sample Purpose:	**REG**	Sample Team:	**Kessler/Ward**

Analytical Suite	Containers
FILTERED METALS	1 - ~~250~~ 125 DUP mL HDPE
TOTAL METALS	1 - ~~250~~ 125 mL HDPE
EXPLOSIVES	1 - 1 L Amb. Glass
VOLATILES	3 - 40 mL Vial
SEMIVOLATILES	1 ~~2~~ DUP - 1 L Amb. Glass
TOC	2 - 40 mL Vial
CYANIDE	1 - 1 L HDPE
ALKALINITY	1 - 1 L HDPE
CHLORIDE	
NITRATE	
SULFATE	
TDS	
TSS	
TURBIDITY	
HARDNESS	1 - 250 mL HDPE

Sketch Location



Comments: Removed ~ 1.5 gal

Logged by/Date: David Kessler 6/17/04 Reviewed by/Date: David Kessler 6/17/04

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GROUNDWATER PURGE FORM

Location Code: **PB-BED-MW20** pump set at 32 Ft.

Sample Number: **DG3001** DTW=13.94 ft

Water Quality Parameter Measurements									
Date/ Time 6/17/04	DTW (ft. BTOC)	Purge Rate (mL/min)	Cumulative Volume Purged (L)	Temp. (degree C)	Conductivity (umhos/cm)	pH (std. units)	Eh (mv)	DO (mg/L)	Turbidity (NTU)
	13.94 –	Static							
1400	14.31	50	.250	24.98	50.18	6.70	18.0	0.84	0.0
1405	14.36	40 ✓	.450	23.10	49.97	6.71	0.2	0.80	0.0
1410	14.44	50 ✓	.700	24.12	50.00	6.72	-12.3	0.80	0.0
1415	14.54	50	.950	24.97	50.22	6.72	-23.5	0.80	0.0
1420	14.70	50	1.200	24.00	50.04	6.71	-32.2	0.76	0.0
1425	14.98	50	1.450	23.16	49.99	6.69	-37.8	0.69	0.0
~~1500~~ 1430	15.00	150 – ✓	2.200	22.64	49.73	6.69	-40.3	0.62	0.0
1435	15.02	100	2.700	21.76	50.00	6.68	-41.5	0.57	0.0
1440	15.16	100	3.200	21.62	49.45	6.68	-43.4	0.53	0.0
1445	15.20	100	3.7	22.73	49.04	6.68	-45.7	0.49	0.0
1450	15.21	50	3.95	23.36	49.15	6.68	-48.0	0.49	0.0
1455	15.20	50	4.20	24.49	49.08	6.68	-50.7	0.51	0.0
1500	15.18	50	4.45	25.29	49.13	6.68	-52.9	0.54	0.0
1505	15.18	50	4.70	25.40	49.13	6.68	-53.4	0.55	0.0
1510	15.18	50	4.95	25.78	49.03	6.68	-54.2	0.60	0.0
1515	15.17	50	5.2	25.98	48.96	6.68	-53.5	0.54	0.0
			≈	1.4 gal					
1515	Collected Sample								
1630	DTW	15.21 Ft							

Abbreviations: BTOC - Below top of casing; DTW - Depth to water; mL - milliliter; L - Liter

GROUNDWATER SAMPLING FORM

Project Number: 843635
Project Name: PBOW
Investigation Site: Background
RFA/COC Number: PB06170451L-1C

Collection Date: 6/17/04
Collection Time: 1515
Sample Filtered (Yes/No): Yes; Metals
Weather/Temp: Partly sunny, hot (85°), breezy

Form Completed By: David Kessler
Sampler(s): D. Kessler, ~~Z. Parham~~ G. Ward
Reviewed By: David Kessler

Sample Name: PBOW-04-PB-BED-MW20-GW-DG3001

MONITORING WELL INFORMATION [use top of casing (TOC) for all measurements]

Well Number: MW20	**Outside Casing Dia. (in): 2"**	**Odor:**
Well Secure (Yes / No): Yes	**Depth to Product (ft): NA**	**Vapor Monitor Type:** PID / LEL – from Findlay
Well Labeled (Yes / No): Yes	**Total Well Depth (ft):** ~~48.6'~~ 52.3	**Vapor Monitor S/N:** 82383 / 35,175
Well Condition: Good	**Depth to Water (ft):** 13.94	**Reading (ppm):** LEL = 100 % O_2 = 18.7 %
Top of Screen: 28'	**Water Column:** ~~34.66 ft~~ 38.36 ft	PID = 0.0 C = 0 ppm H_2S = 0.0 ppm
Screen Height: 20'	**Top of Filter Pack:** 26'	**Depth Pump Set: 32'**
Casing Type: PVC	**Pump Type:** Bladder	**Pump Settings: psi – ~~20~~, Refill – ~~12~~, Discharge - ~~8~~**
		Remarks: 7 psi 8 4

MONITORING WELL PURGE CALCULATIONS

Volume of Water in Casing: Gallons/foot = 0.041 x d^2, where d is casing diameter in inches = (0.041 x (_____)^2) = _____ gal/ft

Well Volume (gallons) = Water Column (ft) x Gal/ft = _____ ft x _____ Gal/ft = _____ gallons

Volume of Water in Filter Pack: Gallons/foot = 0.041 x (D^2-d^2), where D is total borehole dia. in ~~inches~~ & d is casing dia. in inches = 0.041 x ((_____)^2 – (_____)^2) = _____ gal/ft

Filter Pack Volume (gal) = ((Screen Height + Sand Above Set or Water Column) x gal/ft) x porosity (0.3) = ((Screen Height _____ ft + _____ ft) x _____ gal/ft) x 0.3 = _____ gallons

Purge Well Volume: Purge Well Volume – Filter Pack Volume + Well Volume = _____ gal + _____ gal = _____ gal

1 x Purge Well Volume (gal.)	2 x Purge Well Volume (gal.)	3 x Purge Well Volume (gal.)	4 x Purge Well Volume (gal.)	5 x Purge Well Volume (gal.)

LOW-FLOW TUBING PURGE CALCULATIONS (3 tubing/pump volumes required for PBOW)

Volume of Water in Tubing: 1/4" ID Tubing = 0.01 Liters/ft. 3/8" ID Tubing = 0.02 Liters/ft. 2" Bladder Pump Volume = 0.3 Liters Tubing Length = 65 ft.

Tubing Volume (Liters) = ([Tubing Liters/ft. x Tubing length] + Pump volume) x 3 = ([~~0.01~~ 0.02 L/ft x 65 ft] + 0.3 L) x 3 = 4.8 L

Total Volume Purged: 5.2 L Liters to gallons = L x 0.26gal/L (≈ 1.4 gal removed)

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Sample Collection Log

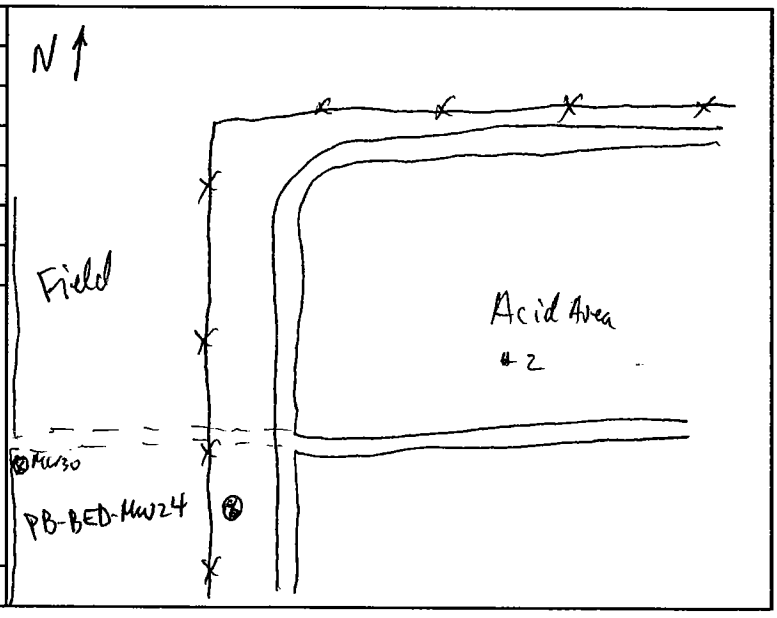
Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	**PB-BED-MW24**	Collection Date:	6/16/04
Sample Number:	**DG3002**	Collection Time:	1330
Sample Name:	**PBOW-04-PB-BED-MW24-DG3002**	Start Depth:	36.5
Sampling Method:	**Low Flow**	End Depth:	36.8
Sample Type:	**GW**	Sample Matrix:	**WATER**
Sample Purpose:	**REG**	Sample Team:	**Kessler/Ward**

Analytical Suite	Containers
FILTERED METALS	1 - ~~250~~ 125 mL HDPE
TOTAL METALS	1 - ~~250~~ 125 mL HDPE
EXPLOSIVES	1 - 1 L Amb. Glass
VOLATILES	3 - 40 mL Vial
SEMIVOLATILES	2 - 1 L Amb. Glass
TOC	2 - 40 mL Vial
CYANIDE	1 - 1 L HDPE
ALKALINITY	1 - 1 L HDPE
CHLORIDE	
NITRATE	
SULFATE	
TDS	
TSS	
TURBIDITY	
HARDNESS	1 - 250 mL HDPE

Sketch Location



Comments: Removed 3.3 gal

Logged by/Date: 6.16.04

Reviewed by/Date: David Kessler 6/16/04

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GROUNDWATER PURGE FORM

Location Code: **PB-BED-MW24**

Sample Number: **DG3002**

pump set at 36.5'

should be 0

Water Quality Parameter Measurements									
Date/ Time 6/16/04	DTW (ft. BTOC)	Purge Rate (mL/min)	Cumulative Volume Purged (L)	Temp. (degree C)	Conductivity (umhos/cm)	pH (std. units)	Eh (mv)	DO (mg/L)	Turbidity (NTU)
1225	25.48		static						
1245	25.59	200	0	16.19	1.381	6.60	-305.9	-1.15	0.0
1250	25.60	200	1.0	15.81	1.335	6.58	-316.1	-1.42	-0.7 (0.0)
1255	25.60	200	2.0	15.61	1.335	6.58	-317.5	-1.42	-0.9 (0.0)
1300	25.60	200	3.0	15.45	1.328	6.59	-317.6	-1.51	-1.1 (0.0)
1305	25.60	200	4.0	15.28	1.326	6.59	-319.7	-1.40	-1.0 (0.0)
1310	25.60	200	5.0	15.08	1.325	6.59	-321.2	-1.21	-1.3 (0.0)
1315	25.60	200	6.0	15.00	1.326	6.60	-321.0	-0.97	-1.6 (0.0)
1320	25.60	200	7.0	14.66	1.334	6.61	-321.9	-0.83	-1.8 (0.0)
1325	25.60	200	8.0	14.66	1.335	6.62	-321.8	-0.84	-1.4 (0.0)
1330	25.60	200	9.0	14.65	1.334	6.63	-321.9	-0.82	-1.5 (0.0)
1330	collected	sample							

Abbreviations: BTOC - Below top of casing; DTW - Depth to water; mL - milliliter; L - Liter

GROUNDWATER SAMPLING FORM

Shaw®

Project Number: 843635
Project Name: PBOW
Investigation Site: Background
RFA/COC Number: PB06160457TL C K

Collection Date: 6/16/04
Collection Time: 1330
Sample Filtered (Yes/No): Yes; Metals
Weather/Temp: cloudy, hot (85°), humid

Form Completed By: David Kessler
Sampler(s): D. Kessler, ~~Z. Parham~~ G. Wand
Reviewed By: David Kessler

Sample Name: PBOW-04-PB-BED-MW24-GW-DG3002

MONITORING WELL INFORMATION [use top of casing (TOC) for all measurements]

Well Number: MW24	Outside Casing Dia. (in): 2"	Odor: Distinct H_2S
Well Secure (Yes / No): Yes	Depth to Product (ft): NA	Vapor Monitor Type: PID / LEL – From Findlay
Well Labeled (Yes / No): Yes	Total Well Depth (ft): 41'	Vapor Monitor S/N: 823831 / 35175
Well Condition: Good	Depth to Water (ft): 25.48 ft	Reading (ppm): LEL = >100 % O_2 = 19.9 %
Top of Screen: 25.5'	Water Column: 15.52 ft	PID = 47.5 ppm C = 0 ppm H_2S = >200 ppm
Screen Height: 15'	Top of Filter Pack: 19 ft	Depth Pump Set: ~~38~~ 36.5'
Casing Type: PVC	Pump Type: Bladder Pump	Pump Settings: psi – 20, Refill – 10, Discharge - 5
		Remarks:

MONITORING WELL PURGE CALCULATIONS

Volume of Water in Casing: Gallons/foot = 0.041 x d^2, where d is casing diameter in inches = (0.041 x (_____)^2) = _____ gal/ft

Well Volume (gallons) = Water Column (ft) x Gal/ft = _____ ft x _____ Gal/ft = _____ gallons

Volume of Water in Filter Pack: Gallons/foot = 0.041 x (D^2-d^2), where D is total borehole dia. in inches & d is casing dia. in inches = 0.041 x ((_____)^2 – (_____)^2) = _____ gal/ft

Filter Pack Volume (gal) = ((Screen Height + ~~Sand Above Set or Water Column) x gal/ft~~) x porosity (0.3) = ((Screen Height _____ ft + _____ ft) x _____ gal/ft) x 0.3 = _____ gallons

PBOW-PB

Purge Well Volume: Purge Well Volume – ~~Filter Pack Volume~~ + Well Volume = _____ gal + _____ gal = _____ gal

1 x Purge Well Volume (gal.)	2 x Purge Well Volume (gal.)	3 x Purge Well Volume (gal.)	4 x Purge Well Volume (gal.)	5 x Purge Well Volume (gal.)

LOW-FLOW TUBING PURGE CALCULATIONS (3 tubing/pump volumes required for PBOW)

Volume of Water in Tubing: 1/4" ID Tubing = 0.01 Liters/ft. (3/8" ID Tubing = 0.02 Liters/ft.) 2" Bladder Pump Volume = 0.3 Liters Tubing Length = 42 ft.

Tubing Volume (Liters) = ([Tubing Liters/ft. x Tubing length] + Pump volume) x 3 = ([0.02 L/ft x 42 ft] + 0.3 L) x 3 = 3.42 L

Total Volume Purged: 9 L Liters to gallons = L x 0.26gal/L (Removed ~ 3.3 gal)

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Sample Collection Log

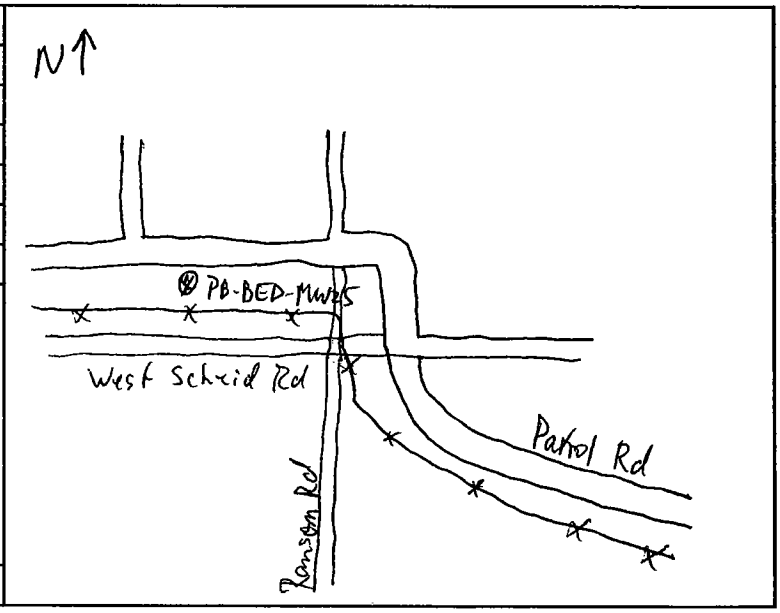
Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	**PB-BED-MW25**	Collection Date:	6/17/04
Sample Number:	**DG3003**	Collection Time:	0945
Sample Name:	**PBOW-04-PB-BED-MW25-DG3003**	Start Depth:	32.0
Sampling Method:	**Low Flow**	End Depth:	32.5
Sample Type:	**GW**	Sample Matrix:	**WATER**
Sample Purpose:	**REG**	Sample Team:	**Kessler/Ward**

Analytical Suite	Containers
FILTERED METALS	1 - ~~250~~ 125 mL HDPE
TOTAL METALS	1 - ~~250~~ 125 mL HDPE
EXPLOSIVES	1 - 1 L Amb. Glass
VOLATILES	3 - 40 mL Vial
SEMIVOLATILES	2 - 1 L Amb. Glass
TOC	2 - 40 mL Vial
CYANIDE	1 - 1 L HDPE
ALKALINITY	1 - 1 L HDPE
CHLORIDE	
NITRATE	
SULFATE	
TDS	
TSS	
TURBIDITY	
HARDNESS	1 - 250 mL HDPE

Sketch Location



Comments: Removed ~4.8 gal

Logged by/Date: Gwrad 6-17-04

Reviewed by/Date: David Kessler 6/17/04

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Sample Collection Log

Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	**PB-BED-MW25**	Collection Date:	6/17/04
Sample Number:	**DG3003-MS**	Collection Time:	0945
Sample Name:	**PBOW-04-PB-BED-MW25-DG3003-MS**	Start Depth:	32.0
Sampling Method:	**Low Flow**	End Depth:	32.5
Sample Type:	**GW**	Sample Matrix:	**WATER**
Sample Purpose:	**MS**	Sample Team:	**Kessler/Ward**

Analytical Suite	Containers	Sketch Location
FILTERED METALS	1 - ~~250~~ 125 mL HDPE	See sample# DG3003 for location information.
TOTAL METALS	1 - ~~250~~ 125 mL HDPE	
EXPLOSIVES	1 - 1 L Amb. Glass	
VOLATILES	3 - 40 mL Vial	
SEMIVOLATILES	2 - 1 L Amb. Glass	
TOC	2 - 40 mL Vial	
CYANIDE	1 - 1 L HDPE	
ALKALINITY	1 - 1 L HDPE	
CHLORIDE		
NITRATE		
SULFATE		
TDS		
TSS		
TURBIDITY		
HARDNESS	1 - 250 mL HDPE	

Comments: See sample# DG3003 for purge and location information.

Logged by/Date: Gwen 6.17.04 Reviewed by/Date: David Kessler 6/17/04

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Sample Collection Log

Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	**PB-BED-MW25**	Collection Date:	6/17/04
Sample Number:	**DG3003-MSD**	Collection Time:	0945
Sample Name:	**PBOW-04-PB-BED-MW25-DG3003-MSD**	Start Depth:	32.0
Sampling Method:	**Low Flow**	End Depth:	32.5
Sample Type:	**GW**	Sample Matrix:	**WATER**
Sample Purpose:	**MSD**	Sample Team:	**Kessler/Ward**

Analytical Suite	Containers	Sketch Location
FILTERED METALS	1 - ~~250~~ 125 mL HDPE	See sample# DG3003 for location information.
TOTAL METALS	1 - ~~250~~ 125 mL HDPE	
EXPLOSIVES	1 - 1 L Amb. Glass	
VOLATILES	3 - 40 mL Vial	
SEMIVOLATILES	2 - 1 L Amb. Glass	
TOC	2 - 40 mL Vial	
CYANIDE	1 - 1 L HDPE	
ALKALINITY	1 - 1 L HDPE	
CHLORIDE		
NITRATE		
SULFATE		
TDS		
TSS		
TURBIDITY		
HARDNESS	1 - 250 mL HDPE	

Comments: See sample# DG3003 for purge and location information.

Logged by/Date: Ward 6.17.04 Reviewed by/Date: David Kessler 6/17/04

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GROUNDWATER PURGE FORM

Location Code: **PB-BED-MW25**

Sample Number: **DG3003**

	13.43			Water Quality Parameter Measurements					
Date/ Time 6-17-04	DTW (ft. BTOC)	Purge Rate (mL/min)	Cumulative Volume Purged (L)	Temp. (degree C)	Conductivity (umhos/cm)	pH (std. units)	Eh (mv)	DO (mg/L)	Turbidity (NTU)
0900	13.59	340	1.0	14.37	1.949	6.93	-141.9	0.91	-1.6(0.0)
0905	13.62	400	2.70	13.91	1.836	7.01	-168.9	0.50	-1.9(0.0)
09:10	13.63	400	3.70	13.45	1.771	7.04	-210.7	0.40	-2.2(0.0)
09:15	13.62	400	5.70	13.41	1.728	7.05	-238.7	0.36	-2.2(0.0)
09:20	13.64	400	7.70	13.39	1.705	7.07	-255.4	0.30	-2.3(0.0)
09:25	13.59	400	9.70	13.60	1.691	7.08	-268.1	0.28	-2.2(0.0)
09:30	13.59	400	11.70	13.57	1.686	7.09	-272.5	0.27	-2.3(0.0)
09:35	13.59	400	13.70	13.59		7.09	-274.5	0.26	-2.1(0.0)
09:40	13.59	400	15.70	13.58	1.675	7.09	-276.5	0.25	-2.2(0.0)
09:45	13.59	400	17.70	13.59	1.672	7.09	-275.5	0.26	-2.2(0.0)
0945	Collected sample								

Abbreviations: BTOC - Below top of casing; DTW - Depth to water; mL - milliliter; L - Liter

GROUNDWATER SAMPLING FORM

Shaw®

Project Number: 843635
Project Name: PBOW
Investigation Site: Background
RFA/COC Number: PB061704/K ACC

Collection Date: 6/17/04
Collection Time: 0545
Sample Filtered (Yes/No): Yes; Metals
Weather/Temp: cloudy, windy, warm(75°)-

Form Completed By: David Kessler
Sampler(s): D. Kessler, ~~Z. Parham~~ G. Ward
Reviewed By: David Kessler

Sample Name: PBOW-04-PB-BED-MW25-GW-DG3003

MONITORING WELL INFORMATION [use top of casing (TOC) for all measurements]

Well Number: MW25	Outside Casing Dia. (in): 2"	Odor: None
Well Secure (Yes / No): Yes	Depth to Product (ft): NA	Vapor Monitor Type: PID / LEL
Well Labeled (Yes / No): Yes	Total Well Depth (ft): 40.6'	Vapor Monitor S/N: /
Well Condition: Good	Depth to Water (ft): 13.43	Reading (ppm): LEL = 0 % O_2 = 20.8 %
Top of Screen: 30'	Water Column: 27.17 Ft	PID: 0.0 ppm C = 0.0 ppm H_2S = 0.0 ppm
Screen Height: 10'	Top of Filter Pack: 25 Ft	Depth Pump Set: ~~32'~~ 35'
Casing Type: PVC	Pump Type: Bladder Pump	Pump Settings: psi – ~~20~~, Refill – 10, Discharge - 5
		Remarks: 15 psi

MONITORING WELL PURGE CALCULATIONS

Volume of Water in Casing: Gallons/foot = 0.041 x d^2, where d is casing diameter in inches = (0.041 x (____)^2) = ____ gal/ft

Well Volume (gallons) = Water Column (ft) x Gal/ft = ____ ft x ____ Gal/ft = ____ gallons

Volume of Water in Filter Pack: Gallons/foot = 0.041 x (D^2-d^2), where D is total borehole dia. in inches & d is casing dia. in inches = 0.041 x ((____)^2 – (____)^2) = ____ gal/ft

Filter Pack Volume (gal) = ((Screen Height + Sand Above Set or Water Column) x gal/ft) x porosity (0.3) = ((Screen Height ____ ft + ____ ft) x ____ gal/ft) x 0.3 = ____ gallons

Purge Well Volume: Purge Well Volume – Filter Pack Volume + Well Volume = ____ gal + ____ gal = ____ gal

1 x Purge Well Volume (gal.)	2 x Purge Well Volume (gal.)	3 x Purge Well Volume (gal.)	4 x Purge Well Volume (gal.)	5 x Purge Well Volume (gal.)

LOW-FLOW TUBING PURGE CALCULATIONS (3 tubing/pump volumes required for PBOW)

Volume of Water in Tubing: 1/4" ID Tubing = 0.01 Liters/ft. (3/8" ID Tubing = 0.02 Liters/ft.) 2" Bladder Pump Volume = 0.3 Liters Tubing Length = 37 ft.

Tubing Volume (Liters) = ([Tubing Liters/ft. x Tubing length] + Pump volume) x 3 = ([~~0.01~~ 0.02 L/ft x 37 ft] + 0.3 L) x 3 = 3.12 L

Total Volume Purged: 18 L Liters to gallons = L x 0.26gal/L = ~4.7 gal

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Sample Collection Log

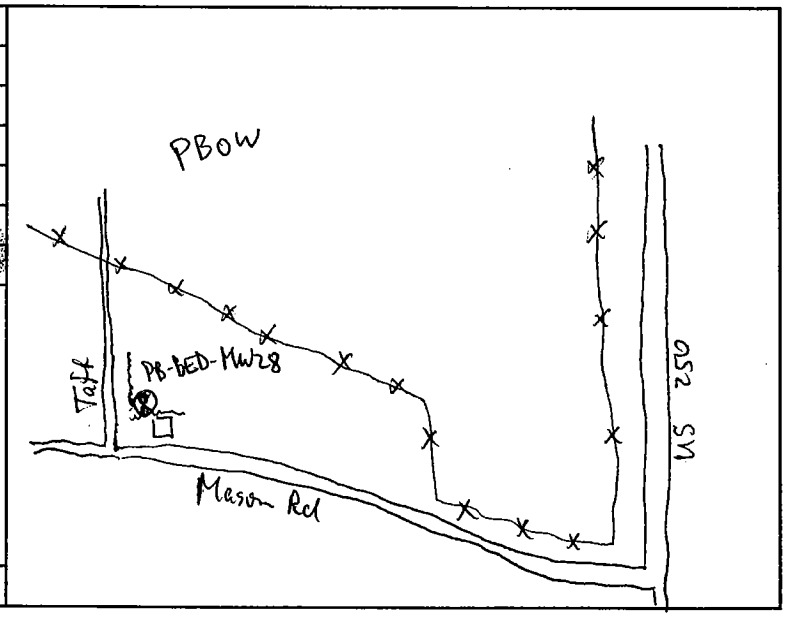
Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	**PB-BED-MW28**	Collection Date:	6/15/04
Sample Number:	**DG3004**	Collection Time:	1330
Sample Name:	**PBOW-04-PB-BED-MW28-DG3004**	Start Depth:	32.0
Sampling Method:	**Low Flow**	End Depth:	32.1
Sample Type:	**GW**	Sample Matrix:	**WATER**
Sample Purpose:	**REG**	Sample Team:	**Kessler/Ward**

Analytical Suite	Containers
FILTERED METALS	1 - ~~250~~ 125 mL HDPE
TOTAL METALS	1 - 250 mL HDPE
EXPLOSIVES	1 - 1 L Amb. Glass
VOLATILES	3 - 40 mL Vial
SEMIVOLATILES	2 - 1 L Amb. Glass
TOC	2 - 40 mL Vial
CYANIDE	1 - 1 L HDPE
ALKALINITY	1 - 1 L HDPE
CHLORIDE	
NITRATE	
SULFATE	
TDS	
TSS	
TURBIDITY	
HARDNESS	1 - ~~250~~ 125 mL HDPE

Sketch Location



Comments: Removed 4 gals. (Purge Vol)

Logged by/Date: Grant 6-15-04

Reviewed by/Date: David Kessler 6/15/04

Shaw
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GROUNDWATER PURGE FORM

Location Code: **PB-BED-MW28**

Sample Number: **DG3004**

Water Quality Parameter Measurements									
Date/ Time 6-15-04	DTW (ft. BTOC)	Purge Rate (mL/min)	Cumulative Volume Purged (L)	Temp. (degree C)	Conductivity (umhos/cm)	pH (std. units)	Eh (mv)	DO (mg/L)	Turbidity (NTU)
1215	5.94	300	300	15.27	1.454	4.00	148.6	0.50	3.2
1220	5.99	300	1800	14.80	1.406	8.90	140.4	0.49	2.2
1225	6.25	300	3,300	14.49	1,381	8.88	139.8	0.47	2.1
1230	6.51	300ml/	4800	14.42	1.353	8.56	136.6	0.46	1.2
1235	6.60	300	6.300	13.84	1,324	8.39	117.2	0.33	2.0
1240	6.55	300	7.800	14.37	1,296	8.29	84.8	0.32	2.2
1245	6.35	180	8.700	15.13	1.286	8.25	32.0	0.34	4.0
12:50	6.35	180	9.600	15.35	1.279	8.20	-3.9	0.39	0.4
12:55	6.35	180	10.500	15.20	1,276	8.12	-42.9	0.39	1.6
13:00	6.35	180	11.400	14.85	1.262	8.02	-91.0	0.37	0.8
13:05	6.35	180	12.300	14.75	1.244	7.94	-114.6	0.36	0.1
13:10	6.35	180	13.200	14.77	1,238	7.91	-124.3	0.35	0.5
13:15	6.35	180	14.100	14.84	1.230	7.90	-129.0	0.34	0.4
13:20	6.35	180	15.000	14.92	1.229	7.89	-131.4	0.33	0.4
13:25	6.35	180	15.900	15.02	1.228	7.88	-132.4	0.33	0.0
13:30	6.35	180	16.800	15.01	1.228	7.89	-131.9	0.33	0.4
1330	Collected	sample							

Abbreviations: BTOC - Below top of casing; DTW - Depth to water; mL - milliliter; L - Liter

GROUNDWATER SAMPLING FORM

Shaw®

Project Number: 843635
Project Name: PBOW
Investigation Site: Background
RFA/COC Number: PB06 1504STL<K

Collection Date: 6/15/04
Collection Time: 1330
Sample Filtered (Yes/No): Yes; Metals
Weather/Temp: partly cloudy, warm -

Form Completed By: D. Kessler
Sampler(s): D. Kessler, ~~Z. Parham~~ & Ward
Reviewed By: David Keasler

Sample Name: PBOW-04-PB-BED-MW28-GW-DG3004

MONITORING WELL INFORMATION [use top of casing (TOC) for all measurements]

Well Number: MW28	Outside Casing Dia. (in): 2"	Odor:
Well Secure (Yes / No): Yes	Depth to Product (ft): NA	Vapor Monitor Type: Findlay PID / LEL - From Findlay
Well Labeled (Yes / No): Yes	Total Well Depth (ft): 41.9'	Vapor Monitor S/N: 82383 / 35175
Well Condition: Good	Depth to Water (ft): 5.94	Reading (ppm): LEL = 0% O_2 = 20.8 %
Top of Screen: 26.65'	Water Column: 35.96 Ft	PID = 0.0 ppm C = 0 ppm H_2S = 0 ppm
Screen Height: 15'	Top of Filter Pack: 17.5 Ft	Depth Pump Set: ~~32~~ 34'
Casing Type: PVC	Pump Type: Bladder	Pump Settings: psi – ~~20~~ 8, Refill – 10, Discharge - 5
		Remarks:

MONITORING WELL PURGE CALCULATIONS

Volume of Water in Casing: Gallons/foot = 0.041 x d^2, where d is casing diameter in inches = (0.041 x (_____)^2) = _____ gal/ft

Well Volume (gallons) = Water Column (ft) x Gal/ft = _____ ft x _____ Gal/ft = _____ gallons

Volume of Water in Filter Pack: Gallons/foot = 0.041 x (D^2-d^2), where D is total borehole dia. in inches & d is casing dia. in inches = 0.041 x ((_____)^2 – (_____)^2) = _____ gal/ft

Filter Pack Volume (gal) = ((Screen Height + Sand Above Screen ~~Water Column~~) x gal/ft) x porosity (0.3) = ((Screen Height _____ ft + _____ ft) x _____ gal/ft) x 0.3 = _____ gallons

Purge Well Volume: Purge Well Volume = ~~Filter Pack Volume~~ + Well Volume = _____ gal + _____ gal = _____ gal

1 x Purge Well Volume (gal.)	2 x Purge Well Volume (gal.)	3 x Purge Well Volume (gal.)	4 x Purge Well Volume (gal.)	5 x Purge Well Volume (gal.)

LOW-FLOW TUBING PURGE CALCULATIONS (3 tubing/pump volumes required for PBOW)

Volume of Water in Tubing: 1/4" ID Tubing = 0.01 Liters/ft. 3/8" ID Tubing = 0.02 Liters/ft. 2" Bladder Pump Volume = 0.3 Liters Tubing Length = 35 ft.

Tubing Volume (Liters) = ([Tubing Liters/ft. x Tubing length] + Pump volume) x 3 = ([0.01 L/ft x 35 ft] + 0.3 L) x 3 = 3 L

Total Volume Purged: 15 L Liters to gallons = L x 0.26gal/L Removed ~4 gal

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Sample Collection Log

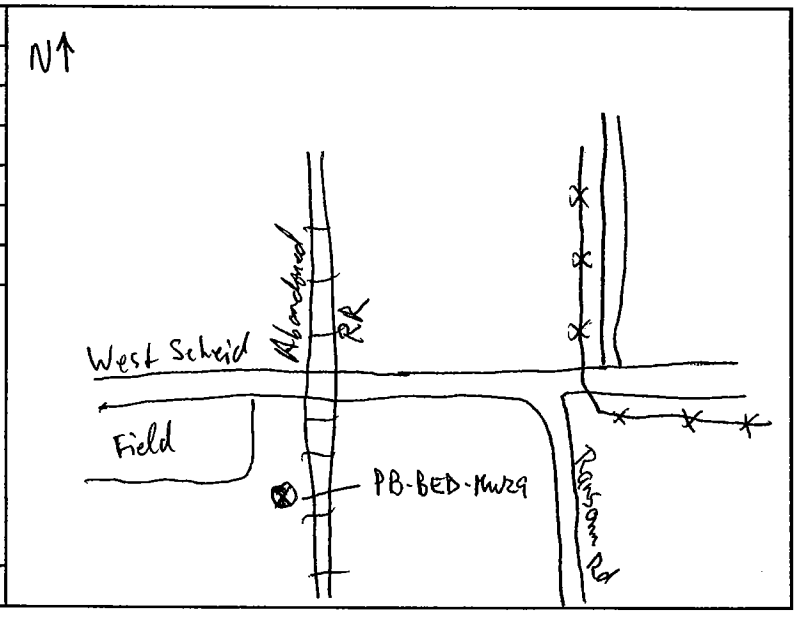
Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	**PB-BED-MW29**	Collection Date:	6/16/04
Sample Number:	**DG3005**	Collection Time:	0955
Sample Name:	**PBOW-04-PB-BED-MW29-DG3005**	Start Depth:	32.0
Sampling Method:	**Low Flow**	End Depth:	32.1
Sample Type:	**GW**	Sample Matrix:	**WATER**
Sample Purpose:	**REG**	Sample Team:	**Kessler/Ward**

Analytical Suite	Containers
FILTERED METALS	1 - ~~250~~ 125 mL HDPE
TOTAL METALS	1 - ~~250~~ 125 mL HDPE
EXPLOSIVES	1 - 1 L Amb. Glass
VOLATILES	3 - 40 mL Vial
SEMIVOLATILES	2 - 1 L Amb. Glass
TOC	2 - 40 mL Vial
CYANIDE	1 - 1 L HDPE
ALKALINITY	1 - 1 L HDPE
CHLORIDE	
NITRATE	
SULFATE	
TDS	
TSS	
TURBIDITY	
HARDNESS	1 - 250 mL HDPE

Sketch Location



Comments: Removed ~ 3 gal

Logged by/Date: Gerard 6.16.04

Reviewed by/Date: David Kessler 6/16/04

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GROUNDWATER PURGE FORM

Pump at 32 Ft.

Location Code: **PB-BED-MW29**

Sample Number: **DG3005**

Water Quality Parameter Measurements									
Date/ Time 6/14/04	DTW (ft. BTOC)	Purge Rate (mL/min)	Cumulative Volume Purged (L)	Temp. (degree C)	Conductivity (umhos/cm)	pH (std. units)	Eh (mv)	DO (mg/L)	Turbidity (NTU)
0820	2.26	— Static							
0840	2.41	110	1.110	15.25	6.643	7.05	-79.3	1.84	8.3
0845	2.43	110	1.660	15.13	7.259	6.90	-82.4	0.84	8.5
decreased 0850	2.43	120	2.260	14.93	7.318	6.80	-82.9	0.68	5.6
0855	2.46	120	2.860	14.78	7.523	6.88	-77.4	0.44	2.8
09:00	2.58	120	3.460	13.89	7.803	6.86	-72.5	0.38	6.2
decreased 09:05	2.70	120	4.060	13.27	7.823	6.85	-70.5	0.26	6.9
09:10	2.70	~~210~~	4.660	13.22	7.831	6.85	-69.0	0.23	1.3
09:15	2.65	205	5.685	13.23	7.950	6.83	-65.3	0.22	5.3
decreased psi 09:20	2.45	200	6.685	13.28	8.086	6.82	-62.5	0.22	0.4
09:25	2.70	200	7.685	13.47	8.407	6.80	-61.1	0.23	0.8
09:30	2.70	200	8.685	13.54	8.737	6.79	-57.1	0.21	0.8
09:35	2.70	200	9.685	13.58	8.898	6.78	-55.3	0.19	0.4
09:40	2.70	200	10.685	13.68	9.043	6.78	-53.5	0.19	0.5
09:45	2.70	200	11.685	13.64	9.111	6.78	-53.1	0.19	0.4
09:50	2.70	200	12.685	13.66	9.124	6.77	-52.9	0.18	0.4
09:55	2.70	200	13.685	13.65	9.125	6.78	-52.9	0.19	0.3
Collected sample at 0955									

DK 6/16/04

Abbreviations: BTOC - Below top of casing; DTW - Depth to water; mL - milliliter; L - Liter

GROUNDWATER SAMPLING FORM

Shaw®

Project Number: 843635
Project Name: PBOW
Investigation Site: Background
RFA/COC Number: PB061604STL-KN

Collection Date: 6/16/04
Collection Time: 0955
Sample Filtered (Yes/No): Yes; Metals
Weather/Temp: Cloudy, warm (70°)

Form Completed By: David Kessler
Sampler(s): D. Kessler, ~~Z. Parham~~ G. Ward
Reviewed By: David Kessler

Sample Name: PBOW-04-PB-BED-MW29-GW-DG3005

MONITORING WELL INFORMATION [use top of casing (TOC) for all measurements]

Well Number: MW29	Outside Casing Dia. (in): 2"	Odor: None
Well Secure (Yes / No): Yes	Depth to Product (ft): NA	Vapor Monitor Type: PID / LEL – From Findlay
Well Labeled (Yes / No): Yes	Total Well Depth (ft): 37.9'	Vapor Monitor S/N: 82383 / 135175
Well Condition: Good	Depth to Water (ft): 2.26	Reading (ppm): LEL = 78 % O_2 = 19.6 %
Top of Screen: 27.65'	Water Column: 35.64	PID = 0.0 C = 0.0 ppm H_2S = 0.0 ppm
Screen Height: 10'	Top of Filter Pack:	Depth Pump Set: 32'
Casing Type: PVC	Pump Type: Bladder Pump	Pump Settings: psi ~~19.5 = 20~~, Refill – 10, Discharge - 5
		Remarks: psi = 8 for 200 ml

MONITORING WELL PURGE CALCULATIONS

Volume of Water in Casing: Gallons/foot = 0.041 x d^2, where d is casing diameter in inches = (0.041 x (_____)^2) = _____ gal/ft

Well Volume (gallons) = Water Column (ft) x Gal/ft = _____ ft x _____ Gal/ft = _____ gallons

Volume of Water in Filter Pack: Gallons/foot = 0.041 x (D^2-d^2), where D is total borehole dia. in inches & d is casing dia. in inches = 0.041 x ((_____)^2 – (_____)^2) = _____ gal/ft

Filter Pack Volume (gal) = ((Screen Height + Sand Above Set or Water Column) x gal/ft) x porosity (0.3) = ((Screen Height _____ ft + _____ ft) x _____ gal/ft) x 0.3 = _____ gallons

Purge Well Volume: Purge Well Volume – Filter Pack Volume + Well Volume = _____ gal + _____ gal = _____ gal

1 x Purge Well Volume (gal.)	2 x Purge Well Volume (gal.)	3 x Purge Well Volume (gal.)	4 x Purge Well Volume (gal.)	5 x Purge Well Volume (gal.)

LOW-FLOW TUBING PURGE CALCULATIONS (3 tubing/pump volumes required for PBOW)

Volume of Water in Tubing: 1/4" ID Tubing = 0.01 Liters/ft. 3/8" ID Tubing = 0.02 Liters/ft. 2" Bladder Pump Volume = 0.3 Liters Tubing Length = 38 ft.

Tubing Volume (Liters) = ([Tubing Liters/ft. x Tubing length] + Pump volume) x 3 = ([0.02 L/ft x 38 ft] + 0.3 L) x 3 = 3.18 L = 0.83 gal

Total Volume Purged: 13.69 L Liters to gallons = L x 0.26gal/L

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Sample Collection Log

Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	**PB-BED-MW25**	Collection Date:	6/17/04
Sample Number:	**DG3006**	Collection Time:	0945
Sample Name:	**PBOW-04-PB-BED-MW25-DG3006**	Start Depth:	32.0
Sampling Method:	**Low Flow**	End Depth:	32.5
Sample Type:	**GW**	Sample Matrix:	**WATER**
Sample Purpose:	**FD**	Sample Team:	**Kessler/Ward**

Analytical Suite	Containers	Sketch Location
FILTERED METALS	1 - ~~250~~ 125 mL HDPE	See sample# DG3003 for location information.
TOTAL METALS	1 - ~~250~~ 125 mL HDPE	
EXPLOSIVES	1 - 1 L Amb. Glass	
VOLATILES	3 - 40 mL Vial	
SEMIVOLATILES	2 - 1 L Amb. Glass	

Comments: See sample# DG3003 for purge and location information.

Logged by/Date: Gerard 6.17.04

Reviewed by/Date: David Keach 6/17/04

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Sample Collection Log

Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	**PB-BED-MW25**	Collection Date:	6/17/04
Sample Number:	**DG3007**	Collection Time:	0945
Sample Name:	**PBOW-04-PB-BED-MW25-DG3007**	Start Depth:	32.0
Sampling Method:	**Low Flow**	End Depth:	32.5
Sample Type:	**GW**	Sample Matrix:	**WATER**
Sample Purpose:	**FS**	Sample Team:	**Kessler/Ward**

Analytical Suite	Containers	Sketch Location
FILTERED METALS	1 - ~~250~~ 500 mL HDPE 500ml	See sample# DG3003 for location information.
TOTAL METALS	1 - ~~250~~ 500 mL HDPE 500ml	
EXPLOSIVES	1 - 1 L Amb. Glass	
VOLATILES	3 - 40 mL Vial	
SEMIVOLATILES	2 - 1 L Amb. Glass	

Comments: See sample# DG3003 for purge and location information.

Logged by/Date: Ward 6.17.04

Reviewed by/Date: David Kessler 6/17/04

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Sample Collection Log

Plum Brook Ordnance Works

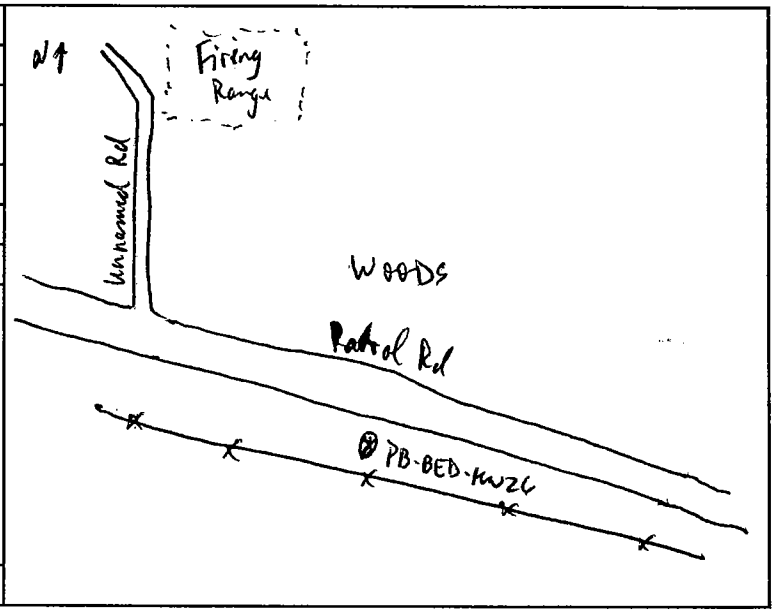
Project No: 843656 Project Manager: S. Downey

Location Code:	**PB-BED-MW26**	Collection Date:	Not Sampled
Sample Number:	**DG3008**	Collection Time:	
Sample Name:	**PBOW-04-PB-BED-MW26-DG3008**	Start Depth:	
Sampling Method:	**Low Flow**	End Depth:	
Sample Type:	**GW**	Sample Matrix:	**WATER**
Sample Purpose:	**REG**	Sample Team:	**Kessler/Ward**

DKK

Analytical Suite	Containers
FILTERED METALS	1 - 250 mL HDPE
TOTAL METALS	1 - 250 mL HDPE
EXPLOSIVES	1 - 1 L Amb. Glass
VOLATILES	3 - 40 mL Vial
SEMIVOLATILES	2 - 1 L Amb. Glass
TOC	2 - 40 mL Vial
CYANIDE	1 - 1 L HDPE
ALKALINITY	1 - 1 L HDPE
CHLORIDE	
NITRATE	
SULFATE	
TDS	
TSS	
TURBIDITY	
HARDNESS	1 - 250 mL HDPE

Sketch Location



Comments:

Logged by/Date: David Kessler 6/17/04 Reviewed by/Date: David Kessler 6/17/04

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GROUNDWATER PURGE FORM

Location Code: **PB-BED-MW26**

Sample Number: **DG3008**

Water Quality Parameter Measurements

Date/ Time	DTW (ft. BTOC)	Purge Rate (mL/min)	Cumulative Volume Purged (L)	Temp. (degree C)	Conductivity (umhos/cm)	pH (std. units)	Eh (mv)	DO (mg/L)	Turbidity (NTU)

Not Sampled

Abbreviations: BTOC - Below top of casing; DTW - Depth to water; mL - milliliter; L - Liter

GROUNDWATER SAMPLING FORM

Shaw®

Project Number: 843635
Project Name: PBOW
Investigation Site: Background
RFA/COC Number: —

Collection Date: Not Sampled
Collection Time: —
Sample Filtered (Yes/No): Yes; Metals
Weather/Temp: —

Form Completed By: David Kessler
Sampler(s): D. Kessler, ~~Z. Parham~~ C. Ward
Reviewed By: David Kessler

Sample Name: PBOW-04-PB-BED-MW26-GW-DG3008

MONITORING WELL INFORMATION [use top of casing (TOC) for all measurements]

Well Number: MW26	**Outside Casing Dia. (in):** 2"	**Odor:**
Well Secure (Yes / No): Yes	**Depth to Product (ft):** NA	**Vapor Monitor Type:** PID / LEL
Well Labeled (Yes / No): Yes	**Total Well Depth (ft):** 60.35'	**Vapor Monitor S/N:** /
Well Condition: Good	**Depth to Water (ft):** 57.52	**Reading (ppm):** LEL = 100 % O_2 = 14.9 %
Top of Screen: 30'	**Water Column:** 2.83 Ft	PID = 14.6 ppm C = 9.99 ppm H_2S = 20 ppm
Screen Height: 15'	**Top of Filter Pack:**	**Depth Pump Set:** ~~32'~~
Casing Type: PVC	**Pump Type:**	**Pump Settings:** —
		Remarks:

MONITORING WELL PURGE CALCULATIONS

Volume of Water in Casing: Gallons/foot = 0.041 x d^2, where d is casing diameter in inches = (0.041 x (_____)^2) = _____gal/ft

Well Volume (gallons) = Water Column (ft) x Gal/ft = _____ ft x _____ Gal/ft = _____gallons

Volume of Water in Filter Pack: Gallons/foot = 0.041 x (D^2-d^2), where D is total borehole dia. in inches & d is casing dia. in inches = 0.041 x ((_____)^2 – (_____)^2) = _____ gal/ft

Filter Pack Volume (gal) = ((Screen Height + Sand Above Set or Water Column) x gal/ft) x porosity (0.3) = ((Screen Height _____ft + _____ ft) x _____gal/ft) x 0.3 = _____gallons

Purge Well Volume: Purge Well Volume – Filter Pack Volume + Well Volume = _____ gal + _____ gal = _____gal

Not Sampled

1 x Purge Well Volume (gal.)	2 x Purge Well Volume (gal.)	3 x Purge Well Volume (gal.)	4 x Purge Well Volume (gal.)	5 x Purge Well Volume (gal.)

LOW-FLOW TUBING PURGE CALCULATIONS (3 tubing/pump volumes required for PBOW)

Volume of Water in Tubing: 1/4" ID Tubing = 0.01 Liters/ft. 3/8" ID Tubing = 0.02 Liters/ft. 2" Bladder Pump Volume = 0.3 Liters Tubing Length = ____ft.

Tubing Volume (Liters) = ([Tubing Liters/ft. x Tubing length] + Pump volume) x 3 = ([0.01 L/ft x ____ft] + 0.3 L) x 3 = _____L

Total Volume Purged: _____L Liters to gallons = L x 0.26gal/L

AUGUST 2004 DOWNGRADIENT GROUNDWATER SAMPLING

Shaw™
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Sample Collection Log

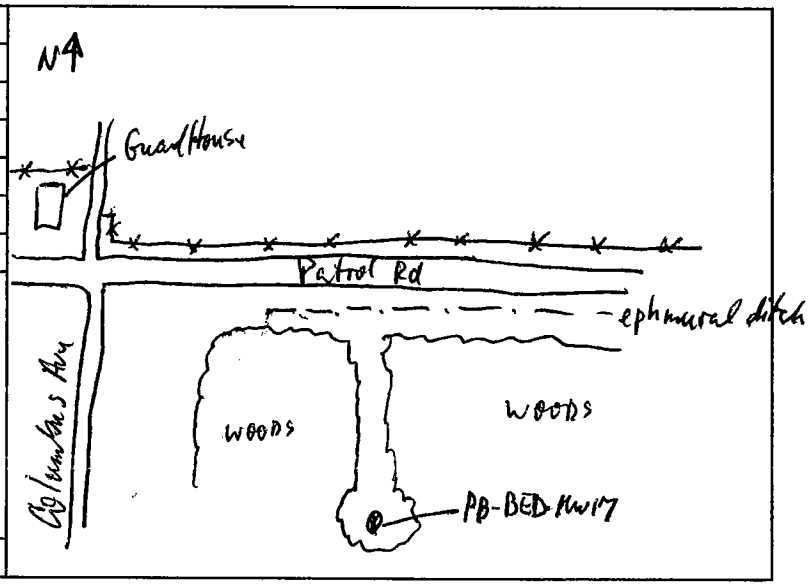
Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	**PB-BED-MW17**	Collection Date:	8/26/04
Sample Number:	**DH3000**	Collection Time:	1715
Sample Name:	**PBOW-04-PB-BED-MW17-DH3000**	Start Depth:	44.0
Sampling Method:	**Low Flow**	End Depth:	44.2
Sample Type:	**GW**	Sample Matrix:	**WATER**
Sample Purpose:	**REG**	Sample Team:	**Kessler/Parham**

Analytical Suite	Containers
FILTERED METALS	1 - 250 mL HDPE
TOTAL METALS	1 - 250 mL HDPE
EXPLOSIVES	1 - 1 L Amb. Glass
VOLATILES	3 - 40 mL Vial
SEMIVOLATILES	2 - 1 L Amb. Glass
TOC	2 - 40 mL Vial
CYANIDE	1 - 1 L HDPE
ALKALINITY	1 - 1 L HDPE
CHLORIDE	
NITRATE	
SULFATE	
TDS	
TSS	
TURBIDITY	
HARDNESS	1 - 250 mL HDPE

Sketch Location



Comments: Removed ~ 2.7 gal

Logged by/Date: David Kessler 8/26/04 Reviewed by/Date: David Kessler 8/26/04

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GROUNDWATER PURGE FORM

Location Code: **PB-BED-MW17**

Sample Number: **DH3000**

Pump set at ~~54~~ 44 OKK Ft

Static DTW = 32.40'

Well bubbling/gurgling. Vapors >500 ppm (H_2S). Perform work behind fan

Water Quality Parameter Measurements									
Date/ Time 8/26/04	DTW (ft. BTOC)	Purge Rate (mL/min)	Cumulative Volume Purged (L)	Temp. (degree C)	Conductivity (umhos/cm)	pH (std. units)	Eh (mv)	DO (mg/L)	Turbidity (NTU)
1600	32.31	100	0	23.27	6.648	6.68	-332.4	0.00	3.1
1605	32.30			21.85	6.622	6.64	-331.2	0.00	13.4
1610	32.30	140		21.08	6.478	6.59	-329.1	0.00	10.4
1615	32.27			19.60	6.214	6.53	-324.6	0.00	3.9
1620	32.00	150	—	—	—	—	—	—	—
1625	32.30	150		18.23	6.207	6.48	-323.2	0.00	~~29.3~~ 5.2
1630	32.30	200	1.0	17.83	6.387	6.45	-321.1	0.90	8.3
1635	32.30	200		17.13	6.393	6.40	-318.9	0.00	
1640	32.30	200							
1645	32.75	180		17.11	6.360	6.39	-319.0	0.00	7.9
1650	32.85	180		17.46	6.578	6.39	-319.7	0.00	8.8
1655	32.95	190		17.35	6.582	6.38	-319.2	3.55	6.8
1700	32.95	190		18.22	6.483	6.42	-318.4	4.69	6.8
1705	32.93	180		18.10	6.426	6.41	-315.6	7.50	8.2
1710	32.89	180	2.7 gal	17.94	6.412	6.40	-315.4	15.70	11.2
1715	Collected sample								

Air bag in flow

Abbreviations: BTOC - Below top of casing; DTW - Depth to water; mL - milliliter; L - Liter

GROUNDWATER SAMPLING FORM

Shaw®

Project Number: 843635
Project Name: PBOW
Investigation Site: Downgradient
RFA/COC Number: PB082604STL-EK

Collection Date: 8/26/04
Collection Time: 1715
Sample Filtered (Yes/No): Yes; Metals
Weather/Temp: cloudy, hot (85°), humid

Form Completed By: David Kessler
Sampler(s): D. Kessler, Z. Parham
Reviewed By: David Kessler

Sample Name: PBOW-04-PB-BED-MW17-GW-DH3000

MONITORING WELL INFORMATION [use top of casing (TOC) for all measurements]

Well Number: MW17	Outside Casing Dia. (in): 3"	Odor: Strong H_2S odor
Well Secure (Yes / No): Yes	Depth to Product (ft): NA	Vapor Monitor Type: PID / LEL
Well Labeled (Yes / No): Yes	Total Well Depth (ft): ~ 64.4'	Vapor Monitor S/N: HS419631
Well Condition: Good	Depth to Water (ft): 32.40	Reading (ppm): LEL = >100 % O_2 = 20.1 %
Top of Screen: 19.4'	Water Column: 32.00	PID = 130.0 ppm C = ppm H_2S = >50 ppm
Screen Height: 45'	Top of Filter Pack: NA	Depth Pump Set: ~~44~~ 22 ft
Casing Type: Open hole	Pump Type: Bladder	Pump Settings: psi – ~~40~~ 22, Refill – 10, Discharge - 5
		Remarks:

MONITORING WELL PURGE CALCULATIONS

Volume of Water in Casing: Gallons/foot = 0.041 x d^2, where d is casing diameter in inches = (0.041 x (_____)^2) = _____gal/ft

Well Volume (gallons) = Water Column (ft) x Gal/ft = _____ ft x _____ Gal/ft = _____gallons

Volume of Water in Filter Pack: Gallons/foot = 0.041 x (D^2-d^2), where D is total borehole dia. in inches & d is casing dia. in inches = 0.041 x ((_____)^2 – (_____)^2) = _____ gal/ft

Filter Pack Volume (gal) = ((Screen Height + Sand Above Set or Water Column) x gal/ft) x porosity (0.3) = ((Screen Height _____ft + _____ ft) x _____gal/ft) x 0.3 = _____gallons

Low Flow

Purge Well Volume: Purge Well Volume – Filter Pack Volume + Well Volume = _____ gal + _____ gal = _____gal

1 x Purge Well Volume (gal.)	2 x Purge Well Volume (gal.)	3 x Purge Well Volume (gal.)	4 x Purge Well Volume (gal.)	5 x Purge Well Volume (gal.)

LOW-FLOW TUBING PURGE CALCULATIONS (3 tubing/pump volumes required for PBOW)

Volume of Water in Tubing: 1/4" ID Tubing = 0.01 Liters/ft. 3/8" ID Tubing = 0.02 Liters/ft. 2" Bladder Pump Volume = 0.3 Liters Tubing Length = 55 ft.

Tubing Volume (Liters) = ([Tubing Liters/ft. x Tubing length] + Pump volume) x 3 = ([0.01 L/ft x 54 ft] + 0.3 L) x 3 = 2.52 L 0.66 gal

Total Volume Purged: 10.2 L Liters to gallons = L x 0.26gal/L 2.7 gal Removed

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Sample Collection Log

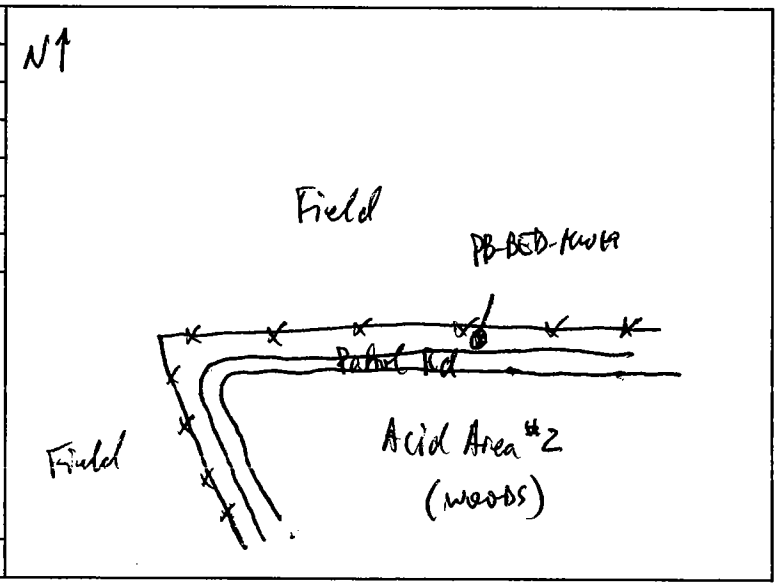
Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	**PB-BED-MW19**	Collection Date:	8/25/04
Sample Number:	**DH3001**	Collection Time:	1700
Sample Name:	**PBOW-04-PB-BED-MW19-DH3001**	Start Depth:	31.4
Sampling Method:	**Low Flow**	End Depth:	31.6
Sample Type:	**GW**	Sample Matrix:	**WATER**
Sample Purpose:	**REG**	Sample Team:	**Kessler/Parham**

Analytical Suite	Containers
FILTERED METALS	1 - 250 mL HDPE
TOTAL METALS	1 - 250 mL HDPE
EXPLOSIVES	1 - 1 L Amb. Glass
VOLATILES	3 - 40 mL Vial
SEMIVOLATILES	2 - 1 L Amb. Glass
TOC	2 - 40 mL Vial
CYANIDE	1 - 1 L HDPE
ALKALINITY	1 - 1 L HDPE
CHLORIDE	
NITRATE	
SULFATE	
TDS	
TSS	
TURBIDITY	
HARDNESS	1 - 250 mL HDPE

Sketch Location



Comments: Removed 1.2 gal

Logged by/Date: David Kessler 8/25/04 Reviewed by/Date: David Kessler 8/25/04

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GROUNDWATER PURGE FORM

Location Code: **PB-BED-MW19** Pump at 30', Inlet at 32 Ft

Sample Number: **DH3001**

Water Quality Parameter Measurements									
Date/ Time	DTW (ft. BTOC)	Purge Rate (mL/min)	Cumulative Volume Purged (L)	Temp. (degree C)	Conductivity (umhos/cm)	pH (std. units)	Eh (mv)	DO (mg/L)	Turbidity (NTU)
8/25/04									
1605	25.63			16.22	0.795	8.76	-239.4	2.83	11.5
1610	25.93	100		16.67	0.790	8.65	-239.0	3.11	10.7
1615	25.99			17.62	0.793	8.59	-238.9	2.99	13.0
1620	26.02	50		18.07	0.821	8.31	-242.1	2.42	21.2
1625	26.10	50		16.83	0.855	7.60	-246.1	1.47	21.1
1630	26.21	80		16.41	0.870	7.10	-250.2	0.88	17.7
1635	26.25			16.00	0.887	6.71	-251.0	0.00	21.5
1640	26.29	80		15.46	0.907	6.54	-248.5	0.00	22.7
1645	26.31			14.89	0.924	6.38	-246.8	0.00	22.4
1650	26.33	90		14.42	0.928	6.31	-244.5	0.00	21.5
1655	26.35			14.23	0.966	6.31	-242.2	0.00	19.6
1700	26.34	90		14.35	0.988	6.29	-242.0	0.00	21.1
	*Collected Sample at 1700								

Abbreviations: BTOC - Below top of casing; DTW - Depth to water; mL - milliliter; L - Liter

GROUNDWATER SAMPLING FORM

Shaw®

Project Number: 843635
Project Name: PBOW
Investigation Site: Downgradient
RFA/COC Number: PB082504STL-CK

Collection Date: 8/25/04
Collection Time: 1700
Sample Filtered (Yes/No): Yes; Metals
Weather/Temp: Partly cloudy, hot (85°).

Form Completed By: D. Kessler
Sampler(s): D. Kessler, Z. Parham
Reviewed By: David Kessler

Sample Name: PBOW-04-PB-BED-MW19-GW-DH30001

MONITORING WELL INFORMATION [use top of casing (TOC) for all measurements]

Well Number: MW19	Outside Casing Dia. (in): 2"	Odor: None, H_2S odor while pumping
Well Secure (Yes / No): Yes	Depth to Product (ft): NA	Vapor Monitor Type: PID / LEL
Well Labeled (Yes / No): Yes	Total Well Depth (ft): 52.2'	Vapor Monitor S/N: H841963
Well Condition: Good	Depth to Water (ft): 25.63	Reading (ppm): LEL = 2 % O_2 = 20.8 %
Top of Screen: 24.5' bgs	Water Column: 26.57	PID = 0.0 ppm C = 0 ppm H_2S = 0 ppm
Screen Height: 25'	Top of Filter Pack: ~ 22.5' bgs	Depth Pump Set
Casing Type: PVC	Pump Type: Bladder	Pump Settings: psi – ~~20~~ 18, Refill – 10, Discharge - 5
		Remarks:

MONITORING WELL PURGE CALCULATIONS

Volume of Water in Casing: Gallons/foot = 0.041 x d^2, where d is casing diameter in inches = (0.041 x (_____)^2) = _____ gal/ft

Well Volume (gallons) = Water Column (ft) x Gal/ft = _____ ft x _____ Gal/ft = _____ gallons

Volume of Water in Filter Pack: Gallons/foot = 0.041 x (D^2-d^2), where D is total borehole dia. in inches & d is casing dia. in inches = 0.041 x ((_____)^2 – (_____)^2) = _____ gal/ft

Filter Pack Volume (gal) = ((Screen Height + Sand Above Set or Water Column) x gal/ft) x porosity (0.3) = ((Screen Height _____ ft + _____ ft) x _____ gal/ft) x 0.3 = _____ gallons

Purge Well Volume: Purge Well Volume – Filter Pack Volume + Well Volume = _____ gal + _____ gal = _____ gal

1 x Purge Well Volume (gal.)	2 x Purge Well Volume (gal.)	3 x Purge Well Volume (gal.)	4 x Purge Well Volume (gal.)	5 x Purge Well Volume (gal.)

Low Flow

LOW-FLOW TUBING PURGE CALCULATIONS (3 tubing/pump volumes required for PBOW)

Volume of Water in Tubing: 1/4" ID Tubing = 0.01 Liters/ft. 3/8" ID Tubing = 0.02 Liters/ft. 2" Bladder Pump Volume = 0.3 Liters Tubing Length = 35 ft.

Tubing Volume (Liters) = ([Tubing Liters/ft. x Tubing length] + Pump volume) x 3 = ([0.01 L/ft x 35 ft] + 0.3 L) x 3 = 1.95 L = (0.51 gal)

Total Volume Purged: _____ L Liters to gallons = L x 0.26gal/L 1.2 gal

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Sample Collection Log

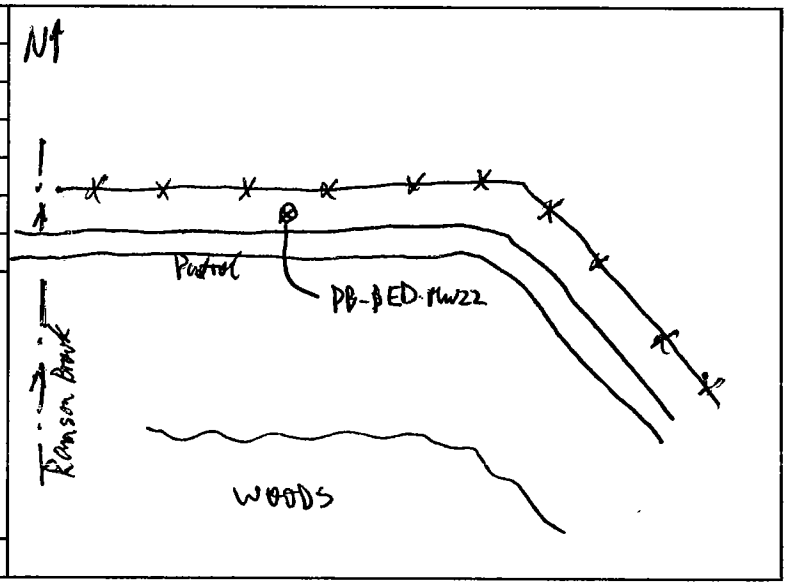
Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	**PB-BED-MW22**	Collection Date:	8/26/04
Sample Number:	**DH3002**	Collection Time:	1110
Sample Name:	**PBOW-04-PB-BED-MW22-DH3002**	Start Depth:	35.0
Sampling Method:	**Low Flow**	End Depth:	35.2
Sample Type:	**GW**	Sample Matrix:	**WATER**
Sample Purpose:	**REG**	Sample Team:	**Kessler/Parham**

Analytical Suite	Containers
FILTERED METALS	1 - 250 mL HDPE
TOTAL METALS	1 - 250 mL HDPE
EXPLOSIVES	1 - 1 L Amb. Glass
VOLATILES	3 - 40 mL Vial
SEMIVOLATILES	2 - 1 L Amb. Glass
TOC	2 - 40 mL Vial
CYANIDE	1 - 1 L HDPE
ALKALINITY	1 - 1 L HDPE
CHLORIDE	
NITRATE	
SULFATE	
TDS	
TSS	
TURBIDITY	
HARDNESS	1 - 250 mL HDPE

Sketch Location



Comments: Removed 2.3 gal

Logged by/Date: David Kessler 8/26/04 Reviewed by/Date: David Kessler 8/26/04

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GROUNDWATER PURGE FORM

Location Code: **PB-BED-MW22** Static at 29.58'

Sample Number: **DH3002** Pump Set at 35 Ft

Water Quality Parameter Measurements									
Date/ Time	DTW (ft. BTOC)	Purge Rate (mL/min)	Cumulative Volume Purged (L)	Temp. (degree C)	Conductivity (umhos/cm)	pH (std. units)	Eh (mv)	DO (mg/L)	Turbidity (NTU)
8/24/04	31.83	0							
1000	31.96	100		16.24	0.885	6.46	-208.0	0.88	102.3
1005	31.91	110		15.92	0.884	6.42	-202.2	0.00	101.4
1010	31.95	120		15.66	0.880	6.41	-201.1	0.00	89.9
1015	31.98	110		15.08	0.868	6.39	-198.3	0.00	76.7
1020	31.99	150		14.91	0.867	6.39	-197.9	0.00	78.4
1025	32.20	150		14.81	0.861	6.37	-201.2	0.00	67.3
1030	32.20	155		14.77	0.857	6.37	-200.6	0.00	70.4
1035	32.18	155		14.76	0.852	6.37	-200.6	0.00	67.8
1040	32.18	140		14.99	0.856	6.43	-197.4	1.79	89.3
1045	32.18	140		15.03	0.849	6.44	-193.1	3.81	76.0
1050	32.18	145		15.20	0.848	6.54	-192.9	5.41	75.1
1055	32.17	150		15.24	0.845	6.62	-191.5	6.59	62.7
1100	32.18	150		15.23	0.847	6.65	-191.9	6.53	59.9
1105	32.18	150	~~2~~ 2.3gal	15.24	0.838	6.64	-192.7	6.48	50.0
1110									
	Collected Sample								

Abbreviations: BTOC - Below top of casing; DTW - Depth to water; mL - milliliter; L - Liter

GROUNDWATER SAMPLING FORM

Shaw®

Project Number: 843635
Project Name: PBOW
Investigation Site: Downgradient
RFA/COC Number: PB082604 STL EK Acc

Collection Date: 8/26/04
Collection Time: 1110
Sample Filtered (Yes/No): Yes; Metals
Weather/Temp: Cloudy, warm (75°), breezy

Form Completed By: David Kessler
Sampler(s): D. Kessler, Z. Parham
Reviewed By: David Kessler

Sample Name: PBOW-04-PB-BED-MW22-GW-DH30002

MONITORING WELL INFORMATION [use top of casing (TOC) for all measurements]

Well Number: MW22	Outside Casing Dia. (in): 2"	Odor: Very Strong H_2S odor
Well Secure (Yes / No): Yes	Depth to Product (ft): NA	Vapor Monitor Type: PID / LEL
Well Labeled (Yes / No): Yes	Total Well Depth (ft): 42'	Vapor Monitor S/N: H841963 1
Well Condition: Good	Depth to Water (ft): 29.58	Reading (ppm): LEL =>100 % O_2 = 16.2 %
Top of Screen: 27'	Water Column: 12.42'	PID= 10.7 ppm C = 0 ppm H_2S=>500 ppm
Screen Height: 15'	Top of Filter Pack: 25'	Depth Pump Set: 35'
Casing Type: PVC	Pump Type: Bladder	Pump Settings: psi – 20, Refill – ~~28~~ 10, Discharge - ~~7~~ 5
		Remarks: Vapors visible (like heat on car during summer)

MONITORING WELL PURGE CALCULATIONS

Volume of Water in Casing: Gallons/foot = 0.041 x d^2, where d is casing diameter in inches = (0.041 x (_____)^2) = _____ gal/ft

Well Volume (gallons) = Water Column (ft) x Gal/ft = _____ ft x _____ Gal/ft = _____ gallons

Volume of Water in Filter Pack: Gallons/foot = 0.041 x (D^2-d^2), where D is total borehole dia. in inches & d is casing dia. in inches = 0.041 x ((_____)^2 – (_____)^2) = _____ gal/ft

Filter Pack Volume (gal) = ((Screen Height + Sand Above Set or Water Column) x gal/ft) x porosity (0.3) = ((Screen Height _____ ft + _____ ft) x _____ gal/ft) x 0.3 = _____ gallons

Purge Well Volume: Purge Well Volume – Filter Pack Volume + Well Volume = _____ gal + _____ gal = _____ gal

Low Flow

1 x Purge Well Volume (gal.)	2 x Purge Well Volume (gal.)	3 x Purge Well Volume (gal.)	4 x Purge Well Volume (gal.)	5 x Purge Well Volume (gal.)

LOW-FLOW TUBING PURGE CALCULATIONS (3 tubing/pump volumes required for PBOW)

Volume of Water in Tubing: 1/4" ID Tubing = 0.01 Liters/ft. 3/8" ID Tubing = 0.02 Liters/ft. 2" Bladder Pump Volume = 0.3 Liters Tubing Length = 38 ft.

Tubing Volume (Liters) = ([Tubing Liters/ft. x Tubing length] + Pump volume) x 3 = ([0.01 L/ft x 38 ft] + 0.3 L) x 3 = 2.04 L 0.53 gal

Total Volume Purged: 8.85 L Liters to gallons = L x 0.26gal/L 2.3 gal

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Sample Collection Log

Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	**PB-BED-MW22**	Collection Date:	8/26/04
Sample Number:	**DH3002-MS**	Collection Time:	1110
Sample Name:	**PBOW-04-PB-BED-MW22-DH3002-MS**	Start Depth:	35.0
Sampling Method:	**Low Flow**	End Depth:	35.2
Sample Type:	**GW**	Sample Matrix:	**WATER**
Sample Purpose:	**MS**	Sample Team:	**Kessler/Parham**

Analytical Suite	Containers	Sketch Location
FILTERED METALS	1 - 250 mL HDPE	See sample# DH3002 for location information.
TOTAL METALS	1 - 250 mL HDPE	
EXPLOSIVES	1 - 1 L Amb. Glass	
VOLATILES	3 - 40 mL Vial	
SEMIVOLATILES	2 - 1 L Amb. Glass	
TOC	2 - 40 mL Vial	
CYANIDE	1 - 1 L HDPE	
ALKALINITY	1 - 1 L HDPE	
CHLORIDE		
NITRATE		
SULFATE		
TDS		
TSS		
TURBIDITY		
HARDNESS	1 - 250 mL HDPE	

Comments: See sample# DH3002 for purge and location information.

Logged by/Date: David Kessler 8/26/04 Reviewed by/Date: David Kessler 8/26/04

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Sample Collection Log

Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	**PB-BED-MW22**	Collection Date:	8/26/04
Sample Number:	**DH3002-MSD**	Collection Time:	1110
Sample Name:	**PBOW-04-PB-BED-MW22-DH3002-MSD**	Start Depth:	35.0
Sampling Method:	**Low Flow**	End Depth:	35.2
Sample Type:	**GW**	Sample Matrix:	**WATER**
Sample Purpose:	**MSD**	Sample Team:	**Kessler/Parham**

Analytical Suite	Containers
FILTERED METALS	1 - 250 mL HDPE
TOTAL METALS	1 - 250 mL HDPE
EXPLOSIVES	1 - 1 L Amb. Glass
VOLATILES	3 - 40 mL Vial
SEMIVOLATILES	2 - 1 L Amb. Glass
TOC	2 - 40 mL Vial
CYANIDE	1 - 1 L HDPE
ALKALINITY	1 - 1 L HDPE
CHLORIDE	
NITRATE	
SULFATE	
TDS	
TSS	
TURBIDITY	
HARDNESS	1 - 250 mL HDPE

Sketch Location

See sample# DH3002 for location information.

Comments: See sample# DH3002 for purge and location information.

Logged by/Date: David Kessler 8/26/04 Reviewed by/Date: David Kessler 8/26/04

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Sample Collection Log

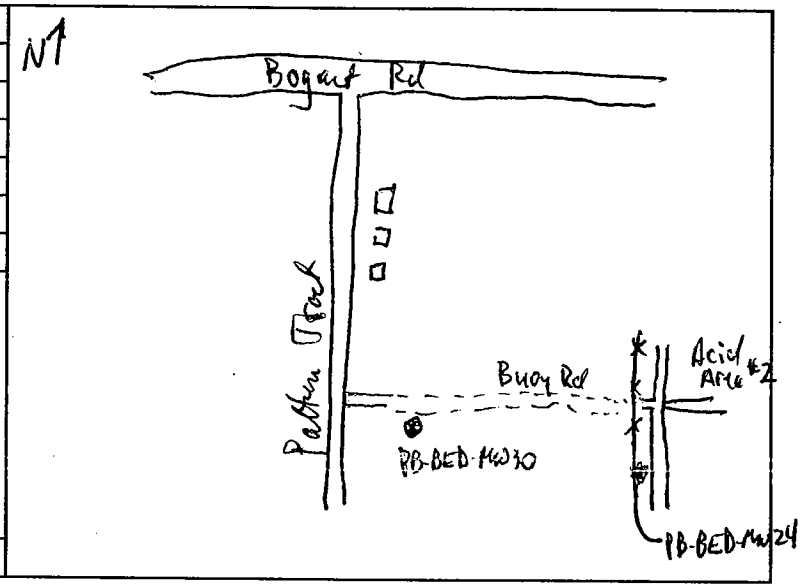
Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	**PB-BED-MW30**	Collection Date:	8/25/04
Sample Number:	**DH3003**	Collection Time:	1355
Sample Name:	**PBOW-04-PB-BED-MW30-DH3003**	Start Depth:	46.2
Sampling Method:	**Low Flow**	End Depth:	46.3
Sample Type:	**GW**	Sample Matrix:	**WATER**
Sample Purpose:	**REG**	Sample Team:	**Kessler/Parham**

Analytical Suite	Containers
FILTERED METALS	1 - 250 mL HDPE
TOTAL METALS	1 - 250 mL HDPE
EXPLOSIVES	1 - 1 L Amb. Glass
VOLATILES	3 - 40 mL Vial
SEMIVOLATILES	2 - 1 L Amb. Glass
TOC	2 - 40 mL Vial
CYANIDE	1 - 1 L HDPE
ALKALINITY	1 - 1 L HDPE
CHLORIDE	
NITRATE	
SULFATE	
TDS	
TSS	
TURBIDITY	
HARDNESS	1 - 250 mL HDPE

Sketch Location



Comments: Removed 1.3 gal

Logged by/Date: David Kessler 8/25/04 Reviewed by/Date: David Kessler 8/25/04

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GROUNDWATER PURGE FORM

Location Code: **PB-BED-MW30**

Sample Number: **DH3003**

Pump at 46 Ft

Water Quality Parameter Measurements									
Date/ Time	DTW (ft. BTOC)	Purge Rate (mL/min)	Cumulative Volume Purged (L)	Temp. (degree C)	Conductivity (umhos/cm)	pH (std. units)	Eh (mv)	DO (mg/L)	Turbidity (NTU)
8/25/04	28.85 - Static								
1306	29.05			23.92	1.334	6.64	-205.4	0.64	20.8
1310	29.18	80		21.57	1.350	6.52	-208.5	0.10	23.8
1315	29.30			20.79	1.305	6.46	-204.0	1.73	30.4
1320	29.35			20.62	1.308	6.43	-203.7	0.90	19.2
1325	29.24	70		21.55	1.291	6.45	-205.4	0.51	24.9
1330	29.25	70		22.05	1.283	6.47	-205.2	0.24	35.2
1335	29.25	65		21.42	1.299	6.45	-203.7	0.00	2.8
1340	29.29			20.59	1.283	6.40	-201.9	0.00	9.6
1345	29.30			20.04	1.282	6.38	-200.7	0.00	17.2
1350	29.31			20.18	1.316	6.37	-221.4	0.00	12.4
1355	29.32			19.81	1.334	6.36	-221.1	0.00	2.1
		Removed 1.3 gal							

Abbreviations: BTOC - Below top of casing; DTW - Depth to water; mL - milliliter; L - Liter

GROUNDWATER SAMPLING FORM

Shaw®

Project Number: 843635
Project Name: PBOW
Investigation Site: Downgradient
RFA/COC Number: PB082504STL-C-K

Collection Date: 8/25/04
Collection Time: 1355
Sample Filtered (Yes/No): Yes; Metals
Weather/Temp: partly cloudy, warm (85°)

Form Completed By: D. Kessler
Sampler(s): D. Kessler, Z. Parham
Reviewed By: D. Kessler

Sample Name: PBOW-04-PB-BED-MW30-GW-DH3003

MONITORING WELL INFORMATION [use top of casing (TOC) for all measurements]

Well Number: MW30	Outside Casing Dia. (in): 2"	Odor: None
Well Secure (Yes / No): Yes	Depth to Product (ft): NA	Vapor Monitor Type: PID / LEL
Well Labeled (Yes / No): Yes	Total Well Depth (ft): 54.53'	Vapor Monitor S/N: H8419631
Well Condition: Good	Depth to Water (ft): 28.85	Reading (ppm): LEL = 0 % O_2 = 20.8 %
Top of Screen: 39.53'	Water Column: 25.68	PID - 0.0 ppm C = 0 ppm H_2S = 0 ppm
Screen Height: 15'	Top of Filter Pack: 39'	Depth Pump Set: 46'
Casing Type: PVC	Pump Type: Bladder	Pump Settings: psi -25, Refill -10, Discharge - 5
		Remarks:

MONITORING WELL PURGE CALCULATIONS

Volume of Water in Casing: Gallons/foot = 0.041 x d^2, where d is casing diameter in inches = (0.041 x (_____)^2) = _____ gal/ft

Well Volume (gallons) = Water Column (ft) x Gal/ft = _____ ft x _____ Gal/ft = _____ gallons

Volume of Water in Filter Pack: Gallons/foot = 0.041 x (D^2-d^2), where D is total borehole dia. in inches & d is casing dia. in inches = 0.041 x ((_____)^2 – (_____)^2) = _____ gal/ft

Filter Pack Volume (gal) = ((Screen Height + Sand Above Set or Water Column) x gal/ft) x porosity (0.3) = ((Screen Height _____ ft + _____ ft) x _____ gal/ft) x 0.3 = _____ gallons

Low-Flow

Purge Well Volume: Purge Well Volume – Filter Pack Volume + Well Volume = _____ gal + _____ gal = _____ gal

1 x Purge Well Volume (gal.)	2 x Purge Well Volume (gal.)	3 x Purge Well Volume (gal.)	4 x Purge Well Volume (gal.)	5 x Purge Well Volume (gal.)

LOW-FLOW TUBING PURGE CALCULATIONS (3 tubing/pump volumes required for PBOW)

Volume of Water in Tubing: 1/4" ID Tubing = 0.01 Liters/ft. 3/8" ID Tubing = 0.02 Liters/ft. 2" Bladder Pump Volume = 0.3 Liters Tubing Length = 60 ft.

Tubing Volume (Liters) = ([Tubing Liters/ft. x Tubing length] + Pump volume) x 3 = ([0.01 L/ft x 60 ft] + 0.3 L) x 3 = 2.7 L

Total Volume Purged: 2.7 L Liters to gallons = L x 0.26gal/L = 0.70 gal

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Sample Collection Log

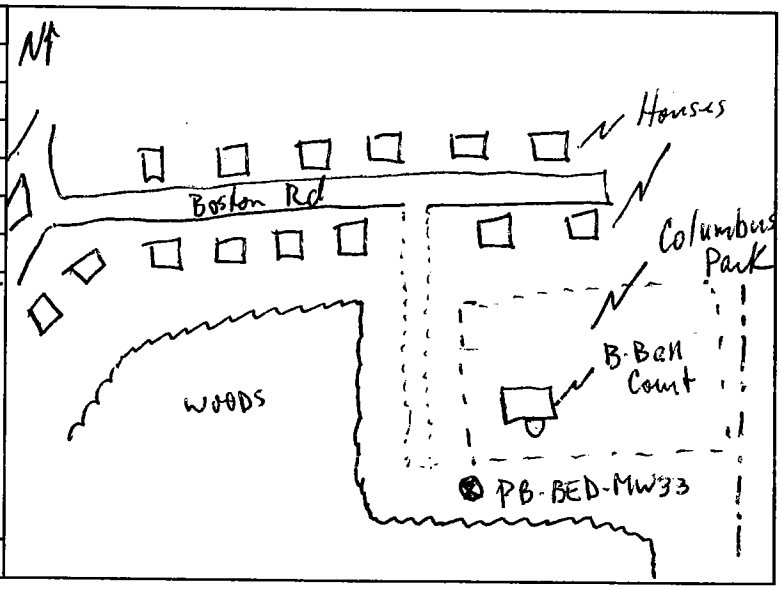
Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	**PB-BED-MW33**	Collection Date:	8/27/04
Sample Number:	**DH3004**	Collection Time:	1140
Sample Name:	**PBOW-04-PB-BED-MW33-DH3004**	Start Depth:	80.3
Sampling Method:	**Low Flow**	End Depth:	85.0
Sample Type:	**GW**	Sample Matrix:	**WATER**
Sample Purpose:	**REG**	Sample Team:	**Kessler/Parham**

Analytical Suite	Containers
FILTERED METALS	1 - 250 mL HDPE ✓
TOTAL METALS	1 - 250 mL HDPE ✓
EXPLOSIVES	1 - 1 L Amb. Glass ✓
VOLATILES	2 ~~3~~ - 40 mL Vial
~~SEMIVOLATILES~~	~~2 - 1 L Amb. Glass~~ e
~~TOC~~	~~2 - 40 mL Vial~~ e
~~CYANIDE~~	~~1 - 1 L HDPE~~ e
~~ALKALINITY~~	1 - 1 L HDPE
~~CHLORIDE~~	
NITRATE	
SULFATE	
TDS	
TSS	
TURBIDITY	
~~HARDNESS~~	1 - 250 mL HDPE

Sketch Location



Comments: Sample collected w/ 2" teflon bailer; filtered w/ hand pump using 0.45 µ micro filter.
No readings collected, insufficient water.

Logged by/Date: David Kessler 8/27/04 Reviewed by/Date: David Kessler 8/27/04

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GROUNDWATER PURGE FORM

Location Code: **PB-BED-MW33**

Sample Number: **DH3004**

Water Quality Parameter Measurements									
Date/ Time	DTW (ft. BTOC)	Purge Rate (mL/min)	Cumulative Volume Purged (L)	Temp. (degree C)	Conductivity (umhos/cm)	pH (std. units)	Eh (mv)	DO (mg/L)	Turbidity (NTU)
8/25/04 1110	72.05	—	0	13.44	2.123	6.49	-214.3	2.28	24.0
1118	77.33	—	2 gal	13.25	2.201	6.56	-221.0	2.15	5.3
1130	82.95	—	3.5 gal	13.75	2.124	6.41	-227.0	1.37	34.7
		Removed	~3.8 gal						
8/27/04	80.34								
8/27/04	1140	Collected	Sample						

Abbreviations: BTOC - Below top of casing; DTW - Depth to water; mL - milliliter; L - Liter

GROUNDWATER SAMPLING FORM

Shaw®

Project Number: 843635
Project Name: PBOW
Investigation Site: Downgradient
RFA/COC Number: PB082704STL-K

Collection Date: 8/27/04
Collection Time: 1140
Sample Filtered (Yes/No): Yes; Metals
Weather/Temp: partly sunny, hot (85°)

Form Completed By: D. Kessler
Sampler(s): D. Kessler, Z. Parham
Reviewed By: David Kessler

Sample Name: PBOW-04-PB-BED-MW33-GW-DH30044

MONITORING WELL INFORMATION [use top of casing (TOC) for all measurements]

Well Number: MW33	Outside Casing Dia. (in): 2"	Odor: Distinct H_2S odor while purging
Well Secure (Yes / No): Yes	Depth to Product (ft): NA	Vapor Monitor Type: PID / LEL
Well Labeled (Yes / No): Yes	Total Well Depth (ft): 88.5' 8/25/04 8/27/04	Vapor Monitor S/N: H841963 / 210
Well Condition: Good	Depth to Water (ft): 72.05 80.34	Reading (ppm): LEL = 1 % O_2 = 0 %
Top of Screen: 68.5'	Water Column: 16.45'	PID = 23.4 ppm C = 0 ppm H_2S = 0 ppm
Screen Height: 20'	Top of Filter Pack: 65.5'	Depth Pump Set:
Casing Type: PVC	Pump Type: ~~Bladder:~~ NA 2" poly bailer	Pump Settings: psi NA, Refill NA, Discharge - NA
	TD of well ~ 83 Ft (sand in casing).	Remarks: Purged w/ bailer

MONITORING WELL PURGE CALCULATIONS

Volume of Water in Casing: Gallons/foot = 0.041 x d^2, where d is casing diameter in inches = (0.041 x (2)^2) = 0.163 gal/ft

Well Volume (gallons) = Water Column (ft) x Gal/ft = 16.45 ft x 0.163 Gal/ft = 2.68 gallons

Volume of Water in Filter Pack: Gallons/foot = 0.041 x (D^2-d^2), where D is total borehole dia. in inches & d is casing dia. in inches = 0.041 x ((5)^2 – (2)^2) = 0.86 gal/ft

Filter Pack Volume (gal) = ((Screen Height + Sand Above Set or Water Column) x gal/ft) x porosity (0.3) = ((Screen Height 16.45 ft + ~~3.55~~ 0 ft) x 0.86 gal/ft) x 0.3 = 4.2 gallons

Purge Well Volume: Purge Well Volume – Filter Pack Volume + Well Volume = 4.2 gal + 2.68 gal = 6.88 gal

1 x Purge Well Volume (gal.)	2 x Purge Well Volume (gal.)	3 x Purge Well Volume (gal.)	4 x Purge Well Volume (gal.)	5 x Purge Well Volume (gal.)
6.88	13.76	20.64	27.52	34.4

LOW-FLOW TUBING PURGE CALCULATIONS (3 tubing/pump volumes required for PBOW)

Volume of Water in Tubing: 1/4" ID Tubing = 0.01 Liters/ft. 3/8" ID Tubing = 0.02 Liters/ft. 2" Bladder Pump Volume = 0.3 Liters Tubing Length = ____ft.

Tubing Volume (Liters) = ([Tubing Liters/ft. x Tubing length] + Pump volume) x 3 = ([0.01 L/ft x ____ft] + 0.3 L) x 3 = _____L

Total Volume Purged: _____ L ~~Liters to gallons~~ = L x 0.26gal/L

Shaw™
Shaw E & I, Inc.

Sample Collection Log

Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	**PB-BED-MW22**	Collection Date:	8/26/04
Sample Number:	**DH3005**	Collection Time:	1110
Sample Name:	**PBOW-04-PB-BED-MW22-DH3005**	Start Depth:	35.0
Sampling Method:	**Low Flow**	End Depth:	35.2
Sample Type:	**GW**	Sample Matrix:	**WATER**
Sample Purpose:	**FD**	Sample Team:	**Kessler/Parham**

Analytical Suite	Containers	Sketch Location
FILTERED METALS	1 - 250 mL HDPE	See sample# DH3002 for location information.
TOTAL METALS	1 - 250 mL HDPE	
EXPLOSIVES	1 - 1 L Amb. Glass	
VOLATILES	3 - 40 mL Vial	
SEMIVOLATILES	2 - 1 L Amb. Glass	

Comments: See sample# DH3002 for purge and location information.

Logged by/Date: David Kessler 8/26/04 Reviewed by/Date: David Kessler 8/26/04

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Sample Collection Log

Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	**PB-BED-MW22**	Collection Date:	8/26/04
Sample Number:	**DH3006**	Collection Time:	1110
Sample Name:	**PBOW-04-PB-BED-MW22-DH3006**	Start Depth:	35.0
Sampling Method:	**Low Flow**	End Depth:	35.2
Sample Type:	**GW**	Sample Matrix:	**WATER**
Sample Purpose:	**FS** — Sent to Accutest	Sample Team:	**Kessler/Parham**

Analytical Suite	Containers
FILTERED METALS	1 - 250 mL HDPE
TOTAL METALS	1 - 250 mL HDPE
EXPLOSIVES	1 - 1 L Amb. Glass
VOLATILES	3 - 40 mL Vial
SEMIVOLATILES	2 - 1 L Amb. Glass

Sketch Location

See sample# DH3002 for location information.

Comments: See sample# DH3002 for purge and location information.

Logged by/Date: David Kessler 8/26/04 Reviewed by/Date: David Kessler 8/26/04

Shaw™
Shaw E & I, Inc.

Sample Collection Log

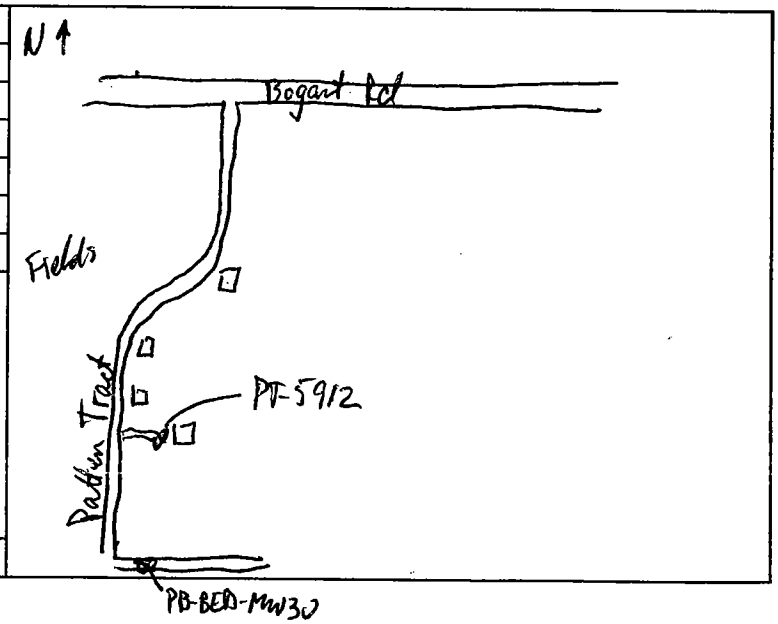
Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	**PT-5912**	Collection Date:	8/27/04
Sample Number:	**DH3007**	Collection Time:	1030
Sample Name:	**PBOW-04-PT-5912-DH30007**	Start Depth:	32.0
Sampling Method:	**Low Flow**	End Depth:	32.2
Sample Type:	**GW**	Sample Matrix:	**WATER**
Sample Purpose:	**REG**	Sample Team:	**Kessler/Parham**

Analytical Suite	Containers
FILTERED METALS	1 - 250 mL HDPE
TOTAL METALS	1 - 250 mL HDPE
EXPLOSIVES	1 - 1 L Amb. Glass
VOLATILES	3 - 40 mL Vial
SEMIVOLATILES	2 - 1 L Amb. Glass
TOC	2 - 40 mL Vial
CYANIDE	1 - 1 L HDPE
ALKALINITY	1 - 1 L HDPE
CHLORIDE	
NITRATE	
SULFATE	
TDS	
TSS	
TURBIDITY	
HARDNESS	1 - 250 mL HDPE

Sketch Location



Comments: Removed 2 gal

Logged by/Date: David Kessler 8/27/04 Reviewed by/Date: David Kessler 8/27/04

Shaw
Shaw E & I, Inc.

GROUNDWATER PURGE FORM

Location Code: **PT-5912** Pump inlet set at 32 Ft

Sample Number: **DH3007**

Water Quality Parameter Measurements									
Date/ Time 8/27/04	DTW (ft. BTOC)	Purge Rate (mL/min)	Cumulative Volume Purged (L)	Temp. (degree C)	Conductivity (umhos/cm)	pH (std. units)	Eh (mv)	DO (mg/L)	Turbidity (NTU)
Static	8.12	—	—	—	—	—	—	—	—
0935	8.21	200		17.70	0.734	6.61	-203.9	2.85	23.8
0940	8.28	150		19.12	0.742	6.61	-211.4	1.20	19.1
0945	8.32	150	~1.9 L	18.72	0.741	~~6.61~~ 6.59	-208.2	0.81	18.2
0950	8.35	150		18.76	0.738	6.54	-205.8	0.79	18.5
0955	8.37	150		19.11	0.736	6.54	-203.0	0.71	18.1
1000	8.39	150	~4.0 L	19.42	0.719	6.56	-199.2	0.73	18.6
1005	8.41	150		19.92	0.696	6.59	-194.8	0.70	19.3
1010	8.43	150		20.31	0.688	6.60	-192.8	0.69	21.0
1015	8.44	150	~5.5 L	20.66	0.684	6.61	-190.8	0.64	21.1
1020	8.44	150		21.12	0.681	6.62	-187.3	0.61	20.1
1025	8.44	150		21.52	0.681	6.63	-187.5	0.64	20.1
1030	8.45	150		21.74	0.680	6.64	-188.0	0.65	19.3
1030 Collected Sample			Removed 2 gal						

Abbreviations: BTOC - Below top of casing; DTW - Depth to water; mL - milliliter; L - Liter

GROUNDWATER SAMPLING FORM

Shaw®

Project Number: 843635
Project Name: PBOW
Investigation Site: Downgradient
RFA/COC Number: PB052704STL-CK

Collection Date: 8/27/04
Collection Time: 1030
Sample Filtered (Yes/No): Yes; Metals
Weather/Temp: partly sunny hot (85°)

Form Completed By: David Kessler
Sampler(s): D. Kessler, Z. Parham
Reviewed By: David Kessler

Sample Name: PBOW-04-PT-5912-GW-DH3007

MONITORING WELL INFORMATION [use top of casing (TOC) for all measurements]

Well Number: PT-5912	Outside Casing Dia. (in): 6"	Odor: None
Well Secure (Yes / No)	Depth to Product (ft): NA (0')	Vapor Monitor Type: PID / LEL
Well Labeled (Yes / No)	Total Well Depth (ft): 58	Vapor Monitor S/N: H841963
Well Condition: Poor	Depth to Water (ft): 8.12	Reading (ppm): LEL = 0 % O_2 = 20.9 %
Top of Screen: open hole	Water Column: 49.88 Ft	PID = 0.1 ppm C = 0 ppm H_2S = 0 ppm
Screen Height:	Top of Filter Pack: None	Depth Pump Set: 32 Ft
Casing Type:	Pump Type: Bladder	Pump Settings: psi 18, Refill 10, Discharge 5
		Remarks:

MONITORING WELL PURGE CALCULATIONS

Volume of Water in Casing: Gallons/foot = 0.041 x d^2, where d is casing diameter in inches = (0.041 x (_____)^2) = _____ gal/ft

Well Volume (gallons) = Water Column (ft) x Gal/ft = _____ ft x _____ Gal/ft = _____ gallons

Volume of Water in Filter Pack: Gallons/foot = 0.041 x (D^2-d^2), where D is total borehole dia. in inches & d is casing dia. in inches = 0.041 x ((_____)^2 – (_____)^2) = _____ gal/ft

Filter Pack Volume (gal) = ((Screen Height + Sand Above Set or Water Column) x gal/ft) x porosity (0.3) = ((Screen Height _____ ft + _____ ft) x _____ gal/ft) x 0.3 = _____ gallons

Purge Well Volume: Purge Well Volume – Filter Pack Volume + Well Volume = _____ gal + _____ gal = _____ gal

Low-Flow

1 x Purge Well Volume (gal.)	2 x Purge Well Volume (gal.)	3 x Purge Well Volume (gal.)	4 x Purge Well Volume (gal.)	5 x Purge Well Volume (gal.)

LOW-FLOW TUBING PURGE CALCULATIONS (3 tubing/pump volumes required for PBOW)

Volume of Water in Tubing: 1/4" ID Tubing = 0.01 Liters/ft. 3/8" ID Tubing = 0.02 Liters/ft. 2" Bladder Pump Volume = 0.3 Liters Tubing Length = 38 ft.

Tubing Volume (Liters) = ([Tubing Liters/ft. x Tubing length] + Pump volume) x 3 = ([0.01 L/ft x 38 ft] + 0.3 L) x 3 = 2.04 L 0.53 gal

Total Volume Purged: _____ L Liters to gallons = L x 0.26gal/L 2 gal

APPENDIX B

SOIL BORING AND MONITORING WELL HTRW DRILL LOGS/ WELL CONSTRUCTION DIAGRAMS

HTRW DRILLING LOG

1. COMPANY NAME: Shaw E+I	DISTRICT: Nashville, TN	HOLE NUMBER: PB-BED-MW28
2. DRILL SUBCONTRACTOR: Miller Drilling		SHEET 1 OF 6 SHEETS
3. PROJECT: PBOW	4. LOCATION: Taft RD/Mason RD Intersection - Sandusky, OH	
5. NAME OF DRILLER: David Gentry	6. MANUFACTURER'S DESIGNATION OF DRILL: Schramm 450, Rig 300	
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT: Post hole dug first 2.3 Ft w/ 3" ID, stainless steel auger. Drilled pilot hole to 14 Ft with 6" OD roller bit. Reamed pilot hole with 10" roller cone bit. Installed 6 5/8" OD black steel isolation casing to 14 Ft. Cored w/ Christensen bit 4 5/8" OD by 3" ID. Borehole reamed w/ 6" roller cone bit. Installed 2" PVC casing, with 15 Ft screen.	8. HOLE LOCATION: See Sketch — N: 610,536.42, E: 1,923,306.40	
	9. SURFACE ELEVATION: Ground: 670.99 Ft	
	10. DATE STARTED: 8/6/03	11. DATE COMPLETED: 8/8/03
12. OVERBURDEN THICKNESS: 2.3 Ft	15. DEPTH GROUNDWATER ENCOUNTERED: Overburden - NA, Bedrock 25' and 27'	
13. DEPTH DRILLED INTO ROCK: 44.2 Ft (1.5 Ft Core left in hole)	16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED: 7.60 Ft BGS 8/9/03 0800 (14 HRS)	
14. TOTAL DEPTH OF HOLE: 46.5 Ft	17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY): —	

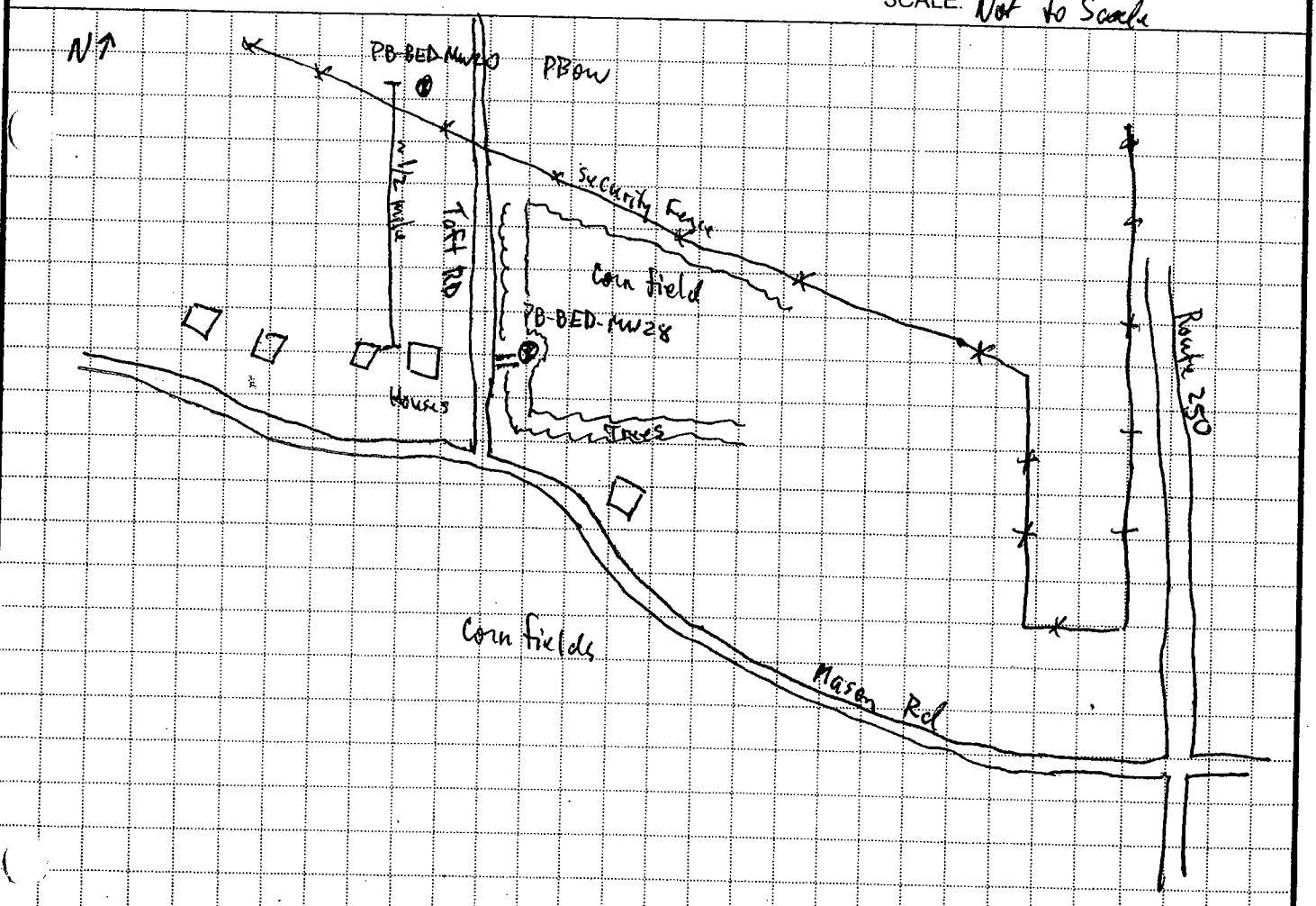
18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
	NA	NA	4

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY
	NA	NA	NA	NA	NA	~90 %

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
	NA	X	NA	David Kessler

LOCATION SKETCH/COMMENTS

SCALE: Not to Scale



PROJECT	HOLE NO.
PBOW	PB-BED-MW28

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: PB-BED-MW28

PROJECT: PBOW

INSPECTOR: D. Kessler

SHEET 2 OF 6 SHEETS

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	HNU SCREENING RESULTS (d)	~~PUSH/SAMPLE INTERVAL~~ (e)	ANALYTICAL SAMPLE NO (f)	USCS (g)	REMARKS (h)
	0	Grass		Core Box			
	1	FILL: Soft, very dark grayish brown, (10YR 3/2), silty SAND, 10% clay, 30% silt, 60% sand, shale fragments, organics, moist	0.0	NA	NA	SM	Began posthole digging at 0855 8/6/03
	2	2.3					Rock encountered 2.3 Ft. Began drilling with 4" roller bit (pilot hole)
	3	SHALE		NA	NA	NA	
	4	SHALE, dark gray/brown, thinly bedded, fractured, dry	0.0				Background PID = 0.0 ppm LEL = 0% C_2 = 0 ppm O_2 = 20.9 ppm % H_2S = 0 ppm
	5	Becoming less weathered with depth					
	6	Competent shale					Breathing Air PID = 0.0 ppm LEL meter: same as background
	7						
	8						
	9						
	10						

PROJECT: PBOW

HOLE NO.: PB-BED-MW28

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: PB-BED-MW28

PROJECT: PBOW | INSPECTOR: D. Kessler | SHEET 3 OF 6 SHEETS

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	HNU SCREENING RESULTS (d)	~~PUSH~~ SAMPLE INTERVAL (e)	ANALYTICAL SAMPLE NO (f)	USCS (g)	REMARKS (h)
	10	SHALE, light gray thinnly bedded, hard. slightly broken.	0.0	Core Box NA	NA	NA	Water in isolation casing.
	14				14 Ft		Drilled pilot hole to 14 Ft. Began reaming w/ 10" roller cone bit. Isolation casing set at 14 Ft, 8 Ft into competent rock. 14'
	15	SHALE, very dark gray, soft, thinnly laminated, slightly broken, slight weathering, occassional pyrite lenses, dry lenses of light gray shale	0.0	Box # 1	Began coring 14 Ft 14.1 14.3 Fracs 14.7' 15.0' 15.2 15.35' 15.55' 16.0' 16.2' 16.4'		Start Time: Run 1 8/8/03 0735 0755 ~~Depth~~
	17				16.9' 17.15'-Mech 17.4'-Mech 17.2-Mech 18.0-Mech 19.9'		Depth 14-24 Run: 10' Recovered: 7.7'
	18				18.6		Tagged borehole 2.3 ft in borehole.
	19				19.45-Mech 19.7'-Mech		No water in borehole
	20						

PROJECT: PBOW | HOLE NO.: PB-BED-MW28

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: PB-BED-MW28

PROJECT: PBOW

INSPECTOR: D. Kessler

SHEET 4 OF 6 SHEETS

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	HNU SCREENING RESULTS (d)	~~PUSH~~ SAMPLE INTERVAL (e)	~~ANALYTICAL SAMPLE~~ NO Fractures (f)	USCS (g)	REMARKS (h)
	20	SHALE, very dark gray, soft, thinly laminated, slightly broken, slight weathering, pyrite lenses common, dry	0.2	Box #1	20.7' 20.8' 21.6' 21.7' Broken ½" to 2" 22.8'	NA	(Run #1 continued) Ohio Shale
	21						
	22						
	23			WASHED AWAY 24'			
	24			Box #2	24' 24.3' mech 24.7' mech	NA	Run #2 End: 0846 Start: 0832 Depth: 24-34' Run: 10' Recovered: ~~8.5~~ 10.5' (Recovered: 1 Ft from Run #1, left 1Ft in borehole) Sphalerite/marcasite calcite x-ls in vugs
	25	very soft shale 25.1-25.6'	0.0		25.1' 25.3' 25.6' 25.9' water bearing		
	26	26-27' shaley lime layer w/ brown calcite/quartz intrusions, calcite crystals in vugs, breccia present.					
	27	Very soft, light gray/gray SHALE 27.7-28 ft, water bearing		WASHED AWAY 27.7	26.9' 27' washed, ground away. water bearing 27.7'		
	28				28.1'		
	29				28.7' mech 28.8' 29.5' 29.9'		
	30						

PROJECT: PBOW

HOLE NO. PB-BED-MW28

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: PB-BED-MW28

PROJECT: PBOW

INSPECTOR: D. Kesslen

SHEET 5 OF 6 SHEETS

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	HNU SCREENING RESULTS (d)	~~PUSH / SAMPLE~~ INTERVAL (e)	~~ANALYTICAL SAMPLE~~ NO Fractures (f)	USCS (g)	REMARKS (h)
	30	SHALE, very dark gray, soft, thinly bedded, slightly broken, slight weathering, limey shale lenses common, pyrite lenses present, wet	0.0	Box #2 (continued)	30.9 32.0' 32.6'	NA	Breathing Air 0.0 ppm Recovered 0.5' of Run #2
	34			34'			
	35			Box #3	34.7' vertical 35.6' 35.9' mech 36.1'	NA	Run #3 End: 1005 start: 0955 Depth 34-36.5' Run: 2.5' Recovered: 3'
	36			36.5			
	37	Shale hardness increasing, weathering decreasing		Box #4	36.5 to 37' Broken 37.5 37.65' 37.9' 38' 38.1	NA	Run #4 End: 1438 Start: 1422 Depth 36.5-46.5 Recovered: 8.5' (1.5 Ft measured in hole)
	38						
	39				39.3' vertical mech		
	40				40'		

PROJECT: PBOW

HOLE NO: PB-BED-MW28

HTRW DRILLING LOG (CONTINUATION SHEET)

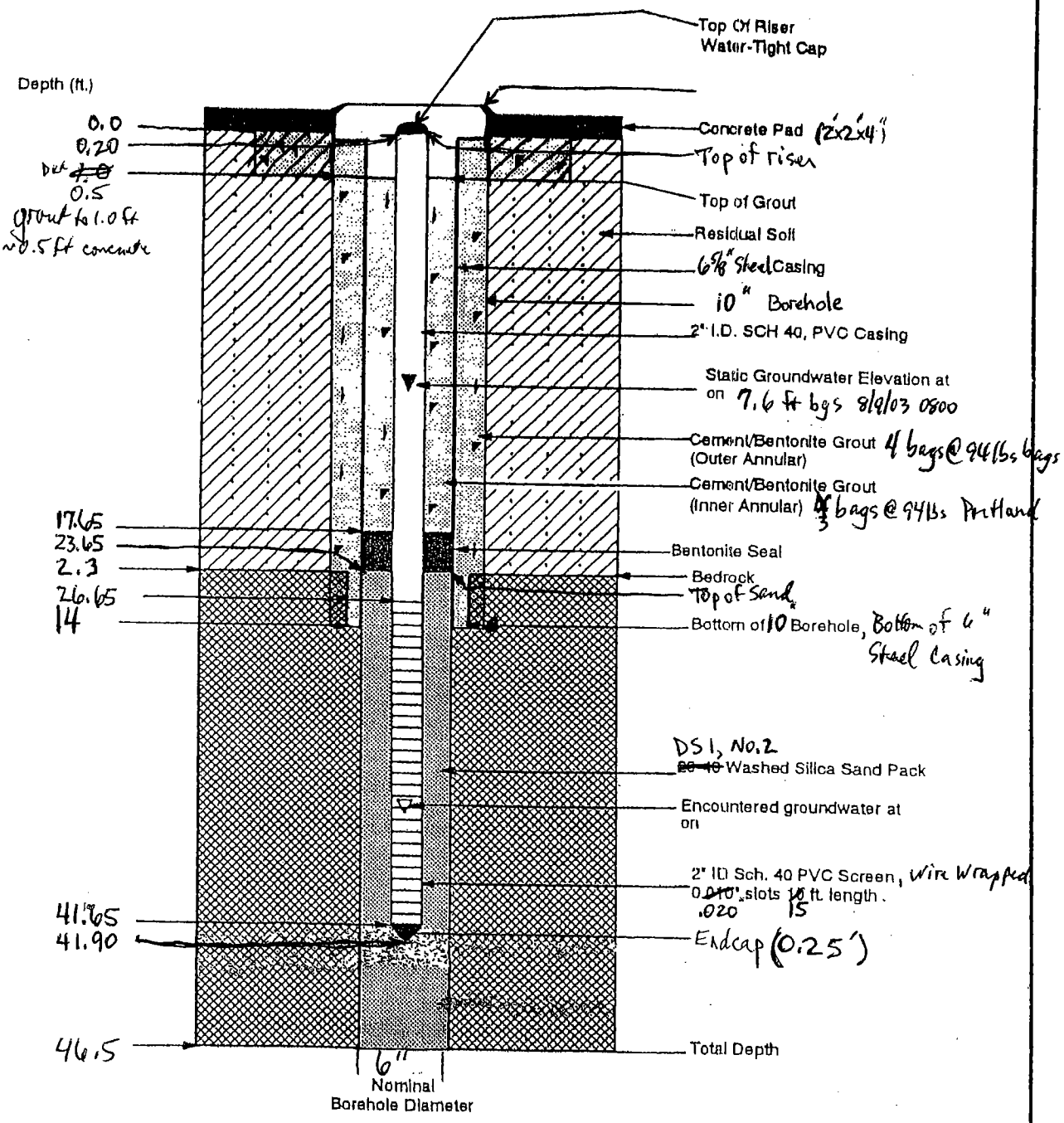
HOLE NUMBER: PB-BED-MW28
SHEET 6 OF 6 SHEETS

PROJECT: PBOW
INSPECTOR: D. Kessler

ELEV (a)	DEPTH (b) 45	DESCRIPTION OF MATERIALS (c)	HNU SCREENING RESULTS (d)	~~PUSH~~ SAMPLE INTERVAL (e) Core Box	~~ANALYTICAL SAMPLE~~ NO Fractures (f)	USCS (g)	REMARKS (h)
	41	SHALE, very dark brown, average hardness, very slight weathering, thinly laminated, wet pyrite crystals (veins @ 1) limey shale layers common		Box #4	41.3 Mech	NA	(Run 4 continued) Depth 36.5-46.5 Recovered 8.5' (1.5 Ft measured in borehole)
	42				42.5' mech		
	43				43' mech		
					43.6 mech		Ohio Shale
	44		0.0		44.3		
	45			45' ~~45-49ER~~			
	46						Left 1.5 core in hole.
					46.5		
	47	Total Depth = 46.5 Ft					
	48						
	49						
	50						

PROJECT: PBOW
HOLE NO: PB-BED-MW28

(Not To Scale)



Notes:

Well No.: PB-BED MW28
Date Installed: 8/8/03
Elevation Top of Casing: 670.83 Ft

Well Construction Diagram
prepared for:
Former Plum Brook Ordnance Works
Sandusky, OH

BW\MWA23DWC.DRW/ll/5-28-03

HTRW DRILLING LOG

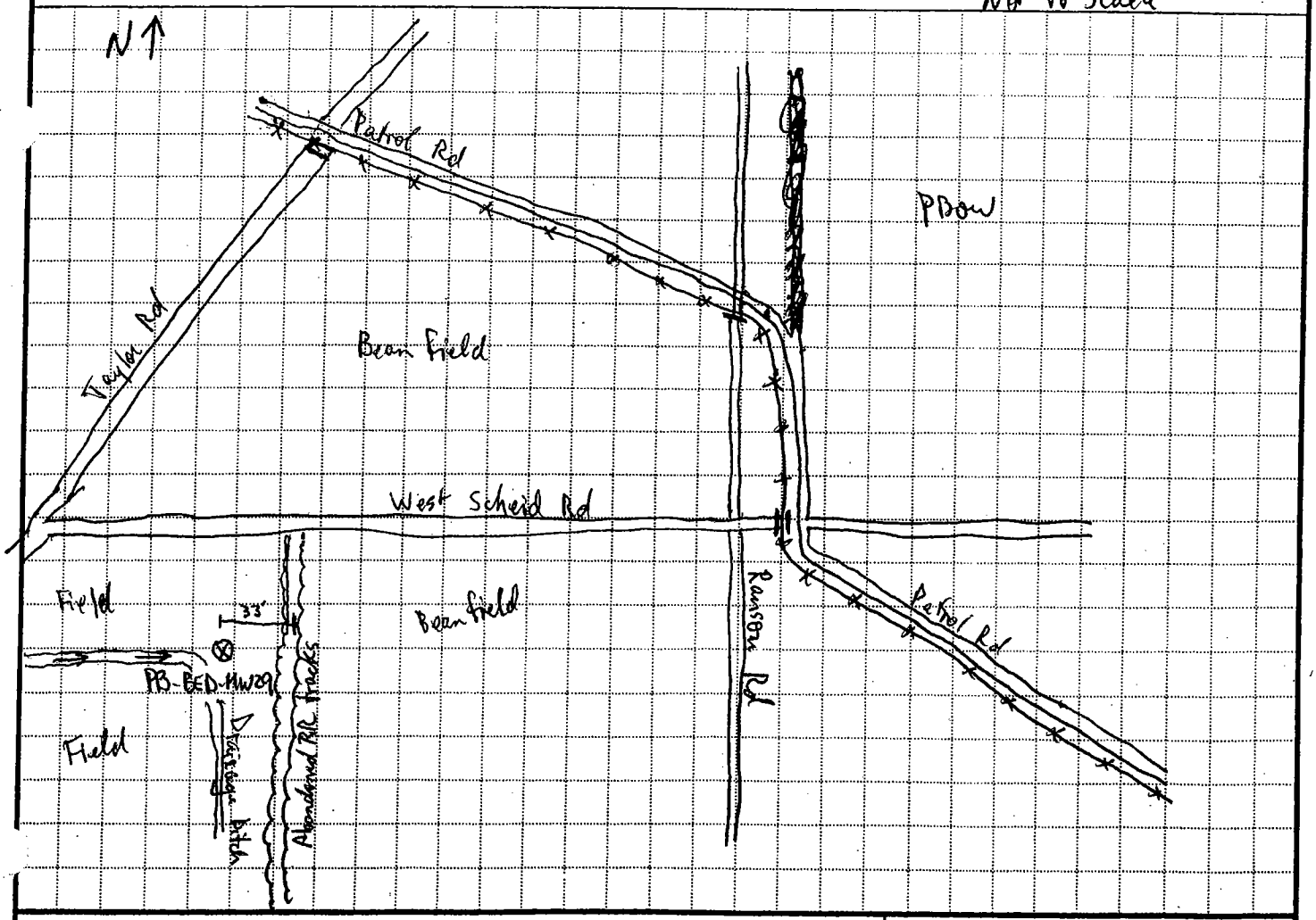
DISTRICT: Nashville, TN		HOLE NUMBER: PB-BED-MW29
1. COMPANY NAME: Shaw E+I	2. DRILL SUBCONTRACTOR: Miller Drilling	SHEET 1 OF 5 SHEETS
3. PROJECT: PBOW	4. LOCATION: Near PBOW, Sandusky, OH	
5. NAME OF DRILLER: David Gentry	6. MANUFACTURER'S DESIGNATION OF DRILL: Schramm 450, Millers Rig 300	
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT: Post hole dug 1st 4 Ft. w/ 3" ID stainless steel handauger. Drilled pilot hole w/ 6" roller bit to 18 Ft. Borehole reamed w/ 10" OD roller cone. Installed 6 5/8" OD black steel isolation casing. Cored bedrock w/ Christian bit 4 5/8" OD by 3" ID. Borehole reamed w/ 6" roller cone. Installed 2" PVC casing, 10 Ft screen	8. HOLE LOCATION: property owned by Mr. Chuck Schickley South of West Schied Rd, West of abandoned RR tracks	
	9. SURFACE ELEVATION: Ground: 678.50 Ft. N: 616,832.04 E: 1,913,519.80	
	10. DATE STARTED: 8/6/03	11. DATE COMPLETED: 8/9/03
12. OVERBURDEN THICKNESS: ~~4 Ft~~ DRY 3.8 Ft	15. DEPTH GROUNDWATER ENCOUNTERED: ~31 Ft	
13. DEPTH DRILLED INTO ROCK: 36 Ft	16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED: —	
14. TOTAL DEPTH OF HOLE: Cut 40 Ft, 0.2 Ft left in hole	17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY): —	

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
	NA	NA	2

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY ~95 %
	NA	NA	NA	NA	NA	

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
	NA	X	NA	David Kessler

LOCATION SKETCH/COMMENTS — SCALE: Not To Scale



PROJECT: PBOW	HOLE NO: PB-BED-MW29

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: PB-BED-MW29

PROJECT: PBOW

INSPECTOR: D. Kresslein

SHEET 2 OF 5 SHEETS

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	HNU SCREENING RESULTS (d)	~~PUSH / SAMPLE INTERVAL~~ (e) Core Box	ANALYTICAL SAMPLE NO (f)	USCS (g)	REMARKS (h)
		Grass					
	1	9 ft, black (10YR 2/1), homogeneous, sandy SILT, 45% sand, 55% silt, dry		NA	NA		Post hole dug first 4 Ft. Description from cuttings. 8/6/03 1300
		1.5				SM 1.5	
	2	SAND, trace silt, (10YR 7/6) yellow, very fine grain, well rounded, moist					Background: PID = 0.0 ppm
	3	color grading to (10YR 5/6) yellowish brown				SP	LEL = 0% C = 0 ppm O_2 = 20.9% H_2S = 0 ppm
		3.8		4		3.8	
	4	SHALE, very severely weathered, 20% sand, 10% silt, very dark brown, very thinly laminated, friable.	0.3	S-1 push 3 ft 4.7			Shale rock prevented 2 Ft split-spoon push total depth
	5						
	6						Began drilling with 6" roller bit at 4.7 Ft
		Competency tancy increasing with depth bdc					
	7						
	8						
	9						
	10						

PROJECT: PBOW

HOLE NO.: PB-BED-MW29

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: PB-BED-MW29

PROJECT: PBOW

INSPECTOR: D. Kressler

SHEET 3 OF 5 SHEETS

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	HNU SCREENING RESULTS (d)	~~PUSH/ SAMPLE INTERVAL~~ (e) Core Box	ANALYTICAL SAMPLE NO (f)	USCS (g)	REMARKS (h)
	10	SHALE, very dark brown, dry		NA	NA	NA	Drilled borehole w/ 6" roller bit (pilot hole)
	11		0.0				Borehole reamed with 10" roller cone to 14
	12						
	13						Logged from Schramm (air drilling) cuttings.
	14						
	15						
	16						
	17						
	18						End of pilot hole at 18'.
	19						
	20						

PROJECT: PBOW

HOLE NO. PB-BED-MW29

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: PB-BED-MW29

PROJECT: PBOW

INSPECTOR: D. Kyssler

SHEET 4 OF 5 SHEETS

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	HNU SCREENING RESULTS (d)	~~PUSH/~~ SAMPLE INTERVAL (e)	~~ANALYTICAL SAMPLE NO~~ Fractures (f)	USCS (g)	REMARKS (h)
	20	SHALE, very dark brown, dry	0.0	Core Box	NA	NA	Logged from Schramm cuttings
	21						
	22						Water in isolation casing.
	23						
		23.5					Drilled w/ 10" roller cone to 24 Ft.
	24	LIMESTONE, gray, hard, very thickly bedded, massive to slightly broken, moderately severe weathering limestone pitted, joints filled w/ clay, vug (1" x ½") quartz x/s, fossiliferous (brachiopods, corals), dry. (Prout Limestone)		24'			Run #1
	25			Box #1	25.6'		End: 1225
					25.7'		Start: 1215
	26						Depth = 24-34'
					26.6' mech.		Recovered: 9.5 Ft
	27				27' clay filled		
					27.5' clay filled		
	28				27.95'		
					28.2' vertical frac 28.2 to 28.5' 29.8'		Background PID = 0.0 ppm LEL = 0% CO = 0 ppm O_2 = 20.8% H_2S = ~2 ppm (?)
	29						
					29.8' clay filled		
	30						

PROJECT: PBOW

HOLE NO.: PB-BED-MW29

HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: PB-BED-MW29

PROJECT: PBOW

INSPECTOR: D. Kessler

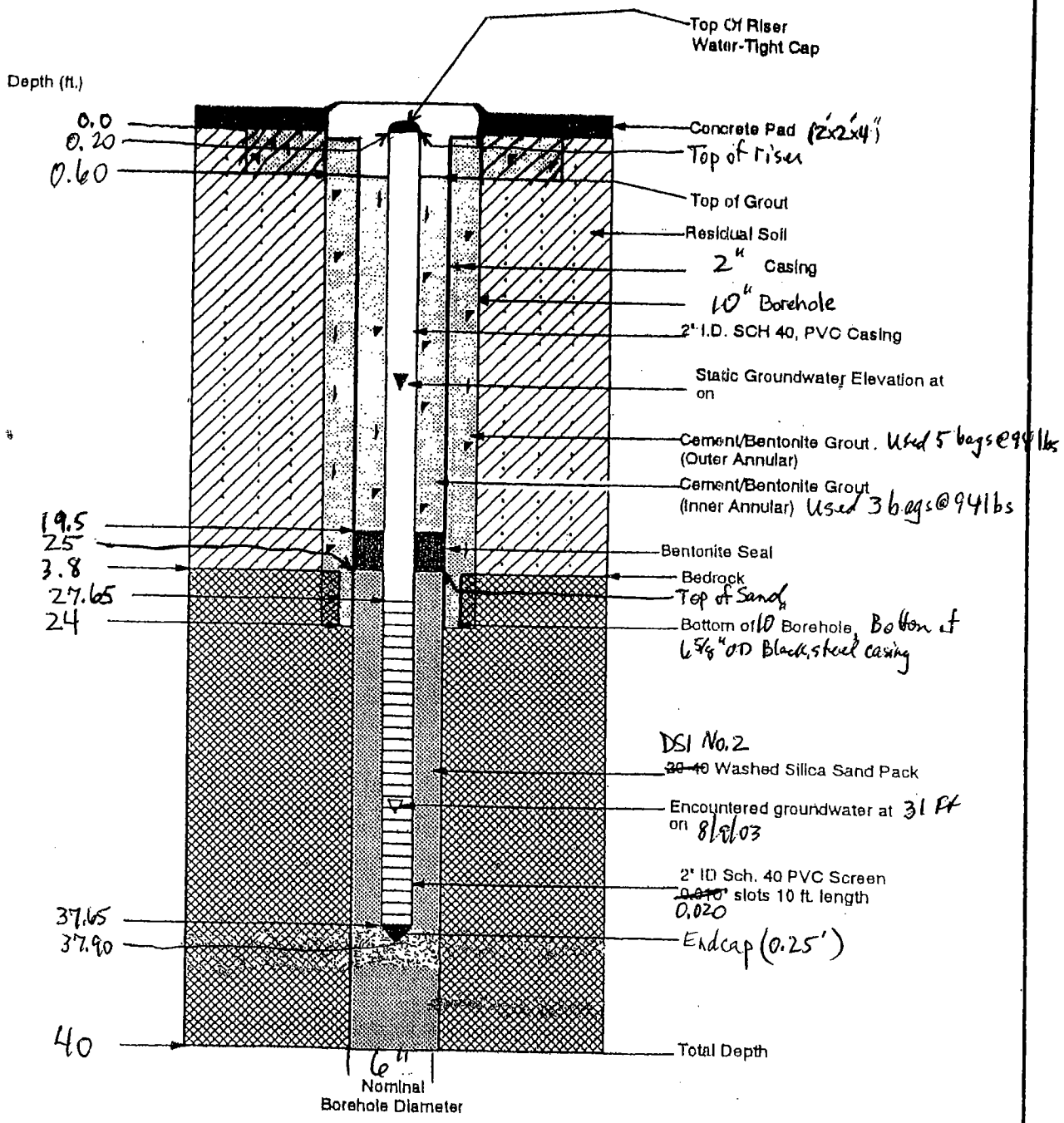
SHEET 5 OF 5 SHEETS

ELEV (a)	DEPTH 30 (b)	DESCRIPTION OF MATERIALS (c)	HNU SCREENING RESULTS (d)	~~RUSH~~ SAMPLE INTERVAL (e) Core Box	ANALYTICAL SAMPLE NO Fractures (f)	USCS (g)	REMARKS (h)
	31	31		Box #1	31' very broken water bearing	NA	Run #1 (Continued) ▽ Groundwater encountered 8/9/03
	32	Limey SHALE, very dark gray, soft thinnly bedded, broken to slightly broken, very severe weathering, pyrite veins/lungs, fossiliferous, (brachiopods), wet	0.0	washed away	31.5' 31.8' clay filled 32.4' clay filled 32.6' clay filled 33' clay filled		
	33						
	34			34	33.8' mechanical		34'
	35	SHALE, very dark gray, soft, thinnly bedded, broken to massive, moderate severe ~~weathering~~ weathering, pyrite, brachiopods, wet (Olentangy Shale)	0.0	Box #2	34.2' 34.4' 35.5' 35.1' 35.2'		Run #2 End: 1350 Start: 1330 Depth: 34-40' Recovered: 5.8 Ft
	36						
	37				37' clay filled		
	38						
	39				38.9' clay filled		
	40	Total Depth = 40 Ft					0.2 Ft left in hole by measurement

PROJECT: PBOW

HOLE NO: PB-BED-MW29

(Not To Scale)



Notes:

Well No.: PB-BED-MW29
Date Installed: 8/9/03
Elevation Top of Casing: 678.30 Ft.

Well Construction Diagram
prepared for:
Former Plum Brook Ordnance Works
Sandusky, OH

BW\MWA23DWG.DRW/ll/5-28-03

HTRW DRILLING LOG

	DISTRICT: Nashville, TN	HOLE NUMBER: PB-BED-MW30
1. COMPANY NAME: Shaw E+I	2. DRILL SUBCONTRACTOR: Miller Drilling	SHEET 1 OF 7 SHEETS

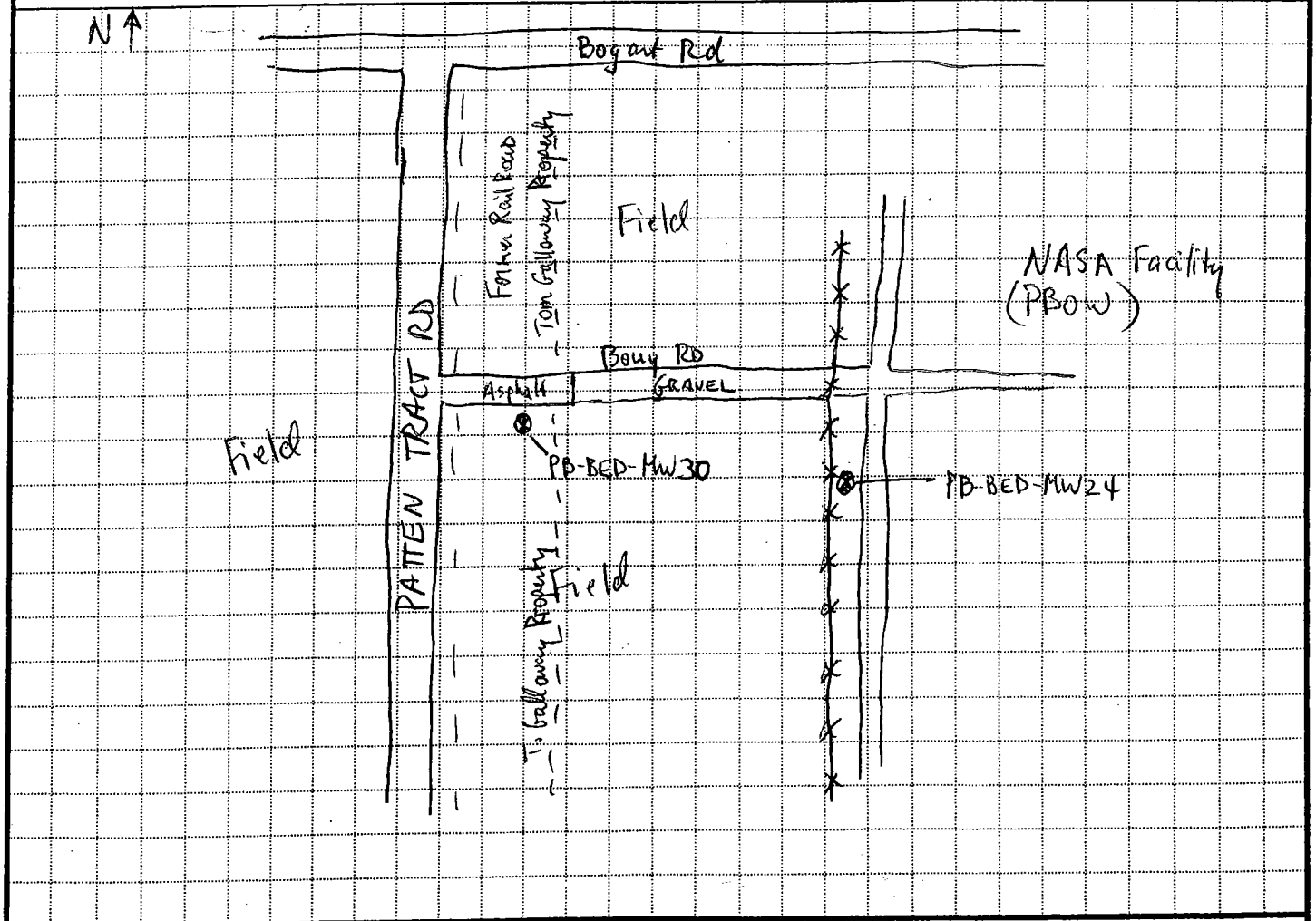
3. PROJECT: PBOW	4. LOCATION: West of PB-BED-MW24 On Bouy Rd, T. Galloway property
5. NAME OF DRILLER: Tracy Thrasher	6. MANUFACTURER'S DESIGNATION OF DRILL: Ingersol Rand T3-W Air Rotary Rig
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT: Soil Samples collected with 2.5" ID/3" OD X 24" length split-spoons. Borehole drilled with 6 5/8" roller cone. Borehole reamed and bedrock cut by 10" OD hammer bit. 6" ID/6 5/8" OD black steel casing installed to 34.3 Ft. Cored rock w/ PQ Bit leaving 4 5/8" OD borehole. Bedrock reamed to 6" OD w/air hammer.	8. HOLE LOCATION: See Sketch
	9. SURFACE ELEVATION: 647.25 Ft (Y) Northing: 623,091.78 (X) Easting: 1,907,134.63
	10. DATE STARTED: 3-15-04 / 11. DATE COMPLETED: 3/19/04
12. OVERBURDEN THICKNESS: 24 Ft	15. DEPTH GROUNDWATER ENCOUNTERED: 10.4 Ft (overburden) / Bedrock gw unknown
13. DEPTH DRILLED INTO ROCK: 34.3 Ft	16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED: 26.83 Ft BGS 3/23/04 0850
14. TOTAL DEPTH OF HOLE: 58.3 Ft	17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY): —

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
	NA	NA	3

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY
	NA	NA	NA	NA	NA	100 %

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
	NA	X	NA	David Keech

LOCATION SKETCH/COMMENTS — SCALE: Not To Scale



PROJECT: PBOW	HOLE NO.: PB-BED-MW30

Shaw E&I, Inc.

HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW30

Project: PBOW | Geologist: D. Kessler | Sheet 2 of 7 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	Analytical Sample No.	Recovery (ft)	Remarks
	1	Fill: (soft, (10YR 2/2) very dark brown, homogeneous, sandy SILT, 30% very fine grain sand, organics (roots), dry	ml	0.0	NA	NA	NA	Posthole dug first 4 Ft Breathing Air: 0.0 ppm 0% LEL 0 ppm CO 0 ppm H_2S 21.5% O_2
	2							
	3	Fill: (Medium stiff (10YR 4/6) dark yellowish brown, mottled (dark brown), clayey SILT, 5% limestone cobbles, low plasticity, dry	ml					Ballast rock used in RR construction encountered at 3 Ft.
	4							
	5	Fill: (Medium stiff, (10YR 4/4) dark yellowish brown, mottled (10%) (black/gray), clayey, sandy SILT, low plasticity, dry) 5.8	ml	0.0	NA	push 1330	2.0/ 2.0	
	6	Fill: (Medium dense, (10YR 4/6), dark yellowish brown, homogeneous, clayey, silty SAND, very fine grain, moist)	Sm	0.0	NA	push 1335	2.0/ 2.0	Styrofoam peanuts (packing material) present 7.8-8.0'
	7							
	8	wet at 8.0-8.4'						
	9	mottling at 8.4 Ft, coarse grain sand layer 9.6-9.7' gray, dark/black brown, moist	Sm	0.0	NA	push 1340	2.0/ 2.0	
	10							

Project: PBOW | Hole Number: PB-BED-MW30

Shaw E & I, Inc.

HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW30

Project: PBOW | Geologist: D. Kessler | Sheet 3 of 7 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	Analytical Sample No.	Recovery (ft)	Remarks
	10	V 10.4	sm		NA	push	2.0/	overburden gw @ 10.4'
	11	Stiff, homogeneous, (10 YR 4/1) dark gray, high plasticity, CLAY, wet	ch	0.0		1345	2.0	
	12				NA	push	2.0/	
	13	As above	ch	NM		1355	2.0	
	14				NA	push	2.0/	
	15	As above trace, well rounded pebbles 1%	ch	NM		1410	2.0	
	16				NA	push	2.0/	
	17	As above granule to pebbles present, content increasing 5-10% vertical fractures wet		NM		1415	2.0	
	18				NA	push	2.0/	
	19	granules to cobbles (15%), shale		NM		1430	2.0	
	20							

Project: PBOW | Hole Number: PB-BED MW30

Shaw E & I, Inc.

HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW30

Project: PBOW | Geologist: D. Kessler | Sheet 4 of 7 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	Analytical Sample No.	Recovery (ft)	Remarks
	20	Stiff, homogeneous, (10YR 4/1) dark gray, high plasticity, sandy CLAY, 15 50% well rounded granules to cobbles (shale), wet	ch	NM	NA	push	NA	
	21	25% fine sand				1440		
	22			NM	NA	NA	NA	
	23							
	24	Refusal @ 24 Ft						
		LIMESTONE, gray, soft						
	25							
	26							
	27							
	28							Borehole/bedrock reamed to 29.5 Ft DTK w/ 10-inch OD hammerbit
				DTK				Installed 6 5/8" casing to 29.5
	29							Began coring 3/18/04 1305 w/ 4 5/8" OD PQ bit
				29.5		Frags		
					Box #1			
	30					29.9		

Project: PBOW | Hole Number: PB-BED-MW30

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Shaw E&I, Inc.

HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW30

Project: PBOW | Geologist: D. Kessler | Sheet 5 of 7 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	~~Analytical Sample No.~~ Fracs	Recovery (ft)	Remarks
	30	Delaware, LIMESTONE, very strong, gray, micro crystalline, fossiliferous (braciopods), massive, fresh weathering, competent, slightly fractured, some oxidation within fractures, dry			Box #1	30.25 (mechanical)		Core Run #1 29.5-39.5' 3/18/04 1305
	31					30.8 Shale LIMEY		Breathing Air: PID = 0.0 ppm LEL = 0% CO = 0 ppm O_2 = 20.8% H_2S = 0 ppm
	32					31.5		
	33					33.5		Hydrocarbon odor while drilling (3.1 ppm downwind)
	34			10.8		34.1		End: 1342 Start: 1305 37 min
	35					34.5 (mech) 34.8 34.9		Hydrocarbon staining 34.5-35.7'
	36					36.1		Measured borehole 39.5 Ft
	37					36.6		Recovered: 10 Ft Cored: 10 Ft 100% Recovery
	38			15.2		37.4 (oxidized)		Hydrocarbon Staining 38.8-39.1
	39					38.9 (oxidized)		
					39.5 Box # 2			39.5' Bottom core sleeved
	40					39.8 (oxidized)		

Project: PBOW | Hole Number: PB-BED-MW30

Shaw E & I, Inc.

HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW30

Project: PBow | Geologist: D. Kessler | Sheet 6 of 7 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	~~Analytical Sample No.~~ Fracs	Recovery (ft)	Remarks
	40	Delaware, LIMESTONE, very strong, gray/light gray microcrystalline, fossiliferous (only 5%), massive, fresh weathering, competent, slightly fractured, calcite filled vertical fracture 47.5'-48.4' wavy shale partings through dry			Box #2			RUN #2 39.5-49.5' End: 1508 Start: 1432 36 min Cored: 10 Ft Recovered: 10 Ft 100% Recovery Hydrocarbon staining odor throughout core
	41			33.0				
	42							
	43					42.75' (oxidation) 42.95' (oxidization)		
	44			37.3				
						44.5' (mechanical)		
	45					45.55' 45.60' } weathered		
	46							
	47			34.7		47.3 47.5' vertical frac calcite filled		
	48					48.4		
	49				49.5	49.3		49.5 Bottom Run #2
	50				Box # 3	} smashed bottom (mechanical)		

Project PBow | Hole Number: PB-BED-MW30

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Shaw E & I, Inc.

HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW30

Project: PBOW | Geologist: D. Keslar | Sheet 7 of 7 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	Analytical ~~Sample No.~~ Fracs	Recovery (ft)	Remarks
	50	Delaware, LIMESTONE, very hard, dark gray, microcrystalline, few fossils, massive, slightly decomposed, moderately fractured, 2 long calcite filled fractures; may be water bearing		NM	Box #3	broken & severely (mechanical) 50.8 (mech) 51.1 51.2 51.3 vertical frac (calcite filled) 52.6 53.1 (mech) 53.9 (mech) 54.5 (oxidized) 55.2 (oxidized) 55.7 56 56.3 (TD) 56.9 (TD) smashed, broken (mech)		Run #3 49.5-58.3 End: 1632 Start: 1558 34 min 8.8 Ft Run w 8.4 Ft Recovery Core smashed/broken in many pieces. Caught in core barrel. Beat repeatedly on core barrel to break.
	58	white, pale green, very carbonaceous fossil?: ~~brachiopod~~ shell?			58.3			Broken shoe catcher clogged under pressure 58.3
	59	Total Depth = 58.3 Ft						Borehole reamed w/ 6" air hammer to 58.3 Ft.
	60							

Project: PBOW | Hole Number: PB-BED-MW30

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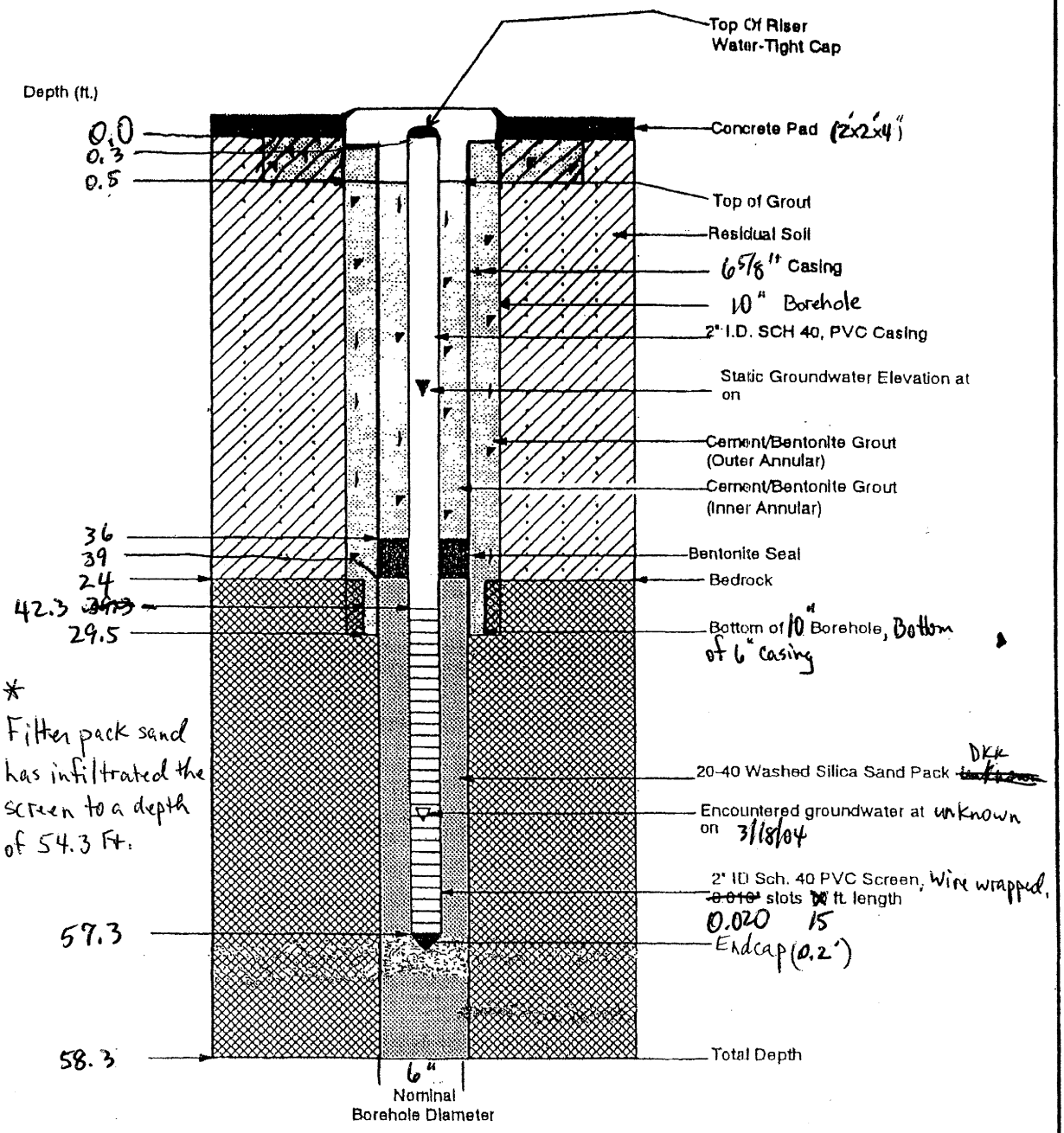


* Filter pack sand has infiltrated the screen to a depth of 54.3 Ft.

Notes:

Well No.: PB-BED-MW30
Date Installed: 3/19/04
Elevation Top of Casing: 646.87 Ft

Well Construction Diagram
prepared for:
PBOW
Sandusky, OH

BW\MWA23DWC.DRW/ll/5-28-03

After well Dev. activities
bottom of borehole measured at 54.53 Ft -(?)

Well Abandoned 4/3/04

HTRW DRILLING LOG

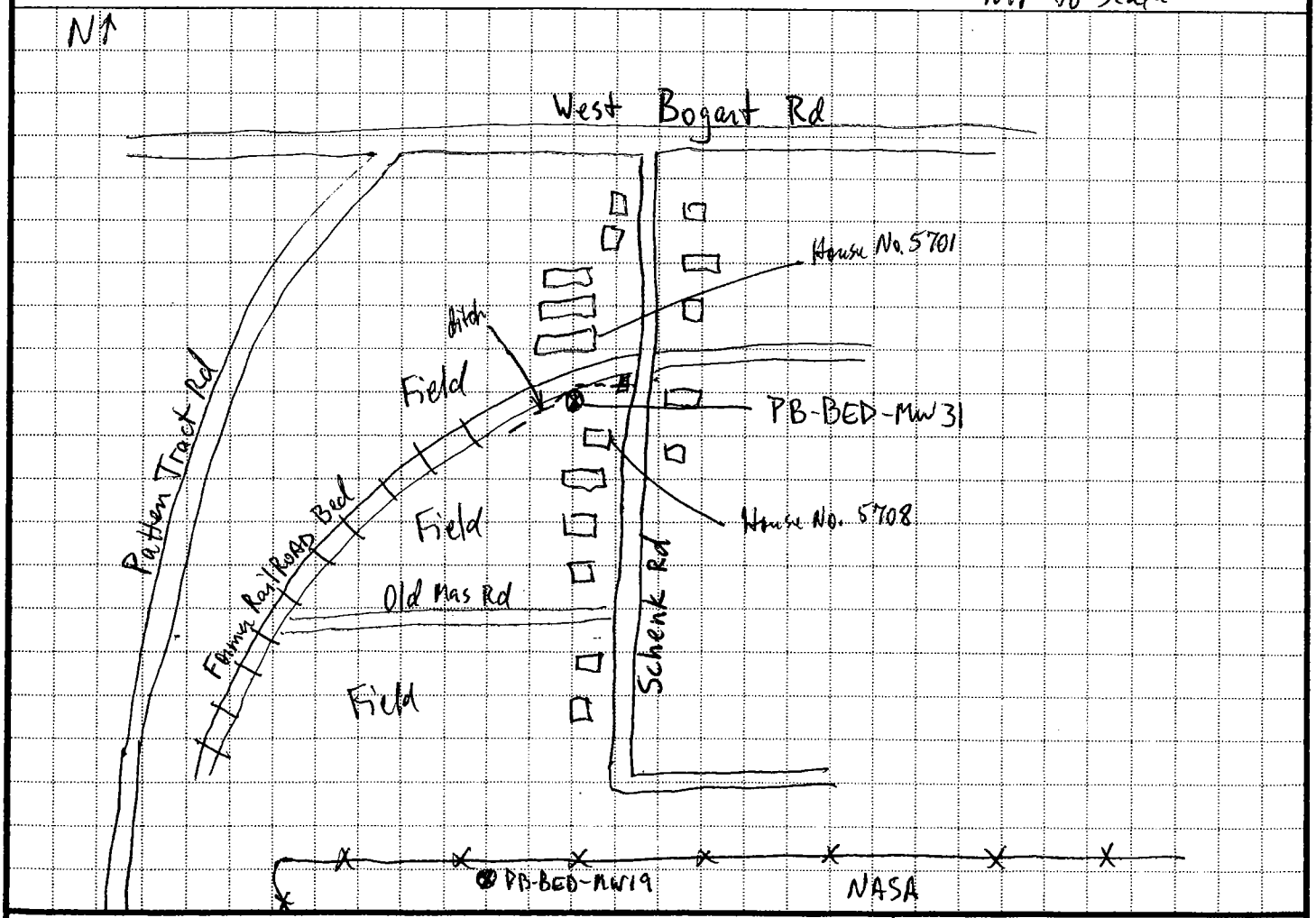
	DISTRICT: Nashville TN	HOLE NUMBER: PB-BED-MW31
1. COMPANY NAME: Shaw E+I	2. DRILL SUBCONTRACTOR: Miller Drilling	SHEET 1 OF 10 SHEETS
3. PROJECT: PBOW	4. LOCATION: Northing(y): 626,721.75, Easting(x): 1,910,435.87	
5. NAME OF DRILLER: Tracy Thrasher	6. MANUFACTURER'S DESIGNATION OF DRILL: Ingersoll Rand T-3W Air Rotary Rig	
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT: Soil Samples collected with 2.5 inch ID/3" OD stainless steel split spoons. Borehole drilled with 6 5/8" roller cone bit. Borehole reamed and bedrock cut with 10" OD hammer bit. Installed 6" ID/ 6 5/8" OD black steel casing to 20 Ft	8. HOLE LOCATION: See Sketch	
	9. SURFACE ELEVATION: Approximately 600 Ft west of Schenk Rd Ground: 632.90 Ft	
	10. DATE STARTED: 3-16-04	11. DATE COMPLETED: 3/20/04
12. OVERBURDEN THICKNESS: 13Ft	15. DEPTH GROUNDWATER ENCOUNTERED: overburden groundwater not encountered	
13. DEPTH DRILLED INTO ROCK: 77.2 Ft	16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED: 75.02' 11.5 hrs (15' water column)	
14. TOTAL DEPTH OF HOLE: 90.2 Ft	17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY): 87.29' BGS, 1.56' water column 3/23/04 0930	

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
	NA	NA	7

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY
	NA	NA	NA	NA	NA	100 %

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
	NA	2" PVC	NA	David Kessler

LOCATION SKETCH/COMMENTS — SCALE: Not To Scale



PROJECT	HOLE NO.
PBOW	PB-BED-MW31

Shaw
Shaw E & I, Inc.

HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW31

Project: PBOW | Geologist: D. Kessler | Sheet 2 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	Analytical Sample No.	Recovery (ft)	Remarks
	0	Fill: (Soft- medium stiff, (10YR 3/6), dark yellowish brown, mottled (black, organic rich) clayey SILT, organics, moist)	ml	0.0	NA	NA	NA	Post hole dug first 4 ft.
	4			4				
	4	Fill: (medium stiff, (10YR 3/6) dark yellowish brown, mottled (black, orangish red (rust)), clayey SILT, organics (roots), moist)	ml	0.0	NA	~~NA~~ push	2.0/ 2.0	
	6			6		0830		
	6	As above		NM	NA	push	2.0/ 2.0	Heavy snow, blowing wind/ field screening not performed
	7.2							
	7.2	soft, (2.5 y 3/2) very dark grayish brown, homogeneous, high plasticity, silty CLAY, moist	ch	8		0833		
	8	consistency stiff, as above		NM	NA	push	2.0/ 2.0	
	10					0840		

Project: PBOW | Hole Number: PB-BED-MW31

Shaw
Shaw E & I, Inc.

HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW31

Project: PBOW | Geologist: D. Kessler | Sheet 3 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	Analytical Sample No.	Recovery (ft)	Remarks
	10	stiff, (2.5 Y 3/2) very dark grayish brown, homogeneous, high plasticity, silty CLAY, moist	ch	NM	NA	push	2.0/ 2.0	
	11							
	12					0850		
		Very stiff, silty CLAY, as above, granules to pebbles 30%, moist		NM	NA	push	2.0/ 2.0	
	13	13 SHALE, very weathered, 13.8						
						0855		
	14	LIMESTONE, hard, friable, very weathered						overburden groundwater not encountered.
		Refusal @ 14.5 Ft	NA					Borehole reamed to 20 Ft with 10" air hammer.
	15	LIMESTONE, competent, gray, dry		NM	NA	NA	NA	
	16							
	17							
								Distinct HC odor 37.9 ppm near borehole.
	18							
	19							Installed Black steel 6" ID/6 5/8" OD to 20'
	20							

Project: PBOW | Hole Number: PB-BED-MW31

Shaw
Shaw E & I, Inc.

HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW31

Project: PBOW | Geologist: D. Kessler | Sheet 4 of 17 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	~~Analytical Sample No.~~ Fracs	Recovery (ft)	Remarks
	20	Delaware, LIMESTONE,		13.3	Box #1	20.4 (mech)		Began Coring 3/19/04 1620
	21	very strong, gray, micro crystalline, fossiliferous, stylolites (brachiopods, coral), massive,				21.2 (mech)		Core Run #1 Drilled 10.1 Ft 20 – 30.1 100% recovery End 1708 Began 1620 48 min
	22	competent, slightly fractured, petroleum				21.9 (some oxidation)		Breathing Air (Background) PID = 0.0 ppm LEL = 0% O_2 = 20.8% H_2S = 0 ppm
	23	staining (light brown) on core and within, dry		37.5				
	24					23.9		Distinct Petroleum odor 8.7 ppm (occassionally) 0% LEL 0.6 ppm in Breathing Air (occassionally) 18 ppm = CO 21.6 = O_2 0 = H_2S
						24.6		
	25					25.1		
						25.2		
	26			23.2				
						26.6		Brown petroleum staining on core throughout section.
	27							
						27.7		
	28							
	29	significant weathering, oxidation in fracture at 29.4. Blank, 1mm shale/clay filled		25.6		29.4		
	30							

Project: PBOW | Hole Number: PB-BED-MW31

Shaw
Shaw E & I, Inc.

HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW31

Project: PBOW | Geologist: D. Kessler | Sheet 5 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	~~Analytical Sample No.~~ Fracs	Recovery (ft)	Remarks
	30	Delaware, LIMESTONE, very strong, gray, micro crystalline, fossiliferous (braciopods), massive, competent, fresh, petroleum staining on core (light brown), dry		12.2	Box #2		-31.1 (clay filled)	Run #2 30.1 - 40.1' ~~Rec~~ Recovery 100%
	31							
	32						-32.2 (mech)	Fresh hydrocarbon spot in fracture at 31.1' (5 mm) diameter circle
	33							Possible water at 31.4' frac
	34							3/19/04 - BTW = 44.2' (from stickup) 3/20/04 - BTW = 36.84 7.4 Ft in 12 hrs
	35						-35' (mech)	USACE/Shaw agree to drill deeper for more water.
	36							
	37							
	38							
	39							End of day
	40							Measured water in borehole 0.6 Ft water column

Project PBOW | Hole Number: PB-BED-MW31

Shaw E & I, Inc.

HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW31

Project: PBOW | Geologist: D. Kessler | Sheet 6 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	Analytical Sample No. Frac's	Recovery (ft)	Remarks
	40	Delaware, LIMESTONE, very strong, gray, microcrystalline, fossiliferous (brachiopods), massive, competent, fresh (no fractures), distinct petroleum staining 40.1'-42'; dry			Box #3			0.4 gal in 12 hrs water ~~40.1 3/20/04 0843~~ Run # 3 40.1-50.1' End: 0928 Began: 0843 45 min 10' Run, Recovered 10' 100% Distinct hydrocarbon odor while drilling 12.5 ppm in drilling mist around borehole. Distinct HC staining on core.
	41			12.2		41.6' (mech)	~~41/6~~ (mech)	
	42					42.3' (mech)		
	43			14.8				
	44							
	45					45.1' (mech)		
	46			4.7				
	47					46.4' (mech)		
	48			3.1				
	49							
	50							

Project: PBOW | Hole Number: PB-BED-MW31

Shaw E & I, Inc.

HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW31

Project: PBow | Geologist: D. Kessler | Sheet 7 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	~~Analytical Sample~~ No.	Recovery (ft)	Remarks
					50.1'	Fracs		50.1'
	50	Delaware, LIMESTONE,						Run #4 (50.1-60.2')
	51	very strong, microcrystalline, gray ~~light~~ dark gray, fossiliferous		NM (RAIN)	Box #4			10.1 Ft Run Recovered 10.1 Ft 100% recovery
	52	(brachiopods), massive, competent fresh, ~~fractured~~ 55.9" + 60',						From stitching TD = 64.75'
		dry, wavy shale partings, pyrite throughout (1 mm - 0.5 mm)						NM45 DTW = 63.75 1255 DTW = 62.50 / 1.25 ft/hr
	53							
	54					54.1 (mech)		
	55					55.2' (mech)		
	56					55.8' } shaley lime 60.' } black		
	57							
	58							
	59							
	60				60.0'			

Project: PBow | Hole Number: PB-BED-MW31

Shaw
Shaw E&I, Inc.

HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW31

Project: PBOW | Geologist: D. Kessler | Sheet 8 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	Analytical ~~Sample~~ No.	Recovery (ft)	Remarks
	60				60.0' Box 5	FRACS		60.2 Ft
		Delaware, LIMESTONE, very strong, microcrystalline, dark gray, fossiliferous (brachiopods, shells), massive, competent, fresh, no fractures, wavy shale laminations throughout, dry		NM (heavy rain)	60.2' Box 5		60.9' (mech)	Run #5, 60.2-70.2', Cored 10 Ft. Recovered 10 Ft 100% Recovery (solid 10 Ft section) until broken to place into core box.
	61							
	62							
	63							
	64						63.8' (mech)	
	65						64.8' (mech)	
	66							
	67						66.7' (mech)	
	68						67.9' (mech)	
							68.6' (mech)	
	69				69.4' Box 6			
	70							

Project: PBOW | Hole Number: PB-BED-MW31

Shaw
Shaw E & I, Inc.

HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW31

Project: PBOW | Geologist: D. Kessler | Sheet 9 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	~~Analytical Sample No.~~ Fracs	Recovery (ft)	Remarks
	70	Delware Fm, LIMESTONE, very strong, microcrystalline, dark gray, fossiliferous, (stylolites, brachiopods, corals), massive, competent, fresh, 3 fractures, wavy shale laminations (0.5-1mm)		NM (RAIN)	Box 6		72.6'	70.2 70.2'-79.5' Run 6 Dec Cored 10 Ft Recovered 9.3 Ft 0.6 Ft in hole TD = 84.4 Ft 93% recovery 4 8 Stickups Run 6 70.2-80.2' water column = 0.8 Ft in 30 min
	71							
	72							
	73							
	74						74' (mech)	
	75						75.4'	
	76							
	77							
	78						78.2'	
	79				79' Box 7			79.5'
	80				Box 7			

Project PBOW | Hole Number: PB-BED-MW31

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Shaw
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HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW31

Project: PBOW | Geologist: D. Kessler | Sheet 10 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	~~Analytical Sample No.~~ Fracs	Recovery (ft)	Remarks
	80							80.2
	81	Delaware Fm. LIMESTONE, Very strong, microcrystalline, dark gray, fossiliferous.			Box #7			Run #7
	82	(stylolites, bracks, corals), massive,		0.0				80.2 - 90.2 Measured TD borehole 90.2 Ft Cored 10 Ft, Recovered 10.6'
	83	competent, fresh weathering, wavy shale partings (0.5 mm).						End: 1749 Began: 1705 44 min
						-83.5' (shale parting)		M
	84							3/19/04 1830 Water level = 90.12'
								3/20/04 0700 = 75.02'
	85							15' 11.5 hrs
	86							
	87	87.1' - 90.2' hydrocarbon staining on core		23.1		-86.7' Frac		
	88					-89.9' (mech.)		* Have lost no drill water.
	89							
	90	Total Depth = 90.2 Ft		12.8				

Project PBOW | Hole Number: PB-BED-MW31

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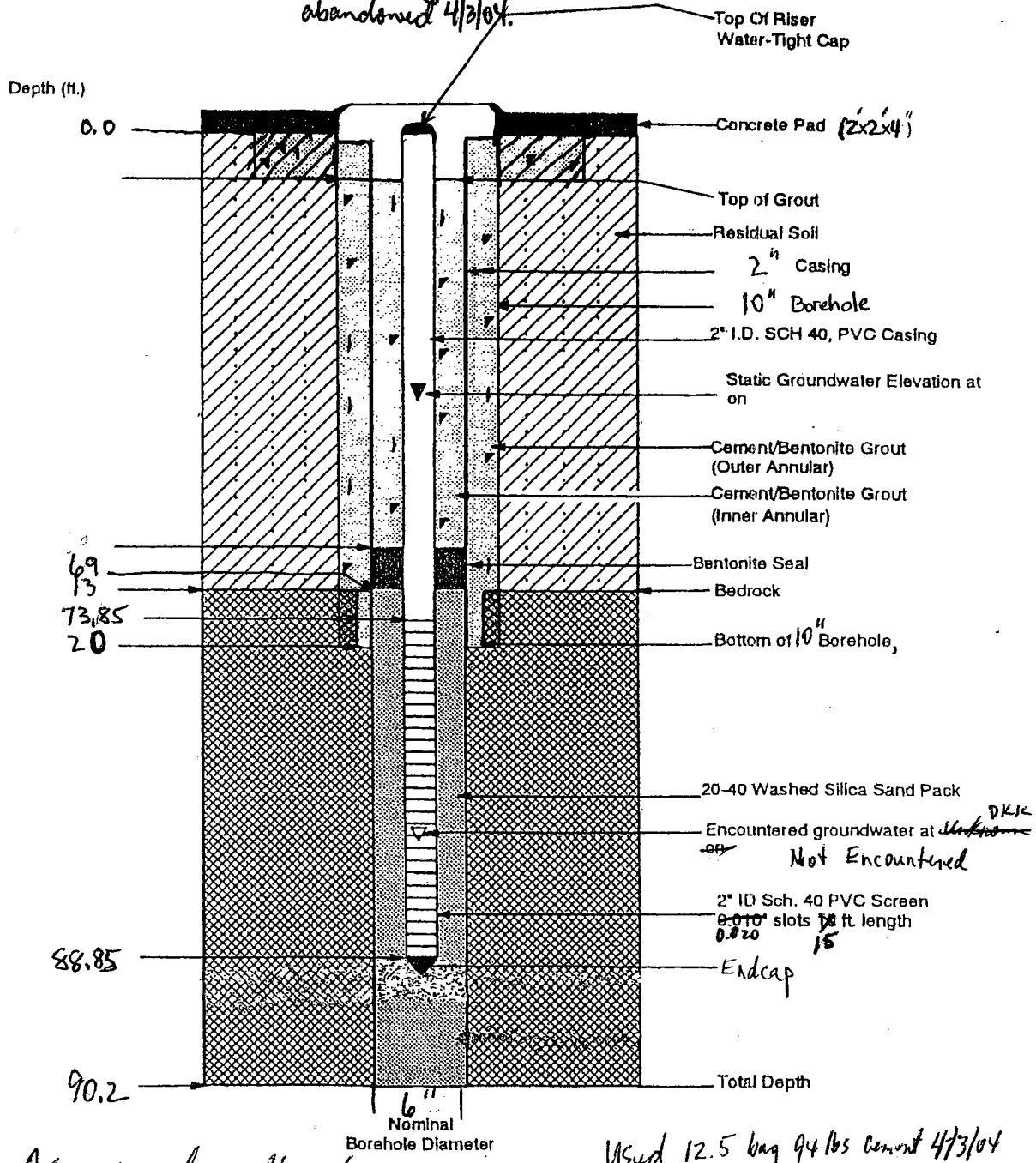
* Installed screen removed. Sand in well mixed w/ grout when trenied into borehole. Well abandoned 4/3/04.

(Not To Scale)



Abandoned well 4/3/04

Used 12.5 bag 94 lbs Cement 4/3/04

Notes:

Well No.: PB-BED-MW31
Date Installed: 3/31/04
Elevation Top of Casing: Not Surveyed Well (Well abandoned).

Well Construction Diagram
prepared for:
PBOW
Sandusky, OH

BWMWA23DWC.DRW/II/5-28-03

Abandoned @ 4/3/04

HTRW DRILLING LOG

1. COMPANY NAME: ~~PBOW~~ Shaw E+I	DISTRICT: Nashville, TN	HOLE NUMBER: PB-BED-MW32
2. DRILL SUBCONTRACTOR: Miller Drilling		SHEET 1 OF 10

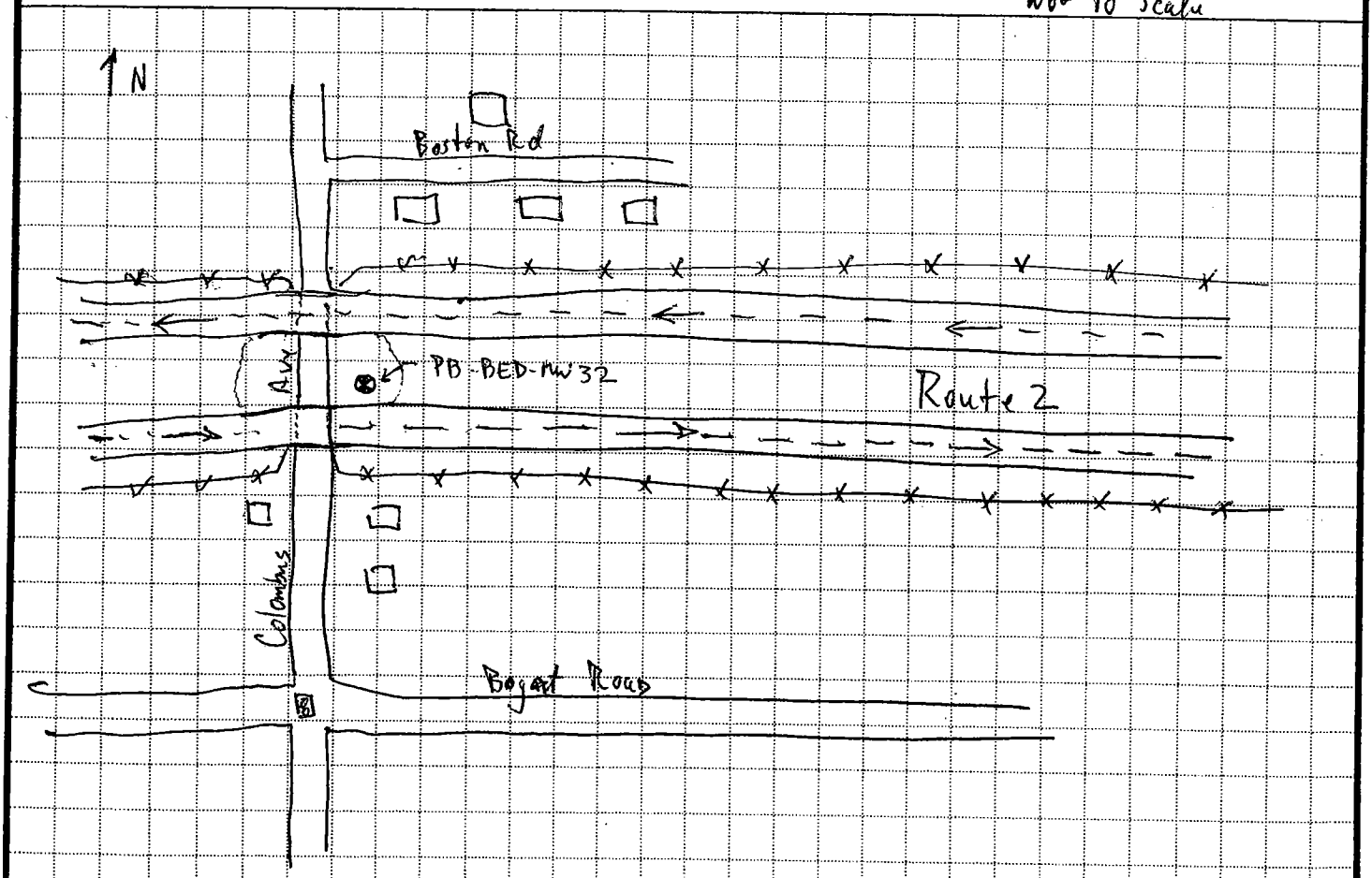
3. PROJECT: PBOW	4. LOCATION: Between E/W Bound Route 2, East of Columbus Ave.
5. NAME OF DRILLER: Tracy Thrasher	6. MANUFACTURER'S DESIGNATION OF DRILL: Ingersall Rand T-3W Air Rotary Rig
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT: Soil Samples collected with 2.5" ID/ 3" OD stainless Steel split spoon. Borehole drilled w/ 6 5/8" roller cone bit. Borehole reamed/bedrock cut w/ 10" OD air hammer bit. Installed 6" ID/6 5/8" OD black steel casing to 25.1 Ft. Bedrock cored w/ 4 5/8" PQ bit.	8. HOLE LOCATION: See Sketch
	9. SURFACE ELEVATION: 627.76 Ft, Northing (Y): 630,607.25, Easting (X): 1,920,393.20
	10. DATE STARTED: 3/29/04 — 11. DATE COMPLETED: 4/1/04
12. OVERBURDEN THICKNESS: 17.5 Ft	15. DEPTH GROUNDWATER ENCOUNTERED: 6.4 Ft overburden/Bedrock not encountered
13. DEPTH DRILLED INTO ROCK: 72.6 Ft	16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED: —
14. TOTAL DEPTH OF HOLE: 90.1 Ft	17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY): —

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
	NA	NA	7

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY
	NA	NA	NA	NA	NA	100 %

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
	NA	yes	NA	David Kessler

LOCATION SKETCH/COMMENTS — SCALE: Not To Scale



PROJECT	HOLE NO.
PBOW	PB-BED-MW32

Shaw
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HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW32

Project: PBOW | Geologist: D. Kessler | Sheet 2 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	Analytical Sample No.	Recovery (ft)	Remarks
		Grass						
	1	FILL: (soft, (10YR 3/1) very dark gray, sandy SILT, organics (roots), dry)	ml		NA	NA	NA	Posthole dug first 4 Ft
	2	FILL: (Medium Stiff, (10YR 5/6) yellowish brown, clayey, silty, SAND (10% clay, 40% silt, 50% sand), sand vf g, mottled (brown's), dry)	Sm	0.0				Breathing Air. PID: 0.0 ppm LEL = 0% CO = 0.0 ppm O_2 = 21.0% H_2S = 0.0 ppm
	3							
	4			4				
	5	5		0.0	NA	S-1	0.3/ 2.0	
	6	FILL: (Loose, (10YR 4/6), dark yellowish brown, homogeneous, SAND, very fine grain, very well rounded, very well sorted, very moist wet)		6		1505		
		6.4						Miller has no sand catchers
	7	Fill (very loose, (2.5Y 3/1) very dark gray, very well sorted, homogenous, SAND, wet)	SP	0.0	NA	S-2	1.4/ 2.0	▽ Encountered OB G-W at 6.4 Ft
	8			8		1510		
		8.2						
	9	Stiff, (5Y 3/1), very dark gray, high plasticity, black mottling (2%), silty CLAY, wet	CH	0.0	NA	S-3	2.0/ 2.0	0.5' slough
	10					1311		

Project: PBOW | Hole Number: PB-BED-MW32

Shaw
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HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW32

Project: PBOW | Geologist: D. Kessler | Sheet 3 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	Analytical Sample No.	Recovery (ft)	Remarks
	10	Stiff, (5Y 3/1) very dark gray, mottled (5%) (gray/black), high plasticity, pebbles/granules, moist	ch	NM	NA	S-4 1520	2.0/ 2.0	(1' slough)
	12	As above, pebbles-granules increasing	ch	NM	NA	S-5 1530	2.0/ 2.0	All slough
	14		ch	0.0	NA	S-6 1540	2.0/ 2.0	(1.5 slough)
	15	15.5 Hard, (2.5Y 3/1) very dark gray, low plasticity, CLAY, granules to pebbles (lm/shale), well rounded, dry very hard 17-17.5'	cl	0.0	NA	S-7 1550	1.5/ 1.5	(1' slough)
	17	Spoon Refusal @ 17.5 Ft						
	18	LIMESTONE, gray		NA	NA	NA	NA	Began cutting w/ 10" air hammer.
	19							Distinct HC odor as cutting bedrock.
	20							

Project: PBOW | Hole Number: PB-BED-MW32

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HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW32

Project: PBow | Geologist: D. Kessler | Sheet 4 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	Analytical Sample No.	Recovery (ft)	Remarks
	20	LIMESTONE, gray, dry		NM	NA	NA	NA	
	21							
	22							
	23							
	24							Borehole reamed w/10" air hammer to 25.1'. Blackstel casing installed to 25.1 ft
	25	Delaware Fm, LIMESTONE, light gray to gray, microcrystalline. Fossiliferous (brachs, stylolites, corals), massive, fresh, hydrocarbon on core, competent, unfractured, dry *0.5-1mm wavy shale laminations throughout core		NM	Box #1	Fracs	25.95' (mech) 26.55' (shale parting) 27.6' (shale parting) 28.4' (mech) 28.5' (mech) 29.9' (mech)	25.1' Began coring 3/31/05 1545 Run #1 (25.1-35.1') 7 8 Ended 1622 Start 1545 37 min Recovered 9.2/10.0 = 92% recovery Distinct hc odor while coring. NM= Not field screened= RAINING. Hydrocarbon on Core
	30							

Project: PBow | Hole Number: PB-BED-MW32

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Shaw E & I, Inc.

HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW32

Project: PBOW | Geologist: D. Kessler | Sheet 5 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	Analytical ~~Sample No.~~ FTracs	Recovery (ft)	Remarks
	30	Delaware Fm, LIMESTONE, light gray to gray, very strong, microcrystalline, fossiliferous (bracks, corals, Stylolite (28.5'), massive, fresh, hydrocarbon on core, competent, unfractured, dry 0.5-1mm wavy shale laminations throughout core		NM	Box #1		30.6' (mech)	NM - Not measured pending.
	31						30.8' (shale parting)	
	32						32.1'	
	33							Healed vertical frac 32.9-34.3'
	34							DTW = 39.4' 1635 TD = 40.05'
					Box #2	~~34.5~~ shale part	34.3 (mech)	DTW = 39.32 1750
	35					~~Box~~ 35.1 Shale parting	(shale parting)	0.08' water
		As above		NM	Box #2			35.1 Run #2 (35.1-45.1')
	36					36.5 shale		TD = 45.1 (measured)
	37							End: 1758 start: 1709 49 min
	38					38.25 shale parting		Recovery = 106% (0.6' from Run #1)
	39					39' (mech)		
	40					39.9'		Oxidized rock? Nubble intact at 39.9'

Project: PBOW | Hole Number: PB-BED-MW32

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HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW32

Project: PBOW | Geologist: D. Kessler | Sheet 6 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	~~Analytical Sample No.~~ Fracs	Recovery (ft)	Remarks
	40	Delaware, limestone, light gray to gray, microcrystalline, fossiliferous (brachs) ~~Dry~~ massive, fresh, competent, unfractured, dry 0.5-1mm wavy shale laminations		NM	Box #2	40.4' (mech)		Run # 2 (cont)
	41					41.5' shale parting (water)		DTW = 48.40' 1635 3/31/04 DTW = 47.5 / 0.9' 4/1/04
	42							
	43							
	44				44	44 (mech)		
					Box #3	Box #3		
	45							Fracs 45.45.5' Began Coring 4/01/04 45.1'
		As above		NM	Box #3	Do		Run # 3 (45.1 - 55.1') Recovery: 8.8/10.0 End 0830 88% Start 0746 44 min
	46							
	47							
	48							Not working water Distinct HC odor while milling
	49					49' (mech)		DTW = 58.6' (after 1.5 hrs)
	50							

Project: PBOW | Hole Number: PB-BED-MW32

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HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW32

Project: PBow | Geologist: D. Kessler | Sheet 7 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	~~Analytical Sample No.~~ Fracs	Recovery (ft)	Remarks
	50	Delaware, LIMESTONE,						Run #3 (cont)
	51	very strong, gray, fossiliferous (bivalves), microcrystalline,		NM	Box #3			
	52	massive, unfractured, fresh, competent, dry						
		0.5-1mm wavy shale laminations						
	53					53.1 (mech)		NM- Not measured RAIN
					53.9'	53.9' healed frac (broke partial frac)		
	54				Box #4			healed frac
						54.7' (mech)		
	55							55.1
		As above		NM	Box # 4			Run #4 (55.1 - 65.1') Recovered: 10/10 100% End: 1155
	56							
	57							
	58							
	59					58.9 (mech)		Not able to measure TD or DTW, core in hole. Drilled Run 5 to collect Run 4 core also.
	60					59.7' (mech)		

Project: PBow | Hole Number: PB-BED-MW-32

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Shaw
Shaw E & I, Inc.

HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW32

Project: PBOW | Geologist: D. Kessler | Sheet 8 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	Analytical Sample ~~No.~~ Fracs	Recovery (ft)	Remarks
	60	Delaware, LIMESTONE,						Run 4 (cont)
		very strong, gray,		NM	Box	5'		
	61	microcrystalline,			# 4	-60.5' (shale parting)		
		fossiliferous (brachs, corals						
		stylolites), massive,				-61.4' (mech)		
	62	fresh, competent,						
		unfractured, shale						
	63	within core 0.5-1 mm						
		thicknesses, dry						
	64	0.5-1 mm wavy shale lamination			63.9' Box #5 65.1'	-63.9' (mech)		
	65							65.1
				NM	Box			Run 5
								65.1-70.1'
	66				#5	-65.9' (mech)		
		66.3-66.4' soft, limestone						End: 1440
		mud? wavy				-66.48'		start: 1418
	67							22 min
								100% recovery
	68					-68.1'		
	69							
	70							

Project PBOW | Hole Number: PB-BED-MW32

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Shaw
Shaw E&I, Inc.

HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW32

Project: PBOW | Geologist: D. Kessler | Sheet 9 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	~~Analytical Sample No.~~ Fracs	Recovery (ft)	Remarks
	70	Delaware, LIME STONE,		NM	Box #5	72.5' (shale parting)		Run 6 (70.1-80.1') start 1531 Recovery 7.9/10.0 79%
	71	very strong, dark gray, fossiliferous (brachs, corals), microcrystalline, massive,						
	72	fresh, competent, unfractured, 0.5-1mm wavy silty laminations, dry				72.9' (mech)		
	73				73.5'	73.5' (mech)		
	74				Box #6	74' (shale parting)		
	75							
	76					75.8' (shale parting)		
	77							
	78							
	79							
	80							

70.1

Project: PBOW | Hole Number: PB-BED-MW32

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Shaw
Shaw E & I, Inc.

HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW32

Project: PBOW | Geologist: D. Kessler | Sheet 10 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	Analytical Sample No.	Recovery (ft)	Remarks
	80	Delaware, LIMESTONE, very strong, dark gray, microcrystalline. Fossiliferous (brachs, corals), massive, fresh, competent, unfractured 0.5-1 mm wavy shale laminations, dry		NM	Box #6 81.7	Fracs 80.6' (mech)	10/ 10	80.1 Run 7 (80.1-90.1') Recovery 100% 4/2/04 - 93.4' ≈ 1.3' water 1800 4/1/04 DTW = 94.3' TD = 94.7 shrinkage 4.6 Will abandon well?
	81							
	82							
	83				Box # 7	83.3 at shale parting		
	84							
	85					85.45' (shale parting)		
	86					86.1' (mech)		
	87							
	88					88.1' (mech)		
	89					89.2' shale parting		
	90	Total Depth 90.1 Ft				89.7' shale parting		

Project: PBOW | Hole Number: PB-BED-MW32

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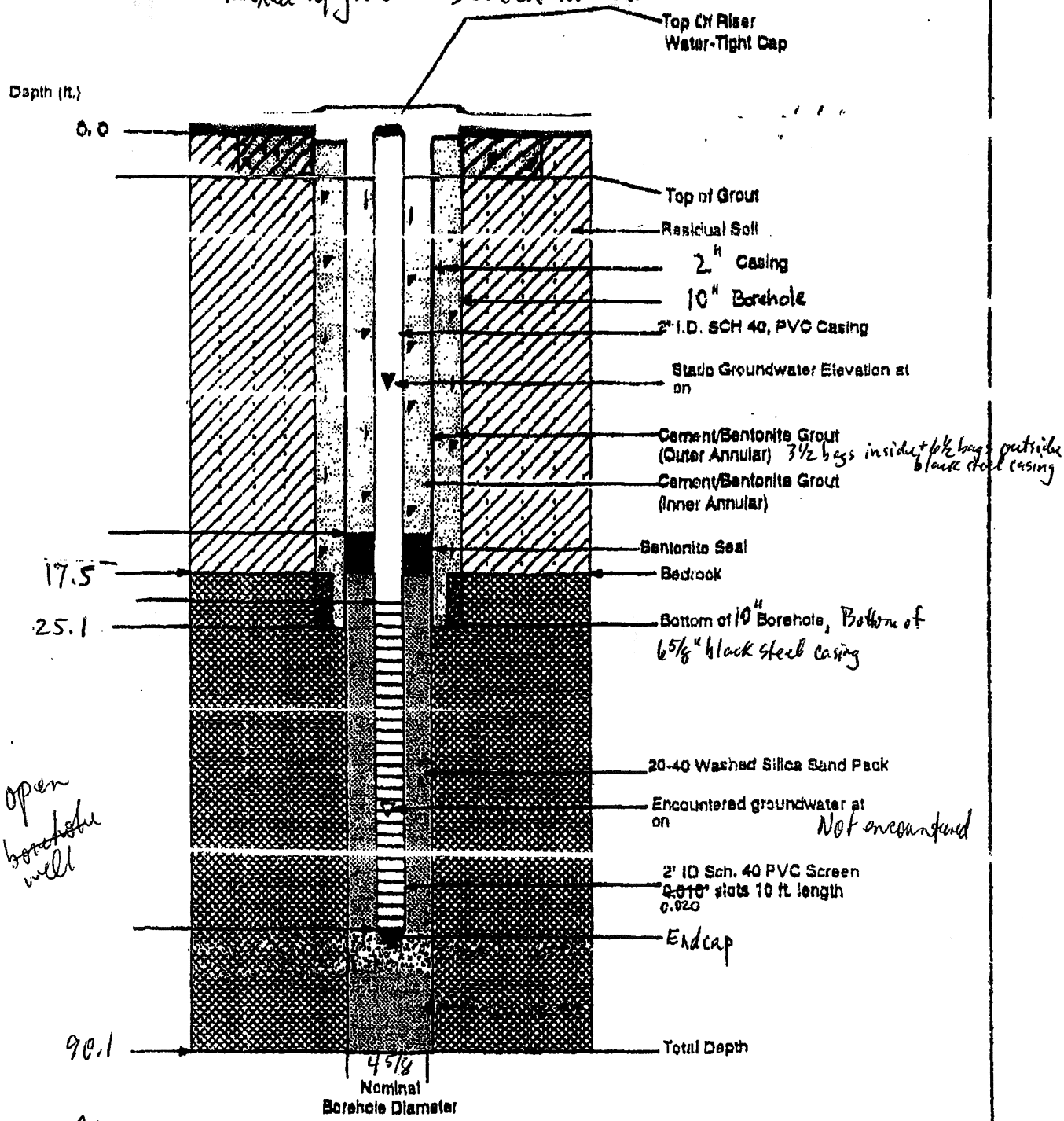
*Well Abandoned 4/3/04.
- Installed screen removed. Sand in borehole mixed w/ grout. Screen not installed. DKK

(Not To Scale)



Abandoned 4/3/04 used 10 bags @ 94 lbs grout

Notes:

Well No.: PB-BED-MW32
Date Installed: —
Elevation Top of Casing: Not Surveyed. Abandoned 4/3/04

Well Construction Diagram
prepared for:
PBOW
Sandusky, OH

HTRW DRILLING LOG

1. COMPANY NAME: Shaw E+I	DISTRICT: Nashville, TN	HOLE NUMBER: PB-BED-MW33
3. PROJECT: PBOW	2. DRILL SUBCONTRACTOR: Miller Drilling	SHEET 1 OF 10
5. NAME OF DRILLER: Tracy Thrasher	4. LOCATION: Perkin Co. Park, End of Boston Road	
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT: Soil Samples collected with 2.5" ID/ 3" OD stainless steel split-spoon. Borehole drilled w/ 6 5/8" roller cone bit. Borehole reamed/ bedrock cut w/ 10" OD air hammer bit. Installed 6" ID/ 6 5/8" OD black steel casing to ~~bedrock~~ 14.5 Ft. Cored bedrock with 4 5/8" PQ bit. Installed 2" monitoring well.	6. MANUFACTURER'S DESIGNATION OF DRILL: Ingersoll Rand T-3W Air Rotary Rig	
	8. HOLE LOCATION: See Sketch	
	9. SURFACE ELEVATION: 619.87 Ft — Northing (Y): 631,564.04 — Easting (X): 1,921,870.27	
	10. DATE STARTED: 3/30/04 — 11. DATE COMPLETED: 4/2/04	
12. OVERBURDEN THICKNESS: 15 Feet	15. DEPTH GROUNDWATER ENCOUNTERED: Overburden GW - 3.5 Ft / Bedrock 74'	
13. DEPTH DRILLED INTO ROCK: 74.5 Ft	16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED: 69.1' BGS @ 12 hrs	
14. TOTAL DEPTH OF HOLE: 89.5 Ft	17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)	

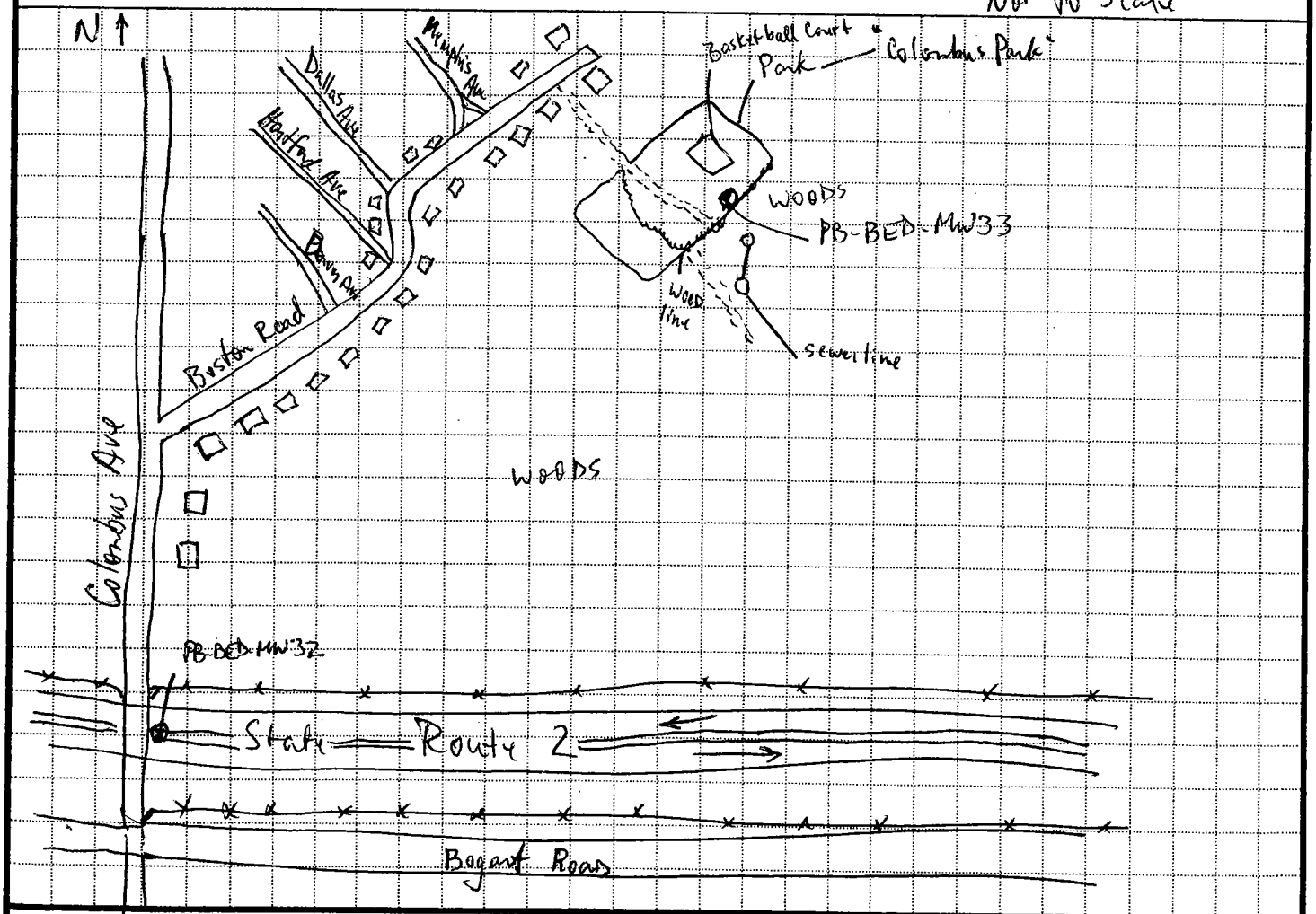
18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
	NA	NA	7 Boxes plus 2.5 Ft not in box

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY
	NA	NA	NA	NA	NA	100 %

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
	NA	Yes 2"	NA	David Keesh

LOCATION SKETCH/COMMENTS

SCALE: Not To Scale



PROJECT	HOLE NO.
PBOW	PB-BED-MW33

Shaw E & I, Inc.

HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW33

Project: PBOW | Geologist: D. Kessler | Sheet 2 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	Analytical Sample No.	Recovery (ft)	Remarks
	0	Grass						Post hole dug first 4 feet 3/30/04
		Fill: (Soft, 2.5Y (2.5/1) black, sandy, SILT, moist) 0.4	ml		NA	NA	NA	
	1	Fill: (GRAVEL) with silt and sand (former road bed for park) 1.5	gm	NM				
	2	Fill: (Loose, (10YR 6/8) brownish yellow, SAND, well sorted, 15-20% silt, dry)	sm					Breathing Air Not Measured. Steady sometimes heavy RAIN.
	3	Overburden groundwater at 3.5'						▽ Overburden GW 3.5' Began drilling
	4			4				
				NM	NA	S-1	2.0/	
	5	5.4					2.0	
		Very stiff, (10YR 4/1) dark gray, homogeneous, high plasticity, CLAY, trace granules - pebbles, wet	ch	6		1035		
	6			NM	NA	S-2	2.0	0.3' slough
	7						2.0	
	8			8		1045		
				NM	NA	S-3	2.0/	
	9	mottling (dark red) (5%), pebbles 2 to 5 mm, dry	ch				2.0	
	10			10		1053		

Project: PBOW | Hole Number: PB-BED-MW33

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HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW33

Project: PBOW | Geologist: D. Kessler | Sheet 3 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	Analytical Sample No.	Recovery (ft)	Remarks
	10	very stiff to hard, (10YR 4/1) dark gray, mottling (10%) (dark/light red "spots", black), high plasticity, CLAY, granules to pebbles increase with depth (15%), dry	CH	NM	NA	S-4 1100	2.0/ 2.0	gravels increase
	12		CH	NM	NA	S-5 1115	2.0/ 2.0	0.5' slough
	14	granules to pebbles 25%	CH	NM	NA	S-6 1125	1.0/ 1.5	(0.5' slough)
	15	Spoon Refusal @ 15 Ft LIMESTONE, dark gray, soft						15' 3/31/04 Installed 6 5/8" steel casing to DTW 19.5 Ft * During reaming/cutting bedrock w/ 10" air hammer, lost borehole (walls fell in), reamed ~13 Ft north. Did not resample new hole.
	19							Bottom of 6 5/8" casing 19.5'
	20							Began coring 4/2/04

Project: PBOW | Hole Number: PB-BED-MW33

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HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW33

Project: PBOW | Geologist: D. Kessler | Sheet 4 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	Analytical Sample No. Fracs	Recovery (ft)	Remarks
	20	Delaware, LIMESTONE, very strong, dark gray, microcrystalline, fossiliferous (brachs, corals) fresh, massive competent, slightly fractured, shale laminations (0.5-1mm), dry		NM	Box #1	20.3' (parting) 21.1'	7.8'/10'	Run #1 (19.5-29.5') Recovered = 78% DTW MW0 = 34.30' DTW MW0 = 34.30' 0 Difference Measured TD = 29.45'
	21							
	22							
	23					23' (parting)		
	24					24.8' (parting)		Distinct HC odor while coring
	25					25.6' (mech)		
	26				Box #1	26.2'		
	27				R1	27.3' (parting)		NM- Not Measured Constant Rain
	28				Box #1	28.6' (mech)		
	29				R2	28.9' (mech)		
	30				Box #2			29.5

Project: PBOW | Hole Number: PB-BED-MW33

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HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW33

Project: PBOW | Geologist: D. Kessler | Sheet 5 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	~~Analytical Sample No.~~ Fracs	Recovery (ft)	Remarks
	30					30.1 (parting)		
	31	Delaware, LIMESTONE, very strong, dark gray, microcrystalline, fossiliferous (brachs, corals) fresh, massive, competent, 0.5-1mm shale laminations dry.		NM		31.3 (mech)	12.2'/10'	Run # 2 (30.1-40.1') Recovery = 122%
	32							End: 1215 Start: 1144 31 min
	33					32.6' (mech)		
	34				Box #2			Measured TD = 39.45 DTW 1243 = 44.20' DTW 1350 = 44.20' 0 Recharge
	35							
	36					36' (parting)		
	37							HC on core 38-39.5'
	38					37.7' (parting)		
					38.5	38.5 (mech)		
	39				Box #3	39.5'		39.5
	40							

Project: PBOW | Hole Number: PB-BED-MW33

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HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW33

Project: PBOW | Geologist: D. Kessler | Sheet 6 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	~~Analytical~~ Sample No. Frac's	Recovery (ft)	Remarks
	40	Delaware, LIMESTONE. very strong, dark gray, microcrystalline, fossils (bracks, corals), fresh, massive, competent, unfractured, shale laminations, dry		12.8	Box #3		92%	RUN #3 (39.5 - 49.5') 9.2/10.= 92% End: 1445 start: 1414 31 min
	41							
	42							
	43							Breathing Air PID = 0.2 ppm LEL = 0.0 % CO_2 = 0 ppm O_2 = 20.3 % H_2S = 0 ppm
				13.9		43.4' (much)		
	44							
	45							
	46			12.3				
	47							
	48				48.4	48.4' (much)		
				8.4	Box #4			
	49							49.5'
	50							

Project: PBOW | Hole Number: PB-BED-MW33

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HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW33

Project: PBOW | Geologist: D. Kessler | Sheet 7 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	Analytical Sample No. Fracs	Recovery (ft)	Remarks
	50	Delaware, LIMESTONE,						Run #4 (49.5-59.5')
	51	very strong, dark gray,		0.7	Box #4		8/10	Recovery 80%
	52	microcrystalline, fossils (brachs, corals)						
		fresh, massive,						Measured TD = 59.4'
	53	competent, slightly				53.3' (mech)		DTW 1600 = 64.10'
		fractured, shale laminations						DTW 1630 = 63.95'
	54	dry		1.3				0.15' recharge
	55			1.2		55.3' (soft rock)		
	56							
					56.7' R5	56.7' (parting)		
	57				Box #4			Solid 5.5' core (56.7-62.2')
	58				58.1 R5	58.1 (mech)		
	59				Box #5			
						59.6' (mech)		59.5
	60							

Project: PBOW | Hole Number: PB-BED-MW33

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HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW33

Project: PBOW | Geologist: D. Kessler | Sheet 8 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	~~Analytical Sample No.~~ Fracs	Recovery (ft)	Remarks
	60	Delaware, LM.						Run #5 (59.5-69.5')
	61	Very strong, dark gray, microcrystalline,		NM				
	62	fossils (brachs/corals), fresh, massive,				62.2' Frac above soft rock	12.5'	Recovered 125%
					Box #5		10'	
	63	competent, unfractured, shale laminations, dry				62.7' (mech) 63.2' (mech.)		Measured TD = 69.2'
	64							DTW 1730 = 74.10 DTW 1750 = 73.95 0.15' recharge
	65					64.5' (mech)		Solid core (62.2-67.6')
	66							63-68.1' very fossiliferous. Ends on irregular wavy shale lamination
	67				67.6	67.6' (parting)		lt colored lm, fossils, shale, dark colored lm, unconformity?
	68				Box #6	68.65' (parting)		
	69					69.2'		69.5
	70							70

Project: PBOW | Hole Number: PB-BED-MW33

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HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW33

Project: PBOW | Geologist: D. Kessler | Sheet 9 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	~~Analytical Sample No.~~ Fracs	Recovery (ft)	Remarks
	70	Delaware, LM, very strong, dark gray, microcrystalline, fossils (brachs/corals), fresh, massive, competent, slightly fractured, shale laminations, dry		NM	Box # 6	70 (shale parting)	10.2/10	Run # 6 (69.5-79.5')
	71					71.6' (parting)		End: 1823
	72							start: 1813
						72.5' (parting)		10 min (drilled w/ shale bit)
	73							Measured TD = 84.4'
								DTW = 1835 84.0
	74					74' parting 74.1'		DTW = 83.8'
								0.2' recharge
	75							Broken lm edges slightly rounded — water?
	76					76.4' — water?		
	77				77.4'	77.4' — water?		
	78				Box #7			
						78.6' (parting)		
	79							
						79.4' (parting)		79.5
	80							

Project: PBOW | Hole Number: PB-BED-MW33

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HTRW DRILLING LOG (continuation sheet)

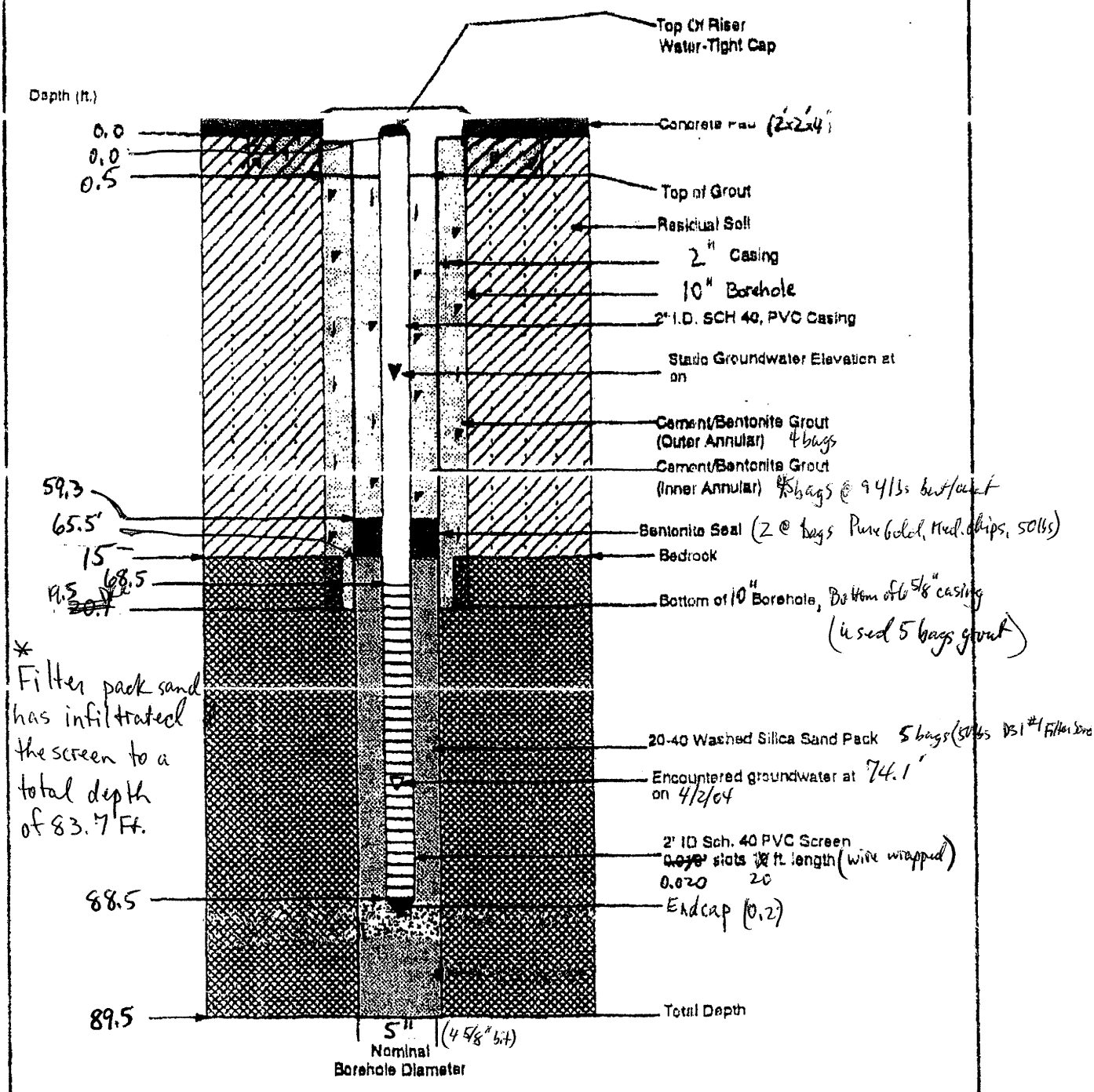
Hole Number: PB-BED-MW33

Project: PBow | Geologist: D. Kessler | Sheet 10 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	~~Analytical Sample No.~~ Faces	Recovery (ft)	Remarks
	80	Delaware, LM, very strong, dark gray, microcrystalline, fossils (brachs / corals) fresh, massive, slightly fractured, shale laminations, dry		0.3	Box #7	81.3' (parting) 81.9' (mech) 82.3 (mech)	10/10	Run #7 (79.5 - 89.5) End 1909 Start 1900 -9min 4/2/04 1910 DTW = 94.1 DTW = 74.1 } 20' 4/3/04 0715
	84	stylolites at 88.5'						Measured TD = 94.5 - 5' stickup = 89.5'
	85					85.3' (mech)		
	86			7.4				Hydrocarbon staining on core 85.3 - 89'
	87					87' (mech)		
	88			3.2	Core Not in Box 87 - 89.5'			
	89					88.8' (mech)		
	90	Total Depth = 89.5 ft						

Project PBow | Hole Number: PB-BED-MW33

(Not To Scale)



Notes:

Well No.: PB-BED-MW33
Date Installed: 4/3/04
Elevation Top of Casing: 619.74 Ft

Well Construction Diagram
prepared for:
PBOW
Sandusky, OH

BWMWA230WC.DRW/II/5-28-03

Well Abandoned 4/3/04

HTRW DRILLING LOG

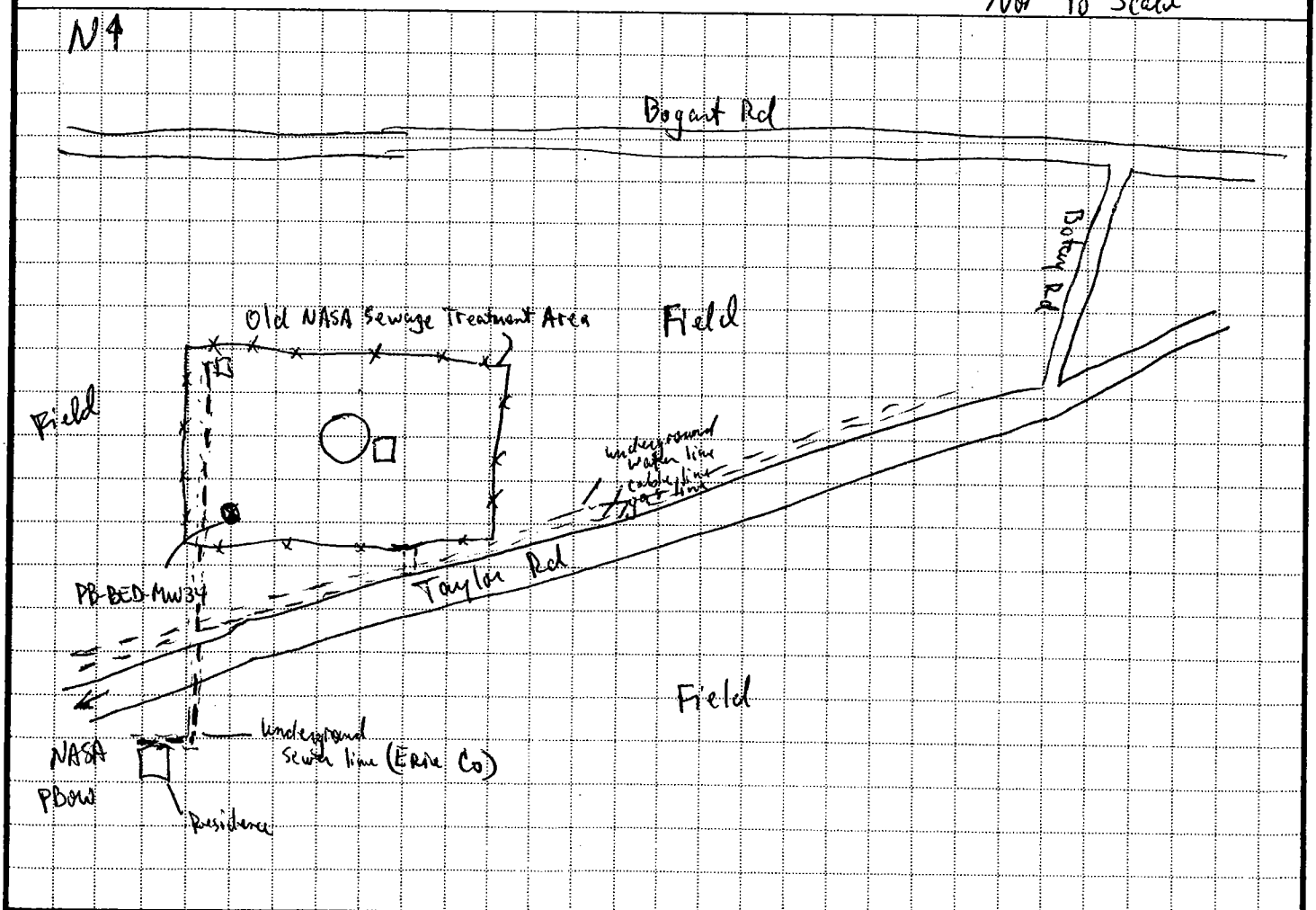
1. COMPANY NAME: Shaw E+I	DISTRICT: Nashville, TN	HOLE NUMBER: PB-BED-MW34
2. DRILL SUBCONTRACTOR: Miller Drilling		SHEET: 1 OF 10 SHEETS
3. PROJECT: PBOW	4. LOCATION: Outside NASA security fence/NASAs Former Sewage Treatment Area	
5. NAME OF DRILLER: Tracy Thrasher	6. MANUFACTURER'S DESIGNATION OF DRILL: Ingersoll Rand T-3W Air Rotary Rig	
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT: Soil Samples collected with 2.5" ID/3" OD stainless steel split spoons.	8. HOLE LOCATION: See Sketch	
Borehole drilled with 6 5/8" roller cone bit. Borehole reamed and bedrock cut with 10" OD air hammer bit. Installed 6" ID/ 6 5/8" OD black steel casing to 41.5 Ft. Coring of bedrock done w/4 5/8" OD PQ bit. Borehole reamed w/ 6" roller cone.	9. SURFACE ELEVATION: 621.00 Ft; Northing(y): 628,322.03; Easting(x): 1,924,720.88	
	10. DATE STARTED: 3-17-04	11. DATE COMPLETED: 3/22/04
12. OVERBURDEN THICKNESS: 19 Ft	15. DEPTH GROUNDWATER ENCOUNTERED: 10.5 Ft overburden/Bedrock gw unknown	
13. DEPTH DRILLED INTO ROCK: 71.1 Ft	16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED: 0.63' water column 3/23/04 0700	
14. TOTAL DEPTH OF HOLE: 90.1 Ft	17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY): —	

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
	NA	NA	6

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY x 100 %
	NA	NA	NA	NA	NA	

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
	NA	yes (open hole)	NA	David Keasler

LOCATION SKETCH/COMMENTS — SCALE: Not To Scale



PROJECT: PBOW	HOLE NO.: PB-BED-MW34

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HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW34

Project: PBOW | Geologist: D. Kessler | Sheet 2 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	Analytical Sample No.	Recovery (ft)	Remarks
		Grass						Post hole dug first 4 Ft
	1	Fill: (Soft, (10YR 4/6) dark yellowish brown, mottled (gray), medium plasticity, clayey SILT, moist)	ml	0.0	NA	NA	NA	Breathing Air: 0.0 ppm - PID; 0% = LEL; 0 ppm = CO; 21.2% = O_2; 0 ppm = H_2S
	2							
	3							
	4	Fill: (Medium Stiff, (10YR 4/1) dark gray, mottled (orange/dark red) 30%, clayey SILT, organics (roots), 10% clay	ml	0.0	NA	push 0845	2.0/ 2.0	
	5							
	6	Fill: Stiff, mottling increases to 30%,	ml	0.0	NA	push 0851	2.0/ 2.0	
	7							
	8							
	9	As above		0.0	NA	push 0856	2.0/ 2.0	
	10							

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HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW34

Project: PBow | Geologist: D. Kessler | Sheet 3 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	Analytical Sample No.	Recovery (ft)	Remarks
	10	As above			NA	Push	1.2/ 2.0	V Encountered inundation @ 10.5 Ft
	11	Stiff, (10YR 4/1) dark gray, high plasticity, CLAY, well rounded pebbles (2%), very moist (granules to pebbles)	ch	0.0		0912		
	12	Very Stiff, as above, rock pebbles (1mm) increasing (5%) granules to pebble size, dry	ch	0.0	NA	Push 0920	2.0/ 2.0	
	13							
	14	As above, gravels increasing (10%) no bedding, dry	ch	0.0	NA	Push 0924	2.0/ 2.0	
	15							
	16				NA		1.1/ 2.0	
	17	As above, Shale 17.5-17.6 Ft,	ch	0.0		0935		
	18	As above, dry		0.0	NA	0942	1.0/ 2.0	
	19	Refusal @ 19 Ft weathered Shale		NA	NA	NA	NA	
	20	20.0						

Project: PBow | Hole Number: PB-BED-MW34

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HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW34

Project: PBOW | Geologist: D. Kessler | Sheet 4 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	Analytical Sample No.	Recovery (ft)	Remarks
	20	~~LIMESTONE~~ DKK ~~SHALE~~ DKK weathered LIMESTONE, dark gray, dry		NA	NA	NA	NA	Cutting w/ 10" OD Air hammer.
	21							Distinct petroleum odor (1k ppm) in dust.
	22							weathered limestone determination based on soft, almost clay cuttings, drilling rate, lack of hammer chatter
	23							
	24							
	25							
	26	Weathered LM, dark gray						Limestone is not competent.
	27							
	28							
	29							
	30							

Project PBOW | Hole Number: PB-BED-MW34

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HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW34

Project: PBOW | Geologist: D. Kessler | Sheet 5 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	Analytical Sample No.	Recovery (ft)	Remarks
	30	Weathered LIMESTONE, dark gray, dry		NA	NA	NA	NA	Weathered limestone determination based on soft, clay like cuttings, lack of hammer chatter, cutting rate
	31							
	32							
	33							
	34							
	35							
		35.5 ft bgs						
		LIMESTONE, competent, dry dark to light gray						
	36							
	37							
	38							
	39							
	40							

Project PBOW | Hole Number: PB-BED-MW34

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HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW34

Project: PBOW | Geologist: D. Kessler | Sheet 6 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	Analytical Sample No.	Recovery (ft)	Remarks
	40	Limestone, gray, competent		NA	NA	NA	NA	10" Borehole drilled to 41.5 Ft. 6 5/8" OD Black steel casing installed to 41.5 Ft
	41			41.5				41.5
	42	Delaware Fm, LIMESTONE, very strong, gray, microcrystalline, massive bedding, fresh weathering, competent, unfractured,		53.7	Box #1	Fracs		Began coring 3/21/04 41.5'-46' Run #1 cored 4.5', Recovered 4Ft Background 89% PID = 0.0ppm LEL = Pump Malfunction O_2 = 20.8% H_2S = 0ppm End: 1515 Began: 1442 33 min
	43	fossiliferous (bracks), wavy shale partings, dry		23.8	Run 1	42.5 (mech)		
	44	Distinct HC on core (brown staining on core)						
	45			32.1		45.5' (shale parting) (mech)		Distinct HC odor during coring near borehole (32.7 ppm) DKK 11:55
	46			15.5	Box #1	46' (mech)		46 Run #2
	47				Run #2	47' (mech)		46-51' cored: 5 Ft Recovered = 5.5 Ft Recovery 110% (Recovery 0.5 from Run 1)
		stylolites				47.6' (mech)		
	48	Fracture 48.35' (10 mm shale filled) broken, dry		17.1				DTW 1625 = 55.03' DTW 1555 = 55.09' 0.6'
	49					49.5' (mech)		
	50							

Project: PBOW | Hole Number: PB-BED-MW34

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HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW34

Project: PBOW | Geologist: D. Kosske | Sheet 7 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	Analytical Sample ~~No.~~ Fracs	Recovery (ft)	Remarks
	50				Run #2 Box 1			Run #2
	51	Delaware Fm, LIMESTONE, very strong, gray, microcrystalline, fresh, fossiliferous (brachs, corals, stylolites), competent, wavy shale partings (black) distinct HC on core (brown staining)			Run #3 Box #2	51.1'		Run #3 51'-61.1' Cored 10.1 Ft Recovered 10.1 Ft 100% recovery End: 1735
	52							
	53					52.7' shale parting (mech)		
	54							3/21/04 1810 Depth to water = 64.8' 3/22/04 0700 = 59.25' 5.6' Recharge
		circular, white corals? 53-53.6'				54.6' (mech)		
	55	hydrocarbon staining in center of several (5mm-30mm in size)				55.2' (mech)		core commonly breaks at shale partings.
	56					55.9' (mech) 56.25'	shale parting	
	57					57.2'	shale parting	
	58					68.2'	shale parting	
	59					59.4'		
	60							

Project: PBOW | Hole Number: PB-BED-MW34

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HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW34

Project: PBOW | Geologist: D. Kessler | Sheet 8 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	~~Analytical Sample No.~~ FRACS	Recovery (ft)	Remarks
	60				Box #2	60.5' (mech)		Run #3
	61	Delaware Fm, LIMESTONE, very strong, dark gray, microcrystalline, fresh, fossiliferous (corals, brachs) competent, wavy shale partings (black), distinct HC on core (dark brown)			Box #3			66.1' Began coring 3/22/04
				15.3		62.2' (mech)		Run #4 61.1 – 71.1' Recovered 10 Ft 100% End: 0947 Began: 0907 40 min
	63			14.8		63.4' (mech)		
	64					64.4' (mech)		1030 DTW = 69.73? 1005 DTW = 79.4'
	65					65.3' (mech)		solid 10 Ft run No Fracs
				16.5				Black substance on tape (water) preventing depth to water to be measured accurately, Can hear gas "burping" in borehole
	66					66.1' (mech)		
	67							Hydrocarbon staining on core (entire length)
	68			17.4				
	69							
	70			8.9		70' (mech)		

Project: PBOW | Hole Number: PB-BED-MW34

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HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW34

Project: PBGW | Geologist: D. Kessler | Sheet 9 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	~~Analytical Sample~~ No.	Recovery (ft)	Remarks
	70	Delaware, Limestone,			Box 4 #4	70' (mech)		very dark staining (HC)
	71	very strong, dark gray,			71.1			strong odor on gas (sulfides?) when coring initially begins. 71.1'
	72	microcrystalline, ~~fossiliferous~~ DFK, competent, wavy shale partings, distinct brown/very dark brown hydrocarbon staining on core					6.2/9.0	Run 5 71.1'-80.1' 9.0 Ft Run 91% 6.2 Ft Recovery 0.8 Ft lost
	73					73'		End: 1148 Began: 1111 37 min
	74					74.2' possible water 74.4 (mech)		Measured TD = 80.1' (84.62 - 4.6 stick-up) 1200 DTW 83.0' 1315 DTW = 80.7 2.3 Ft
	75			1.2				Heavily stained (HC)
	76					76.1' (water making)		70-73 Ft
	77					76.7 water?		Breathing Air: PID = 0.0 ppm LEL: 0% O_2 = 20.8% H_2S = 0.0 ppm
	78			0.7		~~sand~~ DFK 78.5' water?		
	79							
	80			1.2		~~sand~~ DFK		

Project: PBGW | Hole Number: PB-BED-MW34

Shaw E & I, Inc.

HTRW DRILLING LOG (continuation sheet)

Hole Number: PB-BED-MW34

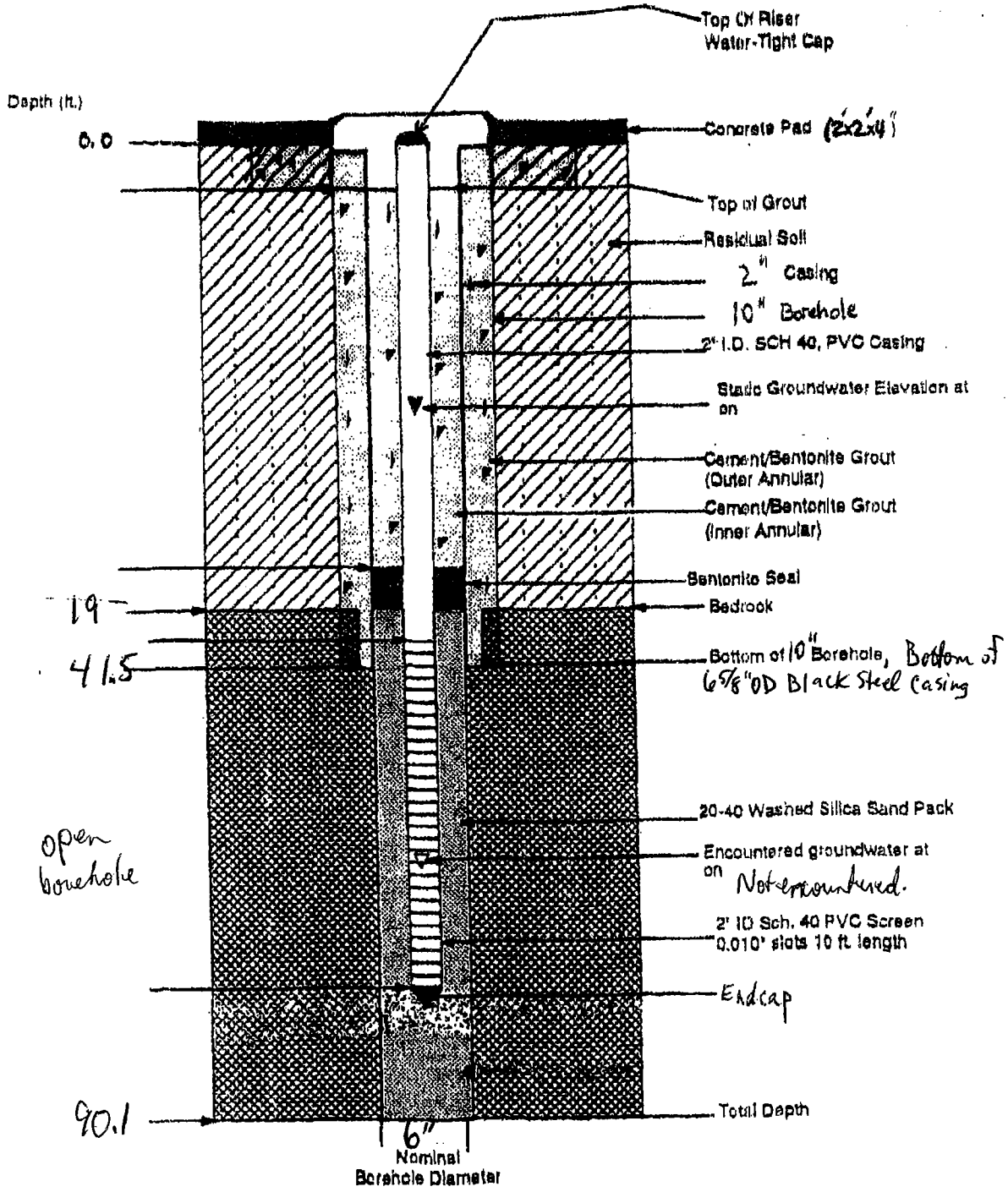
Project: PBOW | Geologist: D. Kessler | Sheet 10 of 10 Sheets

Elev (ft)	Depth (ft) bgs	Description of Materials	USCS	Field Screening Results (ppm)	Geotech. Sample or Core Box No.	~~Analytical Sample No.~~ Fracs	Recovery (ft)	Remarks
	80							80.1
	81	Delaware Fm, LIMESTONE, very strong, gray, microcrystalline, competent, fossiliferous (bracks), wavy shale partings, hydrocarbon staining on core (heavy) ~~80.1-80.5'~~ DCK 79.4-80.1 (Run 5)		0.7	Box # 5	80.4' (shale parting)		Run #6 80.1-90.1' RAN 10 Ft End: 1440 Start: 1335 55 min Recovered 11 Ft (Recovered Footage from Run #5)
	82					86.3'		
	83			0.6				
						83.6' (mech)		Measured Borehole: 94.76' Sticking 4.6' TD: 90.16'?
	84							
						84.6' (mech)		
	85			0.6				
	86					86.3' (rounded edges shale fragments in frac) water?		
	87	Round (oblong), soft rock in limestone, dark gray, marl? gypsum?						
	88					87.9' (mech)		
						88.5' (rounded edges) water? (shale frags)		
	89					89' (shale parting)		
				0.5	Box # 6	89.7 (mech)		
	90	Total Depth = 90.1'						

Project: PBOW | 90.1 | Hole Number: PB-BED-MW34

PVC well not installed
but borehole reamed.

(Not To Scale)



Abandoned well 4/3/04, 0.59' water column after 12 days.

Notes:

Well No.: PB-BED-MW34
Date Installed: 3-22-04
Elevation Top of Casing: Not Surveyed (well abandoned)

Well Construction Diagram
prepared for:
PBOW
Sandusky, OH

BWMWA830WC.DRW/II/5-26-93

APPENDIX C

PHOTOGRAPHS

ROCK CORES

Note:

Name of photograph provides identification of rock core.
Example: 28bx1___R1___T

28 – Name of boring (PB-BED-MW28).
bx1 – Box 1.
R1 – Run 1.
T – Top portion of core or
B – Bottom portion of core or
E – Entire core.

28bx1_R1_E

28bx1_R1_T

28bx2_R2_E

28bx2_R2_T

28bx3_R3_E

28bx4_R4_E

28bx4_R4_M

29bx1_R1_E

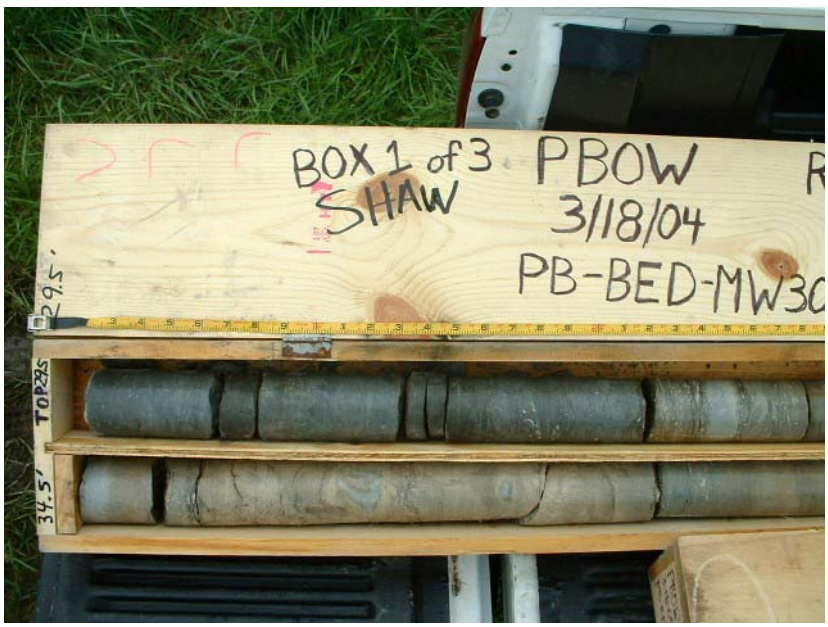
29bx1_R1_M

29bx2_R2_E

29bx2_R2_T

29bx2_R2_B

30bx1_R1_E



30bx1_R1_T

30bx1_R1_M

30bx1_R1_B

30bx2_R2_E

30bx2_R2_T

30bx2_R2_B

30bx3_R2_T

30bx3_R3_E

30bx3_R3_B

31bx1_R1_E

31bx1_R1_T

31bx1_R1_B

31bx2_R2_E

31bx2_R2_T

31bx2_R2_B

31bx3_R3_E

31bx3_R3_T

31bx4_R4_E

31bx4_R4_T

31bx4_R4_M

31bx4_R4_B

31bx5_R5_E

31bx5_R5_T

31bx5_R5_M

31bx5_R5_B

31bx6_R6_E

31bx6_R6_T

31bx6_R6_B

31bx7_R7_E

31bx7_R7_T

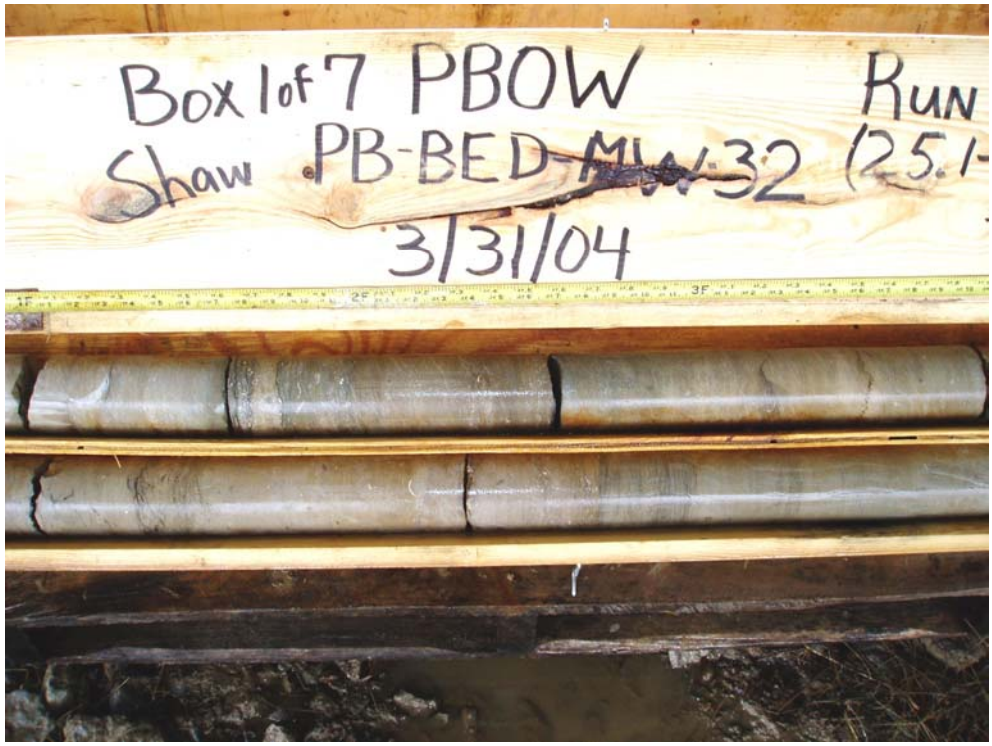
31bx7_R7_B

31bx7_R7_B_Hydrocarbon

31bx8_R7_B

32bx1_R1_E

32bx1_R1_T



32bx1_R1_M

32bx1_R1_B

32bx2_R1+2_E

32bx2_R1+2_T

32bx2_R1+2_B

32bx3_R2+3_E

32bx3_R2+3_T

32bx3_R2+3_B

32bx4_R3+4_E

32bx4_R3+4_T

32bx4_R3+4_B

32bx5_R4+5+6_E

32bx5_R4+5+6_T

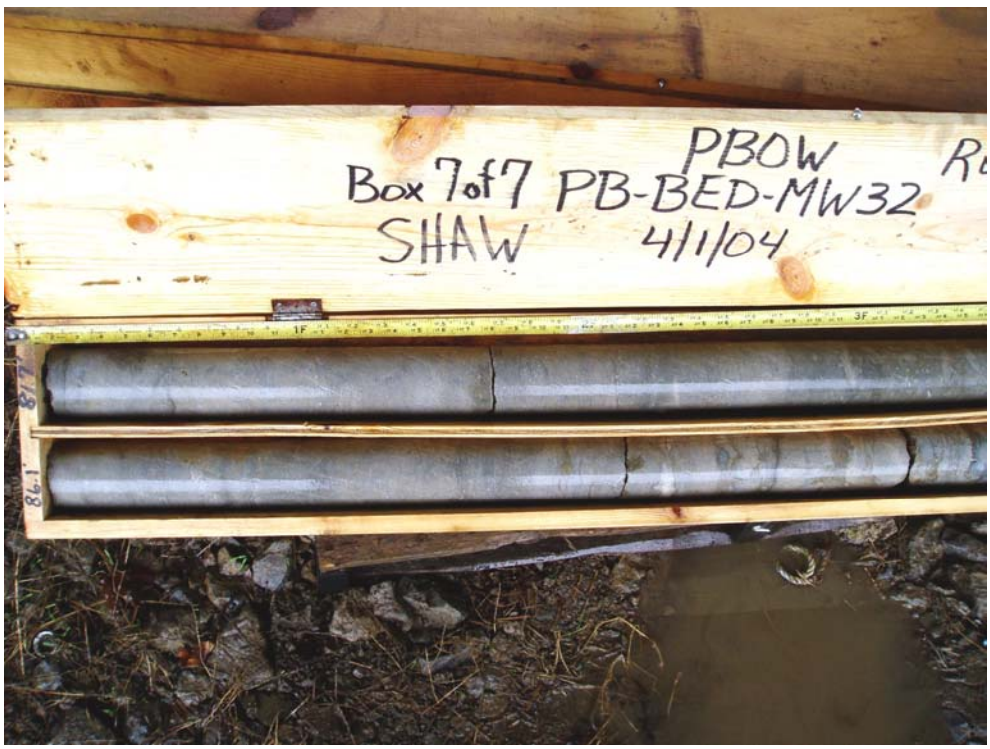
32bx5_R4+5+6_M

32bx6_R6+7_E

32bx6_R6+7_T

32bx6_R6+7_B

32bx7_R7_E



32bx7_R7_T

32bx7_R7_B

33bx1_R1+2_E

33bx1_R1+2_T

33bx1_R1+2_B

33bx2_R2_E

33bx2_R2_T

33bx2_R2_B

33bx3_R2+3_E

33bx3_R2+3_T

33bx3_R2+3_B

33bx4_R3+4+5_E

33bx4_R3+4+5_T

33bx4_R3+4+5_B

33bx5_R5_E

33bx5_R5_T

33bx5_R5_B

33bx6_R5+6_E

33bx6_R5+6_T

33bx6_R5+6_B

33bx7_R6+7_E

33bx7_R6+7_T

33bx7_R6+7_B

34bx1_R1+2_E

34bx1_R1+2_T

34bx1_R1+2_B

34bx2_R3_E

34bx2_R3_T

34bx2_R3_B

34bx3_R3+4_E

34bx3_R3+4_T

34bx3_R3+4_B

34bx4_R4+5_E

34bx4_R4+5_T

34bx4_R4+5_B

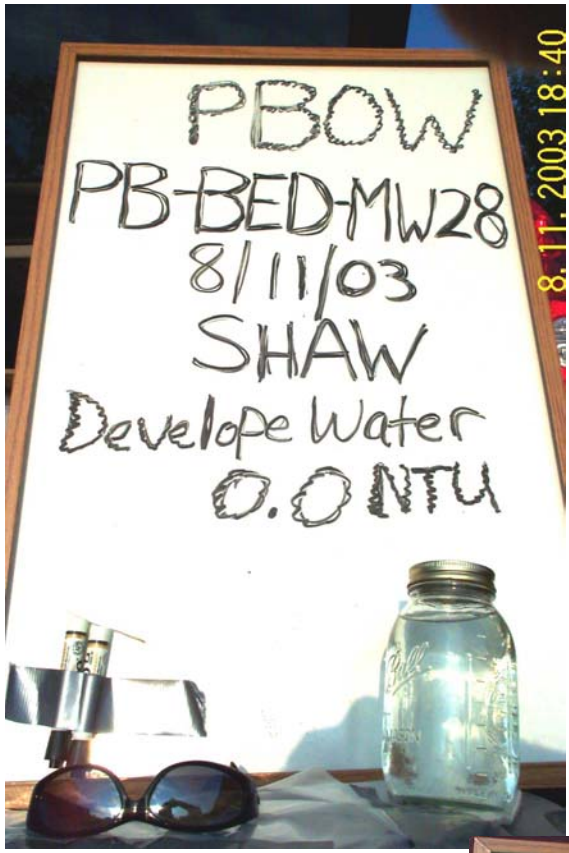
34bx5_R6_E

34bx5_R6_T

34bx5_R6_B

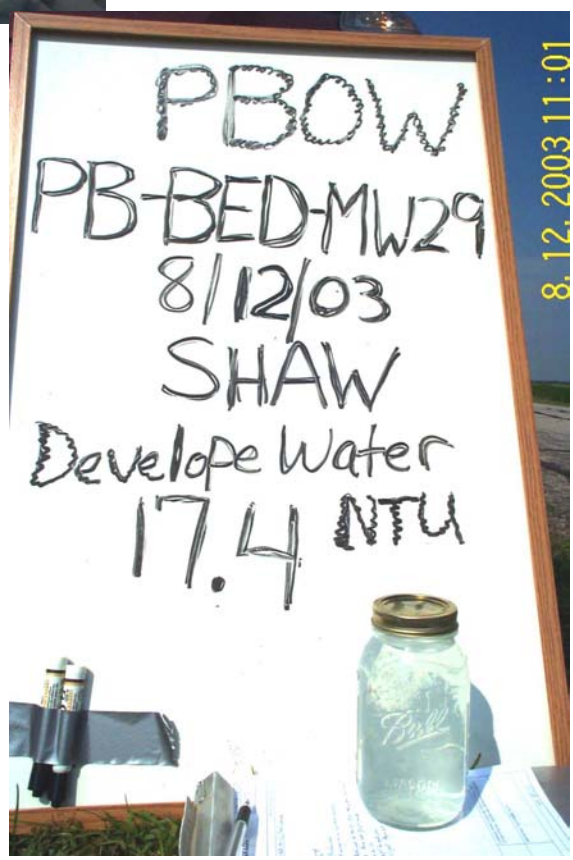
34bx6_R6_B

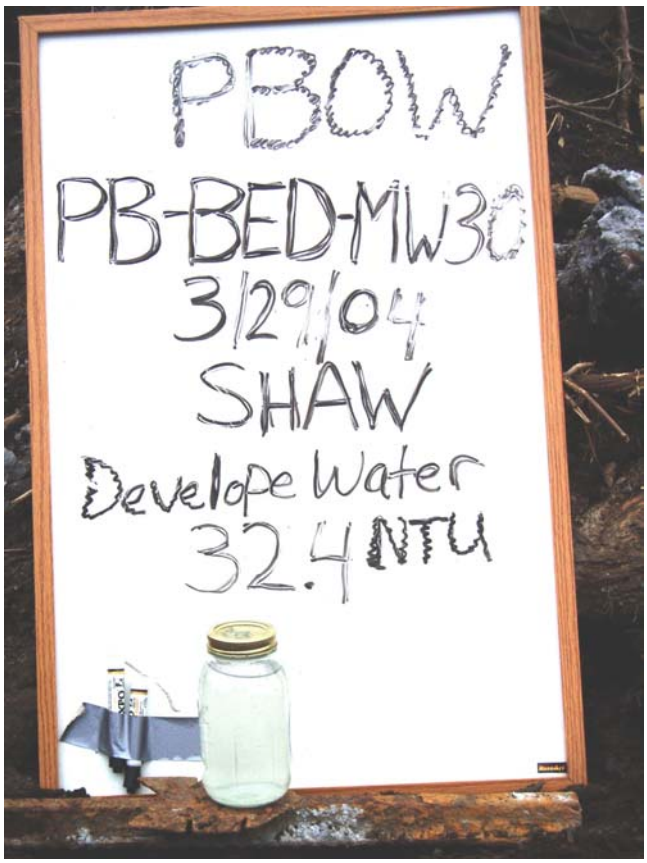
FINAL DEVELOPMENT GROUNDWATER



BED-MW28

BED-MW29





BED-MW30

No Picture taken of BED-MW33 final development water. Monitoring well went dry. Final turbidity reading 280.0 NTU.

APPENDIX D

WELL DEVELOPMENT LOGS

PB-BED-MW28

IT CORPORATION
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Well Development Log

Page 1 of 2

Project Number: 843656
Project Name: PBOW
Form Completed by: D. Kessler
Well Developed by/firm: Miller Drilling

Site ID: Background Well
Location ID: PB-BED-MW28
Date Started: 8/11/03

Monitoring Well Information

Development Method: Pumping/Surging
Development Equipment: 2" Grundfos Pump / Surged well w/ Pump

Screen Height (ft): 15'
Filter pack lenght (ft): 18.25'
Casing Diameter (in): 2"

Begining Measurements (BTOC)
Depth to Water (ft): 7.65'
Total depth of Well (ft): 41.70

Well = 0.0 ppm

Monitoring Well Purge Calculations

Volume of Water in Casing:

Gallons/foot = 0.041 x d^2, where casing diameter in inches = (0.041 x (2)^2) = 0.164 gal/ft.

Well Volume (gallons) = Water Column (ft) x Gal/ft = 34.05 ft x 0.164 gal/ft = 5.58 gallons

7.65'

Volume of Water in Filter Pack:

Gallons/foot = 0.041 x (D^2 - d^2), where D is total borehole diameter in inches & d is casing diameter in inches = 0.041 x ((6)^2 - (2)^2) = 1.31 gal/ft.

Filter Pack Volume (gal) = (the less of the filter pack lenght or water column) x gal/ft x porosity (0.3) = (18.25)ft x (1.31) gal/ft x 0.3 = 7.17 gal

water column = filterpack = 18.25'

Purge Well Volume:

Purge well Volume = Filter pack volume + Well Volume = 7.17 gal + 5.58 gal = 12.75 gal.

1 x Purge Well Volume	2 x Purge Well Volume	3 x Purge Well Volume	4 x Purge Well Volume	5 x Purge Well Volume
12.75	25.5	38.25	51	63.75

Development Record

Time (24 hrs)	Volume Removed (gal)	Water Level (ft) (TOC)	Turbidity (NTU)	Clarity (color)	Temp. (C)	pH (Std Units)	Conductivity (mS/cm)	D.O. (mg/L)	Redox (mV)	Comments
1500	0	7.65	65.4	milky	12.25	8.29	1.397	4.99	195.6	
1510	60	24.52	65.6	"	13.97	8.36	1.376	3.67	175.6	Hose lose, stopped
1520	12	24.58	9.5	clear	13.24	8.04	1.332	2.45	146.6	~1 gpm 125 Hz
1530	18	24.20	4.2	clear	13.24	8.05	1.336	1.95	109.5	125 Hz
1540	20	24.30	3.5	clear	13.24	8.05	1.333	1.80	90.0	140 Hz
1550	30	28.57	44.6	light br	12.76	7.98	1.315	1.79	53.7	140 Hz
1600	~~39~~ 35	36.0	63.1	light br	15.24	7.80	1.293	5.22	55.4	125 Hz
1610	39	29.40	2.7	clear	13.37	8.04	1.326	5.46	52.0	136 Hz
1620	41	29.15	-0.2	clear	13.19	8.05	1.338	3.97	51.3	136 Hz

~1 gpm

Increase speed to 140 Hz surged

Increased to 160 R

Breathing Air = 0.0 ppm PID
LEL = LEL = 0% O_2 = 20.9%
CO = 0 ppm H_2S = Down

PB-BED-MW28 (continued)

(See page 1)

IT CORPORATION

Well Development Log

Page 2 of 2

Project Number: _____
Project Name: _____
Form Completed by: _____
Well Developed by/firm: _____

Site ID: _____
Location ID: _____
Date Started: _____

Monitoring Well Information

Development Method: _____
Development Equipment: _____
_____
_____

Screen Height (ft): _____
Filter pack lenght (ft): _____
Casing Diameter (in): _____

Begining Measurements (BTOC)
Depth to Water (ft): _____
Total depth of Well (ft): _____

Monitoring Well Purge Calculations

Volume of Water in Casing:
Gallons/foot = 0.041 x d^2, where casing diameter in inches = (0.041 x (_____)^2) = _____ gal/ft.
Well Volume (gallons) = Water Column (ft) x Gal/ft = _____ ft x _____ gal/ft = _____ gallons

Volume of Water in Filter Pack:
Gallons/foot = 0.041 x (D^2 - d^2), where D is total borehole diameter in inches & d is casing diameter in inches = 0.041 x ((_____)^2-(_____)^2) = _____ gal/ft.
Filter Pack Volume (gal) = (the less of the filter pack lenght or water column) x gal/ft x porosity (0.3) = (_____)ft x (_____) gal/ft x 0.3 = _____ gal

Purge Well Volume: Purge well Volume = Filter pack volume + Well Volume = _____ gal + _____ gal = _____ gal.

See Page 1

1 x Purge Well Volume	2 x Purge Well Volume	3 x Purge Well Volume	4 x Purge Well Volume	5 x Purge Well Volume

Development Record

Time (24 hrs)	Volume Removed (gal)	Water Level (ft) (TOC)	Turbidity (NTU)	Clarity (color)	Temp. (C)	pH (Std Units)	Conductivity (mS/cm)	D.O. (mg/L)	Redox (mV)	Comments
1630	45	29.00	-0.3	clear	13.17	8.04	1.340	3.32	46.9	136.3 Hz
1640	~~DRY~~ 50	29.07	-0.9	clear	13.17	8.04	1.341	2.91	42.0	"
1650	55	29.05	-0.8	clear	13.19	8.04	1.343	2.72	38.1	"
1655	58	29	-1.0	clear	13.19	8.03	1.342	2.70	36.7	"
										Ended Development

15 45
55 25
: 1

IT CORPORATION
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Well Development Log

Page 1 of 1

Project Number: 843656
Project Name: PBOW
Form Completed by: D. Kessler
Well Developed by/firm: Miller Drilling

Site ID: PBOW
Location ID: PB-BED-MW29
Date Started: 8/12/03

Monitoring Well Information

Development Method: Pumping
Development Equipment: 2" Grundfos Pump | Surging w/ Pump

Screen Height (ft): 10
Filter pack lenght (ft): 12.9
Casing Diameter (in): 2

Begining Measurements (BTOC)
Depth to Water (ft): 3.34
Total depth of Well (ft): 38.02
Water column: 34.68

Monitoring Well Purge Calculations

Volume of Water in Casing:
Gallons/foot = 0.041 x d^2, where casing diameter in inches = (0.041 x (2)^2) = 0.164 gal/ft.
Well Volume (gallons) = Water Column (ft) x Gal/ft = 34.68 ft x 0.164 gal/ft = 5.69 gallons

Volume of Water in Filter Pack:
Gallons/foot = 0.041 x (D^2 - d^2), where D is total borehole diameter in inches & d is casing diameter in inches = 0.041 x ((6)^2 - (2)^2) = 1.31 gal/ft.
Filter Pack Volume (gal) = (the less of the filter pack lenght or water column) x gal/ft x porosity (0.3) = (12.9)ft x (1.31) gal/ft x 0.3 = 5.07 gal

Purge Well Volume: Purge well Volume = Filter pack volume + Well Volume = 5.07 gal + 5.69 gal = 10.76 gal.

1 x Purge Well Volume	2 x Purge Well Volume	3 x Purge Well Volume	4 x Purge Well Volume	5 x Purge Well Volume
10.76	21.52	32.28	43.04	53.80

Filter pack length = 12.9

Development Record

Time (24 hrs)	Volume Removed (gal)	Water Level (ft) (TOC)	Turbidity (NTU)	Clarity (color)	Temp. (C)	pH (Std Units)	Conductivity (mS/cm)	D.O. (mg/L)	Redox (mV)	Comments
0915	0	3.34	544.3	Dark Br	12.25	5.88	13.63	0.78	205.7	125 Hz
0925	10	9.45	55.2	clear	12.49	6.56	11.59	0.22	58.1	" surged well
0935	25	10.20	534.1	Light brown	12.61	6.59	11.65	0.12	37.4	"
0945	35	11.98	45.3	clear	12.37	6.63	10.99	0.12	29.4	"
0955	45	12.94	10.1	clear	12.39	6.64	11.03	0.12	26.2	" surged well
1005	65	14.85	14.0	clear	12.29	6.66	10.62	0.13	23.0	150 Hz
1015	80	16.58	19.5	clear	12.33	6.67	10.73	0.13	23.4	"
1025	95	17.53	12.8	clear	12.30	6.67	10.71	0.13	22.9	"
1035	~~115~~ 110	18.33	~~DRY 38.6~~	clear	12.32	6.67	10.77	0.14	22.5	"
1045	125	18.86	~~DRY~~ 17.4	clear	12.29	6.67	10.88	0.14	22.5	"

PB-BED-MW30

Shaw E & I, Inc.

Well Development Log

Page 1 of 2

Project Number: 843656
Project Name: PBOW
Form Completed by: David Kessler
Well Developed by/firm: Miller Drilling

Site ID: PBOW - Downgradient Well
Location ID: PB-BED-MW30
Date Started: 3/29/04

Monitoring Well Information

Development Method: 2" Grundfos Pump
Development Equipment: "
Surging w/ pump
Drilling Water Lost: None

Screen Height (ft): 15'
Filter pack length (ft): 19.3
Casing Diameter (in): 2"
Drilling Water Recovered (5 X volume): —

Begining Measurements (BTOC)
Depth to Water (ft): 26.44
Total depth of Well (ft): 54.35
(plus 5 times water in well and casing)

Monitoring Well Develope Calculations

Volume of Water in Casing:

Gallons/foot = 0.041 x d^2, where casing diameter in inches = (0.041 x (2)^2) = 0.164 gal/ft.
Well Volume (gallons) = Water Column (ft) x Gal/ft = 27.91 ft x 0.164 gal/ft = 4.57 gallons

Volume of Water in Filter Pack:

Gallons/foot = 0.041 x (D^2 - d^2), where D is total borehole diameter in inches & d is casing diameter in inches = 0.041 x ((6)^2 - (2)^2) = 1.31 gal/ft.
Filter Pack Volume (gal) = (either water column in filter pack or water column) x gal/ft x porosity (0.3) = (15.53 ft x (1.31) gal/ft x 0.3 = 6.10 gal

Purge Well Volume: Purge well Volume = Filter pack volume + Well Volume = 6.10 gal + 4.57 gal = 10.67 gal.

1 x Purge Well Volume	2 x Purge Well Volume	3 x Purge Well Volume	4 x Purge Well Volume	5 x Purge Well Volume
10.67	21.34	32.01	42.68	53.35

Pump on bottom of well

Development Record

Date/Time (24 hrs)	Volume Removed (gal)	Water Level (ft) (TOC)	Turbidity (NTU)	Clarity (color)	Temp. (C)	pH (Std Units)	Conductivity (mS/cm)	Comments
3/29/04 0910	~~5~~ 2	32.10	654.6	black	13.05	6.70	1.568	Very silty, Distinct H_2S odor on all (0ppm)
0920	~~15~~ 8 5	31.32	182.5	cleaning	13.98	6.75	1.553	clean, light black
0930	~~17~~ 7	31.53	57.5	clean	14.04	6.70	1552	clean Hertz 140
0935	~~18~~ 10	30.48	163.1	brown	14.38	6.69	1.549	" Hertz 140.00
0945	11	32.08	39	light gray	13.82	6.68	1.540	" Hertz 145.00
0955	16	33.71	32.4	"	13.61	6.68	1.525	" Hertz 145.00
1005	19	33.80	19.3	"	13.58	6.68	1.520	" Hertz 145.00
1015	22	33.96	21.8	clean	13.66	6.68	1.513	" Hertz 150.00 — Turned up
1025	26	33.92	17.4	"	13.34	6.68	1.503	" Hertz 150.00
1035	29	34.03	22.5	"	13.17	6.69	1.506	" " 150.00 — Turned up
1045	32	35.48	21.0	"	13.08	6.69	1.508	" " 155.00 — Turned up
1055	35	36.25	38.6	clean	13.00	6.70	1.497	" " 155.00 — Turned up
1105	39	37.92	49.1	clean	12.91	6.71	1.502	160.00
1115	43	38.94	60.5	clean	12.94	6.70	1.490	

Shaw
Shaw E & I, Inc.

PB-BED-MW30 (continued)
(See page 1)

Well Development Log

Project Number: _____
Project Name: _____
Form Completed by: _____
Well Developed by/firm: _____

Site ID: _____
Location ID: _____
Date Started: _____

Monitoring Well Information

Development Method: _____
Development Equipment: _____
_____
Drilling Water Lost: _____

Screen Height (ft): _____
Filter pack length (ft): _____
Casing Diameter (in): _____
Drilling Water Recovered (5 X volume): _____

Begining Measurements (BTOC)
Depth to Water (ft): _____
Total depth of Well (ft): _____
(plus 5 times water in well and casing)

Monitoring Well Develope Calculations

Volume of Water in Casing: Gallons/foot = 0.041 x d^2, where casing diameter in inches = (0.041 x (_____)^2) = _____ gal/ft.
Well Volume (gallons) = Water Column (ft) x Gal/ft = _____ ft x _____ gal/ft = _____ gallons

Volume of Water in Filter Pack:
Gallons/foot = 0.041 x (D^2 - d^2), where D is total borehole diameter in inches & d is casing diameter in inches = 0.041 x ((_____)^2- (_____)^2) = _____ gal/ft.
Filter Pack Volume (gal) = (either water column in filter pack or water column) x gal/ft x porosity (0.3) = (_____)ft x (_____) gal/ft x 0.3 = _____ gal

Purge Well Volume: Purge well Volume = Filter pack volume + Well Volume = _____ gal + _____ gal = _____ gal

1 x Purge Well Volume	2 x Purge Well Volume	3 x Purge Well Volume	4 x Purge Well Volume	5 x Purge Well Volume

Development Record

Date/Time (24 hrs)	Volume Removed (gal)	Water Level (ft) (TOC)	Turbidity (NTU)	Clarity (color)	Temp. (C)	pH (Std Units)	Conductivity (mS/cm)	Comments
8/29/04 1125	47	~~42~~ 39.81	36.4	clear	12.94	6.69	1.494	clear Hach 160.0
1135	51	40.76	31.1	clear	13.16	6.71	1.501	" 160.0
1140	53-55	41.05	33.24	clear	13.07	6.70	1.512	

PB-BED-MW33

Shaw
Shaw E & I, Inc.

Well Development Log

Page 1 of 1

Project Number: 843656
Project Name: PBOW
Form Completed by: David Kessler
Well Developed by/firm: Miller Drilling

Site ID: Downgradient well
Location ID: PB-BED-MW33
Date Started: 4/4/04

Monitoring Well Information

Development Method: Pumping
Development Equipment: 2" Grundfos Pump
Drilling Water Lost: 0- (None)

Screen Height (ft): 20 ft
Filter pack length (ft): 24 ft
Casing Diameter (in): 2
Drilling Water Recovered (5 X volume): —

Begining Measurements (BTOC)
Depth to Water (ft): 50.39
Total depth of Well (ft): 83.75 ?
(plus 5 times water in well and casing)

Monitoring Well Develope Calculations

Volume of Water in Casing:

Gallons/foot = 0.041 x d^2, where casing diameter in inches = (0.041 x (2)^2) = 0.164 gal/ft.
Well Volume (gallons) = Water Column (ft) x Gal/ft = 33.36 ft x 0.164 gal/ft = 5.47 gallons

Volume of Water in Filter Pack:

Gallons/foot = 0.041 x (D^2 - d^2), where D is total borehole diameter in inches & d is casing diameter in inches = 0.041 x ((5)^2 - (2)^2) = 0.86 gal/ft.
Filter Pack Volume (gal) = (either water column in filter pack or water column) x gal/ft x porosity (0.3) = (24)ft x (0.86) gal/ft x 0.3 = 6.19 gal

Purge Well Volume: Purge well Volume = Filter pack volume + Well Volume = 5.47 gal + 6.19 gal = 11.66 gal.

1 x Purge Well Volume	2 x Purge Well Volume	3 x Purge Well Volume	4 x Purge Well Volume	5 x Purge Well Volume
11.66	23.32	34.98	46.64	58.30

Development Record

Date/Time (24 hrs)	Volume Removed (gal)	Water Level (ft) ~~(TOC)~~ BGS	Turbidity (NTU)	Clarity (color)	Temp. (C)	pH (Std Units)	Conductivity (mS/cm)	Comments
4/4/04 0900	5	75.5	228.0	Black	12.32	6.65	5.094	slowed pump from 240 to 200
0915	8	81.5	240.8	cleaning	13.89	6.79	4.359	Well went dry
1019	10	78.53	280.0	dark black	9.73	6.95	4.800	~~Dry~~ 112 of 210 Hz to get to surface
1025	11 gal							Dry
1111	11	80.83						Dry

Development Ended

APPENDIX E

HYDRAULIC CONDUCTIVITY DATA

Aquifer Test Results

2004 Groundwater Data Summary and Evaluation Report Former Plum Brook Ordnance Works, Sandusky, Ohio

1.0 Purpose

Slug testing was conducted to estimate the hydraulic conductivity of geologic materials in the vicinity of four monitoring wells at the Plum Brook Ordnance Works, Sandusky, Ohio. Newly installed during the 2004 site-wide groundwater remedial investigation, the following wells were tested:

- PB-BED-MW28
- PB-BED-MW29
- PB-BED-MW30
- PB-BED-MW33.

2.0 Method

The methods of Bouwer and Rice (1976), as implemented through the computer program AQTESOLV® for Windows (HydroSOLVE, Inc. 1989), were used to calculate the hydraulic conductivity near a well. The calculation was based on the rate of water level change after adding a slug of known volume to the well (Falling Test) or sudden removal of a volume of water (Rising Test).

3.0 Theory

The Bouwer and Rice (1976) method for unconfined aquifers is based on the following equation:

$$Q = 2\pi\, KL_e \frac{y}{ln(R_e / r_w)}. \qquad (1)$$

where:

Q = the flux to the well (length^3/time)
K = the hydraulic conductivity of the aquifer (length/time)
L_e = the length of screen contributing water to the well (length)
y = the difference between the water level in the well and the equilibrium water table (length)
R_e = the aquifer radius over which water level changes are dissipated (length)
r_w = the boring radius (length).

The instantaneous change in water level in the well, dy/dt, is given by:

$$dy/dt = -Q/\pi r_c^2 \tag{2}$$

where:

$\pi r_c^2 1$ = the cross sectional area of the well.

Combining equations (1) and (2) yields:

$$\frac{1}{y} dy = -\frac{2KL_e}{r_c^2 ln(R_e/r_w)} dt \tag{3}$$

Integration of (3) between y_o at time t = 0 and y_t at time t and solving for K yields:

$$K = \left[\frac{r_c^2 ln(R_e/r_w)}{2L_e}\right] \frac{1}{t} ln \frac{y_o}{y_t} \tag{4}$$

K and the factor in square brackets are constants. Therefore, field data plotted as $ln(y_t)$ versus t should lie on a straight line with slope:

$$-\frac{2KL_e}{r_c^2 ln(R_e/r_w)}. \tag{5}$$

The factor $ln(R_e/r_w)$ in (4) is an empirical function of aquifer and well geometry. For partially penetrating wells:

$$ln \frac{R_e}{r_w} = \left[\frac{1.1}{ln(L_w/r_w)} + \frac{A + B\, ln[(H - L_w)/r_w]}{L_e/r_w}\right]^{-1}, \tag{6}$$

where:

$\ln [(H-L_w)/r_w] \leq 6.$

For fully penetrating wells:

$$ln \frac{R_e}{r_w} = \left(\frac{1.1}{ln(L_w/r_w)} + \frac{C}{L_e/r_w}\right)^{-1}. \tag{7}$$

The dimensionless parameters A, B, and C are empirical functions of well geometry as determined by electric analog modeling (Bouwer and Rice, 1976).

Hydraulic conductivity is calculated from (4) using the slope and y-intercept of a line fit to the field data and $\ln(R_e/r_w)$ from (6) or (7).

4.0 Assumptions

The Bouwer and Rice (1976) method for unconfined aquifers is based on the assumptions that:

- The aquifer is homogeneous, isotropic and unconfined
- Drawdown is negligible compared to aquifer thickness
- Vadose zone flow is negligible
- Well losses are negligible.

5.0 Procedure

The following steps were followed in estimating the aquifer hydraulic conductivity:

a) Define the aquifer and well geometry using the following parameters (Table 1):

H = Aquifer saturated thickness (assumed)
L_e = Length of saturated well screen
L_w = Static height of water in well
r_c = Radius of well casing
r_w = Radius of boring
ϕ = Porosity of filter pack (Assumed to be 30 percent. Porosity of unconsolidated sand ranges from 25 to 50 percent [Freeze and Cherry, 1979])
y_o = Initial change in water level

b) Using the field data to determine whether water level fluctuations occurred within the screened interval of the well.

When $L_w = L_e$ Water level fluctuations occurred in the screened section of the well. Modify r_c to account for filter pack storage according to:

$$r_c^* = \left[r_c^2 + \phi(r_w^2 - r_c^2)\right]^{1/2} \quad (8)$$

When Lw > Le Water level fluctuations occurred above the screened portion of the well. Note that the filter pack porosity in this case does not affect subsequent calculations, therefore, r_c is used in calculation.

c) Input geometric parameters listed above and time versus drawdown data.

d) Perform hydraulic conductivity calculations. Hydraulic conductivity is calculated interactively using AQTESOLV® for Windows. AQTESOLV® is used to display field data, which is then visually matched with a best-fit line. AQTESOLV® then calculates the hydraulic conductivity from the input geometric data and slope and y-intercept of the best-fit line.

6.0 Results

The slug tests were performed on May 04, 2004 (Attachments 1 and 2). Both falling and rising tests were conducted in PB-BED-MW28, PB-BED-MW29, and PB-BED-MW30 while only a rising test was conducted in PB-BED-MW33, because the water level prior to the test was below the top of the screen.

Table 1 summarizes the depth to groundwater, the total well depth, and the geometric data of each well tested. Values of calculated hydraulic conductivity (K) and transmissivity (T) are summarized in Table 2.

The hydraulic conductivity values of the tested well range from 0.389 ft/day (PB-BED-MW30) to 1.23 ft/day (PB-BED-MW33) with a geometric mean of 0.582 ft/day. The transmissivity (T) was also calculated for each test using an assumed aquifer saturated thickness for each location. T values are summarized in Table 2.

The slug test results were analyzed using AQTESOLV for Windows Pro 3.0, which assumes that the aquifer being tested is homogenous and isotropic. Since the aquifer is rarely a homogenous and isotropic media, the hydraulic conductivity calculation based on the commonly accepted assumption will have uncertainties associated with it. The degree of uncertainty is directly proportional to the deviation of the homogenous and isotropic model from the reality. Therefore, it is recommended that the slug test data be used with caution, knowing the limitations and uncertainties associated with these results.

7.0 References

Bouwer, H., and R.C. Rice, 1976, "A Slug Test Method for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells," Water ***Resources Research***, Vol. 12, No. 3, pp. 423-428.

Cooper, H.H., J.D. Bredehoeft, and I.S. Papadopulos, 1967, "Response of a Finite Diameter Well to an Instantaneous Change of Water," ***Water Resources Research***, Vol. 3, No. 1, pp. 263-269.

Freeze, R.A., and J.A. Cherry, 1979, ***Groundwater***, Prentice-Hall, Englewood Cliffs, New Jersey, 604 pp.

Geraghty and Miller Environmental Services, 1989, ***AQTESOLV, Aquifer Test Design and Analysis Software***, Version 1.1.

Table 1
Summary of Slug Testing Well Geometry Data
Plum Brook Ordnace Work
Erie County, Sandusky, Ohio

Well ID	Water Level (TOC) (ft)	Total Depth (TOC) (ft)	D (ft)	r_c (ft)	r_w (ft)	L_e (ft)	L_w (ft)
PB-BED-MW28	6.45	41.48	35.03	0.083	0.25	15	35.03
PB-BED-MW29	2.59	37.83	35.24	0.083	0.25	10	35.24
PB-BED-MW30	26.32	54.25	27.93	0.083	0.25	15	27.93
PB-BED-MW33	73.89	83.50	9.61	0.083	0.25	20	9.61

Note: D — Aquifer saturated thickness (assumed)

r_c — Radius of well casing

r_w — Radius of boring

L_e — Length of saturated well screen

L_w — Static height of water in well

Φ — Porosity of filter pack (Assumed to be 30 percent. Porosities of unconsolidated sand range from 25 to 50 percent [Freeze and Cherry, 1979])

Table 2

Summary of Hydraulic Conductivities
PBOW, Sandusky, OH

Well No.	Date Tested	Aquifer Response	Saturated Aquifer Thickness (Assumed)	Test Type	Transmisivities T (ft^2/day)	Hydraulic Conductivities K (ft/min)	Hydraulic Conductivities K (cm/sec)	Hydraulic Conductivities K (ft/day)
PB-BED-MW28	5/4/04	Unconfined	35.03	Falling	2.61E+01	5.18E-04	2.63E-04	7.46E-01
				Rising	1.77E+01	3.50E-04	1.78E-04	5.04E-01
PB-BED-MW29	5/4/04	Unconfined	35.24	Falling	1.87E+01	3.69E-04	1.88E-04	5.32E-01
				Rising	2.10E+01	4.14E-04	2.11E-04	5.96E-01
PB-BED-MW30	5/4/04	Unconfined	27.93	Falling	1.09E+01	2.70E-04	1.37E-04	3.89E-01
				Rising	1.10E+01	2.74E-04	1.39E-04	3.94E-01
PB-BED-MW33	5/4/04	Unconfined	9.61	Rising	1.19E+01	8.57E-04	4.36E-04	1.23E+00
Maximum					***2.61E+01***	***8.57E-04***	***4.36E-04***	***1.23E+00***
Minimum					***1.09E+01***	***2.70E-04***	***1.37E-04***	***3.89E-01***
Geometric Mean					***1.59E+01***	***4.04E-04***	***2.05E-04***	***5.82E-01***

ATTACHMENT 1

TIME VERSUS DRAWDOWN DATA

In-Situ Inc. MiniTroll Pro

Report generated: 10/11/04 16:23:27
Report from file: F:\PBOW\slugtest\5-04\mw28f.bin
DataMgr Version 3.71

Serial number: 00008843
Firmware Version 3.09
Unit name:

Test name: mw28f

Test defined on: 05/04/04 16:10:11
Test started on: 05/04/04 16:15:58
Test stopped on: N/A N/A
Test extracted on: N/A

Data gathered using Logarithmic testing
  Maximum time between data points: 10.0000 Minutes.
  Number of data samples: 105

TOTAL DATA SAMPLES 105

Channel number [2]
  Measurement type: Pressure
  Channel name:
  Sensor Range: 30 PSI.
  Specific gravity: 1.000
  Mode: TOC
  User-defined reference: 0.000 Feet H2O
  Referenced on: test start
  Pressure head at reference: 20.102 Feet H2O

Date	Time	ET (min)	Chan[2] Feet H2O
05/04/04	16:15:58	0.0000	0.000
05/04/04	16:15:58	0.0050	-0.011
05/04/04	16:15:58	0.0100	-1.191
05/04/04	16:15:59	0.0150	-3.468
05/04/04	16:15:59	0.0200	-5.749
05/04/04	16:15:59	0.0250	-4.734
05/04/04	16:16:00	0.0300	-3.359
05/04/04	16:16:00	0.0350	-4.123
05/04/04	16:16:00	0.0400	-5.445
05/04/04	16:16:00	0.0450	-5.578
05/04/04	16:16:01	0.0500	-5.040
05/04/04	16:16:01	0.0550	-4.010
05/04/04	16:16:01	0.0600	-2.827
05/04/04	16:16:02	0.0650	-2.716
05/04/04	16:16:02	0.0700	-3.500
05/04/04	16:16:02	0.0750	-4.161
05/04/04	16:16:03	0.0800	-4.759
05/04/04	16:16:03	0.0848	-4.876
05/04/04	16:16:03	0.0900	-4.088
05/04/04	16:16:03	0.0950	-3.903
05/04/04	16:16:04	0.1000	-4.737
05/04/04	16:16:04	0.1058	-4.751
05/04/04	16:16:04	0.1120	-3.826
05/04/04	16:16:05	0.1185	-4.503
05/04/04	16:16:05	0.1255	-5.128
05/04/04	16:16:06	0.1328	-3.879
05/04/04	16:16:06	0.1407	-2.659
05/04/04	16:16:07	0.1490	-3.395
05/04/04	16:16:07	0.1578	-3.808
05/04/04	16:16:08	0.1670	-3.388
05/04/04	16:16:08	0.1770	-3.422
05/04/04	16:16:09	0.1875	-3.500
05/04/04	16:16:10	0.1985	-3.396

)5/04/04	16:16:10	0.2102	-3.404
)5/04/04	16:16:11	0.2227	-3.371
)5/04/04	16:16:12	0.2358	-3.345
)5/04/04	16:16:13	0.2498	-3.317
)5/04/04	16:16:14	0.2647	-3.289
)5/04/04	16:16:15	0.2803	-3.257
)5/04/04	16:16:16	0.2970	-3.225
)5/04/04	16:16:17	0.3147	-3.192
)5/04/04	16:16:18	0.3333	-3.160
)5/04/04	16:16:19	0.3532	-3.124
)5/04/04	16:16:20	0.3742	-3.086
)5/04/04	16:16:22	0.3963	-3.045
)5/04/04	16:16:23	0.4198	-3.007
)5/04/04	16:16:24	0.4447	-2.965
)5/04/04	16:16:26	0.4697	-2.923
)5/04/04	16:16:28	0.4963	-2.880
)5/04/04	16:16:29	0.5247	-2.834
)5/04/04	16:16:31	0.5547	-2.786
)5/04/04	16:16:33	0.5863	-2.735
)5/04/04	16:16:35	0.6213	-2.683
)5/04/04	16:16:37	0.6578	-2.627
)5/04/04	16:16:40	0.6963	-2.572
)5/04/04	16:16:42	0.7380	-2.514
)5/04/04	16:16:45	0.7813	-2.454
)5/04/04	16:16:47	0.8280	-2.391
)5/04/04	16:16:50	0.8763	-2.329
)5/04/04	16:16:53	0.9280	-2.265
)5/04/04	16:16:57	0.9830	-2.198
)5/04/04	16:17:00	1.0413	-2.130
)5/04/04	16:17:04	1.1030	-2.060
)5/04/04	16:17:08	1.1680	-1.991
)5/04/04	16:17:12	1.2380	-1.914
)5/04/04	16:17:16	1.3113	-1.838
)5/04/04	16:17:21	1.3897	-1.766
)5/04/04	16:17:26	1.4730	-1.685
)5/04/04	16:17:31	1.5613	-1.603
)5/04/04	16:17:37	1.6547	-1.525
)5/04/04	16:17:43	1.7530	-1.442
)5/04/04	16:17:49	1.8580	-1.362
)5/04/04	16:17:56	1.9680	-1.279
)5/04/04	16:18:03	2.0847	-1.197
)5/04/04	16:18:10	2.2097	-1.117
)5/04/04	16:18:18	2.3412	-1.034
)5/04/04	16:18:27	2.4813	-0.952
)5/04/04	16:18:36	2.6297	-0.874
)5/04/04	16:18:45	2.7863	-0.795
)5/04/04	16:18:55	2.9530	-0.721
)5/04/04	16:19:06	3.1297	-0.649
)5/04/04	16:19:17	3.3163	-0.579
)5/04/04	16:19:29	3.5147	-0.512
)5/04/04	16:19:41	3.7247	-0.446
)5/04/04	16:19:55	3.9463	-0.385
)5/04/04	16:20:09	4.1813	-0.327
)5/04/04	16:20:24	4.4295	-0.275
)5/04/04	16:20:39	4.6930	-0.227
)5/04/04	16:20:56	4.9730	-0.185
)5/04/04	16:21:14	5.2697	-0.147
)5/04/04	16:21:33	5.5830	-0.115
)5/04/04	16:21:53	5.9147	-0.089
)5/04/04	16:22:14	6.2663	-0.067
)5/04/04	16:22:36	6.6397	-0.051
)5/04/04	16:23:00	7.0347	-0.039
)5/04/04	16:23:25	7.4530	-0.031
)5/04/04	16:23:52	7.8963	-0.024
)5/04/04	16:24:20	8.3663	-0.022
)5/04/04	16:24:50	8.8647	-0.020
)5/04/04	16:25:21	9.3913	-0.018
)5/04/04	16:25:55	9.9497	-0.018
)5/04/04	16:26:30	10.5413	-0.019
)5/04/04	16:27:08	11.1680	-0.019
)5/04/04	16:27:48	11.8313	-0.019

05/04/04 16:28:30 12.5347 -0.021

In-Situ Inc. MiniTroll Pro

Report generated: 10/11/04 16:14:10
Report from file: F:\PBOW\slugtest\5-04\mw28r.bin
DataMgr Version 3.71

Serial number: 00008843
Firmware Version 3.09
Unit name:

Test name: mw28r

Test defined on: 05/04/04 16:12:29
Test started on: 05/04/04 16:29:33
Test stopped on: 05/04/04 16:43:51
Test extracted on: N/A

Data gathered using Logarithmic testing
  Maximum time between data points: 10.0000 Minutes.
  Number of data samples: 107

TOTAL DATA SAMPLES 107

Channel number [2]
  Measurement type: Pressure
  Channel name:
  Sensor Range: 30 PSI.
  Specific gravity: 1.000
  Mode: TOC
  User-defined reference: 0.000 Meters H2O
  Referenced on: test start
  Pressure head at reference: 4.048 Meters H2O

Date	Time	ET (min)	Chan[2] Meters H2O
5/04/04	16:29:33	0.0000	0.000
5/04/04	16:29:34	0.0050	-0.058
5/04/04	16:29:34	0.0100	-0.184
5/04/04	16:29:34	0.0150	-0.120
5/04/04	16:29:34	0.0200	-0.342
5/04/04	16:29:35	0.0250	-0.840
5/04/04	16:29:35	0.0300	-1.241
5/04/04	16:29:35	0.0350	-1.117
5/04/04	16:29:36	0.0400	-0.776
5/04/04	16:29:36	0.0450	-0.715
5/04/04	16:29:36	0.0500	-0.923
5/04/04	16:29:37	0.0550	-1.035
5/04/04	16:29:37	0.0600	-0.942
5/04/04	16:29:37	0.0650	-0.851
5/04/04	16:29:37	0.0700	-0.885
5/04/04	16:29:38	0.0750	-0.963
5/04/04	16:29:38	0.0800	-0.971
5/04/04	16:29:38	0.0848	-0.928
5/04/04	16:29:39	0.0900	-0.912
5/04/04	16:29:39	0.0950	-0.939
5/04/04	16:29:39	0.1000	-0.965
5/04/04	16:29:40	0.1058	-0.957
5/04/04	16:29:40	0.1120	-0.945
5/04/04	16:29:40	0.1185	-0.958
5/04/04	16:29:41	0.1255	-0.969
5/04/04	16:29:41	0.1328	-0.963
5/04/04	16:29:42	0.1407	-0.971
5/04/04	16:29:42	0.1490	-0.976
5/04/04	16:29:43	0.1578	-0.978
5/04/04	16:29:43	0.1670	-0.984
5/04/04	16:29:44	0.1770	-0.987
5/04/04	16:29:45	0.1875	-0.992
5/04/04	16:29:45	0.1985	-0.997

05/04/04	16:29:46	0.2102	-1.001
05/04/04	16:29:47	0.2227	-1.007
05/04/04	16:29:47	0.2358	-1.013
05/04/04	16:29:48	0.2498	-1.019
05/04/04	16:29:49	0.2647	-1.025
05/04/04	16:29:50	0.2803	-1.032
05/04/04	16:29:51	0.2970	-1.039
05/04/04	16:29:52	0.3147	-1.046
05/04/04	16:29:53	0.3333	-1.053
05/04/04	16:29:54	0.3532	-1.063
05/04/04	16:29:56	0.3742	-1.072
05/04/04	16:29:57	0.3963	-1.080
05/04/04	16:29:58	0.4198	-1.090
05/04/04	16:30:00	0.4447	-1.100
05/04/04	16:30:01	0.4697	-1.109
05/04/04	16:30:03	0.4963	-1.120
05/04/04	16:30:05	0.5247	-1.130
05/04/04	16:30:07	0.5547	-1.141
05/04/04	16:30:08	0.5863	-1.152
05/04/04	16:30:11	0.6213	-1.165
05/04/04	16:30:13	0.6578	-1.177
05/04/04	16:30:15	0.6963	-1.190
05/04/04	16:30:18	0.7380	-1.204
05/04/04	16:30:20	0.7813	-1.218
05/04/04	16:30:23	0.8280	-1.232
05/04/04	16:30:26	0.8763	-1.248
05/04/04	16:30:29	0.9280	-1.264
05/04/04	16:30:32	0.9830	-1.280
05/04/04	16:30:36	1.0413	-1.297
05/04/04	16:30:39	1.1030	-1.315
05/04/04	16:30:43	1.1680	-1.334
05/04/04	16:30:48	1.2380	-1.352
05/04/04	16:30:52	1.3113	-1.372
05/04/04	16:30:57	1.3897	-1.392
05/04/04	16:31:02	1.4730	-1.413
05/04/04	16:31:07	1.5613	-1.435
05/04/04	16:31:13	1.6547	-1.456
05/04/04	16:31:18	1.7530	-1.479
05/04/04	16:31:25	1.8580	-1.502
05/04/04	16:31:31	1.9680	-1.525
05/04/04	16:31:38	2.0847	-1.548
05/04/04	16:31:46	2.2097	-1.573
05/04/04	16:31:54	2.3412	-1.597
05/04/04	16:32:02	2.4813	-1.622
05/04/04	16:32:11	2.6297	-1.647
05/04/04	16:32:20	2.7863	-1.674
05/04/04	16:32:30	2.9530	-1.700
05/04/04	16:32:41	3.1297	-1.726
05/04/04	16:32:52	3.3163	-1.752
05/04/04	16:33:04	3.5147	-1.779
05/04/04	16:33:17	3.7247	-1.804
05/04/04	16:33:30	3.9463	-1.831
05/04/04	16:33:44	4.1813	-1.856
05/04/04	16:33:59	4.4295	-1.880
05/04/04	16:34:15	4.6930	-1.903
05/04/04	16:34:32	4.9730	-1.925
05/04/04	16:34:49	5.2697	-1.945
05/04/04	16:35:08	5.5830	-1.964
05/04/04	16:35:28	5.9147	-1.982
05/04/04	16:35:49	6.2663	-1.998
05/04/04	16:36:12	6.6397	-2.013
05/04/04	16:36:35	7.0347	-2.026
05/04/04	16:37:00	7.4530	-2.037
05/04/04	16:37:27	7.8963	-2.047
05/04/04	16:37:55	8.3663	-2.055
05/04/04	16:38:25	8.8647	-2.061
05/04/04	16:38:57	9.3913	-2.066
05/04/04	16:39:30	9.9497	-2.070
05/04/04	16:40:06	10.5413	-2.074
05/04/04	16:40:43	11.1680	-2.076
05/04/04	16:41:23	11.8313	-2.079

'04/04	16:42:05	12.5347	-2.081
'04/04	16:42:50	13.2797	-2.082
'04/04	16:43:37	14.0697	-2.083

In-Situ Inc. MiniTroll Pro

Report generated: 10/11/04 16:28:10
Report from file: F:\PBOW\slugtest\5-04\mw29f.bin
DataMgr Version 3.71

Serial number: 00008843
Firmware Version 3.09
Unit name:

Test name: mw29f

Test defined on: 05/04/04 14:05:36
Test started on: 05/04/04 15:17:18
Test stopped on: 05/04/04 15:34:38
Test extracted on: N/A

Data gathered using Logarithmic testing
  Maximum time between data points: 10.0000 Minutes.
  Number of data samples: 110

TOTAL DATA SAMPLES 110

Channel number [2]
  Measurement type: Pressure
  Channel name:
  Sensor Range: 30 PSI.
  Specific gravity: 1.000
  Mode: TOC
  User-defined reference: 0.000 Feet H2O
  Referenced on: test start
  Pressure head at reference: 26.784 Feet H2O

Date	Time	ET (min)	Chan[2] Feet H2O
5/04/04	15:17:18	0.0000	0.000
5/04/04	15:17:19	0.0050	-0.462
5/04/04	15:17:19	0.0100	-0.563
5/04/04	15:17:19	0.0150	-0.247
5/04/04	15:17:20	0.0200	-0.263
5/04/04	15:17:20	0.0250	-0.668
5/04/04	15:17:20	0.0300	-2.007
5/04/04	15:17:21	0.0350	-2.944
5/04/04	15:17:21	0.0400	-3.599
5/04/04	15:17:21	0.0450	-2.039
5/04/04	15:17:21	0.0500	-1.220
5/04/04	15:17:22	0.0550	-1.755
5/04/04	15:17:22	0.0600	-1.274
5/04/04	15:17:22	0.0650	-1.496
5/04/04	15:17:23	0.0700	-1.163
5/04/04	15:17:23	0.0750	-1.149
5/04/04	15:17:23	0.0800	-1.149
5/04/04	15:17:24	0.0848	-1.161
5/04/04	15:17:24	0.0900	-1.143
5/04/04	15:17:24	0.0950	-1.145
5/04/04	15:17:24	0.1000	-1.040
5/04/04	15:17:25	0.1058	-1.270
5/04/04	15:17:25	0.1120	-1.600
5/04/04	15:17:26	0.1185	-1.239
5/04/04	15:17:26	0.1255	-1.286
5/04/04	15:17:26	0.1328	-0.832
5/04/04	15:17:27	0.1407	-0.772
5/04/04	15:17:27	0.1490	-1.159
5/04/04	15:17:28	0.1578	-0.812
5/04/04	15:17:29	0.1670	-1.151
5/04/04	15:17:29	0.1770	-0.970
5/04/04	15:17:30	0.1875	-0.960
5/04/04	15:17:30	0.1985	-0.527

05/04/04	15:17:31	0.2102	-0.622
05/04/04	15:17:32	0.2227	-0.642
05/04/04	15:17:33	0.2358	-0.596
05/04/04	15:17:33	0.2498	-0.549
05/04/04	15:17:34	0.2647	-0.509
05/04/04	15:17:35	0.2803	-0.465
05/04/04	15:17:36	0.2970	-0.420
05/04/04	15:17:37	0.3147	-0.416
05/04/04	15:17:38	0.3333	-0.348
05/04/04	15:17:40	0.3532	-0.302
05/04/04	15:17:41	0.3742	-0.266
05/04/04	15:17:42	0.3963	-0.217
05/04/04	15:17:44	0.4198	-0.193
05/04/04	15:17:45	0.4447	-0.151
05/04/04	15:17:47	0.4697	-0.117
05/04/04	15:17:48	0.4963	-0.083
05/04/04	15:17:50	0.5247	-0.048
05/04/04	15:17:52	0.5547	-0.016
05/04/04	15:17:54	0.5863	-0.050
05/04/04	15:17:56	0.6213	0.054
05/04/04	15:17:58	0.6578	0.082
05/04/04	15:18:00	0.6963	0.115
05/04/04	15:18:03	0.7380	0.143
05/04/04	15:18:05	0.7813	0.171
05/04/04	15:18:08	0.8280	0.199
05/04/04	15:18:11	0.8763	0.227
05/04/04	15:18:14	0.9280	0.255
05/04/04	15:18:17	0.9830	0.279
05/04/04	15:18:21	1.0413	0.307
05/04/04	15:18:25	1.1030	0.331
05/04/04	15:18:29	1.1680	0.357
05/04/04	15:18:33	1.2380	0.380
05/04/04	15:18:37	1.3113	0.406
05/04/04	15:18:42	1.3897	0.428
05/04/04	15:18:47	1.4730	0.448
05/04/04	15:18:52	1.5613	0.470
05/04/04	15:18:58	1.6547	0.492
05/04/04	15:19:04	1.7530	0.512
05/04/04	15:19:10	1.8580	0.530
05/04/04	15:19:17	1.9680	0.550
05/04/04	15:19:24	2.0847	0.568
05/04/04	15:19:31	2.2097	0.586
05/04/04	15:19:39	2.3412	0.604
05/04/04	15:19:47	2.4813	0.618
05/04/04	15:19:56	2.6297	0.638
05/04/04	15:20:06	2.7863	0.652
05/04/04	15:20:16	2.9530	0.666
05/04/04	15:20:26	3.1297	0.682
05/04/04	15:20:37	3.3163	0.698
05/04/04	15:20:49	3.5147	0.712
05/04/04	15:21:02	3.7247	0.726
05/04/04	15:21:15	3.9463	0.737
05/04/04	15:21:29	4.1813	0.749
05/04/04	15:21:44	4.4295	0.761
05/04/04	15:22:00	4.6930	0.773
05/04/04	15:22:17	4.9730	0.783
05/04/04	15:22:35	5.2697	0.795
05/04/04	15:22:53	5.5830	0.804
05/04/04	15:23:13	5.9147	0.815
05/04/04	15:23:34	6.2663	0.824
05/04/04	15:23:57	6.6397	0.832
05/04/04	15:24:21	7.0347	0.842
05/04/04	15:24:46	7.4530	0.850
05/04/04	15:25:12	7.8963	0.858
05/04/04	15:25:40	8.3663	0.864
05/04/04	15:26:10	8.8647	0.872
05/04/04	15:26:42	9.3913	0.880
05/04/04	15:27:15	9.9497	0.886
05/04/04	15:27:51	10.5413	0.892
05/04/04	15:28:29	11.1680	0.900
05/04/04	15:29:08	11.8313	0.904

)5/04/04	15:29:51	12.5347	0.910
)5/04/04	15:30:35	13.2797	0.916
)5/04/04	15:31:23	14.0697	0.919
)5/04/04	15:32:13	14.9063	0.921
)5/04/04	15:33:06	15.7913	0.925
)5/04/04	15:34:02	16.7297	0.927

In-Situ Inc. MiniTroll Pro

Report generated: 10/11/04 16:28:25
Report from file: F:\PBOW\slugtest\5-04\mw29r.bin
DataMgr Version 3.71

Serial number: 00008843
Firmware Version 3.09
Unit name:

Test name: mw29r

Test defined on: 05/04/04 15:34:55
Test started on: 05/04/04 15:35:10
Test stopped on: 05/04/04 15:48:35
Test extracted on: N/A

Data gathered using Logarithmic testing
  Maximum time between data points: 10.0000 Minutes.
  Number of data samples: 106

TOTAL DATA SAMPLES 106

Channel number [2]
  Measurement type: Pressure
  Channel name:
  Sensor Range: 30 PSI.
  Specific gravity: 1.000
  Mode: TOC
  User-defined reference: 0.000 Feet H2O
  Referenced on: test start
  Pressure head at reference: 18.874 Feet H2O

Date	Time	ET (min)	Chan[2] Feet H2O
05/04/04	15:35:10	0.0000	0.000
05/04/04	15:35:11	0.0050	-1.624
05/04/04	15:35:11	0.0100	-2.290
05/04/04	15:35:11	0.0150	-3.453
05/04/04	15:35:12	0.0200	-3.888
05/04/04	15:35:12	0.0250	-3.817
05/04/04	15:35:12	0.0300	-4.089
05/04/04	15:35:13	0.0350	-4.049
05/04/04	15:35:13	0.0400	-4.085
05/04/04	15:35:13	0.0450	-4.138
05/04/04	15:35:13	0.0500	-4.192
05/04/04	15:35:14	0.0550	-4.244
05/04/04	15:35:14	0.0600	-4.293
05/04/04	15:35:14	0.0650	-4.339
05/04/04	15:35:15	0.0700	-4.381
05/04/04	15:35:15	0.0750	-4.422
05/04/04	15:35:15	0.0800	-4.462
05/04/04	15:35:16	0.0848	-4.496
05/04/04	15:35:16	0.0900	-4.532
05/04/04	15:35:16	0.0950	-4.567
05/04/04	15:35:16	0.1000	-4.599
05/04/04	15:35:17	0.1058	-4.635
05/04/04	15:35:17	0.1120	-4.673
05/04/04	15:35:18	0.1185	-4.712
05/04/04	15:35:18	0.1255	-4.750
05/04/04	15:35:18	0.1328	-4.788
05/04/04	15:35:19	0.1407	-4.828
05/04/04	15:35:19	0.1490	-4.869
05/04/04	15:35:20	0.1578	-4.911
05/04/04	15:35:21	0.1670	-4.944
05/04/04	15:35:21	0.1770	-4.986
05/04/04	15:35:22	0.1875	-5.026
05/04/04	15:35:22	0.1985	-5.065

)5/04/04	15:35:23	0.2102	-5.107
)5/04/04	15:35:24	0.2227	-5.147
)5/04/04	15:35:25	0.2358	-5.190
)5/04/04	15:35:25	0.2498	-5.232
)5/04/04	15:35:26	0.2647	-5.272
)5/04/04	15:35:27	0.2803	-5.313
)5/04/04	15:35:28	0.2970	-5.353
)5/04/04	15:35:29	0.3147	-5.395
)5/04/04	15:35:30	0.3333	-5.433
)5/04/04	15:35:32	0.3532	-5.476
)5/04/04	15:35:33	0.3742	-5.516
)5/04/04	15:35:34	0.3963	-5.554
)5/04/04	15:35:36	0.4198	-5.594
)5/04/04	15:35:37	0.4447	-5.635
)5/04/04	15:35:39	0.4697	-5.671
)5/04/04	15:35:40	0.4963	-5.707
)5/04/04	15:35:42	0.5247	-5.743
)5/04/04	15:35:44	0.5547	-5.778
)5/04/04	15:35:46	0.5863	-5.812
)5/04/04	15:35:48	0.6213	-5.846
)5/04/04	15:35:50	0.6578	-5.880
)5/04/04	15:35:52	0.6963	-5.912
)5/04/04	15:35:55	0.7380	-5.946
)5/04/04	15:35:57	0.7813	-5.981
)5/04/04	15:36:00	0.8280	-6.011
)5/04/04	15:36:03	0.8763	-6.043
)5/04/04	15:36:06	0.9280	-6.073
)5/04/04	15:36:09	0.9830	-6.103
)5/04/04	15:36:13	1.0413	-6.133
)5/04/04	15:36:17	1.1030	-6.161
)5/04/04	15:36:21	1.1680	-6.190
)5/04/04	15:36:25	1.2380	-6.218
)5/04/04	15:36:29	1.3113	-6.246
)5/04/04	15:36:34	1.3897	-6.272
)5/04/04	15:36:39	1.4730	-6.296
)5/04/04	15:36:44	1.5613	-6.322
)5/04/04	15:36:50	1.6547	-6.348
)5/04/04	15:36:56	1.7530	-6.370
)5/04/04	15:37:02	1.8580	-6.395
)5/04/04	15:37:09	1.9680	-6.416
)5/04/04	15:37:16	2.0847	-6.437
)5/04/04	15:37:23	2.2097	-6.459
)5/04/04	15:37:31	2.3412	-6.479
)5/04/04	15:37:39	2.4813	-6.499
)5/04/04	15:37:48	2.6297	-6.519
)5/04/04	15:37:58	2.7863	-6.537
)5/04/04	15:38:08	2.9530	-6.557
)5/04/04	15:38:18	3.1297	-6.573
)5/04/04	15:38:29	3.3163	-6.593
)5/04/04	15:38:41	3.5147	-6.609
)5/04/04	15:38:54	3.7247	-6.625
)5/04/04	15:39:07	3.9463	-6.639
)5/04/04	15:39:21	4.1813	-6.653
)5/04/04	15:39:36	4.4295	-6.667
)5/04/04	15:39:52	4.6930	-6.679
)5/04/04	15:40:09	4.9730	-6.693
)5/04/04	15:40:27	5.2697	-6.705
)5/04/04	15:40:45	5.5830	-6.717
)5/04/04	15:41:05	5.9147	-6.727
)5/04/04	15:41:26	6.2663	-6.742
)5/04/04	15:41:49	6.6397	-6.752
)5/04/04	15:42:13	7.0347	-6.760
)5/04/04	15:42:38	7.4530	-6.772
)5/04/04	15:43:04	7.8963	-6.780
)5/04/04	15:43:32	8.3663	-6.792
)5/04/04	15:44:02	8.8647	-6.800
)5/04/04	15:44:34	9.3913	-6.808
)5/04/04	15:45:07	9.9497	-6.816
)5/04/04	15:45:43	10.5413	-6.824
)5/04/04	15:46:21	11.1680	-6.830
)5/04/04	15:47:00	11.8313	-6.836

05/04/04	15:47:43	12.5347	-6.842
05/04/04	15:48:27	13.2797	-6.852

In-Situ Inc. MiniTroll Pro

Report generated: 10/11/04 16:28:35
Report from file: F:\PBOW\slugtest\5-04\mw30f.bin
DataMgr Version 3.71

Serial number: 00008843
Firmware Version 3.09
Unit name:

Test name: mw30f

Test defined on: 05/04/04 14:04:49
Test started on: 05/04/04 14:07:39
Test stopped on: 05/04/04 14:32:24
Test extracted on: N/A

Data gathered using Logarithmic testing
  Maximum time between data points: 10.0000 Minutes.
  Number of data samples: 116

TOTAL DATA SAMPLES 116

Channel number [2]
  Measurement type: Pressure
  Channel name:
  Sensor Range: 30 PSI.
  Specific gravity: 1.000

Date	Time	ET (min)	Chan[2] Feet H2O
05/04/04	14:07:39	0.0000	24.163
05/04/04	14:07:39	0.0050	24.240
05/04/04	14:07:40	0.0100	24.367
05/04/04	14:07:40	0.0150	33.909
05/04/04	14:07:40	0.0200	43.315
05/04/04	14:07:40	0.0250	30.519
05/04/04	14:07:41	0.0300	23.178
05/04/04	14:07:41	0.0350	23.806
05/04/04	14:07:41	0.0400	29.802
05/04/04	14:07:42	0.0450	33.740
05/04/04	14:07:42	0.0500	31.122
05/04/04	14:07:42	0.0550	27.621
05/04/04	14:07:43	0.0600	27.145
05/04/04	14:07:43	0.0650	29.762
05/04/04	14:07:43	0.0700	30.932
05/04/04	14:07:43	0.0750	29.728
05/04/04	14:07:44	0.0800	27.290
05/04/04	14:07:44	0.0848	26.156
05/04/04	14:07:44	0.0900	27.274
05/04/04	14:07:45	0.0950	28.771
05/04/04	14:07:45	0.1000	28.674
05/04/04	14:07:45	0.1058	27.719
05/04/04	14:07:46	0.1120	27.419
05/04/04	14:07:46	0.1185	27.911
05/04/04	14:07:46	0.1255	28.138
05/04/04	14:07:47	0.1328	27.902
05/04/04	14:07:47	0.1407	27.736
05/04/04	14:07:48	0.1490	27.915
05/04/04	14:07:48	0.1578	27.895
05/04/04	14:07:49	0.1670	27.774
05/04/04	14:07:50	0.1770	27.837
05/04/04	14:07:50	0.1875	27.793
05/04/04	14:07:51	0.1985	27.764
05/04/04	14:07:52	0.2102	27.766
05/04/04	14:07:52	0.2227	27.730
05/04/04	14:07:53	0.2358	27.785

05/04/04	14:07:54	0.2498	27.654
05/04/04	14:07:55	0.2647	27.700
05/04/04	14:07:56	0.2803	27.633
05/04/04	14:07:57	0.2970	27.611
05/04/04	14:07:58	0.3147	27.607
05/04/04	14:07:59	0.3333	27.575
05/04/04	14:08:00	0.3532	27.543
05/04/04	14:08:01	0.3742	27.517
05/04/04	14:08:03	0.3963	27.488
05/04/04	14:08:04	0.4198	27.456
05/04/04	14:08:06	0.4447	27.416
05/04/04	14:08:07	0.4697	27.386
05/04/04	14:08:09	0.4963	27.355
05/04/04	14:08:10	0.5247	27.339
05/04/04	14:08:12	0.5547	27.289
05/04/04	14:08:14	0.5863	27.245
05/04/04	14:08:16	0.6213	27.204
05/04/04	14:08:18	0.6578	27.162
05/04/04	14:08:21	0.6963	27.114
05/04/04	14:08:23	0.7380	27.094
05/04/04	14:08:26	0.7813	27.009
05/04/04	14:08:29	0.8280	26.971
05/04/04	14:08:31	0.8763	26.919
05/04/04	14:08:35	0.9280	26.864
05/04/04	14:08:38	0.9830	26.808
05/04/04	14:08:41	1.0413	26.749
05/04/04	14:08:45	1.1030	26.689
05/04/04	14:08:49	1.1680	26.626
05/04/04	14:08:53	1.2380	26.562
05/04/04	14:08:58	1.3113	26.493
05/04/04	14:09:02	1.3897	26.423
05/04/04	14:09:07	1.4730	26.352
05/04/04	14:09:13	1.5613	26.280
05/04/04	14:09:18	1.6547	26.205
05/04/04	14:09:24	1.7530	26.129
05/04/04	14:09:30	1.8580	26.048
05/04/04	14:09:37	1.9680	25.972
05/04/04	14:09:44	2.0847	25.893
05/04/04	14:09:51	2.2097	25.809
05/04/04	14:09:59	2.3412	25.726
05/04/04	14:10:08	2.4813	25.639
05/04/04	14:10:17	2.6297	25.559
05/04/04	14:10:26	2.7863	25.474
05/04/04	14:10:36	2.9530	25.390
05/04/04	14:10:47	3.1297	25.305
05/04/04	14:10:58	3.3163	25.224
05/04/04	14:11:10	3.5147	25.142
05/04/04	14:11:22	3.7247	25.065
05/04/04	14:11:36	3.9463	24.989
05/04/04	14:11:50	4.1813	24.910
05/04/04	14:12:05	4.4295	24.839
05/04/04	14:12:20	4.6930	24.771
05/04/04	14:12:37	4.9730	24.704
05/04/04	14:12:55	5.2697	24.646
05/04/04	14:13:14	5.5830	24.590
05/04/04	14:13:34	5.9147	24.539
05/04/04	14:13:55	6.2663	24.489
05/04/04	14:14:17	6.6397	24.449
05/04/04	14:14:41	7.0347	24.406
05/04/04	14:15:06	7.4530	24.370
05/04/04	14:15:33	7.8963	24.344
05/04/04	14:16:01	8.3663	24.316
05/04/04	14:16:31	8.8647	24.295
05/04/04	14:17:02	9.3913	24.275
05/04/04	14:17:36	9.9497	24.259
05/04/04	14:18:11	10.5413	24.243
05/04/04	14:18:49	11.1680	24.231
05/04/04	14:19:29	11.8313	24.223
05/04/04	14:20:11	12.5347	24.219
05/04/04	14:20:56	13.2797	24.207

05/04/04	14:21:43	14.0697	24.204
05/04/04	14:22:33	14.9063	24.196
05/04/04	14:23:26	15.7913	24.192
05/04/04	14:24:23	16.7297	24.190
05/04/04	14:25:22	17.7230	24.186
05/04/04	14:26:25	18.7763	24.190
05/04/04	14:27:32	19.8913	24.182
05/04/04	14:28:43	21.0730	24.180
05/04/04	14:29:58	22.3247	24.176
05/04/04	14:31:18	23.6497	24.179

In-Situ Inc. MiniTroll Pro

Report generated: 10/11/04 16:28:43
Report from file: F:\PBOW\slugtest\5-04\mw30r.bin
DataMgr Version 3.71

Serial number: 00008843
Firmware Version 3.09
Unit name:

Test name: mw30r

Test defined on: 05/04/04 14:05:14
Test started on: 05/04/04 14:34:01
Test stopped on: 05/04/04 14:52:13
Test extracted on: N/A

Data gathered using Logarithmic testing
  Maximum time between data points: 10.0000 Minutes.
  Number of data samples: 111

TOTAL DATA SAMPLES 111

Channel number [2]
  Measurement type: Pressure
  Channel name:
  Sensor Range: 30 PSI.
  Specific gravity: 1.000
  Mode: TOC
  User-defined reference: 6.860 Feet H2O
  Referenced on: test start
  Pressure head at reference: 14.758 Feet H2O

Date	Time	ET (min)	Chan[2] Feet H2O
05/04/04	14:34:01	0.0000	6.860
05/04/04	14:34:02	0.0050	6.199
05/04/04	14:34:02	0.0100	4.293
05/04/04	14:34:02	0.0150	0.974
05/04/04	14:34:03	0.0200	-0.929
05/04/04	14:34:03	0.0250	1.365
05/04/04	14:34:03	0.0300	3.085
05/04/04	14:34:03	0.0350	2.031
05/04/04	14:34:04	0.0400	0.325
05/04/04	14:34:04	0.0450	0.859
05/04/04	14:34:04	0.0500	2.077
05/04/04	14:34:05	0.0550	1.988
05/04/04	14:34:05	0.0600	1.029
05/04/04	14:34:05	0.0650	0.912
05/04/04	14:34:06	0.0700	1.547
05/04/04	14:34:06	0.0750	1.710
05/04/04	14:34:06	0.0800	1.261
05/04/04	14:34:06	0.0848	1.069
05/04/04	14:34:07	0.0900	1.337
05/04/04	14:34:07	0.0950	1.492
05/04/04	14:34:07	0.1000	1.307
05/04/04	14:34:08	0.1058	1.152
05/04/04	14:34:08	0.1120	1.301
05/04/04	14:34:08	0.1185	1.321
05/04/04	14:34:09	0.1255	1.190
05/04/04	14:34:09	0.1328	1.239
05/04/04	14:34:10	0.1407	1.239
05/04/04	14:34:10	0.1490	1.178
05/04/04	14:34:11	0.1578	1.206
05/04/04	14:34:11	0.1670	1.166
05/04/04	14:34:12	0.1770	1.170
05/04/04	14:34:13	0.1875	1.147
05/04/04	14:34:13	0.1985	1.139

05/04/04	14:34:14	0.2102	1.117
05/04/04	14:34:15	0.2227	1.105
05/04/04	14:34:16	0.2358	1.083
05/04/04	14:34:16	0.2498	1.069
05/04/04	14:34:17	0.2647	1.032
05/04/04	14:34:18	0.2803	1.018
05/04/04	14:34:19	0.2970	1.000
05/04/04	14:34:20	0.3147	0.972
05/04/04	14:34:21	0.3333	0.949
05/04/04	14:34:23	0.3532	0.923
05/04/04	14:34:24	0.3742	0.895
05/04/04	14:34:25	0.3963	0.871
05/04/04	14:34:27	0.4198	0.843
05/04/04	14:34:28	0.4447	0.814
05/04/04	14:34:30	0.4697	0.784
05/04/04	14:34:31	0.4963	0.754
05/04/04	14:34:33	0.5247	0.722
05/04/04	14:34:35	0.5547	0.685
05/04/04	14:34:37	0.5863	0.653
05/04/04	14:34:39	0.6213	0.613
05/04/04	14:34:41	0.6578	0.575
05/04/04	14:34:43	0.6963	0.532
05/04/04	14:34:46	0.7380	0.490
05/04/04	14:34:48	0.7813	0.439
05/04/04	14:34:51	0.8280	0.391
05/04/04	14:34:54	0.8763	0.337
05/04/04	14:34:57	0.9280	0.292
05/04/04	14:35:00	0.9830	0.238
05/04/04	14:35:04	1.0413	0.185
05/04/04	14:35:08	1.1030	0.131
05/04/04	14:35:11	1.1680	0.074
05/04/04	14:35:16	1.2380	0.014
05/04/04	14:35:20	1.3113	-0.047
05/04/04	14:35:25	1.3897	-0.109
05/04/04	14:35:30	1.4730	-0.172
05/04/04	14:35:35	1.5613	-0.240
05/04/04	14:35:41	1.6547	-0.311
05/04/04	14:35:47	1.7530	-0.379
05/04/04	14:35:53	1.8580	-0.456
05/04/04	14:35:59	1.9680	-0.531
05/04/04	14:36:06	2.0847	-0.603
05/04/04	14:36:14	2.2097	-0.688
05/04/04	14:36:22	2.3412	-0.767
05/04/04	14:36:30	2.4813	-0.845
05/04/04	14:36:39	2.6297	-0.924
05/04/04	14:36:49	2.7863	-1.008
05/04/04	14:36:59	2.9530	-1.089
05/04/04	14:37:09	3.1297	-1.174
05/04/04	14:37:20	3.3163	-1.256
05/04/04	14:37:32	3.5147	-1.337
05/04/04	14:37:45	3.7247	-1.424
05/04/04	14:37:58	3.9463	-1.505
05/04/04	14:38:12	4.1813	-1.579
05/04/04	14:38:27	4.4295	-1.662
05/04/04	14:38:43	4.6930	-1.734
05/04/04	14:39:00	4.9730	-1.809
05/04/04	14:39:18	5.2697	-1.879
05/04/04	14:39:36	5.5830	-1.946
05/04/04	14:39:56	5.9147	-2.008
05/04/04	14:40:17	6.2663	-2.069
05/04/04	14:40:40	6.6397	-2.125
05/04/04	14:41:03	7.0347	-2.176
05/04/04	14:41:29	7.4530	-2.224
05/04/04	14:41:55	7.8963	-2.268
05/04/04	14:42:23	8.3663	-2.307
05/04/04	14:42:53	8.8647	-2.341
05/04/04	14:43:25	9.3913	-2.371
05/04/04	14:43:58	9.9497	-2.403
05/04/04	14:44:34	10.5413	-2.422
05/04/04	14:45:11	11.1680	-2.446
05/04/04	14:45:51	11.8313	-2.462

)5/04/04	14:46:33	12.5347	-2.474
)5/04/04	14:47:18	13.2797	-2.482
)5/04/04	14:48:06	14.0697	-2.496
)5/04/04	14:48:56	14.9063	-2.506
)5/04/04	14:49:49	15.7913	-2.508
)5/04/04	14:50:45	16.7297	-2.512
)5/04/04	14:51:45	17.7230	-2.514

In-Situ Inc. MiniTroll Pro

Report generated: 10/11/04 16:28:51
Report from file: F:\PBOW\slugtest\5-04\mw33r.bin
DataMgr Version 3.71

Serial number: 00010089
Firmware Version 3.09
Unit name:

Test name: mw33r

Test defined on: 05/04/04 10:29:37
Test started on: 05/04/04 17:12:04
Test stopped on: 05/04/04 17:24:41
Test extracted on: N/A

Data gathered using Logarithmic testing
  Maximum time between data points: 10.0000 Minutes.
  Number of data samples: 105

TOTAL DATA SAMPLES 105

Channel number [2]
  Measurement type: Pressure
  Channel name:
  Sensor Range: 30 PSI.
  Specific gravity: 1.000
  Mode: TOC
  User-defined reference: 0.000 Feet H2O
  Referenced on: channel definition.
  Pressure head at reference: 8.648 Feet H2O

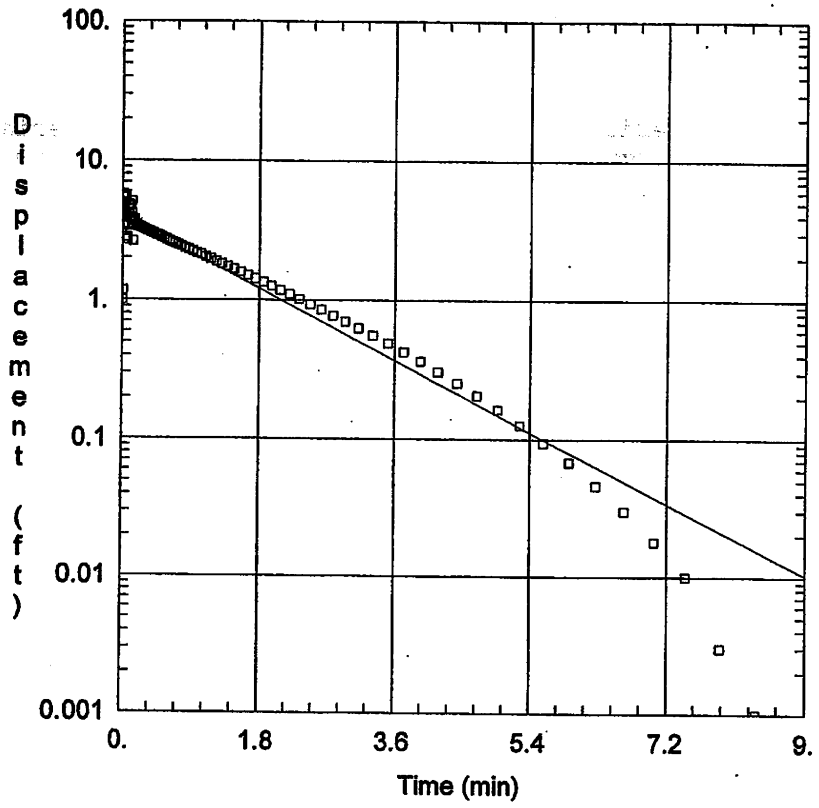
Date	Time	ET (min)	Chan[2] Feet H2O
05/04/04	17:12:04	0.0000	1.735
05/04/04	17:12:04	0.0050	1.592
05/04/04	17:12:04	0.0100	-1.956
05/04/04	17:12:04	0.0150	2.607
05/04/04	17:12:05	0.0200	0.050
05/04/04	17:12:05	0.0250	0.432
05/04/04	17:12:05	0.0300	1.376
05/04/04	17:12:06	0.0350	0.028
05/04/04	17:12:06	0.0400	0.891
05/04/04	17:12:06	0.0450	0.686
05/04/04	17:12:07	0.0500	0.465
05/04/04	17:12:07	0.0550	0.823
05/04/04	17:12:07	0.0600	0.509
05/04/04	17:12:07	0.0650	0.640
05/04/04	17:12:08	0.0700	0.633
05/04/04	17:12:08	0.0750	0.560
05/04/04	17:12:08	0.0800	0.635
05/04/04	17:12:09	0.0848	0.573
05/04/04	17:12:09	0.0900	0.589
05/04/04	17:12:09	0.0950	0.565
05/04/04	17:12:10	0.1000	0.589
05/04/04	17:12:10	0.1058	0.562
05/04/04	17:12:10	0.1120	0.565
05/04/04	17:12:11	0.1185	0.538
05/04/04	17:12:11	0.1255	0.536
05/04/04	17:12:12	0.1328	0.520
05/04/04	17:12:12	0.1407	0.547
05/04/04	17:12:12	0.1490	0.518
05/04/04	17:12:13	0.1578	0.479
05/04/04	17:12:14	0.1670	0.496
05/04/04	17:12:14	0.1770	0.534
05/04/04	17:12:15	0.1875	0.512

05/04/04	17:12:15	0.1985	0.514
05/04/04	17:12:16	0.2102	0.474
05/04/04	17:12:17	0.2227	0.527
05/04/04	17:12:18	0.2358	0.489
05/04/04	17:12:19	0.2498	0.545
05/04/04	17:12:19	0.2647	0.988
05/04/04	17:12:20	0.2803	0.847
05/04/04	17:12:21	0.2970	0.725
05/04/04	17:12:22	0.3147	0.655
05/04/04	17:12:24	0.3333	0.599
05/04/04	17:12:25	0.3532	0.483
05/04/04	17:12:26	0.3742	0.313
05/04/04	17:12:27	0.3963	0.333
05/04/04	17:12:29	0.4198	0.288
05/04/04	17:12:30	0.4447	0.260
05/04/04	17:12:32	0.4697	0.249
05/04/04	17:12:33	0.4963	0.238
05/04/04	17:12:35	0.5247	0.224
05/04/04	17:12:37	0.5547	0.187
05/04/04	17:12:39	0.5863	0.163
05/04/04	17:12:41	0.6213	0.143
05/04/04	17:12:43	0.6578	0.077
05/04/04	17:12:45	0.6963	0.081
05/04/04	17:12:48	0.7380	0.162
05/04/04	17:12:50	0.7813	0.061
05/04/04	17:12:53	0.8280	0.048
05/04/04	17:12:56	0.8763	-0.120
05/04/04	17:12:59	0.9280	0.116
05/04/04	17:13:03	0.9830	0.045
05/04/04	17:13:06	1.0413	-0.032
05/04/04	17:13:10	1.1030	-0.080
05/04/04	17:13:14	1.1680	-0.118
05/04/04	17:13:18	1.2380	-0.138
05/04/04	17:13:22	1.3113	-0.155
05/04/04	17:13:27	1.3897	-0.175
05/04/04	17:13:32	1.4730	-0.195
05/04/04	17:13:37	1.5613	-0.213
05/04/04	17:13:43	1.6547	-0.230
05/04/04	17:13:49	1.7530	-0.248
05/04/04	17:13:55	1.8580	-0.264
05/04/04	17:14:02	1.9680	-0.277
05/04/04	17:14:09	2.0847	-0.292
05/04/04	17:14:16	2.2097	-0.303
05/04/04	17:14:24	2.3412	-0.314
05/04/04	17:14:32	2.4813	-0.325
05/04/04	17:14:41	2.6297	-0.334
05/04/04	17:14:51	2.7863	-0.341
05/04/04	17:15:01	2.9530	-0.350
05/04/04	17:15:11	3.1297	-0.359
05/04/04	17:15:23	3.3163	-0.363
05/04/04	17:15:34	3.5147	-0.370
05/04/04	17:15:47	3.7247	-0.374
05/04/04	17:16:00	3.9463	-0.381
05/04/04	17:16:14	4.1813	-0.383
05/04/04	17:16:29	4.4295	-0.389
05/04/04	17:16:45	4.6930	-0.392
05/04/04	17:17:02	4.9730	-0.383
05/04/04	17:17:20	5.2697	-0.405
05/04/04	17:17:39	5.5830	-0.407
05/04/04	17:17:58	5.9147	-0.411
05/04/04	17:18:20	6.2663	-0.414
05/04/04	17:18:42	6.6397	-0.416
05/04/04	17:19:06	7.0347	-0.420
05/04/04	17:19:31	7.4530	-0.420
05/04/04	17:19:57	7.8963	-0.425
05/04/04	17:20:26	8.3663	-0.427
05/04/04	17:20:55	8.8647	-0.429
05/04/04	17:21:27	9.3913	-0.434
05/04/04	17:22:01	9.9497	-0.436
05/04/04	17:22:36	10.5413	-0.436

05/04/04	17:23:14	11.1680	-0.438
05/04/04	17:23:53	11.8313	-0.440
05/04/04	17:24:36	12.5347	-0.442

ATTACHMENT 2

TIME VERSUS WELL RECOVERY GRAPHS



FALLING TEST ANALYSIS

Data Set: F:\PBOW\slugtest\5-04\mw28f.aqt
Date: 10/11/04 Time: 14:36:50

PROJECT INFORMATION

Company: Shaw E&I
Client: USACE
Project: 843656 04000000
Test Location: PBOW, Sandusky, OH
Test Well: PB-BED-MW28
Test Date: 5/4/04

AQUIFER DATA

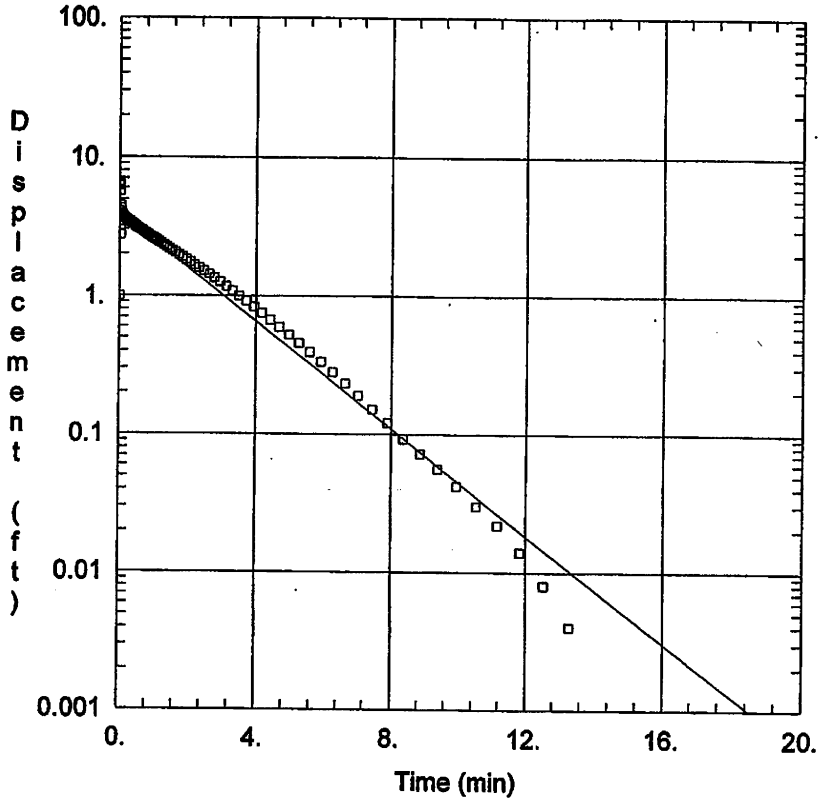
Saturated Thickness: 35.03 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-28)

Initial Displacement: 1. ft
Wellbore Radius: 0.25 ft
Screen Length: 15. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 35.03 ft

SOLUTION

Aquifer Model: Unconfined
K = 0.0005183 ft/min
Solution Method: Bouwer-Rice
y0 = 3.984 ft



RISING TEST ANALYSIS

Data Set: F:\PBOW\slugtest\5-04\mw28r.aqt
Date: 10/11/04 Time: 14:38:07

PROJECT INFORMATION

Company: Shaw E&I
Client: USACE
Project: 843656 04000000
Test Location: PBOW, Sandusky, OH
Test Well: PB-BED-MW28
Test Date: 5/4/04

AQUIFER DATA

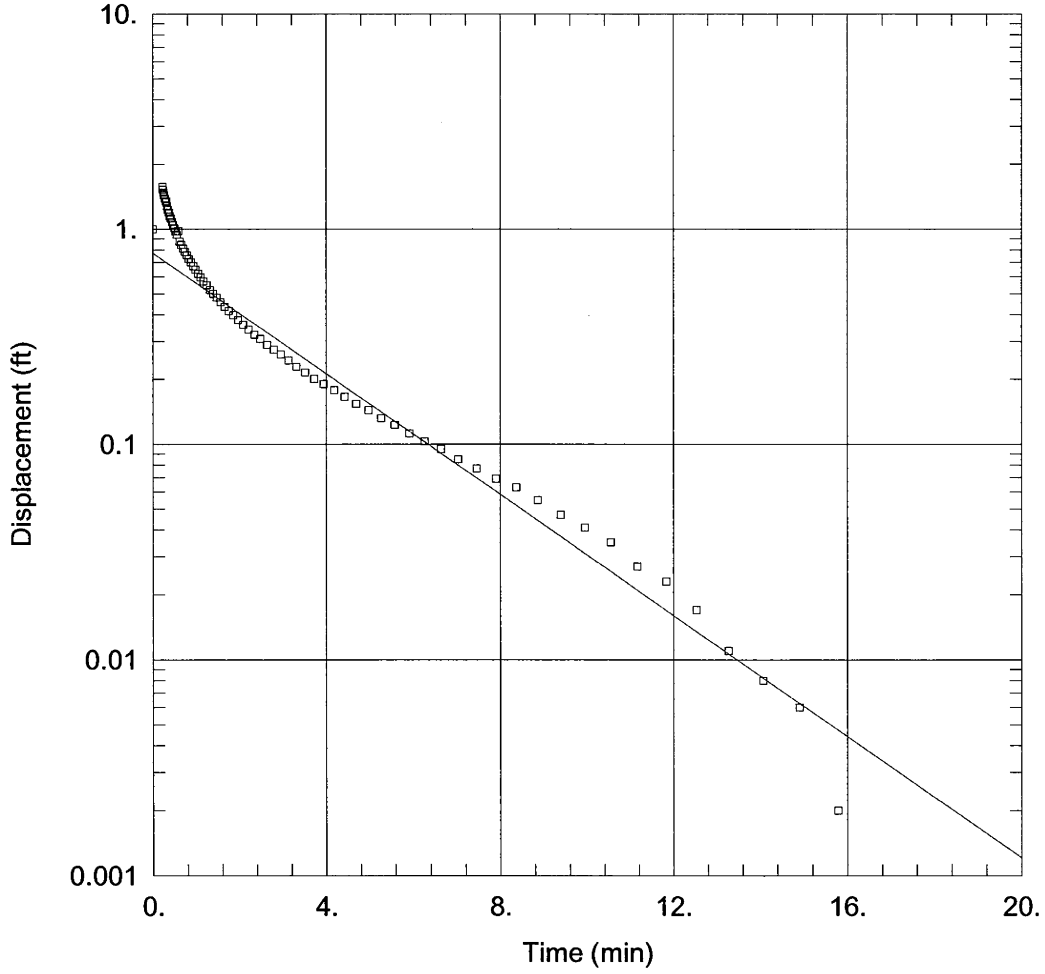
Saturated Thickness: 35.03 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-28)

Initial Displacement: 1. ft
Wellbore Radius: 0.25 ft
Screen Length: 15. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 35.03 ft

SOLUTION

Aquifer Model: Unconfined
K = 0.0003502 ft/min
Solution Method: Bouwer-Rice
y0 = 3.899 ft



FALLING TEST ANALYSIS

Data Set: C:\Documents and Settings\jing.li\My Documents\Projects\PBOW\slugtest\5-04\mw29f.aqt
Date: 03/08/05 Time: 07:46:09

PROJECT INFORMATION

Company: Shaw E&I
Client: USACE
Project: 843656 04000000
Location: PBOW, Sandusky, OH
Test Well: PB-BED-MW29
Test Date: 5/4/04

AQUIFER DATA

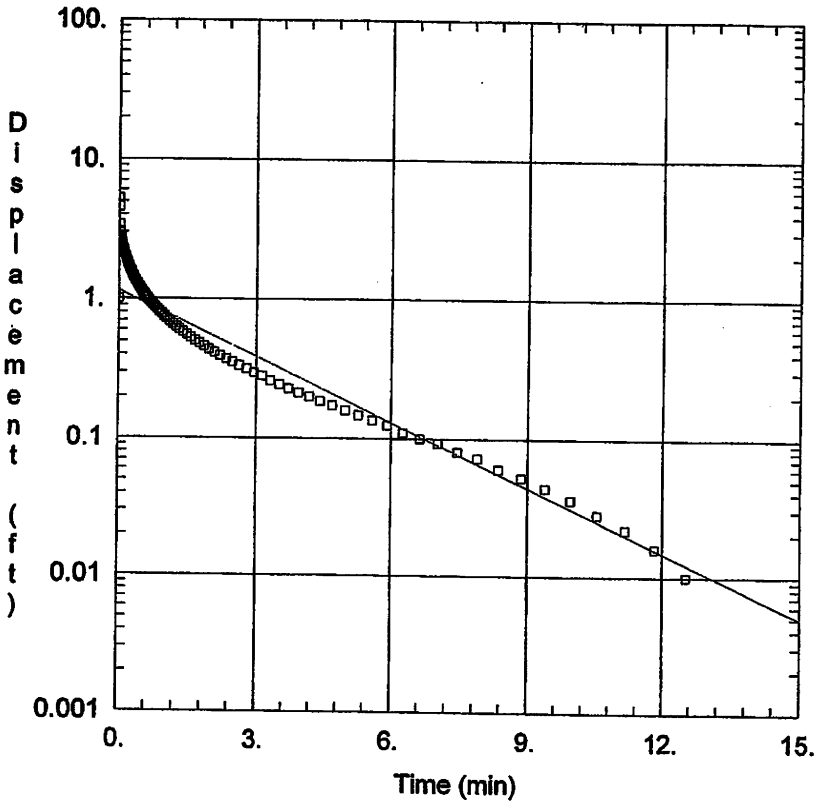
Saturated Thickness: 35.24 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-29)

Initial Displacement: 1. ft
Total Well Penetration Depth: 35.24 ft
Casing Radius: 0.08 ft
Static Water Column Height: 35.24 ft
Screen Length: 10. ft
Wellbore Radius: 0.25 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 0.0003693 ft/min
y0 = 0.7719 ft



RISING TEST ANALYSIS

)ata Set: F:\PBOW\slugtest\5-04\mw29r.aqt
)ate: 10/11/04 Time: 14:41:51

PROJECT INFORMATION

:ompany: Shaw E&I
:lient: USACE
'roject: 843656 04000000
est Location: PBOW, Sandusky, OH
est Well: PB-BED-MW29
est Date: 5/4/04

AQUIFER DATA

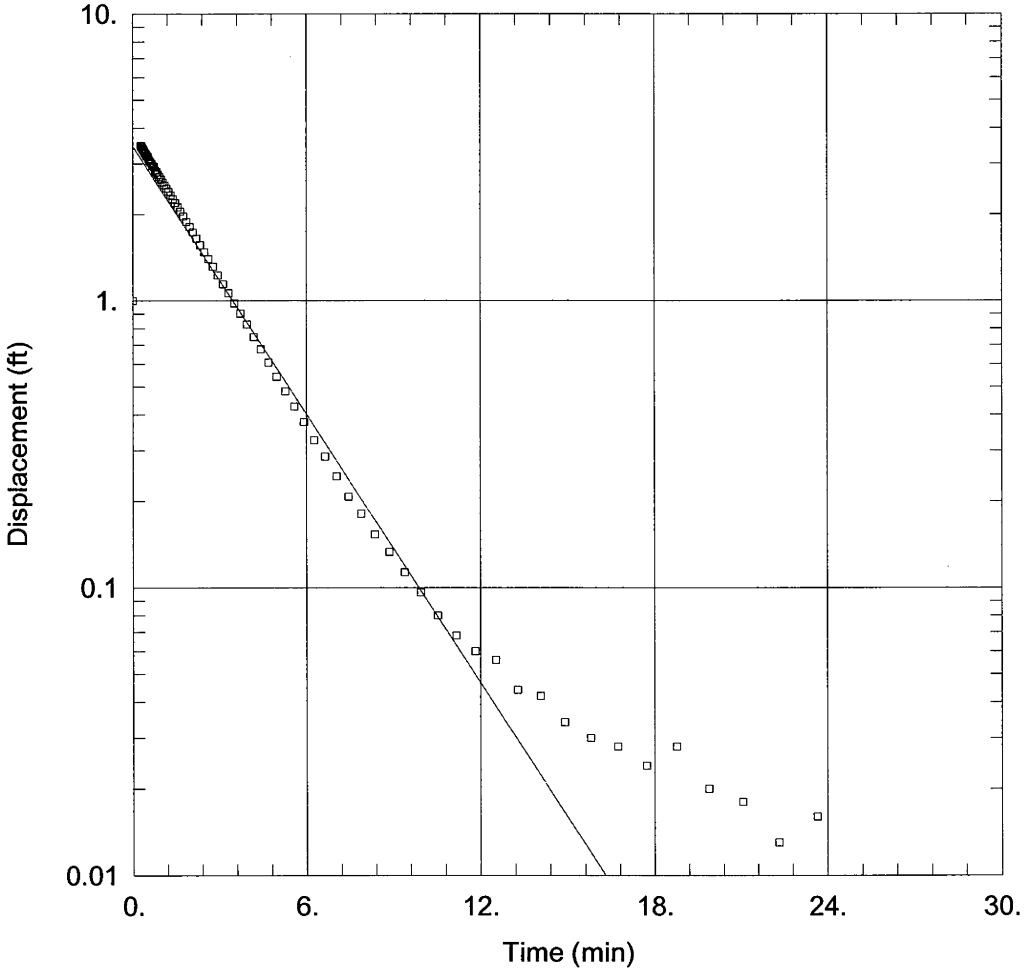
aturated Thickness: 35.24 ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-29)

ıitial Displacement: 1. ft
Vellbore Radius: 0.25 ft
creen Length: 10. ft
ravel Pack Porosity: 0.3
Casing Radius: 0.08 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 35.24 ft

SOLUTION

quifer Model: Unconfined
= 0.0004142 ft/min
Solution Method: Bouwer-Rice
y0 = 1.139 ft



FALLING TEST ANALYSIS

Data Set: C:\Documents and Settings\jing.li\My Documents\Projects\PBOW\slugtest\5-04\mw30f.aqt
Date: 03/08/05 Time: 07:46:22

PROJECT INFORMATION

Company: Shaw E&I
Client: USACE
Project: 843656 04000000
Location: PBOW, Sandusky, OH
Test Well: PB-BED-MW30
Test Date: 5/4/04

AQUIFER DATA

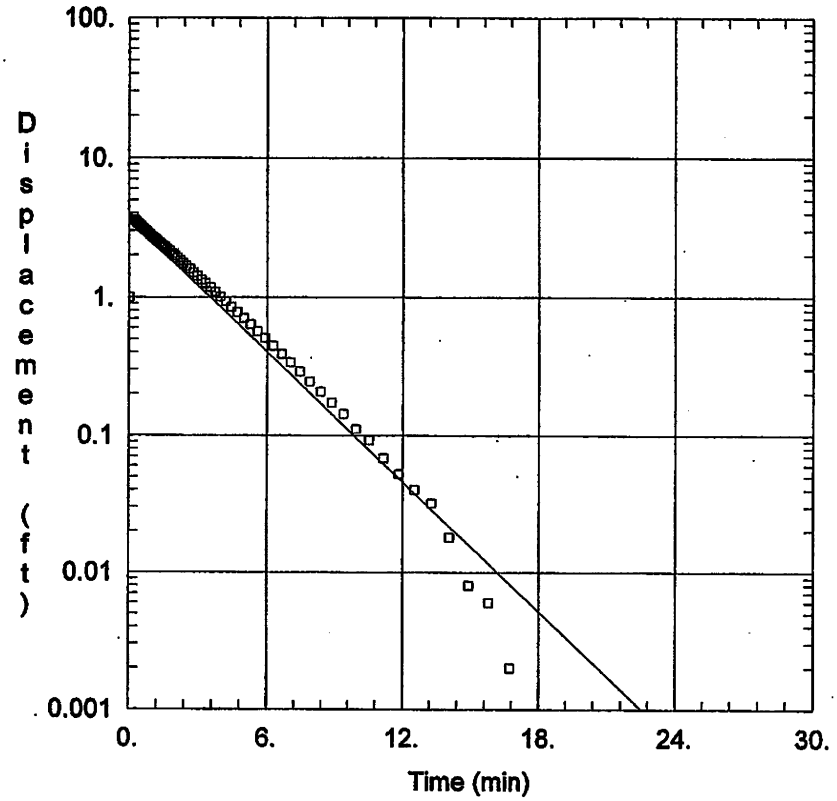
Saturated Thickness: 27.93 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-30)

Initial Displacement: 1. ft
Total Well Penetration Depth: 27.93 ft
Casing Radius: 0.08 ft
Static Water Column Height: 27.93 ft
Screen Length: 15. ft
Wellbore Radius: 0.25 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 0.0002702 ft/min
y0 = 3.45 ft



RISING TEST ANALYSIS

Data Set: F:\PBOW\slugtest\5-04\mw30r.aqt
Date: 10/11/04 Time: 14:33:57

PROJECT INFORMATION

Company: Shaw E&I
Client: USACE
Project: 843656 04000000
Test Location: PBOW, Sandusky, OH
Test Well: PB-BED-MW30
Test Date: 5/4/04

AQUIFER DATA

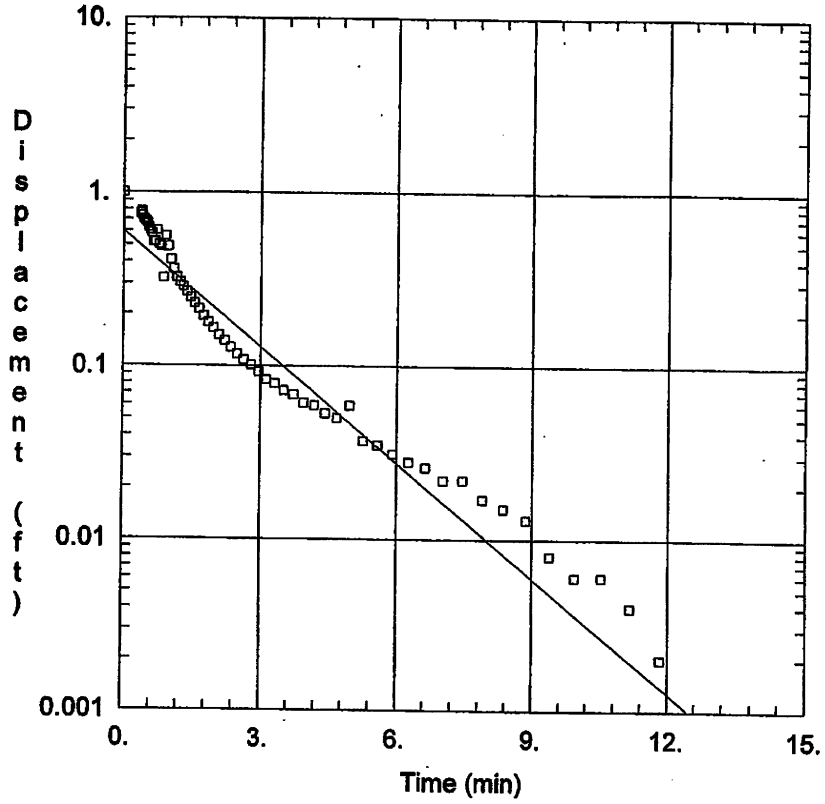
Saturated Thickness: 27.93 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-30)

Initial Displacement: 1. ft
Wellbore Radius: 0.25 ft
Screen Length: 15. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 27.93 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 0.0002736 ft/min
y0 = 3.549 ft



RISING TEST ANALYSIS

Data Set: F:\PBOW\slugtest\5-04\mw33r.aqt
Date: 10/11/04 Time: 14:36:09

PROJECT INFORMATION

Company: Shaw E&I
Client: USACE
Project: 843656 04000000
Test Location: PBOW, Sandusky, OH
Test Well: PB-BED-MW33
Test Date: 5/4/04

AQUIFER DATA

Saturated Thickness: 9.61 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-33)

Initial Displacement: 1. ft
Wellbore Radius: 0.25 ft
Screen Length: 20. ft
Gravel Pack Porosity: 0.3
Casing Radius: 0.08 ft
Well Skin Radius: 0.25 ft
Total Well Penetration Depth: 9.61 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
= 0.0008572 ft/min
y0 = 0.5954 ft

APPENDIX F

LAND SURVEY DATA

FINAL REPORT
of
SURVEYING SERVICES PERFORMED
by
MURPHY & SACKS SURVEYORS / KUSMER & ASSOCIATES J.V.
at the
PLUMBROOK ORDNANCE WORKS, SANDUSKY, OH
for
SHAW E & I (CONTRACT #DACA62-00-D-0002)
AUGUST, 2003 (REVISED 10 MAY, 2004)

SUMMARY OF WORK PERFORMED

1ST Mobilization: Murphy & Sacks Surveyors, in joint venture with Kusmer & Associates, Inc., located 7 background soil sample locations and 2 monitoring well locations within or near the Plumbrook Ordnance Works site. One additional existing monitoring well was re-located at the request of Shaw E&I. Work was performed on-site between 11 August, 2003 and 13 August, 2003 in accordance with Shaw E & I R.F.P. 2003-013 under purchase order #218436 OP in support of Shaw E & I contract DACA62-00-D0002.

2nd Mobilization: An additional 5 monitoring well locations were located during a second deployment to this site between the 26th and 28th of April, 2004. Wells located during said deployment are designated MW-30 through MW-34.

KEY PERSONNEL

W. Robert Kusmer – Ohio Land Surveyor S-6754
Stanley Robert Sacks – North Carolina Surveyor L-2913
Michael A. McKibbin – Murphy & Sacks Hazmat Project Manager
Dan Baynes – On-site Party Chief *
Robert Murphy – Survey Technician *
* all on-site personnel for this project are OSHA 29 Part 1910 40 trained and medically monitored in accordance with Shaw E & I requirements.

FIELD PROCEDURES

Due to the widely scattered nature of the sample locations and the fact that many were located outside of the perimeter of the Plum Brook facility, all sample point and monitoring well locations were obtained by direct static differential GPS observation using three Ashtech Promark III GPS receivers. GPS vectors were adjusted holding fixed station "Clark" using Ashtech post-processing software, producing a least squares adjustment of the WGS 84 positions. A loop using the unadjusted vectors passing the fixed and derived control positions yields a loop precision exceeding 1 part in 100,000. Horizontal and vertical values of Murphy and Sacks control station "Clark" were derived by GPS survey in 1996 from NGS Monuments "Skyway RM 2" and "J-318" (a first order benchmark). Horizontal datum is NAD 83. Vertical datum is NGVD 29. Values were scaled to the Ohio State Plane Coordinate System (North Zone) using a combined scale and ellipsoid factor of 0.9999270034. Values for Murphy & Sacks monument "Clark" are:

Northing (y) 191,029.0899 m
Easting (x) 585,910.9777 m
Ellipsoid Elevation 155.4353 m
Geoid Height -35.1900 m (Geoid 99)

SAMPLE LOCATIONS

Background Soil Sampling Locations (August, 2003)

M&S ID#	Northing (y)	Easting (x)	Ground Elev.	Shaw Designation
SB-07	610,726.99	1,923,542.80	672.84	PBOW-BCG-SB07
SB-08	608,692.03	1,927,935.73	658.70	PBOW-BCG-SB08
SB-09	617,798.34	1,914,534.61	683.69	PBOW-BCG-SB09
SB-10	615,556.41	1,904,177.06	652.47	PBOW-BCG-SB10
SB-11	612,234.68	1,905,930.72	698.76	PBOW-BCG-SB11
SB-12	599,786.85	1,920,737.89	688.85	PBOW-BCG-SB12
SB-13	611,297.92	1,914,322.93	706.06	PBOW-BCG-SB13

Monitoring Well Locations (August, 2003)

M&S ID#	Northing (y)	Easting (x)	Ground / Riser Elev.	Shaw Designation
MW-17	618,572.39	1,917,812.81	661.15 / 664.51	MK-MW 17
MW-28	610,536.42	1,923,306.40	670.99 / 670.83	PB-BED-MW28
MW-29	616,832.04	1,913,519.80	678.50 / 678.30	PB-BED-MW29

Monitoring Well Locations (April, 2004)

M&S ID#	Northing (y)	Easting (x)	Ground / Riser Elev.	Shaw Designation
MW-30	623,091.78	1,907,134.63	647.25 / 646.87	PB-BED-MW30
MW-31	626,721.75	1,910,435.87	632.90 / ***	PB-BED-MW31
MW-32	630,607.25	1,920,393.20	627.76 / ***	PB-BED-MW32
MW-33	631,564.04	1,921,870.27	619.87 / 619.74	PB-BED-MW33
MW-34	628,322.03	1,924,720.88	621.00 / ***	PB-BED-MW34

*** = No riser present at well location

CERTIFICATION

I, Warren Robert Kusmer, Ohio Professional Surveyor #S-6754, hereby certify that the information in this survey report is true to the best of my knowledge and belief.

W Robert Kusmer

Warren Robert Kusmer,
Ohio Professional Surveyor #S-6754

June 2, 2004

Date

LAUNDON • SIMON • KELSER & ASSOC., INC.

ALEX KELSER
REGISTERED LAND SURVEYOR NO. 7871
110 Middle Ave., Elyria, Oh. 44035
Tel.:(440) 322-7625 Fax:(440) 323-4242
e-mail: lsksurvey@yahoo.com

PT-5912

August 30, 2004

Shaw Environmental, Inc.
312 Directors Drive
Knoxville, TN 37923-4799

ATTN: MR. DAVID KESSLER,
GEOLOGIST

In Re: Purchase Order No. 49730
Monitoring Well - Patten Tract, Sandusky, OH.

Dear Mr. Kessler:

It was a pleasure meeting you last Tuesday, August 24, 2004. Per our contract I present the following final data report:

Top Monitoring Well . . . . . .636.22'

Ground @ Well (right below top shot) . . . . . 634.81'

It has been a pleasure working with you on this project. I trust everything has been handled to your satisfaction. Enclosed please find a copy of our invoice, of which we have mailed the original to Mr. Greg Massingale.

Sincerely,

Alex Kelser, P.S. #7871

STATE OF OHIO
ALEX KELSER S-7871
REGISTERED PROFESSIONAL SURVEYOR

AK/gap

Enc.

APPENDIX G

IDW WASTE MANIFESTS
(August 2003 – August 2004)

PB-BED-MW28/MW29 Installation GW/Rock Cuttings Disposal 9/2/03

WASTE MANAGEMENT DIVISION
MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY

DO NOT WRITE IN THIS SPACE
ATT. ☐ DIS. ☐ REJ. ☐ PR. ☐

Required under authority of Part 111 and Part 121 of Act 451, 1994, as amended.

Failure to file may subject you to criminal and/or civil penalties under Sections 324.11151 or 324.12116 MCL.

Please print or type.

Form Approved. OMB No. 2050-0039

UNIFORM HAZARDOUS WASTE MANIFEST

1. Generator's US EPA ID No. OH3800015379 | Manifest Document No. 1023 | 2. Page 1 of | Information in the shaded areas is not required by Federal law.

3. Generator's Name and Mailing Address
USACE-Huntington District
502 8th St., Huntington, WV 25701
Attn: Lisa Humphrey
Site: Usace
6100 Columbus Ave.
Sandusky, OH 44870

4. Generator's Phone (304-) 399-5953

A. State Manifest Document Number: MI 7482640

B. State Generator's ID:

5. Transporter 1 Company Name: Page Transportation
6. US EPA ID Number: NYD986969947
C. State Transporter's ID:
D. Transporter's Phone: 800-331-3177

7. Transporter 2 Company Name:
8. US EPA ID Number:
E. State Transporter's ID:
F. Transporter's Phone:

9. Designated Facility Name and Site Address
US Liquids of Detroit
1923 Frederick St.
Detroit, MI 48211
10. US EPA ID Number: MID980991566
G. State Facility's ID:
H. Facility's Phone: 313-923-0080

	11. US DOT Description (including Proper Shipping Name, Hazard Class, and ID NUMBER). HM	12. Containers No.	Type	13. Total Quantity	14. Unit Wt/Vol	I. Waste No.
a.	Non-RCRA Regulated Waste, Michigan Regulated Liquid Waste	15	DM	825	G	0251
b.	Non-Hazardous Solid Waste	6	DM	330	G	
c.						
d.						

J. Additional Descriptions for Materials Listed Above
Approval #11a) 2485L
Approval #11b) 2486L

15. Special Handling Instructions and Additional Information
EMERG No. 419-334-5060
Water

16. GENERATOR'S CERTIFICATION: I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked, and labeled, and are in all respects in proper condition for transport by highway according to applicable international and national government regulations. If I am a large quantity generator, I certify that I have a program in place to reduce the volume and toxicity of waste generated to the degree I have determined to be economically practicable and that I have selected the practicable method of treatment, storage, or disposal currently available to me which minimizes the present and future threat to human health and the environment; OR; if I am a small quantity generator, I have made a good faith effort to minimize my waste generation and select the best waste management method that is available to me and that I can afford.

	Printed/Typed Name	Signature	Date (Month Day Year)
GENERATOR	Steven L. Thomson		09 02 03
17. Transporter 1 Acknowledgement of Receipt of Materials	Clint Weaver		09 02 03
18. Transporter 2 Acknowledgement of Receipt of Materials			
19. Discrepancy Indication Space			
20. Facility Owner or Operator: Certification of receipt of hazardous materials covered by this manifest except as noted in Item 19.			

TRANSPORTER

FACILITY

800-424-8802 24 HOURS PER DAY.

OHIO EPA

State of Ohio Environmental Protection Agency
Northwest District Office
347 North Dunbridge Road
Bowling Green, Ohio 43402

OHIO EPA ONSITE OBSERVATION LOG

SITE: NASA PLUMBROOK

DATE: 08/12/03

TIME: 09:26

County: Erie
Facility: NASA PLUMBROOK
File: [redacted] DERR

SUMMARY: Per Dave Kessler's phone call on 08/11/03 → bkg bedrock wells in (BED (MW-28) CBED MW-29) 6 10' core boxes full and need to be removed as IDW. Holes are clean - use for specimens @ NWDO → check well constructions.

- bogart-latten Tract - Taylor - Scheid
- development @ BED - MW29
- Removed 6 core boxes from BED MW28 MW29 (bkg locations)

SIGNATURE: John Wlar

Soil/Water Disposal
Downgradient Well Installation

Evergreen RDF
A Waste Management Company Soil/GW at Evergreen Landfill

TICKET: 758130
DATE: 04/02/2004
TIME: 14:37 - 15:31

CUSTOMER: 9371261 / MASTERCARD/VISA CUSTOMERS
GENERATOR: / USACE
COUNTY: 087 / WOOD
TRUCK: SHAW
ROUTE: NA / Non App
COMMENT:

PROF #: S92215
CUYDS: 25
MANIFEST: NO #

P.O.:
GROSS: 27920 LBS
TARE: 17060 LBS
NET: 10860 LBS

COMMODITY	UNIT	QNTY	RATE	PRETAX	TAX	TAX AMOUNT
101 / SOLIDIFICATION DRUM U		22.00			0.00	0.00
20 / 2003 SW STATE FEE IN T		5.43			0.00	0.00
				$ 0.00	$ 0.00	$

IN OPERATOR: THERESA
OUT OPERATOR: THERESA

DRIVER:

THIS MEMORANDUM

is an acknowledgement that a bill of lading has been issued and is not the Original Bill of Lading, nor a copy or duplicate, covering the property named herein, and is intended solely for filing or record.

Downgradient ~~soil~~ Well Installation soil/water Disposal

Shipper's No. _____

Carrier's No. _____

CARRIER: Shaw E+I SCAC Date 4/5/04

TO:	FROM:
Consignee Evergreen Landfill, Management	Shipper USACE
Street 2625 East Broadway, ~~Northwood~~ Dr.	Street 6100 Columbus Ave
Destination Northwood, OH Zip 43619	Origin Sandusky, OH Zip 44870
Route:	Vehicle Number / U.S. DOT Hazmat Reg. No.

Number of Shipping Units	O HM	Description of articles, special marks, and exceptions	* WEIGHT (subject to correction)	CLASS OR RATE	CHARGES (For Carrier use only)	Check column
11 Drums		Nonhazardous Solids (Rock cutting/soil) (Profile No: P922166)	7805 lb			
11 Drums		Nonhazardous Water (Developmental Water from Well Installation - Profile 592215)	4,900 lb			

Remit C.O.D. to:
Address:
City: State: Zip:

COD AMT: $

C. O. D. FEE: Prepaid ☐ Collect ☐ $

TOTAL CHARGES: $

If the shipment moves between two ports by a carrier by water, the law requires that the bill of lading shall state whether it is "carrier's or shipper's weight".
Note. - where the rate is dependent on value, shippers are required to state specifically in writing the agreed or declared value of the property.
The agreed or declared value of the property is hereby specifically stated by the shipper to be not exceeding _____ per _____

Subject to Section 7 of conditions if this shipment is to be delivered to the consignee without recourse on the consignor, the consignor shall sign the following statement.
The carrier shall not make delivery of this shipment without payment of freight and all other lawful charges.
(Signature of Consignor) 4/5/04

FREIGHT CHARGES
FREIGHT PREPAID
Except when box at right is checked ☐ CHECK BOX if charges are to be collect

RECEIVED, subject to the classifications and tariffs in effect on the date of this Bill of Lading, the property described above in apparent good order, except as noted (contents and condition of contents of packages unknown), marked, consigned, and destined as indicated above, which said company (the word company being understood throughout this contract as meaning any person or corporation in possession of the property under the contract) agrees to carry to its usual place of delivery at said destination, if on its own road or its own water line, otherwise to deliver to another carrier on the route to said destination. It is mutually agreed, as to each carrier of all or any of said property over all or any portion of said route to destination, and as to each party at any time interested in all or any said property, that every service to be performed hereunder shall be subject to all the conditions not prohibited by law, whether printed or written, herein contained (as specified in Appendix B to Part 1035) which are hereby agreed to by the shipper and accepted for himself and his assigns.

This is to certify that the above-named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation. PER: David Kesh

SHIPPER: David Kesh (Shaw E+I)
PER: for USACE DATE: 4/5/04

CARRIER: _____
PER: _____ DATE: _____

EMERGENCY RESPONSE TELEPHONE NUMBER: (419) 425-6179

MONITORED AT ALL TIMES THE HAZARDOUS MATERIALS IS IN TRANSPORTATION, INCLUDING STORAGE INCIDENTAL TO TRANSPORTATION (172.604).

This Memorandum is an acknowledgment that a Bill of Lading has been issued and is not the Original Bill of Lading, nor a copy or duplicate, covering the property named herein, and is intended solely for filing or record. Downgradient Rock/Water Disposal Well Installation

Shipper No. _____

Carrier No. _____

Page ___ of ___ Shaw E&I (Name of carrier) (SCAC)

Date April 14, 2004

on Delivery shipments, the letters "COD" must appear before consignee's name or as otherwise provided in Item 430, Sec. 1.

TO:
Consignee Evergreen Landfill - WM mgmt
Street 2625 East Broadway
City Northwood State OH Zip Code 43619

FROM:
Shipper USACE
Street 6100 Columbus Ave
City Sandusky State OH Zip Code 44870
24 hr. Emergency Contact Tel. No. 419-348-5060

Route

Vehicle Number

No. of Units & Container Type	HM	BASIC DESCRIPTION Proper Shipping Name, Hazard Class, Identification Number (UN or NA), Packing Group, per 172.101, 172.202, 172.203	TOTAL QUANTITY (Weight, Volume, Gallons, etc.)	WEIGHT (Subject to Correction)	RATE	CHARGES (For Carrier Use Only)
5 drum		Nonhazardous Solid (Rock Cuttings/Soil) Profile #P92216		2500 lbs		
14 drum		Nonhazardous Waste (developments/water from well installation) - Profile S92215		4000 lbs		

PLACARDS TENDERED: YES ☐ NO ☐

Note – (1) Where the rate is dependent on value, shippers are required to state specifically in writing the agreed or declared value of the property, as follows: "The agreed or declared value of the property is hereby specifically stated by the shipper to be not exceeding _____ per _____."
(2) Where the applicable tariff provisions specify a limitation of the carrier's liability absent a release or a value declaration by the shipper and the shipper does not release the carrier's liability or declare a value, the carrier's liability shall be limited to the extent provided by such provisions. See NMFC Item 172.
(3)Commodities requiring special or additional care or attention in handling or stowing must be so marked and packaged as to ensure safe transportation. See section 2(e) of Item 360, Bills of Lading, Freight Bills and Statements of Charges and Section 1(a) of the Contract Terms and Conditions for a list of such articles.

I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name and are classified, packed, marked and labeled/placarded, and are in all respects in proper condition for transport according to applicable international and national governmental regulations.

Signature

REMIT C.O.D. TO:
ADDRESS

COD Amt: $

C.O.D. FEE:
PREPAID ☐
COLLECT ☐ $

Subject to Section 7 of the conditions, if this shipment is to be delivered to the consignee without recourse on the consignor, the consignor shall sign the following Statement:
The carrier shall not make delivery of this shipment without payment of freight and all other lawful charges.

(Signature of Consignor)

TOTAL CHARGES: $

FREIGHT CHARGES
FREIGHT PREPAID (Indicate when box at right is checked) ☐ Check box if charges are to be collect

RECEIVED, subject to classifications and tariffs in effect on the date of the issue of this Bill of Lading, the property described above in apparent good order, except as noted (contents and condition of contents of packages unknown), marked consigned, and destined as indicated above which said carrier (the word carrier being understood throughout this contract as meaning any person or corporation in possession of the property under contract) agrees to carry to its usual place of delivery at said destination, if on its route, otherwise to deliver to another carrier on the route to said destination. It is mutually agreed as to each carrier of all or any of, said property over all or any portion of said route to destination and as to each party at any time interested in all or any said property, that every service to be performed hereunder shall be subject to all the bill of lading terms and conditions in the governing classification on the date of shipment.
Shipper hereby certifies that he is familiar with all the bill of lading terms and conditions in the governing classification and the said terms and conditions are hereby agreed to by the shipper and accepted for himself and his assigns.

ER Gerald Heffelfinger

CARRIER Gerald Heffelfinger

PER

PER

DATE

3

Permanent post-office address of shipper

STYLE F365-2 Uniform Straight Bill of Lading—Short Form

This Memorandum is an acknowledgment that a Bill of Lading has been issued and is not the Original Bill of Lading, nor a copy or duplicate, covering the property named herein, and is intended solely for filing or record.

Downgradient Well Installation soil and water Disposal

Shipper No. _____

Carrier No. _____

Page _____ of _____

Shaw E&I
(Name of carrier) (SCAC)

Date 4/14/04

On Collect on Delivery shipments, the letters "COD" must appear before consignee's name or as otherwise provided in Item 430, Sec. 1.

TO:
Consignee Evergreen Landfill - c/o Mgmt
Street 2625 East Broadway
City Northwood State OH Zip Code 43619

FROM:
Shipper USACE
Street 6100 Columbus Ave.
City Sandusky State OH Zip Code 44870
24 hr. Emergency Contact Tel. No. 419-348-5066

Route

Vehicle Number

No. of Units & Container Type	HM	BASIC DESCRIPTION Proper Shipping Name, Hazard Class, Identification Number (UN or NA), Packing Group, per 172.101, 172.202, 172.203	TOTAL QUANTITY (Weight, Volume, Gallons, etc.)	WEIGHT (Subject to Correction)	RATE	CHARGES (For Carrier Use Only)
8 drum		Nonhazardous Solid (Rock cuttings/soil) Profile P92216		4000 lbs		
12 drum		Nonhazardous Water (developmental waters from well installation) - Profile S92215		4000 lbs		

PLACARDS TENDERED: YES ☐ NO ☐

Note – (1) Where the rate is dependent on value, shippers are required to state specifically in writing the agreed or declared value of the property, as follows: "The agreed or declared value of the property is hereby specifically stated by the shipper to be not exceeding _____ per _____."
(2) Where the applicable tariff provisions specify a limitation of the carrier's liability absent a release or a value declaration by the shipper and the shipper does not release the carrier's liability or declare a value, the carrier's liability shall be limited to the extent provided by such provisions. See NMFC Item 172.
(3) Commodities requiring special or additional care or attention in handling or stowing must be so marked and packaged as to ensure safe transportation. See section 2(e) of Item 360, Bills of Lading, Freight Bills and Statements of Charges and Section 1(a) of the Contract Terms and Conditions for a list of such articles.

I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name and are classified, packed, marked and labelled/placarded, and are in all respects in proper condition for transport according to applicable international and national governmental regulations.

_____ Signature

REMIT C.O.D. TO: ADDRESS

COD Amt: $

C.O.D. FEE: PREPAID ☐ COLLECT ☐ $

TOTAL CHARGES: $

Subject to Section 7 of the conditions, if this shipment is to be delivered to the consignee without recourse on the consignor, the consignor shall sign the following statement:
The carrier shall not make delivery of this shipment without payment of freight and all other lawful charges.

Gerald Heffelfinger 4/14/04
(Signature of Consignor)

FREIGHT CHARGES
FREIGHT PREPAID (except when box at right is checked) ☐ Check box if charges are to be collect.

RECEIVED, subject to classifications and tariffs in effect on the date of the issue of this Bill of Lading, the property described above in apparent good order, except as noted (contents and condition of contents of packages unknown), marked consigned, and destined as indicated above which said carrier (the word carrier being understood throughout this contract as meaning any person or corporation in possession of the property under contract) agrees to carry to its usual place of delivery at said destination, if on its route, otherwise to deliver to another carrier on the route to said destination. It is mutually agreed as to each carrier of all or any of, said property over all or any portion of said route to destination and as to each party at any time interested in all or any said property, that every service to be performed hereunder shall be subject to all the bill of lading terms and conditions in the governing classification on the date of shipment.
Shipper hereby certifies that he is familiar with all the bill of lading terms and conditions in the governing classification and the said terms and conditions are hereby agreed to by the shipper and accepted for himself and his assigns.

SHIPPER Gerald Heffelfinger
PER
DATE

CARRIER Gerald Heffelfinger
PER
DATE

3

Permanent post-office address of shipper

THIS MEMORANDUM is an acknowledgement that a bill of lading has been issued and is not the Original Bill of Lading, not a copy or duplicate, covering the property named herein, and is intended solely for filing or record.

May 2004 Downgradient Well Sampling

Shipper's No. _____

arrier) Shaw E&I SCAC. _____ Carrier's No. _____

eived, subject to the classifications and tariffs in effect on the date of this Bill of Lading:

at Findlay, OH, date _____ from _____

the property described below, in apparent good order, except as noted (contents and condition of contents of packages unknown), marked, consigned, and destined as indicated below, which said company (the word company being understood throughout this contract as meaning any person or corporation in possession of the property under the contract) agrees to carry to its usual place of delivery at said destination, if on its own road or its own water line, otherwise to deliver to another carrier on the route to said destination. It is mutually agreed, as to each carrier of all or any of said property over all or any portion of said route to destination, and as to each party at any time interested in all or any of said property, that every service to be performed hereunder shall be subject to all the conditions not prohibited by law, whether printed or written, herein contained (as specified in Appendix B to Part 1035) which are hereby agreed to by the shipper and accepted for himself and his assigns.

TO: (Mail or street address of consignee for purposes of notification only.)	FROM:
Consignee Evergreen Landfill - WMagmt	Shipper USACE
Street 2625 East Broadway	Street 6100 Columbus Ave
Destination NORTHWOOD, OH Zip 43619	Origin Sandusky OH Zip 44870
Route:	

Delivering Carrier	Trailer Initial/Number	U.S. DOT Hazmat Reg. Number

No. of packages	HM	Description of articles, special marks, and exceptions	Hazard Class	I.D. Number	Packing Group	*Weight (subject to correction)	Class or rate	Labels required (or exemption)	Check column
1		Nonhazardous Water (Developmental water from Well installation - Profile S92215	NA						

Chg Ck 5/17/04

Remit C.O.D. to:
Address:
City: State: Zip:

COD AMT: $

Charges Advanced $

Subject to Section 7 of conditions, if this shipment is to be delivered to the consignee without recourse on the consignor, the consignor shall sign the following statement:
The carrier shall not make delivery of this shipment without payment of freight and all other lawful charges.

(Signature of consignor)

C. O. D. FEE:
Prepaid ☐
Collect ☐ $

FREIGHT CHARGES
☐ Prepaid ☐ Collect

If the shipment moves between two ports by a carrier by water, the law requires that the bill of lading shall state whether it is "carrier's or shipper's weight".
Note. – where the rate is dependent on value, shippers are required to state specifically in writing the agreed or declared value of the property.
The agreed or declared value of the property is hereby specifically stated by the shipper to be not exceeding _____ per _____

This is to certify that the above-named materials are properly classified, described, packaged, marked and labeled, and are in proper condition for transportation according to the applicable regulations of the Department of Transportation.

Per _____ PLACARDS REQUIRED

PLACARDS SUPPLIED ☐ YES ☐ NO - FURNISHED BY CARRIER

DRIVER'S SIGNATURE:

SPECIAL INSTRUCTIONS:

SHIPPER: _____

PER: _____ DATE: _____

CARRIER: _____

PER: _____ DATE: _____

Permanent post office address of shipper

EMERGENCY RESPONSE TELEPHONE NUMBER: (419) 348-5066

Monitored at all times the Hazardous Material is in transportation including storage incidental to transportation (§172.604).

29-BLS-C3 (Rev. 6/95)

STRAIGHT BILL OF LADING – SHORT FORM – Original – Not Negotiable

June 2004 - Bckgrd Sampling - 10th

Shipper's No. _____

(Carrier) Shaw E&I SCAC. _____ Carrier's No. _____

Received, subject to the classifications and tariffs in effect on the date of this Bill of Lading:

at Findlay, OH., date _____ from _____

the property described below, in apparent good order, except as noted (contents and condition of contents of packages unknown), marked, consigned, and destined as indicated below, which said company (the word company being understood throughout this contract as meaning any person or corporation in possession of the property under the contract) agrees to carry to its usual place of delivery at said destination, if on its own road or its own water line, otherwise to deliver to another carrier on the route to said destination. It is mutually agreed, as to each carrier of all or any of said property over all or any portion of said route to destination, and as to each party at any time interested in all or any of said property, that every service to be performed hereunder shall be subject to all the conditions not prohibited by law, whether printed or written, herein contained (as specified in Appendix B to Part 1035) which are hereby agreed to by the shipper and accepted for himself and his assigns.

TO: (Mail or street address of consignee for purposes of notification only.)	FROM:
Consignee Evergreen Landfill - WMgmt	Shipper USACE
Street 2625 East Broadway	Street 6100 Columbus Ave.
Destination Northwood, OH Zip 43619	Origin Sandusky, OH Zip 44870
Route:	

Delivering Carrier	Trailer Initial/Number	U.S. DOT Hazmat Reg. Number
Shaw E&I		

No. of packages	HM	Description of articles, special marks, and exceptions	Hazard Class	I.D. Number	Packing Group	*Weight (subject to correction)	Class or rate	Labels required (or exemption)	Check column
1		Nonhazardous Water (Developmental water from Well installation - Profile S92215	NA						
		84°56.226							
		Rec'd at Evergreen Ann Mann 6/18/04							

Remit C.O.D. to:
Address:
City: State: Zip:

COD AMT: $

Charges Advanced $

Subject to Section 7 of conditions, if this shipment is to be delivered to the consignee without recourse on the consignor, the consignor shall sign the following statement:
The carrier shall not make delivery of this shipment without payment of freight and all other lawful charges.
(Signature of consignor)

C. O. D. FEE:
Prepaid ☐
Collect ☐ $

FREIGHT CHARGES
☐ Prepaid ☐ Collect

the shipment moves between two ports by a carrier by water, the law requires that the bill of lading shall state whether it is "carrier's or shipper's weight".
ite. – where the rate is dependent on value, shippers are required to state specifically in writing the agreed or declared value of the property.
e agreed or declared value of the property is hereby
ecifically stated by the shipper to be not exceeding _____ per _____

his is to certify that the above-named materials are properly classified, described, packaged, marked and beled, and are in proper condition for transportation according to the applicable regulations of the Department Transportation.

Per _____

PLACARDS REQUIRED

PLACARDS SUPPLIED ☐ YES ☐ NO - FURNISHED BY CARRIER

DRIVER'S SIGNATURE:

SPECIAL INSTRUCTIONS:

SHIPPER: _____ CARRIER: _____

PER: _____ DATE: _____ PER: _____ DATE: _____

Permanent post office address of shipper

EMERGENCY RESPONSE TELEPHONE NUMBER: (419) 348-5066
Monitored at all times the Hazardous Material is in transportation including storage incidental to transportation (§172.604).

29-BLS-C3 (Rev. 6/95)

THIS MEMORANDUM is an acknowledgment that a Bill of Lading has been issued and is not the Original Bill of Lading, nor a copy or duplicate, covering the property named herein, and is intended solely for filing or record.

August 2004 Downgradient Well (GW) Bill of Lading

Shipper's No. _____

Carrier's No. _____

CARRIER: Shaw E&I SCAC Date 8/27/04

TO:	FROM:
Consignee Evergreen Landfill - WMgmt	Shipper USACE
Street 2625 East Broadway	Street 6100 Columbus Ave
Destination Northwood OH Zip 43619	Origin Sandusky OH Zip 44870
Route:	Vehicle Number / U.S. DOT Hazmat Reg. No.

Number of Shipping Units	O HM	Description of articles, special marks, and exceptions	* WEIGHT (subject to correction)	CLASS OR RATE	CHARGES (For Carrier Use Only)	Check column
4		Nonhazardous Water (Purge Water from environmental groundwater monitoring well - plug) Profile # 512215				

Tom H 8/27/04

Remit C.O.D. to: Address: City: State: Zip:	COD AMT: $	C. O. D. FEE: Prepaid ☐ $ Collect ☐ $	TOTAL CHARGES: $

"If the shipment moves between two ports by a carrier by water, the law requires that the bill of lading shall state whether it is "carrier's or shipper's weight".
Note. - where the rate is dependent on value, shippers are required to state specifically in writing the agreed or declared value of the property.
The agreed or declared value of the property is hereby specifically stated by the shipper to be not exceeding _____ per _____

Subject to Section 7 of conditions if this shipment is to be delivered to the consignee without recourse on the consignor, the consignor shall sign the following statement:
The carrier shall not make delivery of this shipment without payment of freight and all other lawful charges.
(Signature of Consignor)

FREIGHT CHARGES
FREIGHT PREPAID
Except when box at right is checked ☐ CHECK BOX if charges are to be collect

RECEIVED, subject to the classifications and tariffs in effect on the date of this Bill of Lading, the property described above in apparent good order, except as noted (contents and condition of contents of packages unknown), marked, consigned, and destined as indicated above, which said company (the word company being understood throughout this contract as meaning any person or corporation in possession of the property under the contract) agrees to carry to its usual place of delivery at said destination, if on its own road or its own water line, otherwise to deliver to another carrier on the route to said destination. It is mutually agreed, as to each carrier of all or any of said property over all or any portion of said route to destination, and as to each party at any time interested in all or any said property, that every service to be performed hereunder shall be subject to all the conditions not prohibited by law, whether printed or written, herein contained (as specified in Appendix B to Part 1035) which are hereby agreed to by the shipper and accepted for himself and his assigns.

This is to certify that the above-named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation. PER:

SHIPPER: USACE	CARRIER:
PER: DATE: 8/27/04	PER: DATE:

EMERGENCY RESPONSE TELEPHONE NUMBER: (419) 348-5066

MONITORED AT ALL TIMES THE HAZARDOUS MATERIALS IS IN TRANSPORTATION, INCLUDING STORAGE INCIDENTAL TO TRANSPORTATION (172.604).

APPENDIX H

DATA VALIDATION SUMMARIES

MAY 2004 DOWNGRADIENT WELL SAMPLING DATA VALIDATION SUMMARY

Data Validation Summary Report
Quarterly Groundwater Sampling May 2004
Former Plum Brook Ordnance Works
Sandusky, Ohio

1.0 Introduction

Level III data validation was performed on 100 percent of the environmental samples collected for the May 2004 Groundwater Sampling event. The analytical data consisted of delivery groups (SDG's) H4E060131, H4E070134 and H4E080113, which were analyzed by Severn Trent Laboratories (STL) and F23936, which was analyzed by Accutest Laboratory.

The following samples were validated for this site investigation:

SDG Number	Sample Number
H4E060131	DF3001, DF3002, DF3005
H4E070134	DF3000
H4E080113	DF3003, DF3004
F23936	DF3006

The chemical parameters for which the samples were analyzed, are identified below:

Parameter (Prep/Analytical Method)
Volatile Organics by GC/MS SW846 5030/8260B
Semivolatile Organics by GC/MS SW846 3510C/8270C
Total and Dissolved Metals by SW846 3005A/6010B and 7470A
Nitroaromatic and Nitramine Explosives by SW846 8330M
Wet Chemistry (TOC, Sulfate, Nitrate, Chloride, Alkalinity, Turbidity, TDS, TSS, Hardness, Cyanide)

GC/MS – Gas chromatography/mass spectrometry. TDS – Total dissolved solids.
TOC – Total organic carbon. TSS – Total suspended solids.

2.0 Procedures

The sample data were validated following the logic identified in the 2002 *EPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* and the 1999 *EPA Contract Laboratory Program National Functional Guidelines for Organic Review* for all areas except blanks. *EPA Region III Modifications to the Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* (February 2002) and *Region III Modifications to National Functional Guidelines for Organic Data Review, Multi-Media, Multi-Concentration (September 1994)* were applied to the areas associated with blank contamination. Specific quality control (QC) criteria as identified in the quality assurance plan (QAP), analytical methods, and laboratory standard operating procedures (SOP) were applied to all sample results. As a result of the use of Update III SW846 test methods for the analytical data and the application of the Contract Laboratory Program (CLP) guidelines during the validation process, there were instances where specific QC requirements for all target compounds were not

defined. In light of applying CLP guidelines to SW846 methods and evaluating the usability of the data during the validation process, specific QC criteria were determined to address all target compounds and are identified in this report for each parameter, as well as in the validation checklists, which function as worksheets. For those analytical methods not addressed by the CLP and Region III guidelines, the validation was based on the method requirements (i.e., SW846, Code of Federal Regulations, SOPs) and technical judgement, following the logic of the CLP validation guidelines. Lab-specific criteria may be found in Attachment A.

3.0 Summary of Data Validation Findings

The overall quality of the data was determined to be acceptable with minimal qualifications. The only rejected data ("R" qualified) were poor performing volatile compounds, which experienced severe calibration problems in the associated calibration data.

Individual validation reports have been prepared for each parameter, and the overall results of the validation findings are summarized in this report. A listing of the validation qualifiers and the reason codes, along with their definitions, is found in Attachment A. The following section highlights the key findings of the data validation for each analysis.

4.0 Analysis-Specific Data Validation Summaries

4.1 Volatile Organics by GC/MS SW846 8260B

Overall, the data are of good quality and are usable as reported by the laboratory with the exceptions noted below. Data were reviewed for the following:

Preservation

Preservation criteria were met for all samples.

Holding Times

Technical holding time criteria were met for all samples.

Initial and Continuing Calibration

The initial calibration (ICAL) and continuing calibrations (CCAL) associated with the project samples met QC criteria, with the following exception(s):

- The following exhibited individual ICAL/CCAL relative response factor (RRF) < 0.1:

SDG Number	Samples Affected	Compound(s)	Validation Qualifier
H4E060131, H4E070134, H4E080113	All	2-Butanone, 4-Methyl-2-pentanone	J/R

- The following exhibited individual CCAL percent difference (%D) > 20%:

SDG Number	Samples Affected	Compound(s)	Validation Qualifier
H4E060131	All	1,1,2-Trichloroethane	UJ
	DF3001	Chloromethane	UJ
	DF3002, DF3005	4-Methyl-2-pentanone, trans-1,3-Dichloropropane	R/UJ
H4E070134	DF3000	1,1,2-Trichloroethane, Chloromethane, trans-1,3-Dichloropropane	UJ
H4E080113	DF3003, DF3004	1,1,2-Trichloroethane, 4-Methyl-2-pentanone, trans-1,3-Dichloropropane	R/UJ

Blanks

The 5X/10X rule for contaminants found in the associated field, trip, and/or method blanks was applied to all sample results. All were found to be acceptable, with the following exception(s):

SDG	Samples Affected	Compound(s)	Blank Contaminant	Validation Qualifier
H4E060131	All	Acetone	Method	B
H4E070134	DF3000	Acetone	Method	B

Surrogate Recoveries

All surrogate recoveries were within QC limits.

Matrix Spike / Matrix Spike Duplicate

Matrix Spike/Matrix Spike Duplicate (MS/MSD) analysis was performed for the project samples, and all QC criteria were met.

Laboratory Control Sample

Laboratory Control Sample (LCS) analysis was performed for the project samples, and all QC criteria were met.

Field Duplicates

Original and field duplicate results were evaluated and no problems were identified.

Internal Standards

All internal standards met QC criteria.

Quantitation

Results quantitated between the method detection limit (MDL) and the reporting limit (RL), which the lab qualified as "J", were qualified as estimated "J" unless blank contamination was present or the results were rejected.

4.2 Semivolatile Organics by GC/MS SW846 8270C

Overall, the data are of good quality and are usable as reported by the laboratory with the exceptions noted below. Data were reviewed for the following:

Preservation

Preservation criteria were met for all samples.

Holding Times

Technical holding time criteria were met for all samples.

Initial and Continuing Calibration

All initial and continuing calibrations associated with the project samples met QC criteria, with the following exception(s):

- The following exhibited individual CCAL %D > 20%:

SDG Number	Samples Affected	Compound(s)	Validation Qualifier
H4E070134	DF3000	2,4-Dinitrophenol, 4,6-Dinitro-2-methylphenol	UJ
H4E080113	DF3003	2,4-Dinitrophenol, 4,6-Dinitro-2-methylphenol	UJ

Blanks

The 5X/10X rule for contaminants found in the associated method blanks was applied to all sample results. All were found to be acceptable.

Surrogate Recoveries

All surrogate recoveries were within QC criteria, with the following exception(s):

SDG Number	Samples Affected	Compound(s)	Validation Qualifier
H4E060131	DF3001, DF3002	All Base/Neutral	J/UJ
	DF3002	All Acidic	UJ
H4E070134	DF3000	All Base/Neutral	J/UJ

Matrix Spike / Matrix Spike Duplicate

MS/MSD analysis was performed for the project samples, and all QC criteria were met, with the following exception(s):

SDG Number	Samples Affected	Compound(s)	Validation Qualifier
H4E060131	All	1,2,4-Trichlorobenzene, Acenaphthene, Pentachlorophenol	UJ

Laboratory Control Sample

LCS analysis was performed for the project samples, and all QC criteria were met.

Field Duplicates

Original and field duplicate results were evaluated, and all QC criteria were met.

Internal Standards

All internal standards met QC criteria.

Quantitation

Results quantified between the MDL and the RL, which the lab qualified as "J", were qualified as estimated "J" unless blank contamination was present or the results were rejected.

4.3 Total and Dissolved Metals by SW846 6010B/7470A

Overall, the data are of good quality and are usable as reported by the laboratory with the exceptions noted below. Data were reviewed for the following:

Preservation

Preservation criteria were met for all samples.

Holding Times

Technical holding time criteria were met for all samples.

Initial and Continuing Calibrations

All initial and continuing calibrations associated with the project samples met QC criteria.

Blanks

The 5X rule for contaminants found in the associated calibration and method blanks was applied to all sample results. All criteria were acceptable with the following exception(s):

SDG	Samples Affected	Compound(s)	Blank Contaminant	Validation Qualifier
H4E060131	All (Total & Dissolved)	Thallium	Method/Cal	B
	DF3001 (Dissolved), DF3002 (Dissolved)	Selenium	Calibration	B
H4E070134	DF3000 (Total & Dissolved)	Arsenic, Manganese	Method/Cal	B
	DF3000 (Dissolved)	Aluminum, Thallium	Method/Cal	B
H4E080113	DF3003, DF3004 (Total & Dissolved)	Thallium	Method/Cal	B
	DF3003 (Total & Dissolved)	Arsenic	Calibration	B
	DF3003 (Dissolved), DF3004 (Dissolved)	Aluminum	Calibration	B

Cal – Calibration.

Matrix Spike / Matrix Spike Duplicate

MS/MSD analysis was performed for the project samples, and all QC criteria were met with the following exception(s):

SDG Number	Samples Affected	Compound(s)	Validation Qualifier
H4E060131	All Total	Aluminum	J
H4E070134	DF3000 (Total)	Selenium	UJ

Laboratory Control Sample

LCS analysis was performed for the project samples, and all QC criteria were met.

Interference Check Sample

All Interference Check Sample (ICS) percent recoveries were acceptable. All QC criteria were met.

Inductively Coupled Plasma Serial Dilutions

All QC criteria were met for the serial dilutions associated with the project samples with the following exception(s):

SDG Number	Samples Affected	Compound(s)	Validation Qualifier
H4E060131	All (Total & Dissolved)	Potassium, Sodium	J
H4E070134	DF3000 (Total & Dissolved)	Potassium, Zinc	J

Field Duplicates

Original and field duplicate results were evaluated, and no problems were identified with the following exceptions:

SDG Number	Samples Affected	Compound(s)	Validation Qualifier
H4E060131	DF3002 (original) DF3005 (FD)	Aluminum (Total), Iron (Total)	J

Quantitation

Results quantified between the MDL and the RL, which the lab qualified as "B", were qualified as estimated "J" unless blank contamination was present or the results were rejected.

4.4 Nitroaromatic and Nitramine Explosives by SW846 8330

Overall, the data are of good quality and are usable as reported by the laboratory with the exceptions noted below. Data were reviewed for the following:

Preservation

Preservation criteria were met for all samples.

Holding Times

Technical holding time criteria were met for all samples.

Initial and Continuing Calibration

All initial and continuing calibrations associated with the project samples met QC criteria.

Blanks

The 5X rule for contaminants found in the associated equipment rinses and method blanks was applied to all sample results. All were found to be acceptable.

Surrogate Recoveries

All surrogate recoveries were within QC criteria.

Matrix Spike / Matrix Spike Duplicate

MS/MSD analysis was performed for the project samples, and all QC criteria were met with the following exceptions:

SDG Number	Samples Affected	Compound(s)	Validation Qualifier
H4E060131, H4E080113	All	Tetryl	UJ

Laboratory Control Sample

LCS analysis was performed for the project samples, and all QC criteria were met.

2ND Column Confirmation

The percent difference QC criteria between columns for analyte concentrations were met.

Field Duplicates

Original and field duplicate results were evaluated, and no problems were identified.

Quantitation

Results quantified between the MDL and the RL, which the lab qualified as "J", were qualified as estimated "J" unless blank contamination was present or the results were rejected.

4.5 Wet Chemistry (TOC, Sulfate, Nitrate, Chloride, Alkalinity, Turbidity, TDS, TSS, Hardness, Cyanide)

Overall, the data are of good quality and are usable as reported by the laboratory, with the exceptions noted below. Data were reviewed for the following:

Preservation

Preservation criteria were met for all samples.

Holding Times

Technical holding time criteria were met for all samples.

Initial and Continuing Calibration

All initial and continuing calibrations associated with the project samples met QC criteria.

Blanks

The 5X rule for contaminants found in the associated equipment rinses and method blanks was applied to all sample results. All were found to be acceptable.

Matrix Spike / Matrix Spike Duplicate

MS/MSD analysis was performed for the project samples, and all QC criteria were met with the following exceptions:

SDG Number	Samples Affected	Compound(s)	Validation Qualifier
H4E060131	DF3001, DF3002	Alkalinity, Cyanide	J/UJ

Laboratory Control Sample

LCS analysis was performed for the project samples, and all QC criteria were met.

Field Duplicates

No field duplicate was associated with this parameter.

Quantitation

Results quantified between the MDL and the RL, which the lab qualified as "B", were qualified as estimated "J" unless blank contamination was present or the results were rejected.

5.0 Quality Assurance Field Split Sample Data Evaluation

Data from the quality assurance split sample: DF3006 (SDG F23936), was validated. The sample was analyzed for volatiles, semivolatiles, metals and explosives. The following section highlights the key findings of the data validation for each analysis.

5.1 Volatiles by SW846 8260B

Overall, the data are of good quality and are usable as reported by the laboratory, with the exceptions noted below. Data were reviewed for the following:

Holding Times

Technical holding time criteria were met for all samples.

Initial and Continuing Calibration

All initial and continuing calibrations associated with the project samples met QC criteria, with the following exception(s):

- The following exhibited individual ICAL/CCAL RRF < 0.1:

SDG Number	Samples Affected	Compound(s)	Validation Qualifier
F23936	DF3006	Acetone	R

- The following exhibited individual CCAL %D > 20%:

SDG Number	Samples Affected	Compound(s)	Validation Qualifier
F23936	DF3006	2-Butanone	UJ

Blanks

The 5X rule for contaminants found in the associated method blanks was applied to all sample results. All were found to be acceptable.

Surrogate Recoveries

All surrogate recoveries were within QC criteria.

Matrix Spike / Matrix Spike Duplicate

MS/MSD analysis was performed for the project samples, and all QC criteria were met.

Laboratory Control Sample

LCS analysis was performed for the project samples, and all QC criteria were met.

Field Split/Original Sample Comparison

SDG F23936

DF3002 (original) and DF3006 field split (FS) results were evaluated. It should be noted that acetone and Methylene Chloride were detected in DF3002 and were non-detect in DF3006.

Quantitation

Results quantified between the MDL and the RL, which the lab qualified as "J", were qualified as estimated "J" unless blank contamination was present or the results were rejected.

5.2 Semivolatiles by SW846 8270C

Overall, the data are of good quality and are usable as reported by the laboratory. Data were reviewed for the following:

Holding Times
Technical holding time criteria were met for all samples.

Initial and Continuing Calibration
All initial and continuing calibrations associated with the project samples met QC criteria.

Blanks
The 5X rule for contaminants found in the associated method blanks was applied to all sample results. All were found to be acceptable.

Surrogate Recoveries
All surrogate recoveries were within QC criteria.

Matrix Spike / Matrix Spike Duplicate
MS/MSD analysis was performed for the project samples, and all QC criteria were met.

Laboratory Control Sample
LCS analysis was performed for the project samples, and all QC criteria were met.

Field Split/Original Sample Comparison

SDG F23936
DF3002 (original) and DF3006 (FS) results were evaluated. It should be noted that Phenol was detected in DF3006 and was non-detect in DF3002.

Quantitation
Results quantified between the MDL and the RL, which the lab qualified as "J", were qualified as estimated "J" unless blank contamination was present or the results were rejected.

5.3 Metals by SW846 6010B/7471A

Overall, the data are of good quality and are usable as reported by the laboratory. Data were reviewed for the following:

Holding Times
Technical holding time criteria were met for all samples.

Initial and Continuing Calibration
All initial and continuing calibrations associated with the project samples met QC criteria.

Blanks

The 5X rule for contaminants found in the associated blanks was applied to all sample results and all were found to be acceptable.

Matrix Spike / Matrix Spike Duplicate

Batch QC was performed for the project samples and all QC criteria were met.

Laboratory Control Sample (LCS)

All QC criteria were met for the LCS associated with the project sample analyses.

Interference Check Sample

All Interference Check Sample (ICS) percent recoveries were acceptable. All QC criteria were met.

Inductively Coupled Plasma Serial Dilutions

All QC criteria were met for the serial dilutions associated with the project.

Field Split/Original Sample Comparison

SDG F23654

DF3002 (original) and DF3006 (FS) results were evaluated. All relative percent difference (RPD) QC criteria (50%) were met with the exception of aluminum and Iron. High RPDs were likely attributed to the lack of sample homogeneity. It should be noted that nickel and thallium were detected in DF3002 and were non-detect in DF3006. The dissolved sample results for aluminum, selenium and thallium were detected in DF3002 and were non-detect in DF3006.

Quantitation

Results quantified between the MDL and the RL, which the lab qualified as "J", were qualified as estimated "J" unless blank contamination was present or the results were rejected.

5.4 Nitroaromatic and Nitramine Explosives by SW846 8330

Overall, the data are of good quality and are usable as reported by the laboratory. Data were reviewed for the following:

Holding Times

Technical holding time criteria were met for all samples.

Initial and Continuing Calibration

All initial and continuing calibrations associated with the project samples met QC criteria.

Blanks

The 5X rule for contaminants found in the associated equipment rinses and method blanks was applied to all sample results. All were found to be acceptable.

Surrogate Recoveries

All surrogate recoveries were within acceptable QC ranges for the surrogates applied.

Matrix Spike / Matrix Spike Duplicate

Batch QC was performed for the project samples and all QC criteria were met.

Laboratory Control Sample (LCS)

LCS was performed for the project samples and all QC criteria were met.

2nd Column Confirmation

Sample results were non-detect.

Field Split/Original Sample Comparison

SDG F23936

DF3002 (original) and DF3006 (FS) results were evaluated. All results were non-detect.

Quantitation

Results quantified between the MDL and the RL, which the lab qualified as "J", were qualified as estimated "J" unless blank contamination was present or the results were rejected.

ATTACHMENT A

Validation Qualifiers

U Not detected. The compound/analyte was analyzed for, but not detected above the associated reporting limit.

J The compound/analyte was positively identified; the reported value is the estimated concentration of the constituent detected in the sample analyzed.

B The concentration reported was detected significantly above the levels reported in the associated equipment rinse samples and/or laboratory method and trip blanks. (5X/10X Rule was applied).

R The reported sample results are rejected due to the following:

1. Severe deficiencies in the supporting quality control data.
2. Anomalies noted in the sampling and/or analysis process, which could affect the validity of the reported data.
3. The presence or absence of the constituent cannot be verified based on the data provided.
4. To indicate not to use a particular result in the event of a reanalysis.

UJ The compound/analyte was analyzed for, but not detected above the established reporting limit. However, review and evaluation of supporting QC data and/or sampling and analysis process have indicated that the "nondetect" may be inaccurate or imprecise. The nondetect result should be estimated.

Validation Reason Code Definitions

Reason Code	Definition
01	Sample received outside of 4+/-2 degrees Celsius
01A	Improper sample preservation
02	Holding time exceeded
02A	Extraction
02B	Analysis
03	Instrument performance – outside criteria
03A	BFB
03B	DFTPP
03C	DDT and/or Endrin % breakdown exceeds criteria
03D	Retention time windows
03E	Resolution
04	Initial calibration results outside specified criteria
04A	Compound mean RRF QC criteria not met
04B	Individual % RSD criteria not met
04C	Correlation coefficient >0.995
05	Continuing calibration results outside specified criteria
05A	Compound mean RRF QC criteria not met
05B	Compound % D QC criteria not met
06	Result qualified as a result of the 5x/10x blank correction
06A	Method or preparation blank
06B	ICB or CCB
06C	ER
06D	TB
06E	FB
07	Surrogate recoveries outside control limits
07A	Sample
07B	Associated method blank or LCS
08	MS/MSD/Duplicate results outside criteria
08A	MS and/or MSD recovery not within control limits (accuracy)
08B	% RPD outside acceptance criteria (precision)
09	Post digestion spike outside criteria (GFAA)
10	Internal standards outside specified control limits
10A	Recovery
10B	Retention time
11	Laboratory control sample recoveries outside specified limits
11A	Recovery
11B	% RPD (if run in duplicate)
12	Interference check standard
13	Serial dilution
14	Tentatively identified compounds
15	Quantitation
16	Multiple results available; alternate analysis preferred
17	Field duplicate RPD criteria is exceeded
18	Percent difference between original and second column exceeds QC criteria
19	Professional judgement was used to qualify the data
20	Pesticide clean-up checks
21	Target compound identification
22	Radiological calibration
23	Radiological quantitation
24	Reported result and/or lab qualifier revised to reflect validation findings

Laboratory Control Limits for QC Samples
Plum Brook Ordinance Works

Spiked Compound	STL			Accutest		
	Water - LCS	Water - MS/MSD		Water - LCS	Water - MS/MSD	
	% Recovery Range	% Recovery Range	Precision RPD (%)	% Recovery Range	% Recovery Range	Precision RPD (%)
Metals, SW-846 6010B/7470A						
Aluminum	90 - 111	75 - 125	20	80 - 120	75 - 125	20
Antimony	90 - 110	75 - 125	20	80 - 120	75 - 125	20
Arsenic	90 - 110	75 - 125	20	80 - 120	83 - 116	20
Barium	90 - 110	75 - 125	20	80 - 120	82 - 116	20
Beryllium	90 - 111	75 - 125	20	80 - 120	86 - 119	20
Cadmium	90 - 110	75 - 125	20	80 - 120	80 - 115	20
Calcium	90 - 110	75 - 125	20	80 - 120	75 - 125	20
Chromium	90 - 110	75 - 125	20	80 - 120	82 - 120	20
Cobalt	90 - 110	75 - 125	20	80 - 120	83 - 117	20
Copper	90 - 110	75 - 125	20	80 - 120	87 - 120	20
Iron	90 - 110	75 - 125	20	80 - 120	76 - 125	20
Lead	90 - 110	75 - 125	20	80 - 120	84 - 118	20
Magnesium	90 - 110	75 - 125	20	80 - 120	75 - 125	20
Manganese	90 - 111	75 - 125	20	80 - 120	75 - 125	20
Mercury	90 - 110	80 - 120	20	80 - 120	62 - 131	15
Nickel	90 - 110	75 - 125	20	80 - 120	81 - 121	20
Potassium	90 - 114	75 - 125	20	80 - 120	76 - 125	20
Selenium	90 - 115	75 - 125	20	80 - 120	84 - 121	20
Silver	90 - 110	75 - 125	20	80 - 120	77 - 125	20
Sodium	90 - 110	75 - 125	20	80 - 120	75 - 125	20
Thallium	90 - 110	75 - 125	20	80 - 120	86 - 121	20
Vanadium	90 - 110	75 - 125	20	80 - 120	87 - 118	20
Zinc	90 - 114	75 - 125	20	80 - 120	82 - 123	20
Volatile Organic Compounds, SW-846 8260B						
1,1,1-Trichloroethane	N/A	N/A	N/A	78 - 132	72 - 133	8
1,1,2,2-Tetrachloroethane	N/A	N/A	N/A	67 - 119	64 - 120	10
1,1,2-Trichloroethane	N/A	N/A	N/A	74 - 115	72 - 116	9
1,1-Dichloroethane	N/A	N/A	N/A	75 - 117	70 - 122	10
1,1-Dichloroethene	70 - 128	62 - 128	26	67 - 134	61 - 137	15
1,2-Dichloroethane	N/A	N/A	N/A	68 - 121	64 - 124	7
1,2-Dichloropropane	N/A	N/A	N/A	78 - 122	74 - 123	8
2-Butanone	N/A	N/A	N/A	58 - 127	51 - 128	10
2-Hexanone	N/A	N/A	N/A	60 - 125	54 - 131	11
4-Methyl-2-pentanone	N/A	N/A	N/A	61 - 128	57 - 136	11
Acetone	N/A	N/A	N/A	44 - 142	45 - 127	15
Benzene	80 - 121	73 - 125	20	80 - 120	72 - 125	7
Bromodichloromethane	N/A	N/A	N/A	75 - 120	72 - 120	8

Laboratory Control Limits for QC Samples
Plum Brook Ordinance Works

Spiked Compound	STL			Accutest		
	Water - LCS	Water - MS/MSD		Water - LCS	Water - MS/MSD	
	% Recovery Range	% Recovery Range	Precision RPD (%)	% Recovery Range	% Recovery Range	Precision RPD (%)
Volatile Organic Compounds, SW-846 8260B (cont,)						
Bromoform	N/A	N/A	N/A	60 - 129	55 - 127	11
Bromomethane	N/A	N/A	N/A	60 - 165	52 - 172	16
Carbon disulfide	N/A	N/A	N/A	65 - 147	60 - 151	12
Carbon tetrachloride	N/A	N/A	N/A	69 - 137	56 - 145	12
Chlorobenzene	80 - 121	71 - 125	20	82 - 112	79 - 113	7
Chloroethane	N/A	N/A	N/A	67 - 148	56 - 164	14
Chloroform	N/A	N/A	N/A	78 - 118	75 - 120	8
Chloromethane	N/A	N/A	N/A	58 - 152	53 - 155	19
Dibromochloromethane	N/A	N/A	N/A	68 - 118	63 - 119	9
Ethylbenzene	N/A	N/A	N/A	82 - 115	73 - 119	8
Methylene chloride	N/A	N/A	N/A	66 - 125	61 - 129	11
Styrene	N/A	N/A	N/A	58 - 125	64 - 124	11
Tetrachloroethene	N/A	N/A	N/A	75 - 126	70 - 126	9
Toluene	77 - 124	69 - 129	20	81 - 114	67 - 123	8
Trichloroethene	80 - 121	56 - 137	20	80 - 115	73 - 117	10
Vinyl chloride	N/A	N/A	N/A	70 - 151	63 - 161	18
cis-1,2-Dichloroethene	N/A	N/A	N/A	81 - 120	74 - 125	9
cis-1,3-Dichloropropene	N/A	N/A	N/A	73 - 115	65 - 112	10
Xylenes (total)	N/A	N/A	N/A	81 - 118	72 - 122	7
trans-1,2-Dichloroethene	N/A	N/A	N/A	74 - 125	70 - 127	11
trans-1,3-Dichloropropene	N/A	N/A	N/A	69 - 115	59 - 116	11
Semivolatile Organic Compounds, SW-846 8270C						
1,2,4-Trichlorobenzene	66 - 113	63 - 113	36	64 - 101	54 - 102	24
1,2-Dichlorobenzene	N/A	N/A	N/A	62 - 100	50 - 101	22
1,3-Dichlorobenzene	N/A	N/A	N/A	59 - 99	50 - 100	23
1,4-Dichlorobenzene	65 - 111	58 - 113	37	60 - 101	51 - 101	23
2,4,5-Trichlorophenol	N/A	N/A	N/A	66 - 104	61 - 102	18
2,4,6-Trichlorophenol	N/A	N/A	N/A	60 - 103	55 - 103	21
2,4-Dichlorophenol	N/A	N/A	N/A	64 - 103	55 - 100	24
2,4-Dimethylphenol	N/A	N/A	N/A	43 - 94	36 - 98	26
2,4-Dinitrophenol	N/A	N/A	N/A	12 - 125	14 - 135	39
2,4-Dinitrotoluene	72 - 131	69 - 131	25	69 - 111	65 - 110	16
2,6-Dinitrotoluene	N/A	N/A	N/A	72 - 111	65 - 111	19
2-Chloronaphthalene	N/A	N/A	N/A	67 - 102	58 - 101	22
2-Chlorophenol	63 - 114	59 - 118	43	62 - 103	53 - 102	24
2-Methylnaphthalene	N/A	N/A	N/A	66 - 100	56 - 100	23
2-Methylphenol	N/A	N/A	N/A	54 - 91	46 - 100	23
2-Nitroaniline	N/A	N/A	N/A	70 - 111	66 - 107	18
2-Nitrophenol	N/A	N/A	N/A	64 - 104	53 - 104	25
3-Nitroaniline	N/A	N/A	N/A	66 - 106	47 - 107	26
3,3'-Dichlorobenzidine	N/A	N/A	N/A	42 110	18 - 112	22
3 and 4-Methylphenol	N/A	N/A	N/A	48 - 86	43 - 100	23
4,6-Dinitro-2-methylphenol	N/A	N/A	N/A	47 - 119	40 - 127	24
4-Bromophenyl phenyl ether	N/A	N/A	N/A	73 - 103	68 - 102	16
4-Chloro-3-methylphenol	71 - 118	66 - 130	29	64 - 103	60 - 101	18
4-Chloroaniline	N/A	N/A	N/A	57 - 104	39 - 101	21
4-Chlorophenyl phenyl ether	N/A	N/A	N/A	71 - 104	65 - 103	18

Laboratory Control Limits for QC Samples
Plum Brook Ordinance Works

Spiked Compound	STL			Accutest		
	Water - LCS	Water - MS/MSD		Water - LCS	Water - MS/MSD	
	% Recovery Range	% Recovery Range	Precision RPD (%)	% Recovery Range	% Recovery Range	Precision RPD (%)
Semivolatile Organic Compounds, SW-846 8270C (cont.)						
4-Methylphenol	N/A	N/A	N/A	NA	NA	NA
4-Nitroaniline	N/A	N/A	N/A	65 - 113	48 - 119	21
4-Nitrophenol	61 - 128	61 - 142	50	22 - 50	32 - 81	28
Acenaphthene	65 - 107	65 - 107	26	69 - 101	60 - 103	20
Acenaphthylene	N/A	N/A	N/A	70 - 113	67 - 113	20
Anthracene	N/A	N/A	N/A	75 - 107	71 - 105	14
Benzo(a)anthracene	N/A	N/A	N/A	73 - 106	70 - 103	16
Benzo(a)pyrene	N/A	N/A	N/A	75 - 114	70 - 113	16
Benzo(b)fluoranthene	N/A	N/A	N/A	73 - 110	67 - 110	17
Benzo(ghi)perylene	N/A	N/A	N/A	63 - 115	63 - 111	17
Benzo(k)fluoranthene	N/A	N/A	N/A	73 - 112	68 - 110	17
Butyl benzyl phthalate	N/A	N/A	N/A	69 - 108	65 - 108	17
Carbazole	N/A	N/A	N/A	74 - 113	71 - 109	16
Chrysene	N/A	N/A	N/A	73 - 103	70 - 100	18
Di-n-butyl phthalate	N/A	N/A	N/A	72 - 109	68 - 107	17
Di-n-octyl phthalate	N/A	N/A	N/A	68 - 120	58 - 126	23
Dibenz(a,h)anthracene	N/A	N/A	N/A	63 - 115	62 - 111	20
Dibenzofuran	N/A	N/A	N/A	69 - 104	64 - 102	17
Diethyl phthalate	N/A	N/A	N/A	64 - 110	59 - 110	18
Dimethyl phthalate	N/A	N/A	N/A	44 - 120	45 - 116	25
Fluoranthene	N/A	N/A	N/A	73 - 111	67 - 108	17
Fluorene	N/A	N/A	N/A	70 - 105	65 - 105	17
Hexachlorobenzene	N/A	N/A	N/A	73 - 103	69 - 102	16
Hexachlorobutadiene	N/A	N/A	N/A	55 - 90	45 - 93	26
Hexachlorocyclopentadiene	N/A	N/A	N/A	26 - 95	20 - 92	34
Hexachloroethane	N/A	N/A	N/A	59 - 104	51 - 105	26
Indeno(1,2,3-cd)pyrene	N/A	N/A	N/A	63 - 118	66 - 111	19
Isophorone	N/A	N/A	N/A	68 - 107	59 - 103	23
Naphthalene	N/A	N/A	N/A	67 - 101	52 - 102	23
Nitrobenzene	N/A	N/A	N/A	66 - 106	56 - 103	25
Pentachlorophenol	71 - 122	71 - 135	37	50 - 111	44 - 118	16
Phenanthrene	N/A	N/A	N/A	73 - 104	69 - 103	15
Phenol	59 - 117	55 - 123	41	25 - 53	31 - 77	26
Pyrene	67 - 114	63 - 114	27	69 - 105	64 - 107	21
bis(2-Chloroethoxy)methane	N/A	N/A	N/A	57 - 103	49 - 100	24
bis(2-Chloroethyl)ether	N/A	N/A	N/A	64 - 106	54 - 103	24
bis(2-Chloroisopropyl)ether	N/A	N/A	N/A	52 - 120	49 - 109	22
bis(2-Ethylhexyl)phthalate	N/A	N/A	N/A	69 - 115	55 - 120	22
n-Nitroso-di-n-propylamine	62 - 114	60 - 117	36	64 - 109	57 - 103	24
n-Nitrosodiphenylamine	N/A	N/A	N/A	74 - 114	72 - 112	16

Laboratory Control Limits for QC Samples
Plum Brook Ordinance Works

Spiked Compound	STL			Accutest		
	Water - LCS	Water - MS/MSD		Water - LCS	Water - MS/MSD	
	% Recovery Range	% Recovery Range	Precision RPD (%)	% Recovery Range	% Recovery Range	Precision RPD (%)
Nitroaromatics and Nitramines, SW-846 8330						
1,3,5-Trinitrobenzene	75 - 121	62 - 127	33	77 - 115	72 - 116	12
1,3-Dinitrobenzene	75 - 121	70 - 121	42	77 - 117	77 - 117	12
2,4,6-Trinitrotoluene	76 - 120	67 - 120	34	76 - 113	70 - 117	14
2,4-Dinitrotoluene	73 - 118	72 - 118	36	74 - 119	72 - 121	15
2,6-Dinitrotoluene	74 - 120	74 - 120	32	77 - 123	77 - 122	16
2-Nitrotoluene	50 - 109	46 - 118	38	68 - 120	75 - 119	17
3-Nitrotoluene	56 - 110	56 - 121	36	69 - 120	66 - 129	16
2-Amino-4,6-dinitrotoluene	69 - 113	59 - 125	34	77 - 121	68 - 128	17
4-Amino-2,6-dinitrotoluene	69 - 113	68 - 113	13	76 - 121	67 - 127	16
4-Nitrotoluene	56 - 111	56 - 111	33	75 - 118	75 - 122	18
HMX	71 - 122	67 - 122	11	79 - 119	73 - 123	13
Nitrobenzene	61 - 114	61 - 114	36	66 - 122	73 - 121	15
RDX	77 - 127	70 - 133	11	73 - 119	65 - 126	13
Tetryl	73 - 119	38 - 132	37	63 - 122	42 - 135	15
Water Quality						
Chloride	90 - 115	43 - 167	23	N/A	N/A	N/A
Cyanide, Total	88 - 113	75 - 125	20	N/A	N/A	N/A
Hardness as $CaCO_3$	84 - 116	10 - 176	23	N/A	N/A	N/A
Nitrate	77 - 116	10 - 132	24	N/A	N/A	N/A
Sulfate	80 - 112	22 - 151	24	N/A	N/A	N/A
Total Alkalinity	90 - 127	10 - 160	24	N/A	N/A	N/A
Total Dissolved Solids	69 - 120	N/A	20	N/A	N/A	N/A
Total Organic Carbon	90 - 110	85 - 117	10	N/A	N/A	N/A
Total Suspended Solids	66 - 119	N/A	20	N/A	N/A	N/A
Turbidity	75 - 125	N/A	20	N/A	N/A	N/A

LCS - Laboratory control sample.
MS/MSD - Matrix spike/matrix spike duplicate.
RPD - Relative percent difference.
STL - Severn Trent Laboratories.
N/A - Not applicable.

JUNE 2004 DOWNGRADIENT WELL SAMPLING DATA VALIDATION SUMMARY

Data Validation Summary Report
Quarterly Groundwater Sampling June 2004
Former Plum Brook Ordnance Works
Sandusky, Ohio

1.0 Introduction

Level III data validation was performed on 100 percent of the environmental samples collected for the June 2004 sampling event. The analytical data consisted of one sample delivery group (SDG) PB047, which was analyzed by Severn Trent Laboratories (STL). In addition, validation of the field-split data, SDG F24891, which were analyzed by Accutest Laboratories, was performed and findings are discussed in section 5.0 of this report. Water matrix was validated.

The following samples were validated for this site investigation:

SDG Number	Sample Number
PB047	DG3000, DG3001, DG3002, DG3003, DG3004, DG3005, DG3006

The chemical parameters for which the samples were analyzed, are identified below:

Parameter (Prep/Analytical Method)
Volatile Organics by GC/MS SW846 5030/8260B
Semivolatile Organics by GC/MS SW846 3510C/8270C
Total and Dissolved Metals by SW846 3005A/6010B and 7470A
Nitroaromatic and Nitramine Explosives by SW846 8330M
Wet Chemistry (TOC, Sulfate, Nitrate, Chloride, Alkalinity, Turbidity, TDS, TSS, Hardness, Cyanide)

GC/MS – Gas chromatography/mass spectrometry.
TDS – Total dissolved solids.
TOC – Total organic carbon.
TSS – Total suspended solids.

2.0 Procedures

The sample data were validated following the logic identified in the *EPA Contract Laboratory Program (CLP) National Functional Guidelines for Inorganic Data Review* (July 2002) and the *EPA Contract Laboratory Program National Functional Guidelines for Organic Review* (October 1999) for all areas except blanks. *EPA Region III Modifications to the Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* (April 1993) and *Region III Modifications to National Functional Guidelines for Organic Data Review, Multi-Media, Multi-Concentration (September 1994)* were applied to the areas associated with blank contamination. Specific quality control (QC) criteria as identified in the quality assurance plan (QAP), analytical methods, and laboratory standard operating procedures (SOP) were applied to all sample results. As a result of the use of Update III SW846 test methods for the analytical data and the application of the Contract Laboratory Program (CLP) guidelines during the validation process, there were instances where specific QC requirements for all target compounds were not defined. This primarily occurred in the organic, GC/MS calibration areas and is due to the fact that the analytical methods are performance-based and allow the use of average calibration responses

in lieu of individual responses, which are defined by CLP protocol. In light of applying CLP guidelines to SW846 methods and evaluating the usability of the data during the validation process, specific QC criteria were determined to address all target compounds and are identified in this report for each parameter, as well as in the validation checklists, which function as worksheets. For those analytical methods not addressed by the CLP and Region III guidelines, the validation was based on the method requirements (i.e., SW846, Code of Federal Regulations, SOPs) and technical judgement, following the logic of the CLP validation guidelines. Lab-specific criteria may be found in Attachment A.

3.0 Summary of Data Validation Findings

The overall quality of the data was determined to be acceptable with minimal qualifications. The only rejected data ("R" qualified) was due to "poor performing" volatile compounds (ketones, some halogenated hydrocarbons, etc.), which experienced poor calibration responses in the associated calibration data and samples that were reanalyzed and have more than one set of results reported. The "R" qualifier was assigned to the samples with more than one set of results to indicate that a given result should not be used to characterize a particular constituent or an analysis for a given sample.

Individual validation reports have been prepared for each parameter, and the overall results of the validation findings are summarized in this report. A listing of the validation qualifiers and the reason codes, along with their definitions, is found in Attachment A. The following section highlights the key findings of the data validation for each analysis.

4.0 Analysis-Specific Data Validation Summaries

4.1 Volatile Organics by GC/MS SW846 8260B

Overall, the data are of good quality and are usable as reported by the laboratory with the exceptions noted below. Data were reviewed for the following:

Holding Times

Technical holding time criteria were met for all samples.

Initial and Continuing Calibration

The initial calibration (ICAL) and continuing calibrations (CCAL) associated with the project samples met QC criteria with the following exception(s):

- The following exhibited individual ICAL/CCAL relative response factor (RRF) <0.1:

SDG Number	Samples Affected	Compound(s)	Validation Qualifier
PB047	All	2-Butanone, 4-Methyl-2-pentanone	R
	DG3001	Bromodichloromethane	R

- The following exhibited individual ICAL relative standard deviation (%RSD) >30 and/or CCAL percent difference (%D) >20:

SDG Number	Samples Affected	Compound(s)	Validation Qualifier
PB047	DG3000, DG3002, DG3004, DG3005	2-Butanone, 4-Methyl-2-pentanone	R
	All	Acetone, Carbon Disulfide, trans-1,3-Dichloropropene, 2-Hexanone	J/B/UJ
	DG3001, DG3003, DG3006	Dibromochloromethane, Tetrachloroethene	J/UJ
	DG3001, DG3003, DG3004, DG3006	1,1,2-Trichloroethane	UJ
	DG3004	1,1-Dichloroethane	UJ

Blanks

The 5X/10X rule for contaminants found in the associated equipment rinses, trip blanks, and method blanks was applied to all sample results. All were found to be acceptable with the following exception(s):

SDG Number	Samples Affected	Compound(s)	Blank Contaminant	Validation Qualifier
PB047	DG3000, DG3001, DG3003, DG3005, DG3006	Acetone	Method/TB	B

Surrogate Recoveries

All surrogate recoveries were within QC limits, with the following exception(s):

SDG Number	Samples Affected	Compound(s)	Validation Qualifier
PB047	DG3001	All	J/B/R/UJ

Matrix Spike / Matrix Spike Duplicate

Matrix Spike/Matrix Spike Duplicate (MS/MSD) analysis was performed for the project samples, and all QC criteria were met.

Laboratory Control Sample

Laboratory Control Sample (LCS) analysis was performed for the project samples, and all QC criteria were met.

Field Duplicates

Original and field duplicate results were evaluated and no problems were identified.

Internal Standards

All internal standards met QC criteria.

Quantitation
Results quantitated between the method detection limit (MDL) and the reporting limit (RL), which the lab qualified as "J", were qualified as estimated "J" unless blank contamination was present or the results were rejected.

4.2 Semivolatile Organics by GC/MS SW846 8270C

Overall, the data are of good quality and are usable as reported by the laboratory with the exceptions noted below. Data were reviewed for the following:

Holding Times
Technical holding time criteria were met for all samples.

Initial and Continuing Calibration
All initial and continuing calibrations associated with the project samples met QC criteria with the following exception(s):

- The following exhibited individual ICAL %RSD >30 and/or CCAL %D >20:

SDG Number	Samples Affected	Compound(s)	Validation Qualifier
PB047	All	2,4-Dinitrophenol, 4,6-Dinitro-2-methylphenol	UJ

Blanks
The 5X/10X rule for contaminants found in the associated equipment rinses and method blanks was applied to all sample results. All were found to be acceptable.

Surrogate Recoveries
All surrogate recoveries were within QC criteria.

Matrix Spike / Matrix Spike Duplicate
MS/MSD analysis was performed for the project samples, and all QC criteria were met.

Laboratory Control Sample
LCS analysis was performed for the project samples, and all QC criteria were met.

Field Duplicates
Original and field duplicate results were evaluated, and all QC criteria were met.

Internal Standards
All internal standards met QC criteria.

Quantitation

Results quantified between the MDL and the RL, which the lab qualified as "J", were qualified as estimated "J" unless blank contamination was present or the results were rejected.

4.3 Total and Dissolved Metals by SW846 6010B/7470A

Overall, the data are of good quality and are usable as reported by the laboratory with the exceptions noted below. Data were reviewed for the following:

Holding Times

Technical holding time criteria were met for all samples.

Initial and Continuing Calibrations

All initial and continuing calibrations associated with the project samples met QC criteria.

Blanks

The 5X rule for contaminants found in the associated equipment rinse, calibration, and method blanks was applied to all sample results. All criteria were acceptable with the following exception(s):

SDG	Samples Affected	Element(s)	Blank Contaminant	Validation Qualifier
PB047 (Total)	DG3000, DG3001, DG3003, DG3004, DG3006	Thallium	Prep/Calibration	B
	DG3000, DG3003, DG3004, DG3005, DG3006	Zinc	Prep	B
	DG3001	Arsenic, Copper	Calibration	B
	DG3003	Selenium	Calibration	B
	DG3004	Mercury	Calibration	B
PB047 (Dissolved)	DG3000, DG3002, DG3004, DG3005	Zinc	Prep	B
	DG3001, DG3004, DG3005, DG3006	Thallium	Prep/Calibration	B
	DG3001	Arsenic	Calibration	B
	DG3003	Mercury	Prep	B

Matrix Spike / Matrix Spike Duplicate

MS/MSD analysis was performed for the project samples, and all QC criteria were met.

Laboratory Control Sample

LCS analysis was performed for the project samples, and all QC criteria were met.

Interference Check Sample

All Interference Check Sample (ICS) percent recoveries were acceptable. All QC criteria were met.

Inductively Coupled Plasma Serial Dilutions

All QC criteria were met for the serial dilutions associated with the project samples with the following exception(s):

SDG	Samples Affected	Element(s)	Validation Qualifier
PB047 (Total/Dissolved)	All	Potassium	J

Field Duplicates

Original and field duplicate results were evaluated, and no problems were identified.

Quantitation

Results quantified between the MDL and the RL, which the lab qualified as "B", were qualified as estimated "J" unless blank contamination was present or the results were rejected.

4.4 Nitroaromatic and Nitramine Explosives by SW846 8330

Overall, the data are of good quality and are usable as reported by the laboratory with the exceptions noted below. Data were reviewed for the following:

Holding Times

Technical holding time criteria were met for all samples.

Initial and Continuing Calibration

All initial and continuing calibrations associated with the project samples met QC criteria.

Blanks

The 5X rule for contaminants found in the associated equipment rinses and method blanks was applied to all sample results. All were found to be acceptable.

Surrogate Recoveries

All surrogate recoveries were within QC criteria.

Matrix Spike / Matrix Spike Duplicate

MS/MSD analysis was performed for the project samples, and all QC criteria were met with the following exception(s):

SDG Number	Samples Affected	Compound(s)	Validation Qualifier
PB047	DG3000, DG3001, DG3002, DG3003, DG3005, DG3006	Tetryl	UJ

Laboratory Control Sample

LCS analysis was performed for the project samples, and all QC criteria were met.

Field Duplicates
Original and field duplicate results were evaluated, and no problems were identified.

Quantitation
Results quantified between the MDL and the RL, which the lab qualified as "J", were qualified as estimated "J" unless blank contamination was present or the results were rejected.

4.5 Wet Chemistry (TOC, Sulfate, Nitrate, Chloride, Alkalinity, Turbidity, TDS, TSS, Hardness, Cyanide)

Overall, the data are of good quality and are usable as reported by the laboratory with the exceptions noted below. Data were reviewed for the following:

Preservation
Preservation criteria were met for all samples.

Holding Times
Technical holding time criteria were met for all samples.

Initial and Continuing Calibration
All initial and continuing calibrations associated with the project samples met QC criteria.

Blanks
The 5X rule for contaminants found in the associated equipment rinses and method blanks was applied to all sample results. All were found to be acceptable.

Matrix Spike / Matrix Spike Duplicate
MS/MSD analysis was performed for the project samples, and all QC criteria were met with the following exception(s):

SDG Number	Samples Affected	Compound(s)	Validation Qualifier
PB047	DG3000, DG3001, DG3002, DG3003, DG3004, DG3005	Cyanide	UJ

Laboratory Control Sample
LCS analysis was performed for the project samples, and all QC criteria were met.

Field Duplicates
Original and field duplicate results were evaluated, and no problems were identified.

Quantitation
Results quantified between the MDL and the RL, which the lab qualified as "J", were qualified as estimated "J" unless blank contamination was present or the results were rejected.

5.0 Quality Assurance Field Split Sample Data Evaluation

Data from the quality assurance split sample: SDG F24891 sample DG3007, were validated. The field split (FS) sample was analyzed for Volatiles by SW846 8260B, Semivolatiles by SW846 8270C, Explosives by SW846 8330, and Total and Dissolved Metals by SW846 6010B and 7470A. The following section highlights the key findings of the data validation for each analysis.

5.1 Volatile Organics by GC/MS SW846 8260B

Overall, the data are of good quality and are usable as reported by the laboratory with the exceptions noted below. Data were reviewed for the following:

Preservation

Preservation criteria were met for all samples.

Holding Times

Technical holding time criteria were met for all samples.

Initial and Continuing Calibration

The ICAL and CCAL associated with the project samples met QC criteria with the following exception(s):

- The following exhibited individual ICAL %RSD >30 and/or CCAL %D >20:

SDG Number	Samples Affected	Compound(s)	Validation Qualifier
F24891	DG3007	Chloroethane	UJ

Blanks

The 5X/10X rule for contaminants found in the associated trip blanks and method blanks was applied to all sample results. All were found to be acceptable.

Surrogate Recoveries

All surrogate recoveries were within QC limits.

Matrix Spike / Matrix Spike Duplicate

MS/MSD analysis was performed for the project samples, and all QC criteria were met.

Laboratory Control Sample

LCS analysis was performed for the project samples, and all QC criteria were met.

Internal Standards
All internal standards met QC criteria.

Field Split/Original Sample Comparison

SDG F24891
DG3003 (original) and DG3007 (FS) results were evaluated. It should be noted that the original sample had positive results for Acetone and Carbon disulfide below the reporting limits. The field split sample had positive results for Carbon disulfide equal to the reporting limit.

Quantitation
Results quantitated between the MDL and the RL, which the lab qualified as "J", were qualified as estimated "J" unless blank contamination was present or the results were rejected.

5.2 Semivolatile Organics by GC/MS SW846 8270C

Overall, the data are of good quality and are usable as reported by the laboratory. Data were reviewed for the following:

Holding Times
Technical holding time criteria were met for all samples.

Initial and Continuing Calibration
The initial calibration and continuing calibrations associated with the project samples met QC criteria.

Blanks
The 5X/10X rule for contaminants found in the associated blanks was applied to all sample results and all were found to be acceptable.

Matrix Spike / Matrix Spike Duplicate
MS/MSD analysis was performed for the project samples, and all QC criteria were met.

Laboratory Control Sample
LCS analysis was performed for the project samples, and all QC criteria were met.

Surrogate Recoveries
All surrogate recoveries were within QC criteria.

Internal Standards
All internal standards met QC.

Field Split/Original Sample Comparison

SDG F24891
DG3003 (original) and DG3007 (FS) results were evaluated. It should be noted that both samples were non-detect for all compounds.

Quantitation
Results quantified between the MDL and the RL, which the lab qualified as "J", were qualified as estimated "J" unless blank contamination was present or the results were rejected.

5.3 Total and Dissolved Metals by SW846 6010B/7470A

Overall, the data are of good quality and are usable as reported by the laboratory with the exceptions noted below. Data were reviewed for the following:

Holding Times
Technical holding time criteria were met for all samples.

Initial and Continuing Calibration
All initial and continuing calibrations associated with the project samples met QC criteria.

Blanks
The 5X rule for contaminants found in the associated blanks was applied to all sample results and all were found to be acceptable.

Matrix Spike / Matrix Spike Duplicate
MS/MSD analysis was performed for the project samples, and all QC criteria were met.

Laboratory Control Sample
All QC criteria were met for the LCS associated with the project sample analyses.

Interference Check Sample
All ICS percent recoveries were acceptable. All QC criteria were met.

Inductively Coupled Plasma Serial Dilutions
All QC criteria were met for the serial dilutions associated with the project with the following exceptions:

SDG Number	Samples Affected	Compound(s)	Validation Qualifier
F24891	DG3007 (Total and Dissolved)	Potassium, Sodium	J

Field Split/Original Sample Comparison

SDG F24891
DG3003 (original) and DG3007 (FS) results were evaluated. All RPD QC criteria for total and dissolved results were met with the exception of Aluminum (65.41%) and Zinc (-53.24%) for Total results.

Quantitation
Results quantified between the MDL and the RL, which the lab qualified as "J", were qualified as estimated "J" unless blank contamination was present or the results were rejected.

5.4 Nitroaromatic and Nitramine Explosives by SW846 8330

Overall, the data are of good quality and are usable as reported by the laboratory. Data were reviewed for the following:

Holding Times
Technical holding time criteria were met for all samples.

Initial and Continuing Calibration
All initial and continuing calibrations associated with the project samples met QC criteria.

Blanks
The 5X rule for contaminants found in the associated equipment rinses and method blanks was applied to all sample results. All were found to be acceptable.

Surrogate Recoveries
All surrogate recoveries were within QC criteria.

Matrix Spike / Matrix Spike Duplicate
MS/MSD analysis was performed for the project samples, and all QC criteria were met.

Laboratory Control Sample
LCS analysis was performed for the project samples, and all QC criteria were met.

Field Split/Original Sample Comparison

SDG F24891
DG3003 (original) and DG3007 (FS) results were evaluated. It should be noted that DG3003 (original) and DG3007 (FS) were non-detect for all compounds.

Quantitation
Results quantified between the MDL and the RL, which the lab qualified as "J", were qualified as estimated "J" unless blank contamination was present or the results were rejected.

ATTACHMENT A

Validation Qualifiers

U Not detected. The compound/analyte was analyzed for, but not detected above the associated reporting limit.

J The compound/analyte was positively identified; the reported value is the estimated concentration of the constituent detected in the sample analyzed.

B The concentration reported was detected below the levels reported in the associated equipment rinse samples and/or laboratory method and trip blanks. (5X/10X Rule was applied).

R The reported sample results are rejected due to the following:

1. Severe deficiencies in the supporting quality control data.
2. Anomalies noted in the sampling and/or analysis process, which could affect the validity of the reported data.
3. The presence or absence of the constituent cannot be verified based on the data provided.
4. To indicate not to use a particular result in the event of a reanalysis.

UJ The compound/analyte was analyzed for, but not detected above the established reporting limit. However, review and evaluation of supporting QC data and/or sampling and analysis process have indicated that the "nondetect" may be inaccurate or imprecise. The nondetect result should be estimated.

Validation Reason Code Definitions

Reason Code	Definition
01	Sample received outside of 4+/-2 degrees Celsius
01A	Improper sample preservation
02	Holding time exceeded
02A	Extraction
02B	Analysis
03	Instrument performance – outside criteria
03A	BFB
03B	DFTPP
03C	DDT and/or Endrin % breakdown exceeds criteria
03D	Retention time windows
03E	Resolution
04	Initial calibration results outside specified criteria
04A	Compound mean RRF QC criteria not met
04B	Individual % RSD criteria not met
04C	Correlation coefficient >0.995
05	Continuing calibration results outside specified criteria
05A	Compound mean RRF QC criteria not met
05B	Compound % D QC criteria not met
06	Result qualified as a result of the 5x/10x blank correction
06A	Method or preparation blank
06B	ICB or CCB
06C	ER
06D	TB
06E	FB
07	Surrogate recoveries outside control limits
07A	Sample
07B	Associated method blank or LCS
08	MS/MSD/Duplicate results outside criteria
08A	MS and/or MSD recovery not within control limits (accuracy)
08B	% RPD outside acceptance criteria (precision)
09	Post digestion spike outside criteria (GFAA)
10	Internal standards outside specified control limits
10A	Recovery
10B	Retention time
11	Laboratory control sample recoveries outside specified limits
11A	Recovery
11B	% RPD (if run in duplicate)
12	Interference check standard
13	Serial dilution
14	Tentatively identified compounds
15	Quantitation
16	Multiple results available; alternate analysis preferred
17	Field duplicate RPD criteria is exceeded
18	Percent difference between original and second column exceeds QC criteria
19	Professional judgement was used to qualify the data
20	Pesticide clean-up checks
21	Target compound identification
22	Radiological calibration
23	Radiological quantitation
24	Reported result and/or lab qualifier revised to reflect validation findings

Laboratory Control Limits for QC Samples
Plum Brook Ordinance Works

Spiked Compound	STL			Accutest		
	Water - LCS	Water - MS/MSD		Water - LCS	Water - MS/MSD	
	% Recovery Range	% Recovery Range	Precision RPD (%)	% Recovery Range	% Recovery Range	Precision RPD (%)
Metals, SW-846 6010B/7470A						
Aluminum	90 - 111	75 - 125	20	80 - 120	75 - 125	20
Antimony	90 - 110	75 - 125	20	80 - 120	75 - 125	20
Arsenic	90 - 110	75 - 125	20	80 - 120	83 - 116	20
Barium	90 - 110	75 - 125	20	80 - 120	82 - 116	20
Beryllium	90 - 111	75 - 125	20	80 - 120	86 - 119	20
Cadmium	90 - 110	75 - 125	20	80 - 120	80 - 115	20
Calcium	90 - 110	75 - 125	20	80 - 120	75 - 125	20
Chromium	90 - 110	75 - 125	20	80 - 120	82 - 120	20
Cobalt	90 - 110	75 - 125	20	80 - 120	83 - 117	20
Copper	90 - 110	75 - 125	20	80 - 120	87 - 120	20
Iron	90 - 110	75 - 125	20	80 - 120	76 - 125	20
Lead	90 - 110	75 - 125	20	80 - 120	84 - 118	20
Magnesium	90 - 110	75 - 125	20	80 - 120	75 - 125	20
Manganese	90 - 111	75 - 125	20	80 - 120	75 - 125	20
Mercury	90 - 110	80 - 120	20	80 - 120	62 - 131	15
Nickel	90 - 110	75 - 125	20	80 - 120	81 - 121	20
Potassium	90 - 114	75 - 125	20	80 - 120	76 - 125	20
Selenium	90 - 115	75 - 125	20	80 - 120	84 - 121	20
Silver	90 - 110	75 - 125	20	80 - 120	77 - 125	20
Sodium	90 - 110	75 - 125	20	80 - 120	75 - 125	20
Thallium	90 - 110	75 - 125	20	80 - 120	86 - 121	20
Vanadium	90 - 110	75 - 125	20	80 - 120	87 - 118	20
Zinc	90 - 114	75 - 125	20	80 - 120	82 - 123	20
Volatile Organic Compounds, SW-846 8260B						
1,1,1-Trichloroethane	N/A	N/A	N/A	78 - 132	72 - 133	8
1,1,2,2-Tetrachloroethane	N/A	N/A	N/A	67 - 119	64 - 120	10
1,1,2-Trichloroethane	N/A	N/A	N/A	74 - 115	72 - 116	9
1,1-Dichloroethane	N/A	N/A	N/A	75 - 117	70 - 122	10
1,1-Dichloroethene	70 - 128	62 - 128	26	67 - 134	61 - 137	15
1,2-Dichloroethane	N/A	N/A	N/A	68 - 121	64 - 124	7
1,2-Dichloropropane	N/A	N/A	N/A	78 - 122	74 - 123	8
2-Butanone	N/A	N/A	N/A	58 - 127	51 - 128	10
2-Hexanone	N/A	N/A	N/A	60 - 125	54 - 131	11
4-Methyl-2-pentanone	N/A	N/A	N/A	61 - 128	57 - 136	11
Acetone	N/A	N/A	N/A	44 - 142	45 - 127	15
Benzene	80 - 121	73 - 125	20	80 - 120	72 - 125	7
Bromodichloromethane	N/A	N/A	N/A	75 - 120	72 - 120	8

Laboratory Control Limits for QC Samples
Plum Brook Ordinance Works

Spiked Compound	STL			Accutest		
	Water - LCS	Water - MS/MSD		Water - LCS	Water - MS/MSD	
	% Recovery Range	% Recovery Range	Precision RPD (%)	% Recovery Range	% Recovery Range	Precision RPD (%)
Volatile Organic Compounds, SW-846 8260B (cont,)						
Bromoform	N/A	N/A	N/A	60 - 129	55 - 127	11
Bromomethane	N/A	N/A	N/A	60 - 165	52 - 172	16
Carbon disulfide	N/A	N/A	N/A	65 - 147	60 - 151	12
Carbon tetrachloride	N/A	N/A	N/A	69 - 137	56 - 145	12
Chlorobenzene	80 - 121	71 - 125	20	82 - 112	79 - 113	7
Chloroethane	N/A	N/A	N/A	67 - 148	56 - 164	14
Chloroform	N/A	N/A	N/A	78 - 118	75 - 120	8
Chloromethane	N/A	N/A	N/A	58 - 152	53 - 155	19
Dibromochloromethane	N/A	N/A	N/A	68 - 118	63 - 119	9
Ethylbenzene	N/A	N/A	N/A	82 - 115	73 - 119	8
Methylene chloride	N/A	N/A	N/A	66 - 125	61 - 129	11
Styrene	N/A	N/A	N/A	58 - 125	64 - 124	11
Tetrachloroethene	N/A	N/A	N/A	75 - 126	70 - 126	9
Toluene	77 - 124	69 - 129	20	81 - 114	67 - 123	8
Trichloroethene	80 - 121	56 - 137	20	80 - 115	73 - 117	10
Vinyl chloride	N/A	N/A	N/A	70 - 151	63 - 161	18
cis-1,2-Dichloroethene	N/A	N/A	N/A	81 - 120	74 - 125	9
cis-1,3-Dichloropropene	N/A	N/A	N/A	73 - 115	65 - 112	10
Xylenes (total)	N/A	N/A	N/A	81 - 118	72 - 122	7
trans-1,2-Dichloroethene	N/A	N/A	N/A	74 - 125	70 - 127	11
trans-1,3-Dichloropropene	N/A	N/A	N/A	69 - 115	59 - 116	11
Semivolatile Organic Compounds, SW-846 8270C						
1,2,4-Trichlorobenzene	66 - 113	63 - 113	36	64 - 101	54 - 102	24
1,2-Dichlorobenzene	N/A	N/A	N/A	62 - 100	50 - 101	22
1,3-Dichlorobenzene	N/A	N/A	N/A	59 - 99	50 - 100	23
1,4-Dichlorobenzene	65 - 111	58 - 113	37	60 - 101	51 - 101	23
2,4,5-Trichlorophenol	N/A	N/A	N/A	66 - 104	61 - 102	18
2,4,6-Trichlorophenol	N/A	N/A	N/A	60 - 103	55 - 103	21
2,4-Dichlorophenol	N/A	N/A	N/A	64 - 103	55 - 100	24
2,4-Dimethylphenol	N/A	N/A	N/A	43 - 94	36 - 98	26
2,4-Dinitrophenol	N/A	N/A	N/A	12 - 125	14 - 135	39
2,4-Dinitrotoluene	72 - 131	69 - 131	25	69 - 111	65 - 110	16
2,6-Dinitrotoluene	N/A	N/A	N/A	72 - 111	65 - 111	19
2-Chloronaphthalene	N/A	N/A	N/A	67 - 102	58 - 101	22
2-Chlorophenol	63 - 114	59 - 118	43	62 - 103	53 - 102	24
2-Methylnaphthalene	N/A	N/A	N/A	66 - 100	56 - 100	23
2-Methylphenol	N/A	N/A	N/A	54 - 91	46 - 100	23
2-Nitroaniline	N/A	N/A	N/A	70 - 111	66 - 107	18
2-Nitrophenol	N/A	N/A	N/A	64 - 104	53 - 104	25
3-Nitroaniline	N/A	N/A	N/A	66 - 106	47 - 107	26
3,3'-Dichlorobenzidine	N/A	N/A	N/A	42 110	18 - 112	22
3 and 4-Methylphenol	N/A	N/A	N/A	48 - 86	43 - 100	23
4,6-Dinitro-2-methylphenol	N/A	N/A	N/A	47 - 119	40 - 127	24
4-Bromophenyl phenyl ether	N/A	N/A	N/A	73 - 103	68 - 102	16
4-Chloro-3-methylphenol	71 - 118	66 - 130	29	64 - 103	60 - 101	18
4-Chloroaniline	N/A	N/A	N/A	57 - 104	39 - 101	21
4-Chlorophenyl phenyl ether	N/A	N/A	N/A	71 - 104	65 - 103	18

Laboratory Control Limits for QC Samples
Plum Brook Ordinance Works

Spiked Compound	STL			Accutest		
	Water - LCS	Water - MS/MSD		Water - LCS	Water - MS/MSD	
	% Recovery Range	% Recovery Range	Precision RPD (%)	% Recovery Range	% Recovery Range	Precision RPD (%)
Semivolatile Organic Compounds, SW-846 8270C (cont.)						
4-Methylphenol	N/A	N/A	N/A	NA	NA	NA
4-Nitroaniline	N/A	N/A	N/A	65 - 113	48 - 119	21
4-Nitrophenol	61 - 128	61 - 142	50	22 - 50	32 - 81	28
Acenaphthene	65 - 107	65 - 107	26	69 - 101	60 - 103	20
Acenaphthylene	N/A	N/A	N/A	70 - 113	67 - 113	20
Anthracene	N/A	N/A	N/A	75 - 107	71 - 105	14
Benzo(a)anthracene	N/A	N/A	N/A	73 - 106	70 - 103	16
Benzo(a)pyrene	N/A	N/A	N/A	75 - 114	70 - 113	16
Benzo(b)fluoranthene	N/A	N/A	N/A	73 - 110	67 - 110	17
Benzo(ghi)perylene	N/A	N/A	N/A	63 - 115	63 - 111	17
Benzo(k)fluoranthene	N/A	N/A	N/A	73 - 112	68 - 110	17
Butyl benzyl phthalate	N/A	N/A	N/A	69 - 108	65 - 108	17
Carbazole	N/A	N/A	N/A	74 - 113	71 - 109	16
Chrysene	N/A	N/A	N/A	73 - 103	70 - 100	18
Di-n-butyl phthalate	N/A	N/A	N/A	72 - 109	68 - 107	17
Di-n-octyl phthalate	N/A	N/A	N/A	68 - 120	58 - 126	23
Dibenz(a,h)anthracene	N/A	N/A	N/A	63 - 115	62 - 111	20
Dibenzofuran	N/A	N/A	N/A	69 - 104	64 - 102	17
Diethyl phthalate	N/A	N/A	N/A	64 - 110	59 - 110	18
Dimethyl phthalate	N/A	N/A	N/A	44 - 120	45 - 116	25
Fluoranthene	N/A	N/A	N/A	73 - 111	67 - 108	17
Fluorene	N/A	N/A	N/A	70 - 105	65 - 105	17
Hexachlorobenzene	N/A	N/A	N/A	73 - 103	69 - 102	16
Hexachlorobutadiene	N/A	N/A	N/A	55 - 90	45 - 93	26
Hexachlorocyclopentadiene	N/A	N/A	N/A	26 - 95	20 - 92	34
Hexachloroethane	N/A	N/A	N/A	59 - 104	51 - 105	26
Indeno(1,2,3-cd)pyrene	N/A	N/A	N/A	63 - 118	66 - 111	19
Isophorone	N/A	N/A	N/A	68 - 107	59 - 103	23
Naphthalene	N/A	N/A	N/A	67 - 101	52 - 102	23
Nitrobenzene	N/A	N/A	N/A	66 - 106	56 - 103	25
Pentachlorophenol	71 - 122	71 - 135	37	50 - 111	44 - 118	16
Phenanthrene	N/A	N/A	N/A	73 - 104	69 - 103	15
Phenol	59 - 117	55 - 123	41	25 - 53	31 - 77	26
Pyrene	67 - 114	63 - 114	27	69 - 105	64 - 107	21
bis(2-Chloroethoxy)methane	N/A	N/A	N/A	57 - 103	49 - 100	24
bis(2-Chloroethyl)ether	N/A	N/A	N/A	64 - 106	54 - 103	24
bis(2-Chloroisopropyl)ether	N/A	N/A	N/A	52 - 120	49 - 109	22
bis(2-Ethylhexyl)phthalate	N/A	N/A	N/A	69 - 115	55 - 120	22
n-Nitroso-di-n-propylamine	62 - 114	60 - 117	36	64 - 109	57 - 103	24
n-Nitrosodiphenylamine	N/A	N/A	N/A	74 - 114	72 - 112	16

Laboratory Control Limits for QC Samples
Plum Brook Ordinance Works

Spiked Compound	STL			Accutest		
	Water - LCS	Water - MS/MSD		Water - LCS	Water - MS/MSD	
	% Recovery Range	% Recovery Range	Precision RPD (%)	% Recovery Range	% Recovery Range	Precision RPD (%)
Nitroaromatics and Nitramines, SW-846 8330						
1,3,5-Trinitrobenzene	75 - 121	62 - 127	33	77 - 115	72 - 116	12
1,3-Dinitrobenzene	75 - 121	70 - 121	42	77 - 117	77 - 117	12
2,4,6-Trinitrotoluene	76 - 120	67 - 120	34	76 - 113	70 - 117	14
2,4-Dinitrotoluene	73 - 118	72 - 118	36	74 - 119	72 - 121	15
2,6-Dinitrotoluene	74 - 120	74 - 120	32	77 - 123	77 - 122	16
2-Nitrotoluene	50 - 109	46 - 118	38	68 - 120	75 - 119	17
3-Nitrotoluene	56 - 110	56 - 121	36	69 - 120	66 - 129	16
2-Amino-4,6-dinitrotoluene	69 - 113	59 - 125	34	77 - 121	68 - 128	17
4-Amino-2,6-dinitrotoluene	69 - 113	68 - 113	13	76 - 121	67 - 127	16
4-Nitrotoluene	56 - 111	56 - 111	33	75 - 118	75 - 122	18
HMX	71 - 122	67 - 122	11	79 - 119	73 - 123	13
Nitrobenzene	61 - 114	61 - 114	36	66 - 122	73 - 121	15
RDX	77 - 127	70 - 133	11	73 - 119	65 - 126	13
Tetryl	73 - 119	38 - 132	37	63 - 122	42 - 135	15
Water Quality						
Chloride	90 - 115	43 - 167	23	N/A	N/A	N/A
Cyanide, Total	88 - 113	75 - 125	20	N/A	N/A	N/A
Hardness as $CaCO_3$	84 - 116	10 - 176	23	N/A	N/A	N/A
Nitrate	77 - 116	10 - 132	24	N/A	N/A	N/A
Sulfate	80 - 112	22 - 151	24	N/A	N/A	N/A
Total Alkalinity	90 - 127	10 - 160	24	N/A	N/A	N/A
Total Dissolved Solids	69 - 120	N/A	20	N/A	N/A	N/A
Total Organic Carbon	90 - 110	85 - 117	10	N/A	N/A	N/A
Total Suspended Solids	66 - 119	N/A	20	N/A	N/A	N/A
Turbidity	75 - 125	N/A	20	N/A	N/A	N/A

LCS - Laboratory control sample.
MS/MSD - Matrix spike/matrix spike duplicate.
RPD - Relative percent difference.
STL - Severn Trent Laboratories.
N/A - Not applicable.

AUGUST 2004 DOWNGRADIENT WELL SAMPLING
DATA VALIDATION SUMMARY

Data Validation Summary Report
Quarterly Groundwater Sampling August 2004
Former Plum Brook Ordnance Works
Sandusky, Ohio

1.0 Introduction

Level III data validation was performed on 100 percent of the environmental samples collected for the August 2004 sampling event. The analytical data consisted of three sample delivery groups (SDGs) H4H260300, H4H270215 and H4H280124, which were analyzed by Severn Trent Laboratories (STL). In addition, validation of the field-split data, SDG F26367, which were analyzed by Accutest Laboratories, was performed and findings are discussed in section 5.0 of this report.

The following samples were validated for this site investigation:

SDG Number	Sample Number
H4H260300	DH3001, DH3003
H4H270215	DH3000, DH3002, DH3005
H4H280124	DH3004, DH3007
F26367	DH3003

The chemical parameters for which the samples were analyzed, are identified below:

Parameter (Prep/Analytical Method)
Volatile Organics by GC/MS SW846 5030/8260B
Semivolatile Organics by GC/MS SW846 3510C/8270C
Total and Dissolved Metals by SW846 3005A/6010B and 7470A
Nitroaromatic and Nitramine Explosives by SW846 8330M
Wet Chemistry (TOC, Sulfate, Nitrate, Chloride, Alkalinity, Turbidity, TDS, TSS, Hardness, Cyanide)

GC/MS – Gas chromatography/mass spectrometry.
TDS – Total dissolved solids.
TOC – Total organic carbon.
TSS – Total suspended solids.

2.0 Procedures

The sample data were validated following the logic identified in the *EPA Contract Laboratory Program (CLP) National Functional Guidelines for Inorganic Data Review* (July 2002) and the *EPA Contract Laboratory Program National Functional Guidelines for Organic Review* (October 1999) for all areas except blanks. *EPA Region III Modifications to the Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* (April 1993) and *Region III Modifications to National Functional Guidelines for Organic Data Review, Multi-Media, Multi-Concentration (September 1994)* were applied to the areas associated with blank contamination. Specific quality control (QC) criteria as identified in the quality assurance plan (QAP), analytical methods, and laboratory standard operating procedures (SOP) were applied to all sample results. As a result of the use of Update III SW846 test methods for the analytical data and the application of the Contract Laboratory Program (CLP) guidelines during the validation process,

there were instances where specific QC requirements for all target compounds were not defined. This primarily occurred in the organic, gas chromatography (GC) and GC/mass spectrometry (MS) calibration areas and is due to the fact that the analytical methods are performance-based and allow the use of average calibration responses in lieu of individual responses, which are defined by CLP protocol. In light of applying CLP guidelines to SW846 methods and evaluating the usability of the data during the validation process, specific QC criteria were determined to address all target compounds and are identified in this report for each parameter, as well as in the validation checklists, which function as worksheets. For those analytical methods not addressed by the CLP and Region III guidelines, the validation was based on the method requirements (i.e., SW846, Code of Federal Regulations, SOPs) and technical judgement, following the logic of the CLP validation guidelines. Lab-specific criteria may be found in Attachment A.

3.0 Summary of Data Validation Findings

The overall quality of the data was determined to be acceptable with minimal qualifications. The only rejected data ("R" qualified) was due to "poor performing" volatile compounds (ketones, some halogenated hydrocarbons, etc.), which experienced poor calibration responses in the associated calibration data and samples that were reanalyzed and have more than one set of results reported. The "R" qualifier was assigned to the samples with more than one set of results to indicate that a given result should not be used to characterize a particular constituent or an analysis for a given sample.

Individual validation reports have been prepared for each parameter, and the overall results of the validation findings are summarized in this report. A listing of the validation qualifiers and the reason codes, along with their definitions, is found in Attachment A. The following section highlights the key findings of the data validation for each analysis.

4.0 Analysis-Specific Data Validation Summaries

4.1 Volatile Organics by GC/MS SW846 8260B

Overall, the data are of good quality and are usable as reported by the laboratory with the exceptions noted below. Data were reviewed for the following:

Initial and Continuing Calibration

The initial calibration (ICAL) and continuing calibrations (CCAL) associated with the project samples met QC criteria with the following exception(s):

- The following exhibited individual ICAL/CCAL relative response factor (RRF) <0.1:

SDG Number	Samples Affected	Compound(s)	Validation Qualifier
H4H260300	DH3003	Acetone, 2-Butanone, 4-Methyl-2-pentanone	R
H4H270215	DH3000, DH3002, DH3005	2-Butanone, 4-Methyl-2-pentanone	R
	DH3000, DH3002	Acetone	R
H4H280124	DH3004	Acetone, 2-Butanone, 4-Methyl-2-pentanone	R/J

- The following exhibited individual ICAL relative standard deviation (%RSD) >30 and/or CCAL percent difference (%D) >20:

SDG Number	Samples Affected	Compound(s)	Validation Qualifier
H4H260300	DH3003	Acetone, 2-Butanone, 2-Hexanone	R/UJ
H4H270215	DH3005	Xylenes (Total)	UJ

Blanks

The 5X/10X rule for contaminants found in the associated equipment rinses, trip blanks, and method blanks was applied to all sample results. All were found to be acceptable with the following exception(s):

SDG Number	Samples Affected	Compound(s)	Blank Contaminant	Validation Qualifier
H4H270215	DH3002, DH3005	Carbon disulfide	TB	B
	DH3002	Toluene	TB	B

Surrogate Recoveries

All surrogate recoveries were within QC limits.

Matrix Spike / Matrix Spike Duplicate

Matrix Spike/Matrix Spike Duplicate (MS/MSD) analysis was performed for the project samples, and all QC criteria were met.

Laboratory Control Sample

Laboratory Control Sample (LCS) analysis was performed for the project samples, and all QC criteria were met.

Field Duplicates

Original and field duplicate results were evaluated and no problems were identified.

Internal Standards

All internal standards met QC criteria.

Quantitation
Results quantitated between the method detection limit (MDL) and the reporting limit (RL), which the lab qualified as "J", were qualified as estimated "J" unless blank contamination was present or the results were rejected.

4.2 Semivolatile Organics by GC/MS SW846 8270C

Overall, the data are of good quality and are usable as reported by the laboratory with the exceptions noted below. Data were reviewed for the following:

Holding Times
Technical holding time criteria were met for all samples.

Initial and Continuing Calibration
All initial and continuing calibrations associated with the project samples met QC criteria with the following exception(s):

- The following exhibited individual ICAL %RSD >30 and/or CCAL %D >20:

SDG Number	Samples Affected	Compound(s)	Validation Qualifier
H4H270215	DH3005	2,4-Dinitrophenol, 4,6-Dinitro-2-methylphenol	UJ

Blanks
The 5X/10X rule for contaminants found in the associated equipment rinses and method blanks was applied to all sample results. All were found to be acceptable.

Surrogate Recoveries
All surrogate recoveries were within QC criteria.

Matrix Spike / Matrix Spike Duplicate
MS/MSD analysis was performed for the project samples, and all QC criteria were met.

Laboratory Control Sample
LCS analysis was performed for the project samples, and all QC criteria were met.

Field Duplicates
Original and field duplicate results were evaluated, and all QC criteria were met.

Internal Standards
All internal standards met QC criteria.

Quantitation

Results quantified between the MDL and the RL, which the lab qualified as "J", were qualified as estimated "J" unless blank contamination was present or the results were rejected.

4.3 Total and Dissolved Metals by SW846 6010B/7470A

Overall, the data are of good quality and are usable as reported by the laboratory with the exceptions noted below. Data were reviewed for the following:

Holding Times

Technical holding time criteria were met for all samples.

Initial and Continuing Calibrations

All initial and continuing calibrations associated with the project samples met QC criteria.

Blanks

The 5X rule for contaminants found in the associated equipment rinse, calibration, and method blanks was applied to all sample results. All criteria were acceptable with the following exception(s):

SDG	Samples Affected	Element(s)	Blank Contaminant	Validation Qualifier
H4H260300	DH3003	Arsenic (dissolved)	ICB/CCB	B
H4H270215	DH3000, DH3002, DH3005	Aluminum (dissolved)	ICB/CCB	B
	DH3000	Aluminum (total), Selenium (total)	ICB/CCB	B
	DH3005	Nickel (total)	ICB/CCB	B
H4H280124	DH3004	Aluminum (dissolved)	ICB/CCB	B

Matrix Spike / Matrix Spike Duplicate

MS/MSD analysis was performed for the project samples, and all QC criteria were met with the following exception(s):

SDG Number	Samples Affected	Compound(s)	Validation Qualifier
H4H260300	DH3003	Aluminum (total)	J
H4H270215	DH3000, DH3002, DH3005	Aluminum (total)	J/B
H4H280124	DH3004	Aluminum (total)	J

Laboratory Control Sample

LCS analysis was performed for the project samples, and all QC criteria were met.

Interference Check Sample

All Interference Check Sample (ICS) percent recoveries were acceptable. All QC criteria were met.

Inductively Coupled Plasma Serial Dilutions

All QC criteria were met for the serial dilutions associated with the project samples with the following exception(s):

SDG	Samples Affected	Element(s)	Validation Qualifier
H4H260300	DH3003	Potassium (dissolved)	J
H4H270215	DH3000, DH3002, DH3005	Potassium (dissolved)	J
H4H280124	DH3004	Potassium (dissolved)	J

Field Duplicates

Original and field duplicate results were evaluated, and no problems were identified.

Quantitation

Results quantified between the MDL and the RL, which the lab qualified as "B", were qualified as estimated "J" unless blank contamination was present or the results were rejected.

4.4 Nitroaromatic and Nitramine Explosives by SW846 8330

Overall, the data are of good quality and are usable as reported by the laboratory. Data were reviewed for the following:

Holding Times

Technical holding time criteria were met for all samples.

Initial and Continuing Calibration

All initial and continuing calibrations associated with the project samples met QC criteria.

Blanks

The 5X rule for contaminants found in the associated equipment rinses and method blanks was applied to all sample results. All were found to be acceptable.

Surrogate Recoveries

All surrogate recoveries were within QC criteria.

Matrix Spike / Matrix Spike Duplicate

MS/MSD analysis was performed for the project samples, and all QC criteria were met.

Laboratory Control Sample

LCS analysis was performed for the project samples, and all QC criteria were met.

Field Duplicates

Original and field duplicate results were evaluated, and no problems were identified.

Quantitation

Results quantified between the MDL and the RL, which the lab qualified as "J", were qualified as estimated "J" unless blank contamination was present or the results were rejected.

4.5 Wet Chemistry (TOC, Sulfate, Nitrate, Chloride, Alkalinity, Turbidity, TDS, TSS, Hardness, Cyanide)

Overall, the data are of good quality and are usable as reported by the laboratory with the exceptions noted below. Data were reviewed for the following:

Holding Times

Technical holding time criteria were met for all samples.

SDG Number	Samples Affected	Compound(s)	Validation Qualifier
H4H270215	DH3000	Cyanide	UJ

Initial and Continuing Calibration

All initial and continuing calibrations associated with the project samples met QC criteria.

Blanks

The 5X rule for contaminants found in the associated equipment rinses and method blanks was applied to all sample results. All were found to be acceptable.

Matrix Spike / Matrix Spike Duplicate

MS/MSD analysis was performed for the project samples, and all QC criteria were met with the following exception(s):

SDG Number	Samples Affected	Compound(s)	Validation Qualifier
H4H260300	DH3003	Nitrate, Cyanide (total)	UJ
H4H270215	DH3000, DH3002	Nitrate, Cyanide (total)	UJ
H4H280124	DH3007	Cyanide (total)	UJ

Laboratory Control Sample

LCS analysis was performed for the project samples, and all QC criteria were met.

Field Duplicates

Original and field duplicate results were evaluated, and no problems were identified.

Quantitation

Results quantified between the MDL and the RL, which the lab qualified as "J", were qualified as estimated "J" unless blank contamination was present or the results were rejected.

5.0 Quality Assurance Field Split Sample Data Evaluation

Data from the quality assurance split sample: SDG F26367 sample DH3006, were validated. The FS sample was analyzed for Volatiles by SW846 8260B, Semivolatiles by SW846 8270C, Explosives by SW846 8330, and Total and Dissolved Metals by SW846 6010B and 7470A. The following section highlights the key findings of the data validation for each analysis.

5.1 Volatile Organics by GC/MS SW846 8260B

Overall, the data are of good quality and are usable as reported by the laboratory with the exceptions noted below. Data were reviewed for the following:

Holding Times

Technical holding time criteria were met for all samples.

Initial and Continuing Calibration

The ICAL and CCAL associated with the project samples met QC criteria.

Blanks

The 5X/10X rule for contaminants found in the associated trip blanks and method blanks was applied to all sample results. All were found to be acceptable.

Surrogate Recoveries

All surrogate recoveries were within QC limits.

Matrix Spike / Matrix Spike Duplicate

MS/MSD analysis was performed for the project samples, and all QC criteria were met with the following exception(s):

SDG Number	Samples Affected	Compound(s)	Validation Qualifier
F26367	DH3006	Trans-1,3-Dichloropropene, Styrene	UJ

Laboratory Control Sample

LCS analysis was performed for the project samples, and all QC criteria were met.

Internal Standards
All internal standards met QC criteria.

Field Split/Original Sample Comparison

SDG F26367
DH3002 (original) and DH3006 field split (FS) results were evaluated. It should be noted that the original sample had positive results for Benzene, Carbon disulfide and Toluene below the reporting limits. The field split sample had non-detect results for all compounds.

Quantitation
Results quantitated between the MDL and the RL, which the lab qualified as "J", were qualified as estimated "J" unless blank contamination was present or the results were rejected.

5.2 Semivolatile Organics by GC/MS SW846 8270C

Overall, the data are of good quality and are usable as reported by the laboratory. Data were reviewed for the following:

Holding Times
Technical holding time criteria were met for all samples.

Initial and Continuing Calibration
The initial calibration and continuing calibrations associated with the project samples met QC criteria.

Blanks
The 5X/10X rule for contaminants found in the associated blanks was applied to all sample results and all were found to be acceptable.

Matrix Spike / Matrix Spike Duplicate
MS/MSD analysis was performed for the project samples, and all QC criteria were met.

Laboratory Control Sample
LCS analysis was performed for the project samples, and all QC criteria were met.

Surrogate Recoveries
All surrogate recoveries were within QC criteria.

Internal Standards
All internal standards met QC.

Field Split/Original Sample Comparison

SDG F26367
DH3002 (original) and DH3006 (FS) results were evaluated. It should be noted that both samples were non-detect for all compounds.

Quantitation
Results quantified between the MDL and the RL, which the lab qualified as "J", were qualified as estimated "J" unless blank contamination was present or the results were rejected.

5.3 Total and Dissolved Metals by SW846 6010B/7470A

Overall, the data are of good quality and are usable as reported by the laboratory with the exceptions noted below. Data were reviewed for the following:

Holding Times
Technical holding time criteria were met for all samples.

Initial and Continuing Calibration
All initial and continuing calibrations associated with the project samples met QC criteria.

Blanks
The 5X rule for contaminants found in the associated blanks was applied to all sample results and all were found to be acceptable with the following exception(s):

SDG	Samples Affected	Element(s)	Blank Contaminant	Validation Qualifier
F26367	DH3006	Aluminum (dissolved)	ICB/CCB	B

Matrix Spike / Matrix Spike Duplicate
MS/MSD analysis was performed for the project samples, and all QC criteria were met.

Laboratory Control Sample (LCS)
All QC criteria were met for the LCS associated with the project sample analyses.

Interference Check Sample
All ICS percent recoveries were acceptable. All QC criteria were met.

Inductively Coupled Plasma Serial Dilutions
All QC criteria were met for the serial dilutions associated with the project

Field Split/Original Sample Comparison

SDG F26367
DH3002 (original) and DH3006 (FS) results were evaluated. All RPD QC criteria for total and dissolved results were met with the exception of Aluminum (64.33%), Iron (136.93%) and Nickel (95.24%) for total results and Aluminum (63.35%) for dissolved results.

Quantitation
Results quantified between the MDL and the RL, which the lab qualified as "J", were qualified as estimated "J" unless blank contamination was present or the results were rejected.

5.4 Nitroaromatic and Nitramine Explosives by SW846 8330

Overall, the data are of good quality and are usable as reported by the laboratory. Data were reviewed for the following:

Holding Times
Technical holding time criteria were met for all samples.

Initial and Continuing Calibration
All initial and continuing calibrations associated with the project samples met QC criteria.

Blanks
The 5X rule for contaminants found in the associated equipment rinses and method blanks was applied to all sample results. All were found to be acceptable.

Surrogate Recoveries
All surrogate recoveries were within QC criteria.

Matrix Spike / Matrix Spike Duplicate
MS/MSD analysis was performed for the project samples, and all QC criteria were met.

Laboratory Control Sample
LCS analysis was performed for the project samples, and all QC criteria were met.

Field Split/Original Sample Comparison

SDG F26367
DH3002 (original) and DH3006 (FS) results were evaluated. It should be noted that DH3002 (original) and DH3006 (FS) were non-detect for all compounds.

Quantitation

Results quantified between the MDL and the RL, which the lab qualified as "J", were qualified as estimated "J" unless blank contamination was present or the results were rejected.

ATTACHMENT A

Validation Qualifiers

U Not detected. The compound/analyte was analyzed for, but not detected above the associated reporting limit.

J The compound/analyte was positively identified; the reported value is the estimated concentration of the constituent detected in the sample analyzed.

B The concentration reported was detected below the levels reported in the associated equipment rinse samples and/or laboratory method and trip blanks. (5X/10X Rule was applied).

R The reported sample results are rejected due to the following:

1. Severe deficiencies in the supporting quality control data.
2. Anomalies noted in the sampling and/or analysis process, which could affect the validity of the reported data.
3. The presence or absence of the constituent cannot be verified based on the data provided.
4. To indicate not to use a particular result in the event of a reanalysis.

UJ The compound/analyte was analyzed for, but not detected above the established reporting limit. However, review and evaluation of supporting QC data and/or sampling and analysis process have indicated that the "nondetect" may be inaccurate or imprecise. The nondetect result should be estimated.

Validation Reason Code Definitions

Reason Code	Definition
01	Sample received outside of 4+/-2 degrees Celsius
01A	Improper sample preservation
02	Holding time exceeded
02A	Extraction
02B	Analysis
03	Instrument performance – outside criteria
03A	BFB
03B	DFTPP
03C	DDT and/or Endrin % breakdown exceeds criteria
03D	Retention time windows
03E	Resolution
04	Initial calibration results outside specified criteria
04A	Compound mean RRF QC criteria not met
04B	Individual % RSD criteria not met
04C	Correlation coefficient >0.995
05	Continuing calibration results outside specified criteria
05A	Compound mean RRF QC criteria not met
05B	Compound % D QC criteria not met
06	Result qualified as a result of the 5x/10x blank correction
06A	Method or preparation blank
06B	ICB or CCB
06C	ER
06D	TB
06E	FB
07	Surrogate recoveries outside control limits
07A	Sample
07B	Associated method blank or LCS
08	MS/MSD/Duplicate results outside criteria
08A	MS and/or MSD recovery not within control limits (accuracy)
08B	% RPD outside acceptance criteria (precision)
09	Post digestion spike outside criteria (GFAA)
10	Internal standards outside specified control limits
10A	Recovery
10B	Retention time
11	Laboratory control sample recoveries outside specified limits
11A	Recovery
11B	% RPD (if run in duplicate)
12	Interference check standard
13	Serial dilution
14	Tentatively identified compounds
15	Quantitation
16	Multiple results available; alternate analysis preferred
17	Field duplicate RPD criteria is exceeded
18	Percent difference between original and second column exceeds QC criteria
19	Professional judgement was used to qualify the data
20	Pesticide clean-up checks
21	Target compound identification
22	Radiological calibration
23	Radiological quantitation
24	Reported result and/or lab qualifier revised to reflect validation findings

Laboratory Control Limits for QC Samples
Plum Brook Ordinance Works

Spiked Compound	STL			Accutest		
	Water - LCS	Water - MS/MSD		Water - LCS	Water - MS/MSD	
	% Recovery Range	% Recovery Range	Precision RPD (%)	% Recovery Range	% Recovery Range	Precision RPD (%)
Metals, SW-846 6010B/7470A						
Aluminum	90 - 111	75 - 125	20	80 - 120	75 - 125	20
Antimony	90 - 110	75 - 125	20	80 - 120	75 - 125	20
Arsenic	90 - 110	75 - 125	20	80 - 120	83 - 116	20
Barium	90 - 110	75 - 125	20	80 - 120	82 - 116	20
Beryllium	90 - 111	75 - 125	20	80 - 120	86 - 119	20
Cadmium	90 - 110	75 - 125	20	80 - 120	80 - 115	20
Calcium	90 - 110	75 - 125	20	80 - 120	75 - 125	20
Chromium	90 - 110	75 - 125	20	80 - 120	82 - 120	20
Cobalt	90 - 110	75 - 125	20	80 - 120	83 - 117	20
Copper	90 - 110	75 - 125	20	80 - 120	87 - 120	20
Iron	90 - 110	75 - 125	20	80 - 120	76 - 125	20
Lead	90 - 110	75 - 125	20	80 - 120	84 - 118	20
Magnesium	90 - 110	75 - 125	20	80 - 120	75 - 125	20
Manganese	90 - 111	75 - 125	20	80 - 120	75 - 125	20
Mercury	90 - 110	80 - 120	20	80 - 120	62 - 131	15
Nickel	90 - 110	75 - 125	20	80 - 120	81 - 121	20
Potassium	90 - 114	75 - 125	20	80 - 120	76 - 125	20
Selenium	90 - 115	75 - 125	20	80 - 120	84 - 121	20
Silver	90 - 110	75 - 125	20	80 - 120	77 - 125	20
Sodium	90 - 110	75 - 125	20	80 - 120	75 - 125	20
Thallium	90 - 110	75 - 125	20	80 - 120	86 - 121	20
Vanadium	90 - 110	75 - 125	20	80 - 120	87 - 118	20
Zinc	90 - 114	75 - 125	20	80 - 120	82 - 123	20
Volatile Organic Compounds, SW-846 8260B						
1,1,1-Trichloroethane	N/A	N/A	N/A	78 - 132	72 - 133	8
1,1,2,2-Tetrachloroethane	N/A	N/A	N/A	67 - 119	64 - 120	10
1,1,2-Trichloroethane	N/A	N/A	N/A	74 - 115	72 - 116	9
1,1-Dichloroethane	N/A	N/A	N/A	75 - 117	70 - 122	10
1,1-Dichloroethene	70 - 128	62 - 128	26	67 - 134	61 - 137	15
1,2-Dichloroethane	N/A	N/A	N/A	68 - 121	64 - 124	7
1,2-Dichloropropane	N/A	N/A	N/A	78 - 122	74 - 123	8
2-Butanone	N/A	N/A	N/A	58 - 127	51 - 128	10
2-Hexanone	N/A	N/A	N/A	60 - 125	54 - 131	11
4-Methyl-2-pentanone	N/A	N/A	N/A	61 - 128	57 - 136	11
Acetone	N/A	N/A	N/A	44 - 142	45 - 127	15
Benzene	80 - 121	73 - 125	20	80 - 120	72 - 125	7
Bromodichloromethane	N/A	N/A	N/A	75 - 120	72 - 120	8

Laboratory Control Limits for QC Samples
Plum Brook Ordinance Works

Spiked Compound	STL			Accutest		
	Water - LCS	Water - MS/MSD		Water - LCS	Water - MS/MSD	
	% Recovery Range	% Recovery Range	Precision RPD (%)	% Recovery Range	% Recovery Range	Precision RPD (%)
Volatile Organic Compounds, SW-846 8260B (cont,)						
Bromoform	N/A	N/A	N/A	60 - 129	55 - 127	11
Bromomethane	N/A	N/A	N/A	60 - 165	52 - 172	16
Carbon disulfide	N/A	N/A	N/A	65 - 147	60 - 151	12
Carbon tetrachloride	N/A	N/A	N/A	69 - 137	56 - 145	12
Chlorobenzene	80 - 121	71 - 125	20	82 - 112	79 - 113	7
Chloroethane	N/A	N/A	N/A	67 - 148	56 - 164	14
Chloroform	N/A	N/A	N/A	78 - 118	75 - 120	8
Chloromethane	N/A	N/A	N/A	58 - 152	53 - 155	19
Dibromochloromethane	N/A	N/A	N/A	68 - 118	63 - 119	9
Ethylbenzene	N/A	N/A	N/A	82 - 115	73 - 119	8
Methylene chloride	N/A	N/A	N/A	66 - 125	61 - 129	11
Styrene	N/A	N/A	N/A	58 - 125	64 - 124	11
Tetrachloroethene	N/A	N/A	N/A	75 - 126	70 - 126	9
Toluene	77 - 124	69 - 129	20	81 - 114	67 - 123	8
Trichloroethene	80 - 121	56 - 137	20	80 - 115	73 - 117	10
Vinyl chloride	N/A	N/A	N/A	70 - 151	63 - 161	18
cis-1,2-Dichloroethene	N/A	N/A	N/A	81 - 120	74 - 125	9
cis-1,3-Dichloropropene	N/A	N/A	N/A	73 - 115	65 - 112	10
Xylenes (total)	N/A	N/A	N/A	81 - 118	72 - 122	7
trans-1,2-Dichloroethene	N/A	N/A	N/A	74 - 125	70 - 127	11
trans-1,3-Dichloropropene	N/A	N/A	N/A	69 - 115	59 - 116	11
Semivolatile Organic Compounds, SW-846 8270C						
1,2,4-Trichlorobenzene	66 - 113	63 - 113	36	64 - 101	54 - 102	24
1,2-Dichlorobenzene	N/A	N/A	N/A	62 - 100	50 - 101	22
1,3-Dichlorobenzene	N/A	N/A	N/A	59 - 99	50 - 100	23
1,4-Dichlorobenzene	65 - 111	58 - 113	37	60 - 101	51 - 101	23
2,4,5-Trichlorophenol	N/A	N/A	N/A	66 - 104	61 - 102	18
2,4,6-Trichlorophenol	N/A	N/A	N/A	60 - 103	55 - 103	21
2,4-Dichlorophenol	N/A	N/A	N/A	64 - 103	55 - 100	24
2,4-Dimethylphenol	N/A	N/A	N/A	43 - 94	36 - 98	26
2,4-Dinitrophenol	N/A	N/A	N/A	12 - 125	14 - 135	39
2,4-Dinitrotoluene	72 - 131	69 - 131	25	69 - 111	65 - 110	16
2,6-Dinitrotoluene	N/A	N/A	N/A	72 - 111	65 - 111	19
2-Chloronaphthalene	N/A	N/A	N/A	67 - 102	58 - 101	22
2-Chlorophenol	63 - 114	59 - 118	43	62 - 103	53 - 102	24
2-Methylnaphthalene	N/A	N/A	N/A	66 - 100	56 - 100	23
2-Methylphenol	N/A	N/A	N/A	54 - 91	46 - 100	23
2-Nitroaniline	N/A	N/A	N/A	70 - 111	66 - 107	18
2-Nitrophenol	N/A	N/A	N/A	64 - 104	53 - 104	25
3-Nitroaniline	N/A	N/A	N/A	66 - 106	47 - 107	26
3,3'-Dichlorobenzidine	N/A	N/A	N/A	42 110	18 - 112	22
3 and 4-Methylphenol	N/A	N/A	N/A	48 - 86	43 - 100	23
4,6-Dinitro-2-methylphenol	N/A	N/A	N/A	47 - 119	40 - 127	24
4-Bromophenyl phenyl ether	N/A	N/A	N/A	73 - 103	68 - 102	16
4-Chloro-3-methylphenol	71 - 118	66 - 130	29	64 - 103	60 - 101	18
4-Chloroaniline	N/A	N/A	N/A	57 - 104	39 - 101	21
4-Chlorophenyl phenyl ether	N/A	N/A	N/A	71 - 104	65 - 103	18

Laboratory Control Limits for QC Samples
Plum Brook Ordinance Works

Spiked Compound	STL			Accutest		
	Water - LCS	Water - MS/MSD		Water - LCS	Water - MS/MSD	
	% Recovery Range	% Recovery Range	Precision RPD (%)	% Recovery Range	% Recovery Range	Precision RPD (%)
Semivolatile Organic Compounds, SW-846 8270C (cont.)						
4-Methylphenol	N/A	N/A	N/A	NA	NA	NA
4-Nitroaniline	N/A	N/A	N/A	65 - 113	48 - 119	21
4-Nitrophenol	61 - 128	61 - 142	50	22 - 50	32 - 81	28
Acenaphthene	65 - 107	65 - 107	26	69 - 101	60 - 103	20
Acenaphthylene	N/A	N/A	N/A	70 - 113	67 - 113	20
Anthracene	N/A	N/A	N/A	75 - 107	71 - 105	14
Benzo(a)anthracene	N/A	N/A	N/A	73 - 106	70 - 103	16
Benzo(a)pyrene	N/A	N/A	N/A	75 - 114	70 - 113	16
Benzo(b)fluoranthene	N/A	N/A	N/A	73 - 110	67 - 110	17
Benzo(ghi)perylene	N/A	N/A	N/A	63 - 115	63 - 111	17
Benzo(k)fluoranthene	N/A	N/A	N/A	73 - 112	68 - 110	17
Butyl benzyl phthalate	N/A	N/A	N/A	69 - 108	65 - 108	17
Carbazole	N/A	N/A	N/A	74 - 113	71 - 109	16
Chrysene	N/A	N/A	N/A	73 - 103	70 - 100	18
Di-n-butyl phthalate	N/A	N/A	N/A	72 - 109	68 - 107	17
Di-n-octyl phthalate	N/A	N/A	N/A	68 - 120	58 - 126	23
Dibenz(a,h)anthracene	N/A	N/A	N/A	63 - 115	62 - 111	20
Dibenzofuran	N/A	N/A	N/A	69 - 104	64 - 102	17
Diethyl phthalate	N/A	N/A	N/A	64 - 110	59 - 110	18
Dimethyl phthalate	N/A	N/A	N/A	44 - 120	45 - 116	25
Fluoranthene	N/A	N/A	N/A	73 - 111	67 - 108	17
Fluorene	N/A	N/A	N/A	70 - 105	65 - 105	17
Hexachlorobenzene	N/A	N/A	N/A	73 - 103	69 - 102	16
Hexachlorobutadiene	N/A	N/A	N/A	55 - 90	45 - 93	26
Hexachlorocyclopentadiene	N/A	N/A	N/A	26 - 95	20 - 92	34
Hexachloroethane	N/A	N/A	N/A	59 - 104	51 - 105	26
Indeno(1,2,3-cd)pyrene	N/A	N/A	N/A	63 - 118	66 - 111	19
Isophorone	N/A	N/A	N/A	68 - 107	59 - 103	23
Naphthalene	N/A	N/A	N/A	67 - 101	52 - 102	23
Nitrobenzene	N/A	N/A	N/A	66 - 106	56 - 103	25
Pentachlorophenol	71 - 122	71 - 135	37	50 - 111	44 - 118	16
Phenanthrene	N/A	N/A	N/A	73 - 104	69 - 103	15
Phenol	59 - 117	55 - 123	41	25 - 53	31 - 77	26
Pyrene	67 - 114	63 - 114	27	69 - 105	64 - 107	21
bis(2-Chloroethoxy)methane	N/A	N/A	N/A	57 - 103	49 - 100	24
bis(2-Chloroethyl)ether	N/A	N/A	N/A	64 - 106	54 - 103	24
bis(2-Chloroisopropyl)ether	N/A	N/A	N/A	52 - 120	49 - 109	22
bis(2-Ethylhexyl)phthalate	N/A	N/A	N/A	69 - 115	55 - 120	22
n-Nitroso-di-n-propylamine	62 - 114	60 - 117	36	64 - 109	57 - 103	24
n-Nitrosodiphenylamine	N/A	N/A	N/A	74 - 114	72 - 112	16

Laboratory Control Limits for QC Samples
Plum Brook Ordinance Works

Spiked Compound	STL			Accutest		
	Water - LCS	Water - MS/MSD		Water - LCS	Water - MS/MSD	
	% Recovery Range	% Recovery Range	Precision RPD (%)	% Recovery Range	% Recovery Range	Precision RPD (%)
Nitroaromatics and Nitramines, SW-846 8330						
1,3,5-Trinitrobenzene	75 - 121	62 - 127	33	77 - 115	72 - 116	12
1,3-Dinitrobenzene	75 - 121	70 - 121	42	77 - 117	77 - 117	12
2,4,6-Trinitrotoluene	76 - 120	67 - 120	34	76 - 113	70 - 117	14
2,4-Dinitrotoluene	73 - 118	72 - 118	36	74 - 119	72 - 121	15
2,6-Dinitrotoluene	74 - 120	74 - 120	32	77 - 123	77 - 122	16
2-Nitrotoluene	50 - 109	46 - 118	38	68 - 120	75 - 119	17
3-Nitrotoluene	56 - 110	56 - 121	36	69 - 120	66 - 129	16
2-Amino-4,6-dinitrotoluene	69 - 113	59 - 125	34	77 - 121	68 - 128	17
4-Amino-2,6-dinitrotoluene	69 - 113	68 - 113	13	76 - 121	67 - 127	16
4-Nitrotoluene	56 - 111	56 - 111	33	75 - 118	75 - 122	18
HMX	71 - 122	67 - 122	11	79 - 119	73 - 123	13
Nitrobenzene	61 - 114	61 - 114	36	66 - 122	73 - 121	15
RDX	77 - 127	70 - 133	11	73 - 119	65 - 126	13
Tetryl	73 - 119	38 - 132	37	63 - 122	42 - 135	15
Water Quality						
Chloride	90 - 115	43 - 167	23	N/A	N/A	N/A
Cyanide, Total	88 - 113	75 - 125	20	N/A	N/A	N/A
Hardness as $CaCO_3$	84 - 116	10 - 176	23	N/A	N/A	N/A
Nitrate	77 - 116	10 - 132	24	N/A	N/A	N/A
Sulfate	80 - 112	22 - 151	24	N/A	N/A	N/A
Total Alkalinity	90 - 127	10 - 160	24	N/A	N/A	N/A
Total Dissolved Solids	69 - 120	N/A	20	N/A	N/A	N/A
Total Organic Carbon	90 - 110	85 - 117	10	N/A	N/A	N/A
Total Suspended Solids	66 - 119	N/A	20	N/A	N/A	N/A
Turbidity	75 - 125	N/A	20	N/A	N/A	N/A

LCS - Laboratory control sample.
MS/MSD - Matrix spike/matrix spike duplicate.
RPD - Relative percent difference.
STL - Severn Trent Laboratories.
N/A - Not applicable.

APPENDIX I

CHEMICAL ANALYTICAL DATA SUMMARY

MAY 2004 DOWNGRADIENT WELL SAMPLING CHEMICAL ANALYTICAL DATA SUMMARY

Chemical Analytical Data Summary
Downgradient Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE			PB-BED-MW17			PB-BED-MW19			PB-BED-MW22			PB-BED-MW22			PB-BED-MW30			PB-BED-MW33		
SAMPLE_NO			DF3000			DF3001			DF3002			DF3005			DF3003			DF3004		
SAMPLE_DATE			6-May-04			5-May-04			5-May-04			5-May-04			7-May-04			7-May-04		
SAMPLE_PURPOSE			REG			REG			REG			FD			REG			REG		
Parameter	Units	Filtered	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual
Explosives																				
Amino-2,6-dinitrotoluene, 4-	ug/L	N	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U
Amino-4,6-dinitrotoluene, 2-	ug/L	N	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U
Dinitrobenzene, 1,3-	ug/L	N	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U
Dinitrotoluene, 2,4-	ug/L	N	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U
Dinitrotoluene, 2,6-	ug/L	N	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U
HMX	ug/L	N	0.5	U	U	0.5	U	U	0.5	U	U	0.5	U	U	0.5	U	U	0.5	U	U
Nitrobenzene	ug/L	N	2.8	G U		0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U
Nitrotoluene, 2-	ug/L	N	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.71	G U	U
Nitrotoluene, 3-	ug/L	N	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U
Nitrotoluene, 4-	ug/L	N	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	I U	U	0.77	G U	U
RDX	ug/L	N	0.5	U	U	0.5	U	U	0.5	U	U	0.5	U	U	0.5	U	U	0.5	U	U
Tetryl	ug/L	N	0.2	I U		0.2	U	UJ	0.2	U	UJ	0.2	U	U	0.2	U	UJ	0.2	U	UJ
Trinitrobenzene, 1,3,5-	ug/L	N	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U
Trinitrotoluene, 2,4,6-	ug/L	N	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U
General Chemistry																				
Alkalinity	ppm	N	789			1050		J	545		J				586					
Chloride	ppm	N	2460			229			47.1						104					
Cyanide, total	ppm	N	0.01	U	U	0.01	U	UJ	0.01	U	UJ				0.01	U	U			
Hardness	ppm	N	2030			662			466						580					
Nitrate	ppm	N	1	G U		0.1	U	U	0.1	U	U				0.1	U	U			
Sulfate	ppm	N	100	G U		21			11.3						32.6					
Total dissolved solids	ppm	N	6040			887			513						739					
Total organic carbon	ppm	N	6.4			5.6			2						10.5					
Total suspended solids	ppm	N	9			32			49						11					
Turbidity	NTU	N	6.3			220			192						98.5					
Metals																				
Aluminum	ug/L	N	122	B	J	61.7	B	J	1480		J	862		J	481			3650		
Aluminum	ug/L	Y	82.4	B	B	45.2	B	J	41.4	B	J	51.5	B	J	91.6	B	B	121	B	B
Antimony	ug/L	N	60	U	U	60	U	U	60	U	U	60	U	U	60	U	U	60	U	U
Antimony	ug/L	Y	60	U	U	60	U	U	60	U	U	60	U	U	60	U	U	60	U	U
Arsenic	ug/L	N	4	B	B	10	U	U	10	U	U	10	U	U	10.2		B	17.7		
Arsenic	ug/L	Y	3.8	B	B	10	U	U	10	U	U	10	U	U	8.7	B	B	13.6		
Barium	ug/L	N	1860			1120			732			712			165	B	J	278		
Barium	ug/L	Y	1910			1050			730			698			170	B	J	259		
Beryllium	ug/L	N	5	U	U	5	U	U	5	U	U	5	U	U	5	U	U	5	U	U
Beryllium	ug/L	Y	5	U	U	5	U	U	5	U	U	5	U	U	5	U	U	5	U	U
Cadmium	ug/L	N	5	U	U	5	U	U	5	U	U	5	U	U	5	U	U	5	U	U
Cadmium	ug/L	Y	5	U	U	5	U	U	5	U	U	5	U	U	5	U	U	5	U	U

Chemical Analytical Data Summary
Downgradient Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE			PB-BED-MW17			PB-BED-MW19			PB-BED-MW22			PB-BED-MW22			PB-BED-MW30			PB-BED-MW33		
SAMPLE_NO			DF3000			DF3001			DF3002			DF3005			DF3003			DF3004		
SAMPLE_DATE			6-May-04			5-May-04			5-May-04			5-May-04			7-May-04			7-May-04		
SAMPLE_PURPOSE			REG			REG			REG			FD			REG			REG		
Calcium	ug/L	N	316000			184000			134000			122000			124000			162000		
Calcium	ug/L	Y	326000			170000			118000			114000			127000			153000		
Chromium	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U	11.6		
Chromium	ug/L	Y	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Cobalt	ug/L	N	50	U	U	50	U	U	50	U	U	50	U	U	50	U	U	4.2	B	J
Cobalt	ug/L	Y	50	U	U	50	U	U	50	U	U	50	U	U	50	U	U	50	U	U
Copper	ug/L	N	25	U	U	52.2			25	U	U	25	U	U	25	U	U	13.1	B	J
Copper	ug/L	Y	25	U	U	25	U	U	25	U	U	25	U	U	25	U	U	25	U	U
Iron	ug/L	N	100	U	U	100	U	U	2220		J	1030		J	251			4920		
Iron	ug/L	Y	100	U	U	100	U	U	100	U	U	100	U	U	100	U	U	120		
Lead	ug/L	N	3	U	U	3	U	U	3	U	U	3	U	U	3	U	U	1.7	B	J
Lead	ug/L	Y	3	U	U	3	U	U	3	U	U	3	U	U	3	U	U	3	U	U
Magnesium	ug/L	N	277000			44600			39500			37700			61900			117000		
Magnesium	ug/L	Y	287000			44800			37900			36700			63600			116000		
Manganese	ug/L	N	4.7	B J	B	15	U	U	91.8			65			46.9	J		164	J	
Manganese	ug/L	Y	4.4	B J	B	2.2	B	J	47.4			46.3			41.4	J		129	J	
Mercury	ug/L	N	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U
Mercury	ug/L	Y	0.46			0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U
Nickel	ug/L	N	40	U	U	9.2	B	J	2.8	B	J	40	U	U	40	U	U	12.7	B	J
Nickel	ug/L	Y	40	U	U	7.9	B	J	40	U	U	40	U	U	3.2	B	J	4.2	B	J
Potassium	ug/L	N	64400	J	J	36500	J	J	4780	B J	J	4410	B J	J	15400	J		39100	J	
Potassium	ug/L	Y	66700	J	J	36500	J	J	4300	B J	J	4120	B J	J	15500	J		38200	J	
Selenium	ug/L	N	5	U	UJ	5	U	U	5	U	U	5	U	U	5	U	U	1.6	B	J
Selenium	ug/L	Y	5	U	U	2.6	B	B	1.7	B	B	5	U	U	5	U	U	5	U	U
Silver	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Silver	ug/L	Y	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Sodium	ug/L	N	662000			74300		J	20400		J	19700		J	72500			278000		
Sodium	ug/L	Y	684000			75400		J	20600		J	19800		J	73500			278000		
Thallium	ug/L	N	10	U	U	5.1	B J	B	4.5	B J	B	4.2	B J	B	3.9	B J	B	3	B J	B
Thallium	ug/L	Y	2.9	B J	B	4.4	B J	B	5.3	B J	B	5.3	B J	B	3.5	B J	B	3	B J	B
Vanadium	ug/L	N	50	U	U	50	U	U	50	U	U	50	U	U	50	U	U	8.6	B	J
Vanadium	ug/L	Y	50	U	U	50	U	U	50	U	U	50	U	U	50	U	U	50	U	U
Zinc	ug/L	N	24.7		J	65.9			22			13.2	B	J	80.6			69.8		
Zinc	ug/L	Y	8.1	B	J	20	U	U	20	U	U	20	U	U	13.4	B	J	5.4	B	J
Semivolatiles																				
Acenaphthene	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U			
Acenaphthylene	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U			
Anthracene	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U			
Benzo(a)anthracene	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U			
Benzo(a)pyrene	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U			

Chemical Analytical Data Summary
Downgradient Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE			PB-BED-MW17			PB-BED-MW19			PB-BED-MW22			PB-BED-MW22			PB-BED-MW30			PB-BED-MW33
SAMPLE_NO			DF3000			DF3001			DF3002			DF3005			DF3003			DF3004
SAMPLE_DATE			6-May-04			5-May-04			5-May-04			5-May-04			7-May-04			7-May-04
SAMPLE_PURPOSE			REG			REG			REG			FD			REG			REG
Benzo(b)fluoranthene	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U	
Benzo(ghi)perylene	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U	
Benzo(k)fluoranthene	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U	
Bis(2-chloroethoxy)methane	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U	
Bis(2-chloroethyl)ether	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U	
Bis(2-chloroisopropyl)ether	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U	
Bis(2-ethylhexyl)phthalate	ug/L	N	2.3	J	J	10	U	UJ	10	U	UJ	10	U	U	10	U	U	
Bromophenyl phenyl ether, 4-	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U	
Butyl benzyl phthalate	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U	
Carbazole	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U	
Chloro-3-methylphenol, 4-	ug/L	N	10	U	U	10	U	U	10	U	UJ	10	U	U	10	U	U	
Chloroaniline, 4-	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U	
Chloronaphthalene, 2-	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U	
Chlorophenol, 2-	ug/L	N	10	U	U	10	U	U	10	U	UJ	10	U	U	10	U	U	
Chlorophenyl phenyl ether, 4-	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U	
Chrysene	ug/L	N	1	J	J	10	U	UJ	10	U	UJ	10	U	U	10	U	U	
Dibenz(a,h)anthracene	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U	
Dibenzofuran	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U	
Dichlorobenzene, 1,2-	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U	
Dichlorobenzene, 1,3-	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U	
Dichlorobenzene, 1,4-	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U	
Dichlorobenzidine, 3,3'-	ug/L	N	50	U	UJ	50	U	UJ	50	U	UJ	50	U	U	50	U	U	
Dichlorophenol, 2,4-	ug/L	N	10	U	U	10	U	U	10	U	UJ	10	U	U	10	U	U	
Diethyl phthalate	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U	
Dimethyl phthalate	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U	
Dimethylphenol, 2,4-	ug/L	N	10	U	U	10	U	U	10	U	UJ	10	U	U	10	U	U	
Di-n-butyl phthalate	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U	
Dinitro-2-methylphenol, 4,6-	ug/L	N	50	U	UJ	50	U	U	50	U	UJ	50	U	U	50	U	UJ	
Dinitrophenol, 2,4-	ug/L	N	50	U	UJ	50	U	U	50	U	UJ	50	U	U	50	U	UJ	
Dinitrotoluene, 2,4-	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U	
Dinitrotoluene, 2,6-	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U	
Di-n-octyl phthalate	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U	
Fluoranthene	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U	
Fluorene	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U	
Hexachlorobenzene	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U	
Hexachlorobutadiene	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U	
Hexachlorocyclopentadiene	ug/L	N	50	U	UJ	50	U	UJ	50	U	UJ	50	U	U	50	U	U	
Hexachloroethane	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U	
Indeno(1,2,3-cd)pyrene	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U	
Isophorone	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U	

Chemical Analytical Data Summary
Downgradient Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE			PB-BED-MW17			PB-BED-MW19			PB-BED-MW22			PB-BED-MW22			PB-BED-MW30			PB-BED-MW33		
SAMPLE_NO			DF3000			DF3001			DF3002			DF3005			DF3003			DF3004		
SAMPLE_DATE			6-May-04			5-May-04			5-May-04			5-May-04			7-May-04			7-May-04		
SAMPLE_PURPOSE			REG			REG			REG			FD			REG			REG		
Methylnaphthalene, 2-	ug/L	N	7.7	J	J	5.2	J	J	10	U	UJ	10	U	U	2.2	J	J			
Methylphenol, 2-	ug/L	N	10	U	U	10	U	U	10	U	UJ	10	U	U	10	U	U			
Methylphenol, 4-	ug/L	N	10	U	U	10	U	U	10	U	UJ	10	U	U	10	U	U			
Naphthalene	ug/L	N	8	J	J	3.7	J	J	10	U	UJ	10	U	U	10	U	U			
Nitroaniline, 2-	ug/L	N	50	U	UJ	50	U	UJ	50	U	UJ	50	U	U	50	U	U			
Nitroaniline, 3-	ug/L	N	50	U	UJ	50	U	UJ	50	U	UJ	50	U	U	50	U	U			
Nitroaniline, 4-	ug/L	N	50	U	UJ	50	U	UJ	50	U	UJ	50	U	U	50	U	U			
Nitrobenzene	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U			
Nitrophenol, 2-	ug/L	N	10	U	U	10	U	U	10	U	UJ	10	U	U	10	U	U			
Nitrophenol, 4-	ug/L	N	50	U	U	50	U	U	50	U	UJ	50	U	U	50	U	U			
n-Nitroso-di-n-propylamine	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U			
n-Nitrosodiphenylamine	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U			
Pentachlorophenol	ug/L	N	50	U	U	50	U	UJ	50	U	UJ	50	U	UJ	50	U	U			
Phenanthrene	ug/L	N	0.85	J	J	10	U	UJ	10	U	UJ	10	U	U	10	U	U			
Phenol	ug/L	N	2.2	J	J	10	U	U	10	U	UJ	10	U	U	10	U	U			
Pyrene	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U	10	U	U			
Trichlorobenzene, 1,2,4-	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	UJ	10	U	U			
Trichlorophenol, 2,4,5-	ug/L	N	10	U	U	10	U	U	10	U	UJ	10	U	U	10	U	U			
Trichlorophenol, 2,4,6-	ug/L	N	10	U	U	10	U	U	10	U	UJ	10	U	U	10	U	U			
Volatiles																				
Acetone	ug/L	N	1300	B	B	220	B	B	140	J B	B	140	J B	B	230	B		290	J B	J
Benzene	ug/L	N	15	J	J	18	J	J	20	U	U	20	U	U	2.4	J	J	17	J	J
Bromodichloromethane	ug/L	N	100	U	U	20	U	U	20	U	U	20	U	U	5	U	U	50	U	U
Bromoform	ug/L	N	100	U	U	20	U	U	20	U	U	20	U	U	5	U	U	50	U	U
Bromomethane	ug/L	N	200	U	U	40	U	U	40	U	U	40	U	U	10	U	U	100	U	U
Butanone, 2-	ug/L	N	130	J	J	100	U	R	100	U	R	100	U	R	25	U	R	73	J	J
Carbon disulfide	ug/L	N	100	U	U	3.2	J	J	20	U	U	20	U	U	4.2	J	J	5.9	J	J
Carbon tetrachloride	ug/L	N	100	U	U	20	U	U	20	U	U	20	U	U	5	U	U	50	U	U
Chlorobenzene	ug/L	N	11	J	J	2.2	J	J	20	U	U	20	U	U	5	U	U	50	U	U
Chloroethane	ug/L	N	200	U	U	40	U	U	40	U	U	40	U	U	10	U	U	100	U	U
Chloroform	ug/L	N	100	U	U	20	U	U	20	U	U	20	U	U	5	U	U	50	U	U
Chloromethane	ug/L	N	200	U	UJ	40	U	UJ	40	U	U	40	U	U	10	U	U	100	U	U
Dibromochloromethane	ug/L	N	100	U	U	20	U	U	20	U	U	20	U	U	5	U	U	50	U	U
Dichloroethane, 1,1-	ug/L	N	100	U	U	20	U	U	20	U	U	20	U	U	5	U	U	50	U	U
Dichloroethane, 1,2-	ug/L	N	100	U	U	20	U	U	20	U	U	20	U	U	5	U	U	50	U	U
Dichloroethene, 1,1-	ug/L	N	100	U	U	20	U	U	20	U	U	20	U	U	5	U	U	50	U	U
Dichloroethene, 1,2-	ug/L	N	100	U	U	20	U	U	20	U	U	20	U	U	5	U	U	50	U	U
Dichloropropane, 1,2-	ug/L	N	100	U	U	20	U	U	20	U	U	20	U	U	5	U	U	50	U	U
Dichloropropene, cis-1,3-	ug/L	N	100	U	U	20	U	U	20	U	U	20	U	U	5	U	U	50	U	U
Dichloropropene, trans-1,3-	ug/L	N	100	U	UJ	20	U	U	20	U	UJ	20	U	UJ	5	U	UJ	50	U	UJ

Chemical Analytical Data Summary
Downgradient Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE			PB-BED-MW17			PB-BED-MW19			PB-BED-MW22			PB-BED-MW22			PB-BED-MW30			PB-BED-MW33		
SAMPLE_NO			DF3000			DF3001			DF3002			DF3005			DF3003			DF3004		
SAMPLE_DATE			6-May-04			5-May-04			5-May-04			5-May-04			7-May-04			7-May-04		
SAMPLE_PURPOSE			REG			REG			REG			FD			REG			REG		
Ethylbenzene	ug/L	N	86	J	J	6.8	J	J	20	U	U	20	U	U	7.5			15	J	J
Hexanone, 2-	ug/L	N	500	U	U	100	U	U	100	U	U	100	U	U	25	U	U	250	U	U
Methyl-2-pentanone, 4-	ug/L	N	500	U	R	100	U	R	100	U	R	100	U	R	25	U	R	250	U	R
Methylene chloride	ug/L	N	34	J	J	7.3	J	J	5.8	J	J	6.1	J	J	10	U	U	24	J	J
Styrene	ug/L	N	100	U	U	20	U	U	20	U	U	20	U	U	5	U	U	50	U	U
Tetrachloroethane, 1,1,2,2-	ug/L	N	100	U	U	20	U	U	20	U	U	20	U	U	5	U	U	50	U	U
Tetrachloroethene	ug/L	N	100	U	U	20	U	U	20	U	U	20	U	U	5	U	U	50	U	U
Toluene	ug/L	N	120			8	J	J	20	U	U	20	U	U	7.2			15	J	J
Trichloroethane, 1,1,1-	ug/L	N	100	U	U	20	U	U	20	U	U	20	U	U	5	U	U	50	U	U
Trichloroethane, 1,1,2-	ug/L	N	100	U	UJ	20	U	UJ	20	U	UJ	20	U	UJ	5	U	UJ	50	U	UJ
Trichloroethene	ug/L	N	100	U	U	20	U	U	20	U	U	20	U	U	5	U	U	50	U	U
Vinyl chloride	ug/L	N	100	U	U	20	U	U	20	U	U	20	U	U	5	U	U	50	U	U
Xylenes, total	ug/L	N	390			66			20	U	U	20	U	U	47			84		

Laboratory Qualifier (Qual) Definitions
B (inorganic) - The analyte was detected below the reporting limit. Estimated value.
B (organic) - The analyte was detected in the sample and the blank.
G - Reporting limit is elevated because of matrix interference.
I - Matrix interference.
J (inorganic) - The analyte was detected in the sample and the blank.
J (organic) - The analyte was detected below the reporting limit. Estimated value.
U - Not detected. The analyte was not detected above the reporting limit.

Validation Qualifier (ValQual) Definitions
B - The analyte was not detected above the level found in an associated blank.
J - The analyte was positively identified; the concentration is estimated.
R - Data rejected.
U - Not detected. The analyte was not detected above the reporting limit.
UJ - Not detected. The reporting limit may be inaccurate or imprecise

JUNE 2004 DOWNGRADIENT WELL SAMPLING CHEMICAL ANALYTICAL DATA SUMMARY

Chemical Analytical Data Summary
Tenth Quarterly Groundwater Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE			IT-BG8-BEDGW-001			PB-BED-MW20			PB-BED-MW24			PB-BED-MW25			PB-BED-MW25		
SAMPLE_NO			DG3000			DG3001			DG3002			DG3003			DG3006		
SAMPLE_DATE			16-Jun-04			17-Jun-04			16-Jun-04			17-Jun-04			17-Jun-04		
SAMPLE_PURPOSE			REG			REG			REG			REG			FD		
Parameter	Units	Filtered	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual
Exposives																	
Amino-2,6-dinitrotoluene, 4-	ug/L	N	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U
Amino-4,6-dinitrotoluene, 2-	ug/L	N	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U
Dinitrobenzene, 1,3-	ug/L	N	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U
Dinitrotoluene, 2,4-	ug/L	N	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U
Dinitrotoluene, 2,6-	ug/L	N	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U
HMX	ug/L	N	0.5	U	U	0.5	U	U	0.5	U	U	0.5	U	U	0.5	U	U
Nitrobenzene	ug/L	N	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U
Nitrotoluene, 2-	ug/L	N	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U
Nitrotoluene, 3-	ug/L	N	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U
Nitrotoluene, 4-	ug/L	N	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U
RDX	ug/L	N	0.5	U	U	0.5	U	U	0.5	U	U	0.5	U	U	0.5	U	U
Tetryl	ug/L	N	0.2	U	UJ	0.2	U	UJ	0.2	U	UJ	0.2	U	UJ	0.2	U	UJ
Trinitrobenzene, 1,3,5-	ug/L	N	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U
Trinitrotoluene, 2,4,6-	ug/L	N	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U
General Chemistry																	
Alkalinity	ppm	N	317			264			769			294					
Chloride	ppm	N	9.6			24200			79			95.4					
Cyanide, total	ppm	N	0.01	U	UJ	0.01	U	UJ	0.01	U	UJ	0.01	U	UJ			
Hardness	ppm	N	312			8900			584			760					
Nitrate	ppm	N	1.5			0.18			0.1	U	U	0.1	U	U			
Sulfate	ppm	N	36			5	U	U	25.5			514					
Total dissolved solids	ppm	N	383			36100			824			1160					
Total organic carbon	ppm	N	1	U	U	2.1			1	U	U	1.9					
Total suspended solids	ppm	N	4	U	U	22			4	U	U	4					
Turbidity	NTU	N	0.5	U	U	4			56.6			2					
Metals																	
Aluminum	ug/L	N	71.8	B	J	180	B	J	78.4	B	J	84.8	B	J	77.1	B	J
Aluminum	ug/L	Y	74.3	B	J	128	B	J	84	B	J	200	U	U	200	U	U
Antimony	ug/L	N	60	U	U	60	U	U	60	U	U	60	U	U	60	U	U
Antimony	ug/L	Y	60	U	U	60	U	U	60	U	U	60	U	U	60	U	U
Arsenic	ug/L	N	10	U	U	3	B	B	10	U	U	10	U	U	10	U	U
Arsenic	ug/L	Y	10	U	U	2.8	B	B	10	U	U	10	U	U	10	U	U
Barium	ug/L	N	27.6	B	J	22500			535			112	B	J	111	B	J
Barium	ug/L	Y	29.8	B	J	23100			590			117	B	J	118	B	J
Beryllium	ug/L	N	5	U	U	5	U	U	5	U	U	5	U	U	5	U	U
Beryllium	ug/L	Y	5	U	U	5	U	U	5	U	U	5	U	U	5	U	U
Cadmium	ug/L	N	5	U	U	5	U	U	5	U	U	5	U	U	5	U	U
Cadmium	ug/L	Y	5	U	U	5	U	U	5	U	U	5	U	U	5	U	U

Chemical Analytical Data Summary
Tenth Quarterly Groundwater Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE			IT-BG8-BEDGW-001			PB-BED-MW20			PB-BED-MW24			PB-BED-MW25			PB-BED-MW25		
SAMPLE_NO			DG3000			DG3001			DG3002			DG3003			DG3006		
SAMPLE_DATE			16-Jun-04			17-Jun-04			16-Jun-04			17-Jun-04			17-Jun-04		
SAMPLE_PURPOSE			REG			REG			REG			REG			FD		
Parameter	Units	Filtered	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual
Calcium	ug/L	N	81800			1880000			125000			194000			192000		
Calcium	ug/L	Y	81300			1940000			135000			193000			195000		
Chromium	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Chromium	ug/L	Y	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Cobalt	ug/L	N	50	U	U	11.4	B	J	50	U	U	50	U	U	50	U	U
Cobalt	ug/L	Y	50	U	U	13	B	J	50	U	U	50	U	U	50	U	U
Copper	ug/L	N	25	U	U	3.2	B	B	25	U	U	25	U	U	25	U	U
Copper	ug/L	Y	25	U	U	25	U	U	25	U	U	25	U	U	25	U	U
Iron	ug/L	N	100	U	U	584			100	U	U	104			98.4	B	J
Iron	ug/L	Y	100	U	U	636			100	U	U	100	U	U	100	U	U
Lead	ug/L	N	3	U	U	4.7	G U	U	3	U	U	3	U	U	3	U	U
Lead	ug/L	Y	3	U	U	4.9	G U	U	3	U	U	3	U	U	3	U	U
Magnesium	ug/L	N	29000			915000			69900			70400			69600		
Magnesium	ug/L	Y	29400			942000			72000			70200			70900		
Manganese	ug/L	N	40.9			170			19.6			105			104		
Manganese	ug/L	Y	47.5			178			22.6			103			104		
Mercury	ug/L	N	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U
Mercury	ug/L	Y	0.2	U	U	0.2	U	U	0.2	U	U	0.06	B	B	0.2	U	U
Nickel	ug/L	N	40	U	U	6.2	B	J	40	U	U	40	U	U	40	U	U
Nickel	ug/L	Y	2.8	B	J	7.2	B	J	40	U	U	40	U	U	40	U	U
Potassium	ug/L	N	4310	B J	J	164000	J	J	21900	J	J	10800	J	J	10700	J	J
Potassium	ug/L	Y	4770	B J	J	170000	J	J	22300	J	J	10900	J	J	10900	J	J
Selenium	ug/L	N	5	U	U	5	U	U	5	U	U	1.5	B	B	5	U	U
Selenium	ug/L	Y	5	U	U	5	U	U	5	U	U	5	U	U	5	U	U
Silver	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Silver	ug/L	Y	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Sodium	ug/L	N	13300			7930000			64400			67000			66300		
Sodium	ug/L	Y	17600			8240000			66400			67700			68400		
Thallium	ug/L	N	4	B J	B	4.2	B J	B	10	U	U	5.2	B J	B	4.4	B J	B
Thallium	ug/L	Y	10	U	U	3.8	B J	B	10	U	U	10	U	U	5.8	B J	B
Vanadium	ug/L	N	50	U	U	50	U	U	50	U	U	50	U	U	50	U	U
Vanadium	ug/L	Y	50	U	U	50	U	U	50	U	U	50	U	U	50	U	U
Zinc	ug/L	N	16.6	B J	B	85.5	J		20	U	U	5.1	B J	B	3.6	B J	B
Zinc	ug/L	Y	17.5	B J	B	102	J		4.2	B J	B	20	U	U	20	U	U
Semivolatiles																	
Acenaphthene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Acenaphthylene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Anthracene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Benzo(a)anthracene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U

Chemical Analytical Data Summary
Tenth Quarterly Groundwater Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE			IT-BG8-BEDGW-001			PB-BED-MW20			PB-BED-MW24			PB-BED-MW25			PB-BED-MW25		
SAMPLE_NO			DG3000			DG3001			DG3002			DG3003			DG3006		
SAMPLE_DATE			16-Jun-04			17-Jun-04			16-Jun-04			17-Jun-04			17-Jun-04		
SAMPLE_PURPOSE			REG			REG			REG			REG			FD		
Parameter	Units	Filtered	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual
Benzo(a)pyrene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Benzo(b)fluoranthene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Benzo(ghi)perylene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Benzo(k)fluoranthene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Bis(2-chloroethoxy)methane	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Bis(2-chloroethyl)ether	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Bis(2-chloroisopropyl)ether	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Bis(2-ethylhexyl)phthalate	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Bromophenyl phenyl ether, 4-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Butyl benzyl phthalate	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Carbazole	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Chloro-3-methylphenol, 4-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Chloroaniline, 4-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Chloronaphthalene, 2-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Chlorophenol, 2-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Chlorophenyl phenyl ether, 4-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Chrysene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Dibenz(a,h)anthracene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Dibenzofuran	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Dichlorobenzene, 1,2-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Dichlorobenzene, 1,3-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Dichlorobenzene, 1,4-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Dichlorobenzidine, 3,3'-	ug/L	N	50	U	U	50	U	U	50	U	U	50	U	U	50	U	U
Dichlorophenol, 2,4-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Diethyl phthalate	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Dimethyl phthalate	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Dimethylphenol, 2,4-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Di-n-butyl phthalate	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Dinitro-2-methylphenol, 4,6-	ug/L	N	50	U	UJ	50	U	UJ	50	U	UJ	50	U	UJ	50	U	UJ
Dinitrophenol, 2,4-	ug/L	N	50	U	UJ	50	U	UJ	50	U	UJ	50	U	UJ	50	U	UJ
Dinitrotoluene, 2,4-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Dinitrotoluene, 2,6-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Di-n-octyl phthalate	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Fluoranthene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Fluorene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Hexachlorobenzene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Hexachlorobutadiene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Hexachlorocyclopentadiene	ug/L	N	50	U	U	50	U	U	50	U	U	50	U	U	50	U	U
Hexachloroethane	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U

Chemical Analytical Data Summary
Tenth Quarterly Groundwater Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE			IT-BG8-BEDGW-001			PB-BED-MW20			PB-BED-MW24			PB-BED-MW25			PB-BED-MW25		
SAMPLE_NO			DG3000			DG3001			DG3002			DG3003			DG3006		
SAMPLE_DATE			16-Jun-04			17-Jun-04			16-Jun-04			17-Jun-04			17-Jun-04		
SAMPLE_PURPOSE			REG			REG			REG			REG			FD		
Parameter	Units	Filtered	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual
Indeno(1,2,3-cd)pyrene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Isophorone	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Methylnaphthalene, 2-	ug/L	N	10	U	U	10	U	U	2	J	J	10	U	U	10	U	U
Methylphenol, 2-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Methylphenol, 4-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Naphthalene	ug/L	N	10	U	U	10	U	U	1.9	J	J	10	U	U	10	U	U
Nitroaniline, 2-	ug/L	N	50	U	U	50	U	U	50	U	U	50	U	U	50	U	U
Nitroaniline, 3-	ug/L	N	50	U	U	50	U	U	50	U	U	50	U	U	50	U	U
Nitroaniline, 4-	ug/L	N	50	U	U	50	U	U	50	U	U	50	U	U	50	U	U
Nitrobenzene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Nitrophenol, 2-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Nitrophenol, 4-	ug/L	N	50	U	U	50	U	U	50	U	U	50	U	U	50	U	U
n-Nitroso-di-n-propylamine	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
n-Nitrosodiphenylamine	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Pentachlorophenol	ug/L	N	50	U	U	50	U	U	50	U	U	50	U	U	50	U	U
Phenanthrene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Phenol	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Pyrene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Trichlorobenzene, 1,2,4-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Trichlorophenol, 2,4,5-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Trichlorophenol, 2,4,6-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U
Volatiles																	
Acetone	ug/L	N	5.6	J B	B	5.7	J B	B	100	U	UJ	4.9	J B	B	4	J B	B
Benzene	ug/L	N	1	U	U	0.34	J	J	100			1	U	U	1	U	U
Bromodichloromethane	ug/L	N	1	U	U	1	U	R	10	U	U	1	U	U	1	U	U
Bromoform	ug/L	N	1	U	U	1	U	UJ	10	U	U	1	U	U	1	U	U
Bromomethane	ug/L	N	2	U	U	2	U	UJ	20	U	U	2	U	U	2	U	U
Butanone, 2-	ug/L	N	5	U	R	5	U	R	50	U	R	5	U	R	5	U	R
Carbon disulfide	ug/L	N	0.16	J	J	1	U	UJ	7.3	J	J	1.9		J	1.9		J
Carbon tetrachloride	ug/L	N	1	U	U	1	U	UJ	10	U	U	1	U	U	1	U	U
Chlorobenzene	ug/L	N	1	U	U	1	U	UJ	10	U	U	1	U	U	1	U	U
Chloroethane	ug/L	N	2	U	U	2	U	UJ	20	U	U	2	U	U	2	U	U
Chloroform	ug/L	N	1	U	U	1	U	UJ	10	U	U	1	U	U	1	U	U
Chloromethane	ug/L	N	2	U	U	2	U	UJ	20	U	U	2	U	U	2	U	U
Dibromochloromethane	ug/L	N	1	U	U	1	U	UJ	10	U	U	1	U	UJ	1	U	UJ
Dichloroethane, 1,1-	ug/L	N	1	U	U	1	U	UJ	10	U	U	1	U	U	1	U	U
Dichloroethane, 1,2-	ug/L	N	1	U	U	1	U	UJ	10	U	U	1	U	U	1	U	U
Dichloroethene, 1,1-	ug/L	N	1	U	U	1	U	UJ	10	U	U	1	U	U	1	U	U
Dichloroethene, 1,2-	ug/L	N	1	U	U	1	U	UJ	10	U	U	1	U	U	1	U	U

Chemical Analytical Data Summary
Tenth Quarterly Groundwater Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE			IT-BG8-BEDGW-001			PB-BED-MW20			PB-BED-MW24			PB-BED-MW25			PB-BED-MW25		
SAMPLE_NO			DG3000			DG3001			DG3002			DG3003			DG3006		
SAMPLE_DATE			16-Jun-04			17-Jun-04			16-Jun-04			17-Jun-04			17-Jun-04		
SAMPLE_PURPOSE			REG			REG			REG			REG			FD		
Parameter	Units	Filtered	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual
Dichloropropane, 1,2-	ug/L	N	1	U	U	1	U	UJ	10	U	U	1	U	U	1	U	U
Dichloropropene, cis-1,3-	ug/L	N	1	U	U	1	U	UJ	10	U	U	1	U	U	1	U	U
Dichloropropene, trans-1,3-	ug/L	N	1	U	UJ	1	U	UJ	10	U	UJ	1	U	UJ	1	U	UJ
Ethylbenzene	ug/L	N	1	U	U	1	U	UJ	45			1	U	U	1	U	U
Hexanone, 2-	ug/L	N	5	U	UJ	5	U	UJ	50	U	UJ	5	U	UJ	5	U	UJ
Methyl-2-pentanone, 4-	ug/L	N	5	U	R	5	U	R	50	U	R	5	U	R	5	U	R
Methylene chloride	ug/L	N	2	U	U	2	U	UJ	20	U	U	2	U	U	2	U	U
Styrene	ug/L	N	1	U	U	1	U	UJ	10	U	U	1	U	U	1	U	U
Tetrachloroethane, 1,1,2,2-	ug/L	N	1	U	U	1	U	UJ	10	U	U	1	U	U	1	U	U
Tetrachloroethene	ug/L	N	1	U	U	1	U	UJ	10	U	U	1	U	UJ	1	U	UJ
Toluene	ug/L	N	1	U	U	1	U	UJ	57			1	U	U	1	U	U
Trichloroethane, 1,1,1-	ug/L	N	1	U	U	1	U	UJ	10	U	U	1	U	U	1	U	U
Trichloroethane, 1,1,2-	ug/L	N	1	U	U	1	U	UJ	10	U	U	1	U	UJ	1	U	UJ
Trichloroethene	ug/L	N	1	U	U	1	U	UJ	10	U	U	1	U	U	1	U	U
Vinyl chloride	ug/L	N	1	U	U	1	U	UJ	10	U	U	1	U	U	1	U	U
Xylenes, total	ug/L	N	1	U	U	1	U	UJ	240			1	U	U	1	U	U

Chemical Analytical Data Summary
Tenth Quarterly Groundwater Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE			PB-BED-MW28			PB-BED-MW29		
SAMPLE_NO			DG3004			DG3005		
SAMPLE_DATE			15-Jun-04			16-Jun-04		
SAMPLE_PURPOSE			REG			REG		
Parameter	Units	Filtered	Result	Qual	ValQual	Result	Qual	ValQual
Exposives								
Amino-2,6-dinitrotoluene, 4-	ug/L	N	0.2	U	U	0.2	U	U
Amino-4,6-dinitrotoluene, 2-	ug/L	N	0.2	U	U	0.2	U	U
Dinitrobenzene, 1,3-	ug/L	N	0.2	U	U	0.2	U	U
Dinitrotoluene, 2,4-	ug/L	N	0.2	U	U	0.2	U	U
Dinitrotoluene, 2,6-	ug/L	N	0.2	U	U	0.2	U	U
HMX	ug/L	N	0.5	U	U	0.5	U	U
Nitrobenzene	ug/L	N	0.2	U	U	0.2	U	U
Nitrotoluene, 2-	ug/L	N	0.2	U	U	0.2	U	U
Nitrotoluene, 3-	ug/L	N	0.2	U	U	0.2	U	U
Nitrotoluene, 4-	ug/L	N	0.2	U	U	0.2	U	U
RDX	ug/L	N	0.5	U	U	0.5	U	U
Tetryl	ug/L	N	0.2	U	U	0.2	U	UJ
Trinitrobenzene, 1,3,5-	ug/L	N	0.2	U	U	0.2	U	U
Trinitrotoluene, 2,4,6-	ug/L	N	0.2	U	U	0.2	U	U
General Chemistry								
Alkalinity	ppm	N	481			467		
Chloride	ppm	N	162			3340		
Cyanide, total	ppm	N	0.01	U	UJ	0.01	U	UJ
Hardness	ppm	N	30.4			1470		
Nitrate	ppm	N	0.1	U	U	0.1	U	U
Sulfate	ppm	N	5	U	U	7.5		
Total dissolved solids	ppm	N	746			5720		
Total organic carbon	ppm	N	4.7			4.5		
Total suspended solids	ppm	N	8			14		
Turbidity	NTU	N	0.72			7.5		
Metals								
Aluminum	ug/L	N	129	B	J	120	B	J
Aluminum	ug/L	Y	78.1	B	J	107	B	J
Antimony	ug/L	N	60	U	U	60	U	U
Antimony	ug/L	Y	60	U	U	60	U	U
Arsenic	ug/L	N	10	U	U	10	U	U
Arsenic	ug/L	Y	10	U	U	10	U	U
Barium	ug/L	N	337			9110		
Barium	ug/L	Y	343			9050		
Beryllium	ug/L	N	5	U	U	5	U	U
Beryllium	ug/L	Y	5	U	U	5	U	U
Cadmium	ug/L	N	5	U	U	5	U	U
Cadmium	ug/L	Y	5	U	U	5	U	U

Chemical Analytical Data Summary
Tenth Quarterly Groundwater Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE			PB-BED-MW28			PB-BED-MW29		
SAMPLE_NO			DG3004			DG3005		
SAMPLE_DATE			15-Jun-04			16-Jun-04		
SAMPLE_PURPOSE			REG			REG		
Parameter	Units	Filtered	Result	Qual	ValQual	Result	Qual	ValQual
Calcium	ug/L	N	17400			272000		
Calcium	ug/L	Y	17300			282000		
Chromium	ug/L	N	10	U	U	10	U	U
Chromium	ug/L	Y	10	U	U	10	U	U
Cobalt	ug/L	N	50	U	U	2.6	B	J
Cobalt	ug/L	Y	50	U	U	2.6	B	J
Copper	ug/L	N	25	U	U	19.8	B	J
Copper	ug/L	Y	25	U	U	6.1	B	J
Iron	ug/L	N	184			1000		
Iron	ug/L	Y	125			892		
Lead	ug/L	N	3	U	U	3	U	U
Lead	ug/L	Y	3	U	U	3	U	U
Magnesium	ug/L	N	7280			188000		
Magnesium	ug/L	Y	7250			196000		
Manganese	ug/L	N	10.6	B	J	43.6		
Manganese	ug/L	Y	11.6	B	J	44.8		
Mercury	ug/L	N	0.1	B	B	0.2	U	U
Mercury	ug/L	Y	0.2	U	U	0.2	U	U
Nickel	ug/L	N	40	U	U	40	U	U
Nickel	ug/L	Y	40	U	U	40	U	U
Potassium	ug/L	N	15900	J	J	116000	J	J
Potassium	ug/L	Y	14000	J	J	120000	J	J
Selenium	ug/L	N	5	U	U	5	U	U
Selenium	ug/L	Y	5	U	U	5	U	U
Silver	ug/L	N	10	U	U	10	U	U
Silver	ug/L	Y	10	U	U	10	U	U
Sodium	ug/L	N	269000			1E+06		
Sodium	ug/L	Y	272000			1E+06		
Thallium	ug/L	N	3.9	B J	B	10	U	U
Thallium	ug/L	Y	4	B J	B	2.5	B J	B
Vanadium	ug/L	N	50	U	U	50	U	U
Vanadium	ug/L	Y	50	U	U	50	U	U
Zinc	ug/L	N	15.4	B J	B	27.4	J	B
Zinc	ug/L	Y	14.7	B J	B	23.5	J	B
Semivolatiles								
Acenaphthene	ug/L	N	10	U	U	10	U	U
Acenaphthylene	ug/L	N	10	U	U	10	U	U
Anthracene	ug/L	N	10	U	U	10	U	U
Benzo(a)anthracene	ug/L	N	10	U	U	10	U	U

Chemical Analytical Data Summary
Tenth Quarterly Groundwater Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE			PB-BED-MW28			PB-BED-MW29		
SAMPLE_NO			DG3004			DG3005		
SAMPLE_DATE			15-Jun-04			16-Jun-04		
SAMPLE_PURPOSE			REG			REG		
Parameter	Units	Filtered	Result	Qual	ValQual	Result	Qual	ValQual
Benzo(a)pyrene	ug/L	N	10	U	U	10	U	U
Benzo(b)fluoranthene	ug/L	N	10	U	U	10	U	U
Benzo(ghi)perylene	ug/L	N	10	U	U	10	U	U
Benzo(k)fluoranthene	ug/L	N	10	U	U	10	U	U
Bis(2-chloroethoxy)methane	ug/L	N	10	U	U	10	U	U
Bis(2-chloroethyl)ether	ug/L	N	10	U	U	10	U	U
Bis(2-chloroisopropyl)ether	ug/L	N	10	U	U	10	U	U
Bis(2-ethylhexyl)phthalate	ug/L	N	10	U	U	10	U	U
Bromophenyl phenyl ether, 4-	ug/L	N	10	U	U	10	U	U
Butyl benzyl phthalate	ug/L	N	10	U	U	10	U	U
Carbazole	ug/L	N	10	U	U	10	U	U
Chloro-3-methylphenol, 4-	ug/L	N	10	U	U	10	U	U
Chloroaniline, 4-	ug/L	N	10	U	U	10	U	U
Chloronaphthalene, 2-	ug/L	N	10	U	U	10	U	U
Chlorophenol, 2-	ug/L	N	10	U	U	10	U	U
Chlorophenyl phenyl ether, 4-	ug/L	N	10	U	U	10	U	U
Chrysene	ug/L	N	10	U	U	10	U	U
Dibenz(a,h)anthracene	ug/L	N	10	U	U	10	U	U
Dibenzofuran	ug/L	N	10	U	U	10	U	U
Dichlorobenzene, 1,2-	ug/L	N	10	U	U	10	U	U
Dichlorobenzene, 1,3-	ug/L	N	10	U	U	10	U	U
Dichlorobenzene, 1,4-	ug/L	N	10	U	U	10	U	U
Dichlorobenzidine, 3,3'-	ug/L	N	50	U	U	50	U	U
Dichlorophenol, 2,4-	ug/L	N	10	U	U	10	U	UJ
Diethyl phthalate	ug/L	N	10	U	U	10	U	U
Dimethyl phthalate	ug/L	N	10	U	U	10	U	U
Dimethylphenol, 2,4-	ug/L	N	10	U	U	10	U	U
Di-n-butyl phthalate	ug/L	N	10	U	U	10	U	U
Dinitro-2-methylphenol, 4,6-	ug/L	N	50	U	UJ	50	U	UJ
Dinitrophenol, 2,4-	ug/L	N	50	U	UJ	50	U	U
Dinitrotoluene, 2,4-	ug/L	N	10	U	U	10	U	U
Dinitrotoluene, 2,6-	ug/L	N	10	U	U	10	U	U
Di-n-octyl phthalate	ug/L	N	10	U	U	10	U	U
Fluoranthene	ug/L	N	10	U	U	10	U	U
Fluorene	ug/L	N	10	U	U	10	U	U
Hexachlorobenzene	ug/L	N	10	U	U	10	U	U
Hexachlorobutadiene	ug/L	N	10	U	U	10	U	U
Hexachlorocyclopentadiene	ug/L	N	50	U	U	50	U	U
Hexachloroethane	ug/L	N	10	U	U	10	U	U

Chemical Analytical Data Summary
Tenth Quarterly Groundwater Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE			PB-BED-MW28			PB-BED-MW29		
SAMPLE_NO			DG3004			DG3005		
SAMPLE_DATE			15-Jun-04			16-Jun-04		
SAMPLE_PURPOSE			REG			REG		
Parameter	Units	Filtered	Result	Qual	ValQual	Result	Qual	ValQual
Indeno(1,2,3-cd)pyrene	ug/L	N	10	U	U	10	U	U
Isophorone	ug/L	N	10	U	U	10	U	U
Methylnaphthalene, 2-	ug/L	N	10	U	U	10	U	U
Methylphenol, 2-	ug/L	N	10	U	U	10	U	U
Methylphenol, 4-	ug/L	N	10	U	U	10	U	U
Naphthalene	ug/L	N	10	U	U	10	U	U
Nitroaniline, 2-	ug/L	N	50	U	U	50	U	U
Nitroaniline, 3-	ug/L	N	50	U	U	50	U	U
Nitroaniline, 4-	ug/L	N	50	U	U	50	U	U
Nitrobenzene	ug/L	N	10	U	U	10	U	U
Nitrophenol, 2-	ug/L	N	10	U	U	10	U	U
Nitrophenol, 4-	ug/L	N	50	U	U	50	U	U
n-Nitroso-di-n-propylamine	ug/L	N	10	U	U	10	U	U
n-Nitrosodiphenylamine	ug/L	N	10	U	U	10	U	U
Pentachlorophenol	ug/L	N	50	U	U	50	U	U
Phenanthrene	ug/L	N	10	U	U	10	U	U
Phenol	ug/L	N	10	U	U	10	U	U
Pyrene	ug/L	N	10	U	U	10	U	U
Trichlorobenzene, 1,2,4-	ug/L	N	10	U	U	10	U	U
Trichlorophenol, 2,4,5-	ug/L	N	10	U	U	10	U	U
Trichlorophenol, 2,4,6-	ug/L	N	10	U	U	10	U	U
Volatiles								
Acetone	ug/L	N	10	U	UJ	9.1	J B	B
Benzene	ug/L	N	1.1			0.23	J	J
Bromodichloromethane	ug/L	N	1	U	U	1	U	U
Bromoform	ug/L	N	1	U	U	1	U	U
Bromomethane	ug/L	N	2	U	U	2	U	U
Butanone, 2-	ug/L	N	5	U	R	5	U	R
Carbon disulfide	ug/L	N	0.1	J	J	1	U	UJ
Carbon tetrachloride	ug/L	N	1	U	U	1	U	U
Chlorobenzene	ug/L	N	1	U	U	1	U	U
Chloroethane	ug/L	N	2	U	U	2	U	U
Chloroform	ug/L	N	1	U	U	1	U	U
Chloromethane	ug/L	N	2	U	U	2	U	U
Dibromochloromethane	ug/L	N	1	U	U	1	U	U
Dichloroethane, 1,1-	ug/L	N	1	U	UJ	1	U	U
Dichloroethane, 1,2-	ug/L	N	1	U	U	1	U	U
Dichloroethene, 1,1-	ug/L	N	1	U	U	1	U	U
Dichloroethene, 1,2-	ug/L	N	1	U	U	1	U	U

Chemical Analytical Data Summary
Tenth Quarterly Groundwater Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE			PB-BED-MW28			PB-BED-MW29		
SAMPLE_NO			DG3004			DG3005		
SAMPLE_DATE			15-Jun-04			16-Jun-04		
SAMPLE_PURPOSE			REG			REG		
Parameter	Units	Filtered	Result	Qual	ValQual	Result	Qual	ValQual
Dichloropropane, 1,2-	ug/L	N	1	U	U	1	U	U
Dichloropropene, cis-1,3-	ug/L	N	1	U	U	1	U	U
Dichloropropene, trans-1,3-	ug/L	N	1	U	UJ	1	U	UJ
Ethylbenzene	ug/L	N	1	U	U	0.55	J	J
Hexanone, 2-	ug/L	N	5	U	UJ	5	U	UJ
Methyl-2-pentanone, 4-	ug/L	N	5	U	R	5	U	R
Methylene chloride	ug/L	N	2	U	U	2	U	U
Styrene	ug/L	N	1	U	U	1	U	U
Tetrachloroethane, 1,1,2,2-	ug/L	N	1	U	U	1	U	U
Tetrachloroethene	ug/L	N	1	U	U	1	U	U
Toluene	ug/L	N	0.13	J	J	1	U	U
Trichloroethane, 1,1,1-	ug/L	N	1	U	U	1	U	U
Trichloroethane, 1,1,2-	ug/L	N	1	U	UJ	1	U	U
Trichloroethene	ug/L	N	1	U	U	1	U	U
Vinyl chloride	ug/L	N	1	U	U	1	U	U
Xylenes, total	ug/L	N	1	U	U	3.7		

Laboratory Qualifier (Qual) Definitions

B (inorganic) - The analyte was detected below the reporting limit. Estimated val
B (organic) - The analyte was detected in the sample and the blank.
G - Reporting limit is elevated because of matrix interference.
J (inorganic) - The analyte was detected in the sample and the blank.
J (organic) - The analyte was detected below the reporting limit. Estimated value
U - Not detected. The analyte was not detected above the reporting limit.

Validation Qualifier (ValQual) Definitions

B - The analyte was not detected above the level found in an associated blank.
J - The analyte was positively identified; the concentration is estimated.
R - Data rejected.
U - Not detected. The analyte was not detected above the reporting limit.
UJ - Not detected. The reporting limit may be inaccurate or imprecise

Chemical Analytical Data Summary
Tenth Quarterly Groundwater Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE
SAMPLE_NO
SAMPLE_DATE
SAMPLE_PURPOSE

Parameter	Units	Filtered
Exposives		
Amino-2,6-dinitrotoluene, 4-	ug/L	N
Amino-4,6-dinitrotoluene, 2-	ug/L	N
Dinitrobenzene, 1,3-	ug/L	N
Dinitrotoluene, 2,4-	ug/L	N
Dinitrotoluene, 2,6-	ug/L	N
HMX	ug/L	N
Nitrobenzene	ug/L	N
Nitrotoluene, 2-	ug/L	N
Nitrotoluene, 3-	ug/L	N
Nitrotoluene, 4-	ug/L	N
RDX	ug/L	N
Tetryl	ug/L	N
Trinitrobenzene, 1,3,5-	ug/L	N
Trinitrotoluene, 2,4,6-	ug/L	N
General Chemistry		
Alkalinity	ppm	N
Chloride	ppm	N
Cyanide, total	ppm	N
Hardness	ppm	N
Nitrate	ppm	N
Sulfate	ppm	N
Total dissolved solids	ppm	N
Total organic carbon	ppm	N
Total suspended solids	ppm	N
Turbidity	NTU	N
Metals		
Aluminum	ug/L	N
Aluminum	ug/L	Y
Antimony	ug/L	N
Antimony	ug/L	Y
Arsenic	ug/L	N
Arsenic	ug/L	Y
Barium	ug/L	N
Barium	ug/L	Y
Beryllium	ug/L	N
Beryllium	ug/L	Y
Cadmium	ug/L	N
Cadmium	ug/L	Y

Chemical Analytical Data Summary
Tenth Quarterly Groundwater Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE
SAMPLE_NO
SAMPLE_DATE
SAMPLE_PURPOSE

Parameter	Units	Filtered
Calcium	ug/L	N
Calcium	ug/L	Y
Chromium	ug/L	N
Chromium	ug/L	Y
Cobalt	ug/L	N
Cobalt	ug/L	Y
Copper	ug/L	N
Copper	ug/L	Y
Iron	ug/L	N
Iron	ug/L	Y
Lead	ug/L	N
Lead	ug/L	Y
Magnesium	ug/L	N
Magnesium	ug/L	Y
Manganese	ug/L	N
Manganese	ug/L	Y
Mercury	ug/L	N
Mercury	ug/L	Y
Nickel	ug/L	N
Nickel	ug/L	Y
Potassium	ug/L	N
Potassium	ug/L	Y
Selenium	ug/L	N
Selenium	ug/L	Y
Silver	ug/L	N
Silver	ug/L	Y
Sodium	ug/L	N
Sodium	ug/L	Y
Thallium	ug/L	N
Thallium	ug/L	Y
Vanadium	ug/L	N
Vanadium	ug/L	Y
Zinc	ug/L	N
Zinc	ug/L	Y
Semivolatiles		
Acenaphthene	ug/L	N
Acenaphthylene	ug/L	N
Anthracene	ug/L	N
Benzo(a)anthracene	ug/L	N

Chemical Analytical Data Summary
Tenth Quarterly Groundwater Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE
SAMPLE_NO
SAMPLE_DATE
SAMPLE_PURPOSE

Parameter	Units	Filtered
Benzo(a)pyrene	ug/L	N
Benzo(b)fluoranthene	ug/L	N
Benzo(ghi)perylene	ug/L	N
Benzo(k)fluoranthene	ug/L	N
Bis(2-chloroethoxy)methane	ug/L	N
Bis(2-chloroethyl)ether	ug/L	N
Bis(2-chloroisopropyl)ether	ug/L	N
Bis(2-ethylhexyl)phthalate	ug/L	N
Bromophenyl phenyl ether, 4-	ug/L	N
Butyl benzyl phthalate	ug/L	N
Carbazole	ug/L	N
Chloro-3-methylphenol, 4-	ug/L	N
Chloroaniline, 4-	ug/L	N
Chloronaphthalene, 2-	ug/L	N
Chlorophenol, 2-	ug/L	N
Chlorophenyl phenyl ether, 4-	ug/L	N
Chrysene	ug/L	N
Dibenz(a,h)anthracene	ug/L	N
Dibenzofuran	ug/L	N
Dichlorobenzene, 1,2-	ug/L	N
Dichlorobenzene, 1,3-	ug/L	N
Dichlorobenzene, 1,4-	ug/L	N
Dichlorobenzidine, 3,3'-	ug/L	N
Dichlorophenol, 2,4-	ug/L	N
Diethyl phthalate	ug/L	N
Dimethyl phthalate	ug/L	N
Dimethylphenol, 2,4-	ug/L	N
Di-n-butyl phthalate	ug/L	N
Dinitro-2-methylphenol, 4,6-	ug/L	N
Dinitrophenol, 2,4-	ug/L	N
Dinitrotoluene, 2,4-	ug/L	N
Dinitrotoluene, 2,6-	ug/L	N
Di-n-octyl phthalate	ug/L	N
Fluoranthene	ug/L	N
Fluorene	ug/L	N
Hexachlorobenzene	ug/L	N
Hexachlorobutadiene	ug/L	N
Hexachlorocyclopentadiene	ug/L	N
Hexachloroethane	ug/L	N

Chemical Analytical Data Summary
Tenth Quarterly Groundwater Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE
SAMPLE_NO
SAMPLE_DATE
SAMPLE_PURPOSE

Parameter	Units	Filtered
Indeno(1,2,3-cd)pyrene	ug/L	N
Isophorone	ug/L	N
Methylnaphthalene, 2-	ug/L	N
Methylphenol, 2-	ug/L	N
Methylphenol, 4-	ug/L	N
Naphthalene	ug/L	N
Nitroaniline, 2-	ug/L	N
Nitroaniline, 3-	ug/L	N
Nitroaniline, 4-	ug/L	N
Nitrobenzene	ug/L	N
Nitrophenol, 2-	ug/L	N
Nitrophenol, 4-	ug/L	N
n-Nitroso-di-n-propylamine	ug/L	N
n-Nitrosodiphenylamine	ug/L	N
Pentachlorophenol	ug/L	N
Phenanthrene	ug/L	N
Phenol	ug/L	N
Pyrene	ug/L	N
Trichlorobenzene, 1,2,4-	ug/L	N
Trichlorophenol, 2,4,5-	ug/L	N
Trichlorophenol, 2,4,6-	ug/L	N
Volatiles		
Acetone	ug/L	N
Benzene	ug/L	N
Bromodichloromethane	ug/L	N
Bromoform	ug/L	N
Bromomethane	ug/L	N
Butanone, 2-	ug/L	N
Carbon disulfide	ug/L	N
Carbon tetrachloride	ug/L	N
Chlorobenzene	ug/L	N
Chloroethane	ug/L	N
Chloroform	ug/L	N
Chloromethane	ug/L	N
Dibromochloromethane	ug/L	N
Dichloroethane, 1,1-	ug/L	N
Dichloroethane, 1,2-	ug/L	N
Dichloroethene, 1,1-	ug/L	N
Dichloroethene, 1,2-	ug/L	N

Chemical Analytical Data Summary
Tenth Quarterly Groundwater Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE
SAMPLE_NO
SAMPLE_DATE
SAMPLE_PURPOSE

Parameter	Units	Filtered	
Dichloropropane, 1,2-	ug/L	N	
Dichloropropene, cis-1,3-	ug/L	N	
Dichloropropene, trans-1,3-	ug/L	N	
Ethylbenzene	ug/L	N	lue.
Hexanone, 2-	ug/L	N	
Methyl-2-pentanone, 4-	ug/L	N	
Methylene chloride	ug/L	N	
Styrene	ug/L	N	ɜ.
Tetrachloroethane, 1,1,2,2-	ug/L	N	
Tetrachloroethene	ug/L	N	
Toluene	ug/L	N	
Trichloroethane, 1,1,1-	ug/L	N	
Trichloroethane, 1,1,2-	ug/L	N	
Trichloroethene	ug/L	N	
Vinyl chloride	ug/L	N	
Xylenes, total	ug/L	N	

AUGUST 2004 DOWNGRADIENT WELL SAMPLING CHEMICAL ANALYTICAL DATA SUMMARY

Chemical Analytical Data Summary
Downgradient Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE			PB-BED-MW17			PB-BED-MW19			PB-BED-MW22			PB-BED-MW22			PB-BED-MW30			PB-BED-MV	
SAMPLE_NO			DH3000			DH3001			DH3002			DH3005			DH3003			DH3004	
SAMPLE_DATE			26-Aug-04			25-Aug-04			26-Aug-04			26-Aug-04			25-Aug-04			27-Aug-0	
SAMPLE_PURPOSE			REG			REG			REG			FD			REG			REG	
Parameter	Units	Filtered	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual
Explosives																			
Amino-2,6-dinitrotoluene, 4-	ug/L	N	0.23	G U	U	0.2	I U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.55	G U
Amino-4,6-dinitrotoluene, 2-	ug/L	N	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	I U	U	0.48	G U
Dinitrobenzene, 1,3-	ug/L	N	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U
Dinitrotoluene, 2,4-	ug/L	N	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U
Dinitrotoluene, 2,6-	ug/L	N	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U
HMX	ug/L	N	0.5	U	U	0.5	U	U	0.5	U	U	0.5	U	U	0.5	U	U	0.5	U
Nitrobenzene	ug/L	N	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U
Nitrotoluene, 2-	ug/L	N	0.33	G U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.16	J	J	0.2	U
Nitrotoluene, 3-	ug/L	N	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U
Nitrotoluene, 4-	ug/L	N	0.2	I U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.23			0.2	U
RDX	ug/L	N	0.5	I U	U	0.5	U	U	0.5	U	U	0.5	U	U	0.5	U	U	0.5	U
Tetryl	ug/L	N	0.2	I U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U
Trinitrobenzene, 1,3,5-	ug/L	N	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U
Trinitrotoluene, 2,4,6-	ug/L	N	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.43	G U
General Chemistry																			
Alkalinity	ppm	N	855			634			467						646				
Chloride	ppm	N	2790			396			33.4						101				
Cyanide, total	ppm	N	0.01	U	UJ	0.01	U	UJ	0.01	U	UJ				0.01	U	UJ		
Hardness	ppm	N	1940			584			424						564				
Nitrate	ppm	N	2	G U	UJ	0.1	U	UJ	0.1	U	UJ				0.1	U	UJ		
Sulfate	ppm	N	50	G U	U	29.5			5	U	U				52.5				
Total dissolved solids	ppm	N	4690			836			519						857				
Total organic carbon	ppm	N	1			5.6			1.8						8.9				
Total suspended solids	ppm	N	22			79			31						34				
Turbidity	NTU	N	36.4			118			252						90.5				
Metals																			
Aluminum	ug/L	N	136	B	B	67.3	B	B	717		J	1080		J	377		J	567	
Aluminum	ug/L	Y	95.3	B	B	50.3	B	B	63.6	B	B	64.1	B	B	352			118	B
Antimony	ug/L	N	60	U	U	60	U	U	60	U	U	60	U	U	60	U	U	60	U
Antimony	ug/L	Y	60	U	U	60	U	U	60	U	U	60	U	U	60	U	U	60	U
Arsenic	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	6.1	B	J	11.9	
Arsenic	ug/L	Y	10	U	U	10	U	U	10	U	U	10	U	U	5.4	B	B	12	
Barium	ug/L	N	1790			1190			695			701			187	B	J	161	B
Barium	ug/L	Y	1810			1140			700			694			187	B	J	148	B
Beryllium	ug/L	N	5	U	U	5	U	U	5	U	U	5	U	U	5	U	U	5	U
Beryllium	ug/L	Y	5	U	U	5	U	U	5	U	U	5	U	U	5	U	U	5	U
Cadmium	ug/L	N	5	U	U	5	U	U	5	U	U	5	U	U	5	U	U	5	U
Cadmium	ug/L	Y	5	U	U	5	U	U	5	U	U	5	U	U	5	U	U	5	U

Chemical Analytical Data Summary
Downgradient Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE			PB-BED-MW17			PB-BED-MW19			PB-BED-MW22			PB-BED-MW22			PB-BED-MW30			PB-BED-MV	
SAMPLE_NO			DH3000			DH3001			DH3002			DH3005			DH3003			DH3004	
SAMPLE_DATE			26-Aug-04			25-Aug-04			26-Aug-04			26-Aug-04			25-Aug-04			27-Aug-0	
SAMPLE_PURPOSE			REG			REG			REG			FD			REG			REG	
Parameter	Units	Filtered	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual
Calcium	ug/L	N	312000			185000			118000			117000			140000			134000	
Calcium	ug/L	Y	316000			181000			117000			115000			140000			131000	
Chromium	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U	10	U
Chromium	ug/L	Y	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U	10	U
Cobalt	ug/L	N	50	U	U	50	U	U	50	U	U	50	U	U	50	U	U	50	U
Cobalt	ug/L	Y	50	U	U	50	U	U	50	U	U	50	U	U	50	U	U	50	U
Copper	ug/L	N	25	U	U	31.5			25	U	U	25	U	U	25	U	U	25	U
Copper	ug/L	Y	25	U	U	13	B	J	25	U	U	25	U	U	25	U	U	25	U
Iron	ug/L	N	100	U	U	100	U	U	593			620			175			2320	
Iron	ug/L	Y	100	U	U	100	U	U	100	U	U	100	U	U	190			640	
Lead	ug/L	N	3	U	U	3	U	U	3	U	U	3	U	U	3	U	U	3	U
Lead	ug/L	Y	3	U	U	3	U	U	3	U	U	3	U	U	3	U	U	3	U
Magnesium	ug/L	N	279000			36300			36600			37100			69600			108000	
Magnesium	ug/L	Y	284000			36500			37000			36400			69800			108000	
Manganese	ug/L	N	6.3	B	J	2	B	J	57.5			56			27.9			80.3	
Manganese	ug/L	Y	5	B	J	2.8	B	J	47			46.2			28.5			77.8	
Mercury	ug/L	N	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U
Mercury	ug/L	Y	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U
Nickel	ug/L	N	40	U	U	4.9	B	B	3.1	B	B	40	U	U	40	U	U	40	U
Nickel	ug/L	Y	40	U	U	5.1	B	B	40	U	U	40	U	U	40	U	U	40	U
Potassium	ug/L	N	67000	J		38900	J		3980	B J	J	4410	B J	J	15900	J		26800	J
Potassium	ug/L	Y	68500	J	J	39300	J	J	3730	B J	J	3750	B J	J	15700	J	J	27200	J
Selenium	ug/L	N	2.1	B	B	5	U	U	5	U	U	5	U	U	5	U	U	5	U
Selenium	ug/L	Y	5	U	U	1.8	B	J	5	U	U	5	U	U	5	U	U	5	U
Silver	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U	10	U
Silver	ug/L	Y	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U	10	U
Sodium	ug/L	N	685000			80500			18500			18700			83600			187000	
Sodium	ug/L	Y	699000			80800			18700			18500			83700			187000	
Thallium	ug/L	N	10	U	U	10	U	U	3.3	B	J	4.1	B	J	10	U	U	3.8	B
Thallium	ug/L	Y	3.3	B	J	2.6	B	J	10	U	U	5.8	B	J	4	B	J	10	U
Vanadium	ug/L	N	50	U	U	50	U	U	50	U	U	50	U	U	50	U	U	5.1	B
Vanadium	ug/L	Y	50	U	U	50	U	U	50	U	U	50	U	U	50	U	U	4.2	B
Zinc	ug/L	N	11.5	B	J	96.6			4.5	B	J	5.2	B	J	9.5	B	J	12.1	B
Zinc	ug/L	Y	6.1	B	J	43.6			4.2	B	J	20	U	U	10.9	B	J	4.7	B
Semivolatiles																			
Acenaphthene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Acenaphthylene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Anthracene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Benzo(a)anthracene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		

Chemical Analytical Data Summary
Downgradient Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE			PB-BED-MW17			PB-BED-MW19			PB-BED-MW22			PB-BED-MW22			PB-BED-MW30			PB-BED-MV	
SAMPLE_NO			DH3000			DH3001			DH3002			DH3005			DH3003			DH3004	
SAMPLE_DATE			26-Aug-04			25-Aug-04			26-Aug-04			26-Aug-04			25-Aug-04			27-Aug-0	
SAMPLE_PURPOSE			REG			REG			REG			FD			REG			REG	
Parameter	Units	Filtered	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual
Benzo(a)pyrene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Benzo(b)fluoranthene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Benzo(ghi)perylene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Benzo(k)fluoranthene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Bis(2-chloroethoxy)methane	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Bis(2-chloroethyl)ether	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Bis(2-chloroisopropyl)ether	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Bis(2-ethylhexyl)phthalate	ug/L	N	10	U	U	10	U	U	10	U	U	2.5	J	J	10	U	U		
Bromophenyl phenyl ether, 4-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Butyl benzyl phthalate	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Carbazole	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Chloro-3-methylphenol, 4-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Chloroaniline, 4-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Chloronaphthalene, 2-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Chlorophenol, 2-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Chlorophenyl phenyl ether, 4-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Chrysene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Dibenz(a,h)anthracene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Dibenzofuran	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Dichlorobenzene, 1,2-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Dichlorobenzene, 1,3-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Dichlorobenzene, 1,4-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Dichlorobenzidine, 3,3'-	ug/L	N	50	U	U	50	U	U	50	U	U	50	U	U	50	U	U		
Dichlorophenol, 2,4-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Diethyl phthalate	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Dimethyl phthalate	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Dimethylphenol, 2,4-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Di-n-butyl phthalate	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Dinitro-2-methylphenol, 4,6-	ug/L	N	50	U	U	50	U	U	50	U	U	50	U	UJ	50	U	U		
Dinitrophenol, 2,4-	ug/L	N	50	U	U	50	U	U	50	U	U	50	U	UJ	50	U	U		
Dinitrotoluene, 2,4-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Dinitrotoluene, 2,6-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Di-n-octyl phthalate	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Fluoranthene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Fluorene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Hexachlorobenzene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Hexachlorobutadiene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Hexachlorocyclopentadiene	ug/L	N	50	U	U	50	U	U	50	U	U	50	U	U	50	U	U		
Hexachloroethane	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		

Chemical Analytical Data Summary
Downgradient Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE			PB-BED-MW17			PB-BED-MW19			PB-BED-MW22			PB-BED-MW22			PB-BED-MW30			PB-BED-MV	
SAMPLE_NO			DH3000			DH3001			DH3002			DH3005			DH3003			DH3004	
SAMPLE_DATE			26-Aug-04			25-Aug-04			26-Aug-04			26-Aug-04			25-Aug-04			27-Aug-0	
SAMPLE_PURPOSE			REG			REG			REG			FD			REG			REG	
Parameter	Units	Filtered	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual
Indeno(1,2,3-cd)pyrene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Isophorone	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Methylnaphthalene, 2-	ug/L	N	12			11			10	U	U	10	U	U	6.2	J	J		
Methylphenol, 2-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Methylphenol, 4-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Naphthalene	ug/L	N	13			7	J	J	10	U	U	10	U	U	3.8	J	J		
Nitroaniline, 2-	ug/L	N	50	U	U	50	U	U	50	U	U	50	U	U	50	U	U		
Nitroaniline, 3-	ug/L	N	50	U	U	50	U	U	50	U	U	50	U	U	50	U	U		
Nitroaniline, 4-	ug/L	N	50	U	U	50	U	U	50	U	U	50	U	U	50	U	U		
Nitrobenzene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Nitrophenol, 2-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Nitrophenol, 4-	ug/L	N	50	U	U	50	U	U	50	U	U	50	U	U	50	U	U		
n-Nitroso-di-n-propylamine	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
n-Nitrosodiphenylamine	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Pentachlorophenol	ug/L	N	50	U	U	50	U	U	50	U	U	50	U	U	50	U	U		
Phenanthrene	ug/L	N	1.2	J	J	0.89	J	J	10	U	U	10	U	U	10	U	U		
Phenol	ug/L	N	2.6	J	J	10	U	U	10	U	U	10	U	U	10	U	U		
Pyrene	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Trichlorobenzene, 1,2,4-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Trichlorophenol, 2,4,5-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Trichlorophenol, 2,4,6-	ug/L	N	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U		
Volatiles																			
Acetone	ug/L	N	500	U	R	71	U	R	10	U	R	10	U	U	50	U	R	310	J B
Benzene	ug/L	N	13	J	J	28			0.21	J	J	0.18	J	J	3.4	J	J	18	J
Bromodichloromethane	ug/L	N	50	U	U	7.1	U	U	1	U	U	1	U	U	5	U	U	50	U
Bromoform	ug/L	N	50	U	U	7.1	U	U	1	U	U	1	U	U	5	U	U	50	U
Bromomethane	ug/L	N	100	U	U	14	U	U	2	U	U	2	U	U	10	U	U	100	U
Butanone, 2-	ug/L	N	250	U	R	36	U	R	5	U	R	5	U	R	25	U	R	250	U
Carbon disulfide	ug/L	N	8.9	J	J	1.7	J	J	0.19	J	B	0.22	J	B	3.7	J	J	17	J
Carbon tetrachloride	ug/L	N	50	U	U	7.1	U	U	1	U	U	1	U	U	5	U	U	50	U
Chlorobenzene	ug/L	N	50	U	U	7.1	U	U	1	U	U	1	U	U	5	U	U	50	U
Chloroethane	ug/L	N	100	U	U	14	U	U	2	U	U	2	U	U	10	U	U	100	U
Chloroform	ug/L	N	50	U	U	7.1	U	U	1	U	U	1	U	U	5	U	U	50	U
Chloromethane	ug/L	N	100	U	U	14	U	U	2	U	U	2	U	U	10	U	U	100	U
Dibromochloromethane	ug/L	N	50	U	U	7.1	U	U	1	U	U	1	U	U	5	U	U	50	U
Dichloroethane, 1,1-	ug/L	N	50	U	U	7.1	U	U	1	U	U	1	U	U	5	U	U	50	U
Dichloroethane, 1,2-	ug/L	N	50	U	U	7.1	U	U	1	U	U	1	U	U	5	U	U	50	U
Dichloroethene, 1,1-	ug/L	N	50	U	U	7.1	U	U	1	U	U	1	U	U	5	U	U	50	U
Dichloroethene, 1,2-	ug/L	N	50	U	U	7.1	U	U	1	U	U	1	U	U	5	U	U	50	U

Chemical Analytical Data Summary
Downgradient Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE			PB-BED-MW17			PB-BED-MW19			PB-BED-MW22			PB-BED-MW22			PB-BED-MW30			PB-BED-MV
SAMPLE_NO			DH3000			DH3001			DH3002			DH3005			DH3003			DH3004
SAMPLE_DATE			26-Aug-04			25-Aug-04			26-Aug-04			26-Aug-04			25-Aug-04			27-Aug-0
SAMPLE_PURPOSE			REG			REG			REG			FD			REG			REG
Parameter	Units	Filtered	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual
Dichloropropane, 1,2-	ug/L	N	50	U	U	7.1	U	U	1	U	U	1	U	U	5	U	U	50	U
Dichloropropene, cis-1,3-	ug/L	N	50	U	U	7.1	U	U	1	U	U	1	U	U	5	U	U	50	U
Dichloropropene, trans-1,3-	ug/L	N	50	U	U	7.1	U	U	1	U	U	1	U	U	5	U	U	50	U
Ethylbenzene	ug/L	N	62			8.8			1	U	U	1	U	U	9.1			14	J
Hexanone, 2-	ug/L	N	250	U	U	36	U	UJ	5	U	U	5	U	U	25	U	UJ	250	U
Methyl-2-pentanone, 4-	ug/L	N	250	U	R	36	U	R	5	U	R	5	U	R	25	U	R	250	U
Methylene chloride	ug/L	N	100	U	U	14	U	U	2	U	U	2	U	U	10	U	U	100	U
Styrene	ug/L	N	50	U	U	7.1	U	U	1	U	U	1	U	U	5	U	U	50	U
Tetrachloroethane, 1,1,2,2-	ug/L	N	50	U	U	7.1	U	U	1	U	U	1	U	U	5	U	U	50	U
Tetrachloroethene	ug/L	N	50	U	U	7.1	U	U	1	U	U	1	U	U	5	U	U	50	U
Toluene	ug/L	N	98			11			0.11	J	B	1	U	U	10			9.5	J
Trichloroethane, 1,1,1-	ug/L	N	50	U	U	7.1	U	U	1	U	U	1	U	U	5	U	U	50	U
Trichloroethane, 1,1,2-	ug/L	N	50	U	U	7.1	U	U	1	U	U	1	U	U	5	U	U	50	U
Trichloroethene	ug/L	N	50	U	U	7.1	U	U	1	U	U	1	U	U	5	U	U	50	U
Vinyl chloride	ug/L	N	50	U	U	7.1	U	U	1	U	U	1	U	U	5	U	U	50	U
Xylenes, total	ug/L	N	280			95			1	U	U	1	U	UJ	56			56	

Chemical Analytical Data Summary
Downgradient Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE			V33		PT-5912	
SAMPLE_NO					DH3007	
SAMPLE_DATE			4		27-Aug-04	
SAMPLE_PURPOSE					REG	
Parameter	Units	Filtered	ValQual	Result	Qual	ValQual
Explosives						
Amino-2,6-dinitrotoluene, 4-	ug/L	N	U	0.2	U	U
Amino-4,6-dinitrotoluene, 2-	ug/L	N	U	0.2	U	U
Dinitrobenzene, 1,3-	ug/L	N	U	0.2	U	U
Dinitrotoluene, 2,4-	ug/L	N	U	0.2	U	U
Dinitrotoluene, 2,6-	ug/L	N	U	0.2	U	U
HMX	ug/L	N	U	0.5	U	U
Nitrobenzene	ug/L	N	U	0.2	U	U
Nitrotoluene, 2-	ug/L	N	U	0.2	U	U
Nitrotoluene, 3-	ug/L	N	U	0.2	U	U
Nitrotoluene, 4-	ug/L	N	U	0.2	U	U
RDX	ug/L	N	U	0.5	I U	U
Tetryl	ug/L	N	U	0.2	U	U
Trinitrobenzene, 1,3,5-	ug/L	N	U	0.2	U	U
Trinitrotoluene, 2,4,6-	ug/L	N	U	0.2	U	U
General Chemistry						
Alkalinity	ppm	N		333		
Chloride	ppm	N		14.9		
Cyanide, total	ppm	N		0.01	U	UJ
Hardness	ppm	N		350		
Nitrate	ppm	N		0.1	U	U
Sulfate	ppm	N		70.5		
Total dissolved solids	ppm	N		452		
Total organic carbon	ppm	N		2.9		
Total suspended solids	ppm	N		21		
Turbidity	NTU	N		37		
Metals						
Aluminum	ug/L	N	J	443		J
Aluminum	ug/L	Y	B	83.4	B	B
Antimony	ug/L	N	U	60	U	U
Antimony	ug/L	Y	U	60	U	U
Arsenic	ug/L	N		10	U	U
Arsenic	ug/L	Y		10	U	U
Barium	ug/L	N	J	187	B	J
Barium	ug/L	Y	J	180	B	J
Beryllium	ug/L	N	U	5	U	U
Beryllium	ug/L	Y	U	5	U	U
Cadmium	ug/L	N	U	5	U	U
Cadmium	ug/L	Y	U	5	U	U

Chemical Analytical Data Summary
Downgradient Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE			V33		PT-5912	
SAMPLE_NO					DH3007	
SAMPLE_DATE			4		27-Aug-04	
SAMPLE_PURPOSE					REG	
Parameter	Units	Filtered	ValQual	Result	Qual	ValQual
Calcium	ug/L	N		95900		
Calcium	ug/L	Y		94900		
Chromium	ug/L	N	U	10	U	U
Chromium	ug/L	Y	U	10	U	U
Cobalt	ug/L	N	U	50	U	U
Cobalt	ug/L	Y	U	50	U	U
Copper	ug/L	N	U	25	U	U
Copper	ug/L	Y	U	25	U	U
Iron	ug/L	N		1680		
Iron	ug/L	Y		77.9	B	J
Lead	ug/L	N	U	3	U	U
Lead	ug/L	Y	U	3	U	U
Magnesium	ug/L	N		31500		
Magnesium	ug/L	Y		31300		
Manganese	ug/L	N		95		
Manganese	ug/L	Y		92.2		
Mercury	ug/L	N	U	0.2	U	U
Mercury	ug/L	Y	U	0.2	U	U
Nickel	ug/L	N	U	40	U	U
Nickel	ug/L	Y	U	40	U	U
Potassium	ug/L	N		1460	B J	J
Potassium	ug/L	Y	J	1340	B J	J
Selenium	ug/L	N	U	1.8	B	B
Selenium	ug/L	Y	U	5	U	U
Silver	ug/L	N	U	10	U	U
Silver	ug/L	Y	U	10	U	U
Sodium	ug/L	N		9720		
Sodium	ug/L	Y		9630		
Thallium	ug/L	N	J	10	U	U
Thallium	ug/L	Y	U	10	U	U
Vanadium	ug/L	N	J	50	U	U
Vanadium	ug/L	Y	J	50	U	U
Zinc	ug/L	N	J	173		
Zinc	ug/L	Y	J	4.4	B	J
Semivolatiles						
Acenaphthene	ug/L	N		10	U	U
Acenaphthylene	ug/L	N		10	U	U
Anthracene	ug/L	N		10	U	U
Benzo(a)anthracene	ug/L	N		10	U	U

Chemical Analytical Data Summary
Downgradient Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE			V33		PT-5912	
SAMPLE_NO					DH3007	
SAMPLE_DATE			4		27-Aug-04	
SAMPLE_PURPOSE					REG	
Parameter	Units	Filtered	ValQual	Result	Qual	ValQual
Benzo(a)pyrene	ug/L	N		10	U	U
Benzo(b)fluoranthene	ug/L	N		10	U	U
Benzo(ghi)perylene	ug/L	N		10	U	U
Benzo(k)fluoranthene	ug/L	N		10	U	U
Bis(2-chloroethoxy)methane	ug/L	N		10	U	U
Bis(2-chloroethyl)ether	ug/L	N		10	U	U
Bis(2-chloroisopropyl)ether	ug/L	N		10	U	U
Bis(2-ethylhexyl)phthalate	ug/L	N		10	U	U
Bromophenyl phenyl ether, 4-	ug/L	N		10	U	U
Butyl benzyl phthalate	ug/L	N		10	U	U
Carbazole	ug/L	N		10	U	U
Chloro-3-methylphenol, 4-	ug/L	N		10	U	U
Chloroaniline, 4-	ug/L	N		10	U	U
Chloronaphthalene, 2-	ug/L	N		10	U	U
Chlorophenol, 2-	ug/L	N		10	U	U
Chlorophenyl phenyl ether, 4-	ug/L	N		10	U	U
Chrysene	ug/L	N		10	U	U
Dibenz(a,h)anthracene	ug/L	N		10	U	U
Dibenzofuran	ug/L	N		10	U	U
Dichlorobenzene, 1,2-	ug/L	N		10	U	U
Dichlorobenzene, 1,3-	ug/L	N		10	U	U
Dichlorobenzene, 1,4-	ug/L	N		10	U	U
Dichlorobenzidine, 3,3'-	ug/L	N		50	U	U
Dichlorophenol, 2,4-	ug/L	N		10	U	U
Diethyl phthalate	ug/L	N		10	U	U
Dimethyl phthalate	ug/L	N		10	U	U
Dimethylphenol, 2,4-	ug/L	N		10	U	U
Di-n-butyl phthalate	ug/L	N		10	U	U
Dinitro-2-methylphenol, 4,6-	ug/L	N		50	U	U
Dinitrophenol, 2,4-	ug/L	N		50	U	U
Dinitrotoluene, 2,4-	ug/L	N		10	U	U
Dinitrotoluene, 2,6-	ug/L	N		10	U	U
Di-n-octyl phthalate	ug/L	N		10	U	U
Fluoranthene	ug/L	N		10	U	U
Fluorene	ug/L	N		10	U	U
Hexachlorobenzene	ug/L	N		10	U	U
Hexachlorobutadiene	ug/L	N		10	U	U
Hexachlorocyclopentadiene	ug/L	N		50	U	U
Hexachloroethane	ug/L	N		10	U	U

Chemical Analytical Data Summary
Downgradient Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE			V33		PT-5912	
SAMPLE_NO					DH3007	
SAMPLE_DATE			4		27-Aug-04	
SAMPLE_PURPOSE					REG	
Parameter	Units	Filtered	ValQual	Result	Qual	ValQual
Indeno(1,2,3-cd)pyrene	ug/L	N		10	U	U
Isophorone	ug/L	N		10	U	U
Methylnaphthalene, 2-	ug/L	N		10	U	U
Methylphenol, 2-	ug/L	N		10	U	U
Methylphenol, 4-	ug/L	N		10	U	U
Naphthalene	ug/L	N		10	U	U
Nitroaniline, 2-	ug/L	N		50	U	U
Nitroaniline, 3-	ug/L	N		50	U	U
Nitroaniline, 4-	ug/L	N		50	U	U
Nitrobenzene	ug/L	N		10	U	U
Nitrophenol, 2-	ug/L	N		10	U	U
Nitrophenol, 4-	ug/L	N		50	U	U
n-Nitroso-di-n-propylamine	ug/L	N		10	U	U
n-Nitrosodiphenylamine	ug/L	N		10	U	U
Pentachlorophenol	ug/L	N		50	U	U
Phenanthrene	ug/L	N		10	U	U
Phenol	ug/L	N		10	U	U
Pyrene	ug/L	N		10	U	U
Trichlorobenzene, 1,2,4-	ug/L	N		10	U	U
Trichlorophenol, 2,4,5-	ug/L	N		10	U	U
Trichlorophenol, 2,4,6-	ug/L	N		10	U	U
Volatiles						
Acetone	ug/L	N	J	50	U	R
Benzene	ug/L	N	J	7.6		
Bromodichloromethane	ug/L	N	U	5	U	U
Bromoform	ug/L	N	U	5	U	U
Bromomethane	ug/L	N	U	10	U	U
Butanone, 2-	ug/L	N	R	25	U	R
Carbon disulfide	ug/L	N	J	0.96	J	J
Carbon tetrachloride	ug/L	N	U	5	U	U
Chlorobenzene	ug/L	N	U	5	U	U
Chloroethane	ug/L	N	U	10	U	U
Chloroform	ug/L	N	U	5	U	U
Chloromethane	ug/L	N	U	10	U	U
Dibromochloromethane	ug/L	N	U	5	U	U
Dichloroethane, 1,1-	ug/L	N	U	5	U	U
Dichloroethane, 1,2-	ug/L	N	U	5	U	U
Dichloroethene, 1,1-	ug/L	N	U	5	U	U
Dichloroethene, 1,2-	ug/L	N	U	5	U	U

Laboratory Qualifier (Qual) Definitions

Chemical Analytical Data Summary
Downgradient Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE			V33	PT-5912		
SAMPLE_NO				DH3007		
SAMPLE_DATE			4	27-Aug-04		
SAMPLE_PURPOSE				REG		
Parameter	Units	Filtered	ValQual	Result	Qual	ValQual
Dichloropropane, 1,2-	ug/L	N	U	5	U	U
Dichloropropene, cis-1,3-	ug/L	N	U	5	U	U
Dichloropropene, trans-1,3-	ug/L	N	U	5	U	U
Ethylbenzene	ug/L	N	J	1.7	J	J
Hexanone, 2-	ug/L	N	U	25	U	U
Methyl-2-pentanone, 4-	ug/L	N	R	25	U	R
Methylene chloride	ug/L	N	U	10	U	U
Styrene	ug/L	N	U	5	U	U
Tetrachloroethane, 1,1,2,2-	ug/L	N	U	5	U	U
Tetrachloroethene	ug/L	N	U	5	U	U
Toluene	ug/L	N	J	3	J	J
Trichloroethane, 1,1,1-	ug/L	N	U	5	U	U
Trichloroethane, 1,1,2-	ug/L	N	U	5	U	U
Trichloroethene	ug/L	N	U	5	U	U
Vinyl chloride	ug/L	N	U	5	U	U
Xylenes, total	ug/L	N		3.6	J	J

B (inorganic) - The analyte was detected below the reporting limit. Estimated value.
B (organic) - The analyte was detected in the sample and the blank.
G - Reporting limit is elevated because of matrix interference.
I - Matrix interference.
J (inorganic) - The analyte was detected in the sample and the blank.
J (organic) - The analyte was detected below the reporting limit. Estimated value.
U - Not detected. The analyte was not detected above the reporting limit.

Validation Qualifier (ValQual) Definitions
B - The analyte was not detected above the level found in an associated blank.
J - The analyte was positively identified; the concentration is estimated.
R - Data rejected.
U - Not detected. The analyte was not detected above the reporting limit.
UJ - Not detected. The reporting limit may be inaccurate or imprecise

APPENDIX J

DETECTED HITS SUMMARY EXCLUDING "B" QUALIFIERS

MAY 2004 DOWNGRADIENT WELL SAMPLING
DETECTED HITS SUMMARY EXCLUDING "B" QUALIFIERS

Detected Hits Summary Excluding "B" Qualifiers
Downgradient Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE			PB-BED-MW17			PB-BED-MW19			PB-BED-MW22			PB-BED-MW22			PB-BED-MW30			PB-BED-MW33		
SAMPLE_NO			DF3000			DF3001			DF3002			DF3005			DF3003			DF3004		
SAMPLE_DATE			6-May-04			5-May-04			5-May-04			5-May-04			7-May-04			7-May-04		
SAMPLE_PURPOSE			REG			REG			REG			FD			REG			REG		
Parameter	Units	Filtered	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual
Volatiles																				
Acetone	ug/L	N	-	-	-	-	-	-	-	-	-	-	-	-	230	B		290	J B	J
Benzene	ug/L	N	15	J	J	18	J	J	-	-	-	-	-	-	2.4	J	J	17	J	J
Butanone, 2-	ug/L	N	130	J	J	-	-	-	-	-	-	-	-	-	-	-	-	73	J	J
Carbon disulfide	ug/L	N	-	-	-	3.2	J	J	-	-	-	-	-	-	4.2	J	J	5.9	J	J
Chlorobenzene	ug/L	N	11	J	J	2.2	J	J	-	-	-	-	-	-	-	-	-	-	-	-
Ethylbenzene	ug/L	N	86	J	J	6.8	J	J	-	-	-	-	-	-	7.5			15	J	J
Methylene chloride	ug/L	N	34	J	J	7.3	J	J	5.8	J	J	6.1	J	J	-	-	-	24	J	J
Toluene	ug/L	N	120			8	J	J	-	-	-	-	-	-	7.2			15	J	J
Xylenes, total	ug/L	N	390			66			-	-	-	-	-	-	47			84		
Semivolatiles																				
Bis(2-ethylhexyl)phthalate	ug/L	N	2.3	J	J	-	-	-	-	-	-	-	-	-	-	-	-			
Chrysene	ug/L	N	1	J	J	-	-	-	-	-	-	-	-	-	-	-	-			
Methylnaphthalene, 2-	ug/L	N	7.7	J	J	5.2	J	J	-	-	-	-	-	-	2.2	J	J			
Naphthalene	ug/L	N	8	J	J	3.7	J	J	-	-	-	-	-	-	-	-	-			
Phenanthrene	ug/L	N	0.85	J	J	-	-	-	-	-	-	-	-	-	-	-	-			
Phenol	ug/L	N	2.2	J	J	-	-	-	-	-	-	-	-	-	-	-	-			
Metals																				
Aluminum	ug/L	N	122	B	J	61.7	B	J	1480		J	862		J	481			3650		
Aluminum	ug/L	Y	-	-	-	45.2	B	J	41.4	B	J	51.5	B	J	-	-	-	-	-	-
Arsenic	ug/L	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	17.7		
Arsenic	ug/L	Y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13.6		
Barium	ug/L	N	1860			1120			732			712			165	B	J	278		
Barium	ug/L	Y	1910			1050			730			698			170	B	J	259		
Calcium	ug/L	N	316000			184000			134000			122000			124000			162000		
Calcium	ug/L	Y	326000			170000			118000			114000			127000			153000		
Chromium	ug/L	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11.6		
Chromium	ug/L	Y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cobalt	ug/L	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.2	B	J
Cobalt	ug/L	Y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Copper	ug/L	N	-	-	-	52.2			-	-	-	-	-	-	-	-	-	13.1	B	J
Copper	ug/L	Y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iron	ug/L	N	-	-	-	-	-	-	2220		J	1030		J	251			4920		
Iron	ug/L	Y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	120		
Lead	ug/L	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.7	B	J
Lead	ug/L	Y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magnesium	ug/L	N	277000			44600			39500			37700			61900			117000		
Magnesium	ug/L	Y	287000			44800			37900			36700			63600			116000		
Manganese	ug/L	N	-	-	-	-	-	-	91.8			65			46.9	J		164	J	
Manganese	ug/L	Y	-	-	-	2.2	B	J	47.4			46.3			41.4	J		129	J	

Detected Hits Summary Excluding "B" Qualifiers
Downgradient Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE			PB-BED-MW17			PB-BED-MW19			PB-BED-MW22			PB-BED-MW22			PB-BED-MW30			PB-BED-MW33		
SAMPLE_NO			DF3000			DF3001			DF3002			DF3005			DF3003			DF3004		
SAMPLE_DATE			6-May-04			5-May-04			5-May-04			5-May-04			7-May-04			7-May-04		
SAMPLE_PURPOSE			REG			REG			REG			FD			REG			REG		
Parameter	Units	Filtered	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual
Mercury	ug/L	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mercury	ug/L	Y	0.46			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	ug/L	N	-	-	-	9.2	B	J	2.8	B	J	-	-	-	-	-	-	12.7	B	J
Nickel	ug/L	Y	-	-	-	7.9	B	J	-	-	-	-	-	-	3.2	B	J	4.2	B	J
Potassium	ug/L	N	64400	J	J	36500	J	J	4780	B J	J	4410	B J	J	15400	J		39100	J	
Potassium	ug/L	Y	66700	J	J	36500	J	J	4300	B J	J	4120	B J	J	15500	J		38200	J	
Selenium	ug/L	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.6	B	J
Selenium	ug/L	Y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	ug/L	N	662000			74300		J	20400		J	19700		J	72500			278000		
Sodium	ug/L	Y	684000			75400		J	20600		J	19800		J	73500			278000		
Thallium	ug/L	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium	ug/L	Y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	ug/L	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8.6	B	J
Vanadium	ug/L	Y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc	ug/L	N	24.7		J	65.9			22			13.2	B	J	80.6			69.8		
Zinc	ug/L	Y	8.1	B	J	-	-	-	-	-	-	-	-	-	13.4	B	J	5.4	B	J
General Chemistry																				
Alkalinity	ppm	N	789			1050		J	545		J				586					
Chloride	ppm	N	2460			229			47.1						104					
Hardness	ppm	N	2030			662			466						580					
Sulfate	ppm	N	-	-	-	21			11.3						32.6					
Total dissolved solids	ppm	N	6040			887			513						739					
Total organic carbon	ppm	N	6.4			5.6			2						10.5					
Total suspended solids	ppm	N	9			32			49						11					
Turbidity	NTU	N	6.3			220			192						98.5					

Laboratory Qualifier (Qual) Definitions
B (inorganic) - The analyte was detected below the reporting limit. Estimated value.
J (inorganic) - The analyte was detected in the sample and the blank.
J (organic) - The analyte was detected below the reporting limit. Estimated value.

Validation Qualifier (ValQual) Definitions
J - The analyte was positively identified; the concentration is estimated.

JUNE 2004 DOWNGRADIENT WELL SAMPLING
DETECTED HITS SUMMARY EXCLUDING "B" QUALIFIERS

Detected Hits Summary Excluding "B" Qualifiers
Tenth Quarterly Groundwater Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE			IT-BG8-BEDGW-001			PB-BED-MW20			PB-BED-MW24			PB-BED-MW25			PB-BED-MW25			PB-BED-MW28			PB-BED-MW29		
SAMPLE_NO			DG3000			DG3001			DG3002			DG3003			DG3006			DG3004			DG3005		
SAMPLE_DATE			16-Jun-04			17-Jun-04			16-Jun-04			17-Jun-04			17-Jun-04			15-Jun-04			16-Jun-04		
SAMPLE_PURPOSE			REG			REG			REG			REG			FD			REG			REG		
Parameter	Units	Filtered	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual
Explosives																							
Alkalinity	ppm	N	317			264			769			294						481			467		
Chloride	ppm	N	9.6			24200			79			95.4						162			3340		
Hardness	ppm	N	312			8900			584			760						30.4			1470		
Nitrate	ppm	N	1.5			0.18			-	-	-	-	-	-				-	-	-	-	-	-
Sulfate	ppm	N	36			-	-	-	25.5			514						-	-	-	7.5		
Total dissolved solids	ppm	N	383			36100			824			1160						746			5720		
Total organic carbon	ppm	N	-	-	-	2.1			-	-	-	1.9						4.7			4.5		
Total suspended solids	ppm	N	-	-	-	22			-	-	-	4						8			14		
Turbidity	NTU	N	-	-	-	4			56.6			2						0.72			7.5		
Volatiles																							
Acetone	ug/L	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzene	ug/L	N	-	-	-	0.34	J	J	100			-	-	-	-	-	-	1.1			0.23	J	J
Carbon disulfide	ug/L	N	0.16	J	J	-	-	-	7.3	J	J	1.9		J	1.9		J	0.1	J	J	-	-	-
Ethylbenzene	ug/L	N	-	-	-	-	-	-	45			-	-	-	-	-	-	-	-	-	0.55	J	J
Toluene	ug/L	N	-	-	-	-	-	-	57			-	-	-	-	-	-	0.13	J	J	-	-	-
Xylenes, total	ug/L	N	-	-	-	-	-	-	240			-	-	-	-	-	-	-	-	-	3.7		
Semivolatiles																							
Methylnaphthalene, 2-	ug/L	N	-	-	-	-	-	-	2	J	J	-	-	-	-	-	-	-	-	-	-	-	-
Naphthalene	ug/L	N	-	-	-	-	-	-	1.9	J	J	-	-	-	-	-	-	-	-	-	-	-	-
Metals																							
Aluminum	ug/L	N	71.8	B	J	180	B	J	78.4	B	J	84.8	B	J	77.1	B	J	129	B	J	120	B	J
Aluminum	ug/L	Y	74.3	B	J	128	B	J	84	B	J	-	-	-	-	-	-	78.1	B	J	107	B	J
Arsenic	ug/L	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	ug/L	Y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Barium	ug/L	N	27.6	B	J	22500			535			112	B	J	111	B	J	337			9110		
Barium	ug/L	Y	29.8	B	J	23100			590			117	B	J	118	B	J	343			9050		
Calcium	ug/L	N	81800			1880000			125000			194000			192000			17400			272000		
Calcium	ug/L	Y	81300			1940000			135000			193000			195000			17300			282000		
Cobalt	ug/L	N	-	-	-	11.4	B	J	-	-	-	-	-	-	-	-	-	-	-	-	2.6	B	J
Cobalt	ug/L	Y	-	-	-	13	B	J	-	-	-	-	-	-	-	-	-	-	-	-	2.6	B	J
Copper	ug/L	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19.8	B	J
Copper	ug/L	Y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.1	B	J
Iron	ug/L	N	-	-	-	584			-	-	-	104			98.4	B	J	184			1000		
Iron	ug/L	Y	-	-	-	636			-	-	-	-	-	-	-	-	-	125			892		
Magnesium	ug/L	N	29000			915000			69900			70400			69600			7280			188000		
Magnesium	ug/L	Y	29400			942000			72000			70200			70900			7250			196000		

Detected Hits Summary Excluding "B" Qualifiers
Tenth Quarterly Groundwater Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE			IT-BG8-BEDGW-001			PB-BED-MW20			PB-BED-MW24			PB-BED-MW25			PB-BED-MW25			PB-BED-MW28			PB-BED-MW29		
SAMPLE_NO			DG3000			DG3001			DG3002			DG3003			DG3006			DG3004			DG3005		
SAMPLE_DATE			16-Jun-04			17-Jun-04			16-Jun-04			17-Jun-04			17-Jun-04			15-Jun-04			16-Jun-04		
SAMPLE_PURPOSE			REG			REG			REG			REG			FD			REG			REG		
Parameter	Units	Filtered	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual
Manganese	ug/L	N	40.9			170			19.6			105			104			10.6	B	J	43.6		
Manganese	ug/L	Y	47.5			178			22.6			103			104			11.6	B	J	44.8		
Mercury	ug/L	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mercury	ug/L	Y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	ug/L	N	-	-	-	6.2	B	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	ug/L	Y	2.8	B	J	7.2	B	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potassium	ug/L	N	4310	B J	J	164000	J	J	21900	J	J	10800	J	J	10700	J	J	15900	J	J	116000	J	J
Potassium	ug/L	Y	4770	B J	J	170000	J	J	22300	J	J	10900	J	J	10900	J	J	14000	J	J	120000	J	J
Selenium	ug/L	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Selenium	ug/L	Y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	ug/L	N	13300			7930000			64400			67000			66300			269000			1320000		
Sodium	ug/L	Y	17600			8240000			66400			67700			68400			272000			1380000		
Thallium	ug/L	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium	ug/L	Y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc	ug/L	N	-	-	-	85.5	J		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc	ug/L	Y	-	-	-	102	J		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Laboratory Qualifier (Qual) Definitions
B (inorganic) - The analyte was detected below the reporting limit. Estimated value.
J (inorganic) - The analyte was detected in the sample and the blank.
J (organic) - The analyte was detected below the reporting limit. Estimated value.

Validation Qualifier (ValQual) Definitions
J - The analyte was positively identified; the concentration is estimated.

AUGUST 2004 DOWNGRADIENT WELL SAMPLING
DETECTED HITS SUMMARY EXCLUDING "B" QUALIFIERS

Detected Hits Summary Excluding "B" Qualifiers
Downgradient Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE			PB-BED-MW17			PB-BED-MW19			PB-BED-MW22			PB-BED-MW22			PB-BED-MW30			PB-BED-MW33			PT-5912		
SAMPLE_NO			DH3000			DH3001			DH3002			DH3005			DH3003			DH3004			DH3007		
SAMPLE_DATE			26-Aug-04			25-Aug-04			26-Aug-04			26-Aug-04			25-Aug-04			27-Aug-04			27-Aug-04		
SAMPLE_PURPOSE			REG			REG			REG			FD			REG			REG			REG		
Parameter	Units	Filtered	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual
Explosives																							
Nitrotoluene, 2-	ug/L	N	-	-	-	-	-	-	-	-	-	-	-	-	0.16	J	J	-	-	-	-	-	-
Nitrotoluene, 4-	ug/L	N	-	-	-	-	-	-	-	-	-	-	-	-	0.23			-	-	-	-	-	-
Volatiles																							
Acetone	ug/L	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	310	J B	J	-	-	-
Benzene	ug/L	N	13	J	J	28			0.21	J	J	0.18	J	J	3.4	J	J	18	J	J	7.6		
Carbon disulfide	ug/L	N	8.9	J	J	1.7	J	J	-	-	-	-	-	-	3.7	J	J	17	J	J	0.96	J	J
Ethylbenzene	ug/L	N	62			8.8			-	-	-	-	-	-	9.1			14	J	J	1.7	J	J
Toluene	ug/L	N	98			11			-	-	-	-	-	-	10			9.5	J	J	3	J	J
Xylenes, total	ug/L	N	280			95			-	-	-	-	-	-	56			56			3.6	J	J
Semivolatiles																							
Bis(2-ethylhexyl)phthalate	ug/L	N	-	-	-	-	-	-	-	-	-	2.5	J	J	-	-	-				-	-	-
Methylnaphthalene, 2-	ug/L	N	12			11			-	-	-	-	-	-	6.2	J	J				-	-	-
Naphthalene	ug/L	N	13			7	J	J	-	-	-	-	-	-	3.8	J	J				-	-	-
Phenanthrene	ug/L	N	1.2	J	J	0.89	J	J	-	-	-	-	-	-	-	-	-				-	-	-
Phenol	ug/L	N	2.6	J	J	-	-	-	-	-	-	-	-	-	-	-	-				-	-	-
Metals																							
Aluminum	ug/L	N	-	-	-	-	-	-	717		J	1080		J	377		J	567		J	443		J
Aluminum	ug/L	Y	-	-	-	-	-	-	-	-	-	-	-	-	352			-	-	-	-	-	-
Arsenic	ug/L	N	-	-	-	-	-	-	-	-	-	-	-	-	6.1	B	J	11.9			-	-	-
Arsenic	ug/L	Y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12			-	-	-
Barium	ug/L	N	1790			1190			695			701			187	B	J	161	B	J	187	B	J
Barium	ug/L	Y	1810			1140			700			694			187	B	J	148	B	J	180	B	J
Calcium	ug/L	N	312000			185000			118000			117000			140000			134000			95900		
Calcium	ug/L	Y	316000			181000			117000			115000			140000			131000			94900		
Copper	ug/L	N	-	-	-	31.5			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Copper	ug/L	Y	-	-	-	13	B	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iron	ug/L	N	-	-	-	-	-	-	593			620			175			2320			1680		
Iron	ug/L	Y	-	-	-	-	-	-	-	-	-	-	-	-	190			640			77.9	B	J
Magnesium	ug/L	N	279000			36300			36600			37100			69600			108000			31500		
Magnesium	ug/L	Y	284000			36500			37000			36400			69800			108000			31300		

Detected Hits Summary Excluding "B" Qualifiers
Downgradient Monitoring
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE			PB-BED-MW17			PB-BED-MW19			PB-BED-MW22			PB-BED-MW22			PB-BED-MW30			PB-BED-MW33			PT-5912		
SAMPLE_NO			DH3000			DH3001			DH3002			DH3005			DH3003			DH3004			DH3007		
SAMPLE_DATE			26-Aug-04			25-Aug-04			26-Aug-04			26-Aug-04			25-Aug-04			27-Aug-04			27-Aug-04		
SAMPLE_PURPOSE			REG			REG			REG			FD			REG			REG			REG		
Parameter	Units	Filtered	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual
Manganese	ug/L	N	6.3	B	J	2	B	J	57.5			56			27.9			80.3			95		
Manganese	ug/L	Y	5	B	J	2.8	B	J	47			46.2			28.5			77.8			92.2		
Nickel	ug/L	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	ug/L	Y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potassium	ug/L	N	67000	J		38900	J		3980	B J	J	4410	B J	J	15900	J		26800	J		1460	B J	J
Potassium	ug/L	Y	68500	J	J	39300	J	J	3730	B J	J	3750	B J	J	15700	J	J	27200	J	J	1340	B J	J
Selenium	ug/L	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Selenium	ug/L	Y	-	-	-	1.8	B	J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sodium	ug/L	N	685000			80500			18500			18700			83600			187000			9720		
Sodium	ug/L	Y	699000			80800			18700			18500			83700			187000			9630		
Thallium	ug/L	N	-	-	-	-	-	-	3.3	B	J	4.1	B	J	-	-	-	3.8	B	J	-	-	-
Thallium	ug/L	Y	3.3	B	J	2.6	B	J	-	-	-	5.8	B	J	4	B	J	-	-	-	-	-	-
Vanadium	ug/L	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.1	B	J	-	-	-
Vanadium	ug/L	Y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.2	B	J	-	-	-
Zinc	ug/L	N	11.5	B	J	96.6			4.5	B	J	5.2	B	J	9.5	B	J	12.1	B	J	173		
Zinc	ug/L	Y	6.1	B	J	43.6			4.2	B	J	-	-	-	10.9	B	J	4.7	B	J	4.4	B	J
General Chemistry																							
Alkalinity	ppm	N	855			634			467						646						333		
Chloride	ppm	N	2790			396			33.4						101						14.9		
Hardness	ppm	N	1940			584			424						564						350		
Sulfate	ppm	N	-	-	-	29.5			-	-	-				52.5						70.5		
Total dissolved solids	ppm	N	4690			836			519						857						452		
Total organic carbon	ppm	N	1			5.6			1.8						8.9						2.9		
Total suspended solids	ppm	N	22			79			31						34						21		
Turbidity	NTU	N	36.4			118			252						90.5						37		

Laboratory Qualifier (Qual) Definitions
B (inorganic) - The analyte was detected below the reporting limit. Estimated value.
B (organic) - The analyte was detected in the sample and the blank.
J (inorganic) - The analyte was detected in the sample and the blank.
J (organic) - The analyte was detected below the reporting limit. Estimated value.

Validation Qualifier (ValQual) Definitions
J - The analyte was positively identified; the concentration is estimated.

APPENDIX K

DATA QUALITY EVALUATION
MAY 2004 SAMPLING

MAY 2004 DOWNGRADIENT WELL SAMPLING DATA QUALITY EVALUATION

Table of Contents

Page

List of Tables ..... K-ii
List of Acronyms ..... K-iii
K.1.0 Introduction K-1
K.2.0 Field Sampling and QC Activities K-2
K.2.1 Trip Blanks K-2
K.2.2 Field Duplicates K-3
K.2.3 Field Split Samples K-3
K.3.0 Analytical Program and QC Activities K-5
K.3.1 Laboratory QA/QC Procedures K-5
K.3.1.1 Method/Calibration Blanks K-5
K.3.1.2 Matrix Spikes and Laboratory Control Spikes K-6
K.3.1.3 Calibration K-7
K.3.1.4 Column Agreement K-8
K.3.1.5 Surrogate Recoveries K-8
K.3.2 Reporting Limits K-9
K.3.3 Holding Times/Preservation K-10
K.4.0 Data Evaluation and Usability K-11
K.5.0 References K-14

List of Tables

Table	Title
K-1	Sample Cross-reference
K-2	Summary of Analytes Detected in Blanks
K-3	Summary of Original, Field Duplicate, and Field Split Results and RPD Calculations
K-4	Summary of Data Validation Reason Codes
K-5	Summary of Data Validation Qualifiers Assigned and Reason Codes for Qualification
K-6	Laboratory and Validation Qualifier Definitions

List of Acronyms

AR/COC	analysis request/chain of custody
CCAL	continuing calibration
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
DI	deionized
DQE	data quality evaluation
DQO	data quality objectives
EPA	U.S. Environmental Protection Agency
HPLC	high-performance liquid chromatography
ICAL	initial calibration
LCS	laboratory control sample
MDL	method detection limit
MQL	method quantitation limit
MRL	method reporting limit
MS	matrix spike
MSD	matrix spike duplicate
PBOW	Plum Brook Ordnance Works
%D	percent difference
PQL	practical quantitation limit
QA/QC	quality assurance/quality control
RSD	relative standard deviation
SAP	sampling and analysis plan
RL	reporting limit
RPD	relative percent difference
RRF	relative response factor
SOP	standard operating procedures
STL	Severn Trent Laboratory
TDS	total dissolved solids
TOC	total organic compounds
TSS	total suspended solids
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound

K.1.0 Introduction

This appendix presents results of the quality assurance/quality control (QA/QC) measures implemented for the sampling and analysis activities at the Plum Brook Ordnance Works (PBOW) – Sandusky, Ohio. The quality indicators from every aspect of the data collection have been reviewed, and an assessment of the data with regard to project-specific objectives is presented. Successful execution of project-specific objectives and procedures provides strong support for the acceptance of the data generated as adequate for the purpose of evaluating the analytical results from this assessment at PBOW.

Shaw Environmental, Inc. (Formerly IT Corporation) conducted field-sampling activities at PBOW in May 2004. Severn Trent Laboratories (STL) in Knoxville, Tennessee, and North Canton, Ohio, analyzed the project samples. Accutest Laboratories of Orlando, Florida, analyzed the field split samples. All data analyzed were reviewed for accuracy and completeness. One hundred percent of the data analyzed were subjected to data validation following Unites States Environmental Protection Agency (USEPA) guidelines in the *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review*, (EPA, 1999) and *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review*, (EPA, 2002). The criteria for blank evaluation were based on those detailed in *Region III Modifications to National Functional Guidelines for Organic Data Review* (EPA, 1994) and *Region III Modifications to the Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses* (EPA, 1993). Since these documents specify procedures for Contract Laboratory Program (CLP) data, they are used as guidelines only. Method and laboratory quality assurance and quality control requirements supercede these guidelines where applicable. Laboratory criteria are provided in Attachment A of Appendix H. Data were evaluated against specific criteria to verify the achievement of precision, accuracy, representativeness, completeness, and comparability goals established to meet the project data quality objectives (DQO). To verify that these DQOs were met, field measurements, sampling and handling procedures, laboratory analysis and reporting, and all nonconformances and discrepancies in the data were examined to determine compliance with the appropriate and applicable procedures defined in the site-wide sampling and analysis plan (SAP). The results of this review are presented in the following sections, with all analytical outliers or nonconformances discussed where they occurred.

K.2.0 Field Sampling and QC Activities

Shaw was retained by the U. S. Army Corps of Engineers (USACE), Nashville District, to conduct investigation and sampling activities at PBOW. Field activities at this site included collection of the downgradient groundwater samples. The collection of these samples along with their associated QA and QC samples are discussed in this section of the Data Quality Evaluation (DQE).

All project and field duplicate samples collected were submitted to STL. Sample shipments from the field were performed under custody and documented using standard Shaw Analysis Request/Chain of Custody (AR/COC) forms. These forms provided project-specific analytical specifications and QC instructions to the laboratory. A formal COC transfer record was prepared and included with these forms to document custody during sample transportation, storage, and disposition by the laboratory. Table K-1 summarizes the field sample number, location, sample type, date of collection, and sample delivery group for each sample collected. Table K-2 summarizes the detected compounds in the method blank and trip blanks associated with the PBOW samples.

K.2.1 Trip Blanks

Aqueous samples designated for volatile organic compound (VOC) analysis may be susceptible to contamination by diffusion of organic compounds into the sample container. Trip blanks are analyzed in order to assess the potential for contamination to be introduced to an aqueous volatile sample during transport and handling procedures. A trip blank is a sample of analyte-free deionized (DI) water that is prepared at the laboratory, shipped to the field with sample containers, and returned to the laboratory with the water matrix samples receiving VOC analysis. A trip blank is then analyzed for volatile organics using the same sample preparation and analysis procedures used for the actual field samples. Three trip blank samples were collected. Three trip blanks contained target analytes.

The data validator applied the 5X-10X rule to the samples for the analytes detected. The 10 times limit is applicable only for common laboratory contaminants such as acetone, methylene chloride, and 2-butanone. No samples were qualified "B" for associated trip blank contamination by the data validator, indicating that contamination was not introduced during transport or handling procedures.

K.2.2 Field Duplicates

Field duplicate samples are collected and submitted to the laboratory for analysis along with their corresponding original samples. The data generated from the analysis of field duplicate samples are used to evaluate the precision of the sample collection and analysis procedures. High relative percent difference (RPD) between an original sample and its field duplicate may indicate a difference in sample matrix or sample collection rather than true problems with precision of sample analysis. Also, when estimated "J," blank-contaminated "B," or nondetected "U" results are reported, there is a potential for increased variability between the primary and duplicate sample results.

Field duplicate samples were collected at a frequency of approximately one for every ten samples collected (10 percent). One field duplicate sample was collected during this sampling event. Table K-3 compares the original and field duplicate results and shows the RPDs calculated for those detected compounds. Compounds not presented in the table were not detected in either the original or field duplicate samples. In cases where duplicates were performed and one result is less than the reporting limit, but greater than the method detection limit (MDL), the RPD is reported, but should be considered an estimated value.

The acceptance criterion of 30 percent RPD was used to evaluate these sample results. Data was qualified only if the analyte was detected in both samples. Iron and carbon disulfide were qualified "J." In most cases, original and field duplicate data compared well as demonstrated by the RPDs calculated. The instances where they do not compare well involve estimated or blank-contaminated data. RPD is calculated by using the following formula:

$$RPD = \left| \frac{A - B}{(A + B)/2} \right| \quad x \quad 100$$

where:

RPD	=	relative percent difference
A	=	original result
B	=	field duplicate result.

K.2.3 Field Split Samples

Split samples were collected in conjunction with field duplicate samples and sent to Accutest Laboratories. The split samples were submitted to the laboratory for the same analysis as their

corresponding field duplicates and original field samples. The split samples are used to determine if data results are reproducible when analyzed by two different laboratories. Results are also evaluated to determine if a contracted laboratory's preparation and analysis procedures are in control and meet the approved method criteria.

Field split samples were collected at a frequency of approximately one for every ten regular samples. One split sample was collected during this sampling event.

Table K-3 compares the original and field split results and shows the RPDs calculated for those detected compounds. Compounds not presented in the table were not detected in either the original or field split samples. The analytes compare well when both labs reported above their reporting limits and there was no blank contamination.

K.3.0 Analytical Program and QC Activities

The project QA/QC program described in the SAP was followed for the collection and laboratory analysis of samples. Each of the analytical methods used require that method-specific QA/QC protocols be followed during sample analysis. These protocols are a critical part of the methods employed and were followed by the laboratory during sample analysis. Specific measures included detailed record keeping procedures, instrument calibrations, and analysis of method blanks, blank spikes, matrix spikes/matrix spike duplicates (MS/MSD), surrogates, and internal standards. The following SW-846 and USEPA methods were used to analyze PBOW samples:

Parameter	Method
Volatiles	SW-846 5030/8260B
Semivolatiles	SW-846 3510/8270C
Nitroaromatic Compounds	SW-846 8330M
Metals	SW-846 3005A/6010B/7470A
Turbidity	EPA 180.1
Alkalinity	EPA 310.1
Total Organic Carbon (TOC)	SW-846 9060
Hardness	EPA 130.2
Total Dissolved Solids (TDS)	EPA 160.1
Total Suspended Solids (TSS)	EPA 160.2
Chloride	EPA 325.2
Total Cyanide	SW-846 9012A
Nitrate	EPA 353.2
Sulfate	EPA 375.4

Appendix I contains validated analytical data summaries for the samples collected during this field investigation. The validator used the QA/QC criteria defined in the SAP to evaluate the data for all parameters for which criteria were provided. If acceptance criteria were not provided in the SAP, the validator used the laboratory-derived acceptance criteria or analytical method criteria to qualify data. Any qualifiers added to these data by the data validator are included in the summaries.

K.3.1 Laboratory QA/QC Procedures

The following sections discuss specific QA/QC protocols required and performed by the laboratory during this investigation.

K.3.1.1 Method/Calibration Blanks

Method blanks are analyzed with each analytical "batch" processed on a per matrix (i.e., soil and water) basis. Method blanks are carried step-wise through the same analytical procedure as their

associated field samples, including the addition of solvents, surrogate and standard spikes, and reagents as required in the analysis process. The purpose of a method blank is to identify any possible contaminants that may be introduced to the sample as a result of any part of the analytical process. The data validator evaluated all blank data associated with each sample. When estimated or positive concentrations of compounds/analytes were reported in the corresponding field samples, associated samples were evaluated and qualified using the 5X-10X rule. The 10-times limit is applicable for common laboratory contaminants such as acetone, methylene chloride, 2-butanone, and certain phthalates.

For some analyses, initial and continuing calibration blanks are performed throughout the run sequence. These blanks verify the presence of carry over contamination for the analytes of interest.

Qualifiers applied to samples based on detections in the calibration and/or method blanks are summarized below:

SDG Number	Sample Number Affected	Blank Contaminant	Blank	Validation Qualifier
H4E060131	DF3001, DF3002	Selenium (dissolved)	Calibration	B
	DF3001, DF3002, DF3005	Thallium (dissolved/total)	Calibration/Method	B
	DF3001, DF3002, DF3005	Acetone	Method	B
H4E070134	DF3000	Aluminum (dissolved)	Calibration	B
	DF3000	Arsenic (dissolved/total)	Calibration	B
	DF3000	Manganese (dissolved/total)	Method	B
	DF3000	Thallium (dissolved)	Calibration/Method	B
	DF3000	Acetone	Method	B
H4E080113	DF3003, DF3004	Aluminum (dissolved)	Calibration	B
	DF3003	Arsenic (dissolved/total)	Calibration	B
	DF3003, DF3004	Thallium (dissolved/total)	Calibration/Method	B

B - blank contamination

K.3.1.2 Matrix Spikes and Laboratory Control Spikes

Two types of spikes were generally performed for all analyses: MS and laboratory control samples (LCS). MS compounds are spiked into an aliquot of a field sample. LCS compounds are spiked into a blank matrix. The spiked compounds are representative compounds that are quantified during performance of the method. Recovery of the spiked compound is used as an assessment of analytical accuracy for the sample matrix analyzed. These results are useful in distinguishing sample matrix interferences from analysis interferences through a comparison of MS and LCS recovery data. Often, spikes are performed in duplicate (as an MSD or LCS duplicate). In this manner, the precision of the assessment can be quantified as the RPD of the original and duplicate spike.

Matrix spikes were assigned at a frequency of 1 for every 20 field samples collected. An MS and MSD were assigned in the field to sample DF3002. This sample corresponds to location PB-BED-MW22. Additional sample volume was provided to the laboratory for the MS/MSD analyses. This sampling frequency meets the collection criteria for this program as specified in the SAP. In addition to the overall collection frequency, the analytical method requires that the laboratory analyze 1 set of spikes per analytical batch. To comply with this method requirement, the laboratory may have to analyze batch QC with a work order. The validator evaluated the batch QC. The laboratory statistically determined target acceptance limits were used to assess the spike recovery and RPD.

The MS/MSD criteria were met with a few exceptions. The following samples were qualified:

SDG Number	Sample Number Affected	Analyte(s)	Validation Qualifier
Explosives			
H4E060131	DF3001, DF3002	Tetryl	UJ
H4E080113	DF3003, DF3004	Tetryl	UJ
Wet Chemistry			
H4E060131	DF3001, DF3002	Cyanide	UJ
	DF3001, DF3002	Total Alkalinity	J
Metals			
H4E060131	DF3001, DF3002, DF3005	Aluminum (total)	J
Semivolatiles			
H4E060131	DF3001, DF3002, DF3005	1,2,4-Trichlorobenzene, Acenaphthene, Pentachlorophenol	UJ

UJ - undetected, estimated

LCS results are used to evaluate lab method performance in the same manner as the MS/MSD results except the LCS is not performed on an actual field sample matrix. An LCS is prepared for each analytical "batch" for each parameter and matrix analyzed. All LCS recoveries met the established QC criteria.

K.3.1.3 Calibration

A few compounds exhibited unacceptable performances in the calibration standards. The relative response factor (RRF) of 4-methyl-2-pentanone and 2-butanone were less than 0.1. 4-Methyl-2-pentanone and 2-butanone were rejected in all samples except the field split and DF3000. Acetone was rejected in samples was rejected in the field split.

The following compounds exhibited individual initial calibration (ICAL) percent relative standard deviation (%RSD) greater than 30 and/or continuing calibration (CCAL) percent differences (%D) greater than 20.

SDG Number	Analysis	Samples	Compounds	Validation Qualifier
F23936	Volatiles	DF3006	Acetone	R
		DF3006	2-Butanone	UJ
H4E060131	Volatiles	DF3001, DF3002, DF3005	1,1,2-Trichloroethane	UJ
		DF3001	Chloromethane	UJ
		DF3001, DF3002, DF3005	2-Butanone, 4-Methyl-2-Pentanone	R
		DF3002, DF3005	Trans-1,3-Dichloropropene	UJ
H4E070134	Semivolatiles	DF3000	2,4-Dinitrophenol, 4,6-Dintro-2-Methylphenol	UJ
	Volatiles	DF3000	1,1,2-Trichloroethane, Chloromethane, Trans-1,3-Dichloropropene	UJ
		DF3000	4-Methyl-2-Pentanone	R
		DF3000	2-Butanone	J
H4E080113	Semivolatiles	DF3003	2,4-Dinitrophenol, 4,6-Dintro-2-Methylphenol	UJ
	Volatiles	DF3003	1,1,2-Trichloroethane, Trans-1,3-Dichloropropene	UJ
		DF3003	4-Methyl-2-Pentanone, 2-Butanone	R

R- rejected
J - estimated
UJ - undetected, estimated

K.3.1.4 Column Agreement

For high-performance liquid chromatography (HPLC) analyses, sample results are confirmed using two dissimilar columns. In order for an analyte to be reported, it must be detected on both columns. Results differing by greater than 40 percent are qualified estimated, "J." All detections were in agreement. No data were qualified.

K.3.1.5 Surrogate Recoveries

Surrogate standards are non-target compounds that are added to all samples prior to extraction or purging. They are used in organic analyses to monitor the percent recovery efficiencies of the sample preparation and analytical procedures. Semivolatile surrogate recoveries for samples DF3001, DF3002, and DF3000 were below laboratory established QC limits. Results for the affected samples should be considered biased low.

DF3001, DF3002, and DF3000 were qualified as follows:

SDG Number	Samples Affected	Compound(s)	Validation Qualifier
H4E060131	DF3001, DF3002	All Base/Neutral	J/UJ
	DF3002	All Acid	UJ
H4E070134	DF3000	All Base/Neutral	J/UJ

K.3.2 Reporting Limits

Limits have been established to describe project sensitivity requirements. Each laboratory is required to demonstrate method performance through MDL studies for every method employed. These studies are required to be laboratory-specific so that individual laboratory variables such as equipment brands, reagent suppliers, and chemist technique are factored into the performance study. MDLs are established using controlled matrices (i.e., DI water). Practical quantitation limits (PQL) or method quantitation limits (MQL) used for this project are those statistically determined by the laboratories. The analytical program executed for this project required the use of SW-846 methods, which specify the procedure for calculating the MDLs. The PQL/MQL calculation adjusts the limit by a predetermined mathematical factor for the analysis of actual environmental sample matrices (i.e., soil, groundwater, etc.). Method reporting limits (MRL) are based on the project action or decision levels.
These limits are generally defined as follows:

- ***MDL.*** The minimum concentration of an analyte that can be measured and reported with 99 percent confidence that the concentration is greater than zero.
- ***MQL/PQL.*** The lowest level that the laboratory has demonstrated its ability to reliably quantitate target analytes within the criteria required for a given method. It is the lowest concentration at which the data are reported without qualification.
- ***MRL.*** A threshold value below which the laboratory reports a result as non-detected. Ideally, the MRL will be established anywhere between the MDL and 1/2 the project action levels.

An MDL is the lower limit at which the laboratory can differentiate a measurement from background. The MDL is determined in accordance with the procedures in 40 Code of Federal Regulations (CFR) Part 136. If project action levels are near or below the MDL, it is unlikely the sensitivity of the method will be achievable. A compromise must be reached. The PQL/MQL is the lower limit at which a measurement becomes meaningful. This measurement (the PQL or the reporting limit [RL]) is generally a multiple of three to five times the MDL.

Most samples were handled and analyzed as expected without significant changes to the anticipated project MQLs.

K.3.3 Holding Times/Preservation

All laboratory results submitted for this investigation have been reviewed with respect to laboratory adherence to extraction and analysis holding times. Maximum sample extraction and analysis hold times were those specified in USACE document EM200-1-3 (USACE, 2001). All holding time criteria were acceptable for the samples collected.

K.4.0 Data Evaluation and Usability

The analytical data review process identified a few analytical nonconformance issues that were noted during this analytical program. These anomalies have been discussed in the previous sections of this appendix. Table K-5 summarizes all compounds requiring qualifier application due to anomalies discovered during data validation. Table K-4 defines the reason codes for qualification, and Table K-6 defines the data validation qualifiers.

The following definitions are used for defining precision, accuracy, representativeness, completeness, and comparability as they have been applied to this evaluation.

Precision. Precision is a measurement of mutual agreement among individual measurements of the same property, usually under prescribed similar conditions. Precision data were obtained through the analysis and evaluation of duplicate QA samples. Accuracy was determined through the analysis and evaluation of method blanks, LCSs, trip blanks, equipment rinsates, and MS samples.

Accuracy. Accuracy is a measurement of bias in a system and is expressed as a percent recovery. These QA samples were collected and/or analyzed at the frequency established in the SAP, verifying the completeness element of the DQOs along with the evaluation of holding times and reporting limits. Percent recovery is calculated as follows:

$$Percent\ Recovery = \left(\frac{(x - s)}{T} \right) * 100$$

Where:

X = the lab determined concentration of a spiked sample
S = the sample native concentration prior to spike
T = the true concentration of the spike

Relative Percent Difference is calculated as follows:

$$Relative\ Percent\ Difference = \left[\frac{|D1 - D2|}{\frac{D1 + D2}{2}} \right] * 100$$

Where:

D1 and D2 = the results of duplicate measurements

Representativeness. Representativeness is a qualitative parameter that expresses the degree to which sample data actually represent the matrix and site conditions. For example, in conducting groundwater monitoring, representativeness requires proper location of wells and the collection of samples under consistent, documented procedures. Wells are located based upon the results of the hydrological study in progress and are designed to provide maximum coverage of the flow conditions. Requirements and procedures for sample collection and handling are designed to maximize sample representativeness. Representativeness also can be monitored by reviewing field documentation and performing field audits.

The samples were collected using Shaw standard operating procedures (SOP) and were fully documented through the use of standard Shaw field forms. Samples are representative of the matrix and site sampled.

Completeness. Completeness is a measure of the amount of valid data that are obtained during a sampling event as compared to the amount of data expected under optimum conditions. No data points were qualified "R," rejected, in the validation process because of QC criteria as described in the previous sections of this report. Completeness is calculated as follows:

$$Completeness\ \% = \left(\frac{D_r}{D_c}\right) X\ 100$$

Where:

D_r = the number of data points for which valid results are reported
D_c = the number of valid samples/data points that are collected and reach the laboratory for analysis.

During this task, 5 monitoring wells were sampled resulting in approximately 1149 targeted analytical records, including duplicate and split records. Eleven data points were rejected due to anomalies discovered during the validation process. Using the above calculation, greater than 99 percent completeness is achieved for the task.

Comparability. Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. Comparability ensures that results for the sampling event can be compared with data from other past and/or future sampling programs. Comparability for this sampling event was achieved through the use of established and recognized techniques and accepted standard USEPA methods. All samples collected and analyzed were

subjected to the same sampling, handling, preparation, analysis, reporting, and validation criteria for the purpose of achieving comparability goals within the data set. Only data of known quality (i.e., precision and bias) can be compared.

Statement of Data Usability. The overall results of the analyses, as discussed in this evaluation, suggest that representative samples were collected and analyzed, and the results are indicative of the media analyzed, with the exception of the few anomalies noted. The data do reflect expected site conditions and are usable for their intended purpose.

Tables K-1 through K-6 summarize the analytical program and the results for the data validation effort for all samples collected by Shaw at PBOW.

K.5.0 References

U.S. Army Corps of Engineers (USACE), 2001, ***Engineering Design – Requirements for the Preparation of Sampling and Analysis Plans***, EM200-1-3, February.

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Table K-1

Sample Cross-reference
Downgradient Wells
Former Plum Brook Ordnance Works
Sandusky, Ohio

Sample Type	Sample Location	Sample Number	Sample Date	Sample Purpose	SDG Number
GW	PB-BED-MW17	DF3000	6-May-04	REG	H4E070134
GW	PB-BED-MW19	DF3001	5-May-04	REG	H4E060131
GW	PB-BED-MW22	DF3002	5-May-04	REG	H4E060131
GW	PB-BED-MW22	DF3005	5-May-04	FD	H4E060131
GW	PB-BED-MW22	DF3006	5-May-04	FS	F23936
GW	PB-BED-MW30	DF3003	7-May-04	REG	H4E080113
GW	PB-BED-MW33	DF3004	7-May-04	REG	H4E080113

SDG - Sample delivery group.
GW - Groundwater.
REG - Regular.
FD - Field duplicate.
FS - Field split.

Table K-2

Summary of Analytes Detected in Blanks
Former Plum Brook Ordnance Works
Sandusky, Ohio

Sample Delivery Group	Sample Number	Analysis Date	Sample Purpose	Parameter	Result	Units	Lab Qualifier
F23936	SF954636	18-May-04	BLK	TRICHLOROETHYLENE	0.61	ug/L	J
H4E060131	DF5000	8-May-04	TB	ACETONE	4.7	ug/L	J B
H4E060131	DF5000	8-May-04	TB	CHLOROBENZENE	0.19	ug/L	J
H4E060131	DF5000	8-May-04	TB	CHLOROFORM	0.13	ug/L	J
H4E060131	DF5000	8-May-04	TB	METHYLENE CHLORIDE	0.31	ug/L	J
H4E060131	GFQAGBW	10-May-04	BLK	POTASSIUM	74.7	ug/L	B
H4E060131	GFQAGBW	10-May-04	BLK	THALLIUM	9.7	ug/L	B
H4E060131	GFQX3BW	7-May-04	BLK	ACETONE	3.8	ug/L	J
H4E060131	GFWG2BW	10-May-04	BLK	ACETONE	3.3	ug/L	J
H4E070134	DF5002	8-May-04	TB	ACETONE	3.5	ug/L	J B
H4E070134	DF5002	8-May-04	TB	CHLOROBENZENE	0.14	ug/L	J
H4E070134	DF5002	8-May-04	TB	CHLOROFORM	0.15	ug/L	J
H4E070134	DF5002	8-May-04	TB	METHYLENE CHLORIDE	0.25	ug/L	J
H4E080113	DF5003	10-May-04	TB	ACETONE	4.2	ug/L	J B
H4E080113	DF5003	10-May-04	TB	CHLOROBENZENE	0.18	ug/L	J
H4E080113	DF5003	10-May-04	TB	CHLOROFORM	0.14	ug/L	J
H4E080113	DF5003	10-May-04	TB	METHYLENE CHLORIDE	0.23	ug/L	J
H4E080113	GF4J4BW	18-May-04	BLK	MANGANESE	4	ug/L	B
H4E080113	GF4J4BW	18-May-04	BLK	POTASSIUM	92	ug/L	B
H4E080113	GF4J4BW	18-May-04	BLK	THALLIUM	5	ug/L	B

BLK - Method blank
TB - Trip blank
µg/L - Micrograms per liter.

Table K-3

Summary of Original, Field Duplicate, and Field Split Results and RPD Calculations
Former Plum Brook Ordnance Works
Sandusky, Ohio

LOCATION_CODE			PB-BED-MW22		PB-BED-MW22		PB-BED-MW22		Relative Percent Difference between	Relative Percent Difference between
SAMPLE_NO			DF3002		DF3005		DF3006			
SAMPLE_DATE			5-May-04		5-May-04		5-May-04			
SAMPLE_PURPOSE			REG		FD		FS			
Parameter	**Units**	**Filtered**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**	**REG and FD**	**REG and FS**
Aluminum	ug/L	N	1480	J	862	J	618		52.78	82.17
Aluminum	ug/L	Y	41.4	J	51.5	J	200	U	21.74	131.40
Barium	ug/L	N	732		712		702		2.77	4.18
Barium	ug/L	Y	730		698		678		4.48	7.39
Calcium	ug/L	N	134000		122000		121000		9.38	10.20
Calcium	ug/L	Y	118000		114000		112000		3.45	5.22
Iron	ug/L	N	2220	J	1030	J	744		73.23	99.60
Magnesium	ug/L	N	39500		37700		36700		4.66	7.35
Magnesium	ug/L	Y	37900		36700		35400		3.22	6.82
Manganese	ug/L	N	91.8		65		63.6		34.18	36.29
Manganese	ug/L	Y	47.4		46.3		44.2		2.35	6.99
Nickel	ug/L	N	2.8	J	40	U	40	U	173.83	173.83
Potassium	ug/L	N	4780	J	4410	J	4380	J	8.05	8.73
Potassium	ug/L	Y	4300	J	4120	J	4170	J	4.28	3.07
Selenium	ug/L	Y	1.7	B	5	U	10	U	98.51	141.88
Sodium	ug/L	N	20400	J	19700	J	17600		3.49	14.74
Sodium	ug/L	Y	20600	J	19800	J	17400		3.96	16.84
Thallium	ug/L	N	4.5	B	4.2	B	10	U	6.90	75.86
Thallium	ug/L	Y	5.3	B	5.3	B	10	U	0.00	61.44
Vanadium	ug/L	N	50	U	50	U	0.61	J	0.00	195.18
Zinc	ug/L	N	22		13.2	J	16.1	J	50.00	30.97
Phenol	ug/L	N	10	U	10	U	3.6	J	0.00	94.12
Acetone	ug/L	N	140	B	140	B	50	U	0.00	94.74
Methylene chloride	ug/L	N	5.8	J	6.1	J	2	U	5.04	97.44

RPD > 30%
N - No.
Y - Yes.
REG - Regular.
FD - Field duplicate.
FS - Field split.
µg/L - Micrograms per liter.

Table K-4

Summary of Data Validation Reason Codes
Plum Brook Ordnance Works
Sandusky, Ohio

Reason Code	Description
01	Sample received outside of 4+/-2 degrees Celsius
01A	Improper sample preservation
02	Holding Time Exceeded
02A	Extraction
02B	Analysis
03	Instrument Performance - Outside Criteria
03A	BFB
03B	DFTPP
03C	DDT and/or Endrin % breakdown exceeds criteria
03D	retention time windows
03E	Resolution
04	Initial Calibration results outside specified criteria
04A	Compound mean RRF<0.05
04B	Compound %RSD>30
04C	Correlation Coefficient<0.995
05	Continuing Calibration results outside specified criteria
05A	Compound mean RRF<0.05
05B	Compound %D>25
06	Result qualified as a result of the 5x/10x blank correction
06A	Method or Preparation Blank
06B	ICB or CCB
06C	ER
06D	TB
06E	FB
07	Surrogate Recoveries outside control limits
07A	Sample
07B	Associated method blank or LCS
08	MS/MSD/Duplicate results outside criteria
08A	MS and/or MSD recovery not within control limits (accuracy)
08B	%RPD outside acceptance criteria (precision)
09	Post Digestion Spike outside criteria (GFAA)
10	Internal Standards outside specified control limits
10A	Recovery
10B	Retention Time
11	Laboratory Control Sample recoveries outside specified control limits
11A	Recovery
11B	%RPD (if run in duplicate)
12	Interference Check Standard
13	Serial Dilution
14	Tentatively Identified Compounds
15	Quantitation
16	Multiple results available; alternate analysis preferred
17	Field duplicate RPD criteria exceeded
18	Percent difference between original and second column > 25%
19	Professional judgement was used to qualify the data
20	Pesticide clean-up checks
21	Target compound identification
22	Radiological calibration
23	Radiological quantitation
24	Reported result and/or lab qualifier revised to reflect validation findings
999	See hard copy for details.

Table K-5

Summary of Data Validation Qualifiers Assigned and Reason Codes for Qualification
Former Plum Brook Ordnance Works
Sandusky, Ohio

SAMPLE DELIVERY GROUP	SAMPLE NUMBER	ANALYSIS	PARAMETER	VQ	Reason Codes (1,2) R1	R2	R3	R4
F23936	DF3006	METALS	POTASSIUM	J	15			
F23936	DF3006	METALS	VANADIUM	J	15			
F23936	DF3006	METALS	ZINC	J	15			
F23936	DF3006	SEMIVOLATILES	PHENOL	J	15			
F23936	DF3006	VOLATILES	ACETONE	R	04A	05A		
F23936	DF3006	VOLATILES	METHYL ETHYL KETONE	UJ	05B			
H4E060131	DF3001	CYANIDE	CYANIDE, TOTAL	UJ	08A			
H4E060131	DF3001	EXPLOSIVES	TETRYL	UJ	08A			
H4E060131	DF3001	GEN CHEMISTRY	TOTAL ALKALINITY	J	08A			
H4E060131	DF3001	METALS	ALUMINUM	J	08A	15		
H4E060131	DF3001	METALS	ALUMINUM	J	15			
H4E060131	DF3001	METALS	MANGANESE	J	15			
H4E060131	DF3001	METALS	NICKEL	J	15			
H4E060131	DF3001	METALS	POTASSIUM	J	13			
H4E060131	DF3001	METALS	SELENIUM	B	06B	15		
H4E060131	DF3001	METALS	SODIUM	J	13			
H4E060131	DF3001	METALS	THALLIUM	B	06A	06B	15	
H4E060131	DF3001	METALS	THALLIUM	B	06A	06B	16	
H4E060131	DF3001	SEMIVOLATILES	1,2,4-TRICHLOROBENZENE	UJ	07A	08A		
H4E060131	DF3001	SEMIVOLATILES	1,2-DICHLOROBENZENE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	1,3-DICHLOROBENZENE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	1,4-DICHLOROBENZENE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	2,2'-OXYBIS(1-CHLOROPROPANE)	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	2,4-DINITROTOLUENE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	2,6-DINITROTOLUENE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	2-CHLORONAPHTHALENE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	2-METHYLNAPHTHALENE	J	07A			
H4E060131	DF3001	SEMIVOLATILES	2-NITROANILINE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	3,3'-DICHLOROBENZIDINE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	3-NITROANILINE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	4-BROMOPHENYL PHENYL ETHER	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	4-CHLOROANILINE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	4-CHLOROPHENYL PHENYL ETHER	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	4-NITROANILINE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	ACENAPHTHENE	UJ	07A	08A		
H4E060131	DF3001	SEMIVOLATILES	ACENAPHTHYLENE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	ANTHRACENE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	BENZO(A)ANTHRACENE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	BENZO(A)PYRENE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	BENZO(B)FLUORANTHENE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	BENZO(GHI)PERYLENE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	BENZO(K)FLUORANTHENE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	BIS(2-CHLOROETHOXY)METHANE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	BIS(2-CHLOROETHYL) ETHER	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	BIS(2-ETHYLHEXYL) PHTHALATE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	BUTYL BENZYL PHTHALATE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	CARBAZOLE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	CHRYSENE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	DI-N-BUTYL PHTHALATE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	DI-N-OCTYL PHTHALATE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	DIBENZ(A,H)ANTHRACENE	UJ	07A			

Table K-5

Summary of Data Validation Qualifiers Assigned and Reason Codes for Qualification
Former Plum Brook Ordnance Works
Sandusky, Ohio

SAMPLE DELIVERY GROUP	SAMPLE NUMBER	ANALYSIS	PARAMETER	VQ	Reason Codes (1,2)			
					R1	R2	R3	R4
H4E060131	DF3001	SEMIVOLATILES	DIBENZOFURAN	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	DIETHYL PHTHALATE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	DIMETHYL PHTHALATE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	FLUORANTHENE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	FLUORENE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	HEXACHLOROBENZENE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	HEXACHLOROBUTADIENE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	HEXACHLOROCYCLOPENTADIENE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	HEXACHLOROETHANE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	INDENO(1,2,3-CD)PYRENE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	ISOPHORONE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	N-NITROSODI-N-PROPYLAMINE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	N-NITROSODIPHENYLAMINE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	NAPHTHALENE	J	07A			
H4E060131	DF3001	SEMIVOLATILES	NITROBENZENE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	PENTACHLOROPHENOL	UJ	08A			
H4E060131	DF3001	SEMIVOLATILES	PHENANTHRENE	UJ	07A			
H4E060131	DF3001	SEMIVOLATILES	PYRENE	UJ	07A			
H4E060131	DF3001	VOLATILES	1,1,2-TRICHLOROETHANE	UJ	05B			
H4E060131	DF3001	VOLATILES	2-BUTANONE	R	04A	05A		
H4E060131	DF3001	VOLATILES	4-METHYL-2-PENTANONE	R	04A	05A		
H4E060131	DF3001	VOLATILES	ACETONE	B	06A			
H4E060131	DF3001	VOLATILES	BENZENE	J	15			
H4E060131	DF3001	VOLATILES	CARBON DISULFIDE	J	15			
H4E060131	DF3001	VOLATILES	CHLOROBENZENE	J	15			
H4E060131	DF3001	VOLATILES	CHLOROMETHANE	UJ	05B			
H4E060131	DF3001	VOLATILES	ETHYLBENZENE	J	15			
H4E060131	DF3001	VOLATILES	METHYLENE CHLORIDE	J	15			
H4E060131	DF3001	VOLATILES	TOLUENE	J	15			
H4E060131	DF3002	CYANIDE	CYANIDE, TOTAL	UJ	08A			
H4E060131	DF3002	EXPLOSIVES	TETRYL	UJ	08A			
H4E060131	DF3002	GEN CHEMISTRY	TOTAL ALKALINITY	J	08A			
H4E060131	DF3002	METALS	ALUMINUM	J	08A	17		
H4E060131	DF3002	METALS	ALUMINUM	J	15			
H4E060131	DF3002	METALS	IRON	J	17			
H4E060131	DF3002	METALS	NICKEL	J	15			
H4E060131	DF3002	METALS	POTASSIUM	J	13	15		
H4E060131	DF3002	METALS	SELENIUM	B	06B	15		
H4E060131	DF3002	METALS	SODIUM	J	13			
H4E060131	DF3002	METALS	THALLIUM	B	06A	06B	15	
H4E060131	DF3002	METALS	THALLIUM	B	06A	06B	16	
H4E060131	DF3002	SEMIVOLATILES	1,2,4-TRICHLOROBENZENE	UJ	07A	08A		
H4E060131	DF3002	SEMIVOLATILES	1,2-DICHLOROBENZENE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	1,3-DICHLOROBENZENE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	1,4-DICHLOROBENZENE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	2,2'-OXYBIS(1-CHLOROPROPANE)	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	2,4,5-TRICHLOROPHENOL	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	2,4,6-TRICHLOROPHENOL	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	2,4-DICHLOROPHENOL	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	2,4-DIMETHYLPHENOL	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	2,4-DINITROPHENOL	UJ	07A			

Table K-5

Summary of Data Validation Qualifiers Assigned and Reason Codes for Qualification
Former Plum Brook Ordnance Works
Sandusky, Ohio

SAMPLE DELIVERY GROUP	SAMPLE NUMBER	ANALYSIS	PARAMETER	VQ	Reason Codes (1,2)			
					R1	R2	R3	R4
H4E060131	DF3002	SEMIVOLATILES	2,4-DINITROTOLUENE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	2,6-DINITROTOLUENE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	2-CHLORONAPHTHALENE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	2-CHLOROPHENOL	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	2-METHYLNAPHTHALENE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	2-METHYLPHENOL	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	2-NITROANILINE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	2-NITROPHENOL	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	3,3'-DICHLOROBENZIDINE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	3-NITROANILINE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	4,6-DINITRO-2-METHYLPHENOL	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	4-BROMOPHENYL PHENYL ETHER	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	4-CHLORO-3-METHYLPHENOL	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	4-CHLOROANILINE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	4-CHLOROPHENYL PHENYL ETHER	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	4-METHYLPHENOL	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	4-NITROANILINE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	4-NITROPHENOL	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	ACENAPHTHENE	UJ	07A	08A		
H4E060131	DF3002	SEMIVOLATILES	ACENAPHTHYLENE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	ANTHRACENE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	BENZO(A)ANTHRACENE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	BENZO(A)PYRENE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	BENZO(B)FLUORANTHENE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	BENZO(GHI)PERYLENE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	BENZO(K)FLUORANTHENE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	BIS(2-CHLOROETHOXY)METHANE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	BIS(2-CHLOROETHYL) ETHER	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	BIS(2-ETHYLHEXYL) PHTHALATE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	BUTYL BENZYL PHTHALATE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	CARBAZOLE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	CHRYSENE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	DI-N-BUTYL PHTHALATE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	DI-N-OCTYL PHTHALATE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	DIBENZ(A,H)ANTHRACENE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	DIBENZOFURAN	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	DIETHYL PHTHALATE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	DIMETHYL PHTHALATE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	FLUORANTHENE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	FLUORENE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	HEXACHLOROBENZENE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	HEXACHLOROBUTADIENE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	HEXACHLOROCYCLOPENTADIENE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	HEXACHLOROETHANE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	INDENO(1,2,3-CD)PYRENE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	ISOPHORONE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	N-NITROSODI-N-PROPYLAMINE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	N-NITROSODIPHENYLAMINE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	NAPHTHALENE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	NITROBENZENE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	PENTACHLOROPHENOL	UJ	07A	08A		

Table K-5

Summary of Data Validation Qualifiers Assigned and Reason Codes for Qualification
Former Plum Brook Ordnance Works
Sandusky, Ohio

SAMPLE DELIVERY GROUP	SAMPLE NUMBER	ANALYSIS	PARAMETER	VQ	Reason Codes (1,2)			
					R1	R2	R3	R4
H4E060131	DF3002	SEMIVOLATILES	PHENANTHRENE	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	PHENOL	UJ	07A			
H4E060131	DF3002	SEMIVOLATILES	PYRENE	UJ	07A			
H4E060131	DF3002	VOLATILES	1,1,2-TRICHLOROETHANE	UJ	05B			
H4E060131	DF3002	VOLATILES	2-BUTANONE	R	04A	05A		
H4E060131	DF3002	VOLATILES	4-METHYL-2-PENTANONE	R	04A	05A	05B	
H4E060131	DF3002	VOLATILES	ACETONE	B	06A	15		
H4E060131	DF3002	VOLATILES	METHYLENE CHLORIDE	J	15			
H4E060131	DF3002	VOLATILES	TRANS-1,3-DICHLOROPROPENE	UJ	05B			
H4E060131	DF3005	METALS	ALUMINUM	J	08A	17		
H4E060131	DF3005	METALS	ALUMINUM	J	15			
H4E060131	DF3005	METALS	IRON	J	17			
H4E060131	DF3005	METALS	POTASSIUM	J	13	15		
H4E060131	DF3005	METALS	SODIUM	J	13			
H4E060131	DF3005	METALS	THALLIUM	B	06A	06B	15	
H4E060131	DF3005	METALS	THALLIUM	B	06A	06B	16	
H4E060131	DF3005	METALS	ZINC	J	15			
H4E060131	DF3005	SEMIVOLATILES	1,2,4-TRICHLOROBENZENE	UJ	08A			
H4E060131	DF3005	SEMIVOLATILES	ACENAPHTHENE	UJ	08A			
H4E060131	DF3005	SEMIVOLATILES	PENTACHLOROPHENOL	UJ	08A			
H4E060131	DF3005	VOLATILES	1,1,2-TRICHLOROETHANE	UJ	05B			
H4E060131	DF3005	VOLATILES	2-BUTANONE	R	04A	05A		
H4E060131	DF3005	VOLATILES	4-METHYL-2-PENTANONE	R	04A	05A	05B	
H4E060131	DF3005	VOLATILES	ACETONE	B	06A	15		
H4E060131	DF3005	VOLATILES	METHYLENE CHLORIDE	J	15			
H4E060131	DF3005	VOLATILES	TRANS-1,3-DICHLOROPROPENE	UJ	05B			
H4E070134	DF3000	METALS	ALUMINUM	B	06B	15		
H4E070134	DF3000	METALS	ALUMINUM	J	15			
H4E070134	DF3000	METALS	ARSENIC	B	06B	15		
H4E070134	DF3000	METALS	MANGANESE	B	06A	15		
H4E070134	DF3000	METALS	POTASSIUM	J	13			
H4E070134	DF3000	METALS	SELENIUM	UJ	08A			
H4E070134	DF3000	METALS	THALLIUM	B	06A	06B	15	
H4E070134	DF3000	METALS	ZINC	J	13	15		
H4E070134	DF3000	METALS	ZINC	J	13			
H4E070134	DF3000	SEMIVOLATILES	1,2,4-TRICHLOROBENZENE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	1,2-DICHLOROBENZENE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	1,3-DICHLOROBENZENE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	1,4-DICHLOROBENZENE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	2,2'-OXYBIS(1-CHLOROPROPANE)	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	2,4-DINITROPHENOL	UJ	05B			
H4E070134	DF3000	SEMIVOLATILES	2,4-DINITROTOLUENE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	2,6-DINITROTOLUENE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	2-CHLORONAPHTHALENE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	2-METHYLNAPHTHALENE	J	07A	15		
H4E070134	DF3000	SEMIVOLATILES	2-NITROANILINE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	3,3'-DICHLOROBENZIDINE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	3-NITROANILINE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	4,6-DINITRO-2-METHYLPHENOL	UJ	05B			
H4E070134	DF3000	SEMIVOLATILES	4-BROMOPHENYL PHENYL ETHER	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	4-CHLOROANILINE	UJ	07A			

Table K-5

Summary of Data Validation Qualifiers Assigned and Reason Codes for Qualification
Former Plum Brook Ordnance Works
Sandusky, Ohio

SAMPLE DELIVERY GROUP	SAMPLE NUMBER	ANALYSIS	PARAMETER	VQ	Reason Codes (1,2) R1	R2	R3	R4
H4E070134	DF3000	SEMIVOLATILES	4-CHLOROPHENYL PHENYL ETHER	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	4-NITROANILINE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	ACENAPHTHENE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	ACENAPHTHYLENE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	ANTHRACENE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	BENZO(A)ANTHRACENE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	BENZO(A)PYRENE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	BENZO(B)FLUORANTHENE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	BENZO(GHI)PERYLENE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	BENZO(K)FLUORANTHENE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	BIS(2-CHLOROETHOXY)METHANE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	BIS(2-CHLOROETHYL) ETHER	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	BIS(2-ETHYLHEXYL) PHTHALATE	J	07A	15		
H4E070134	DF3000	SEMIVOLATILES	BUTYL BENZYL PHTHALATE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	CARBAZOLE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	CHRYSENE	J	07A	15		
H4E070134	DF3000	SEMIVOLATILES	DI-N-BUTYL PHTHALATE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	DI-N-OCTYL PHTHALATE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	DIBENZ(A,H)ANTHRACENE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	DIBENZOFURAN	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	DIETHYL PHTHALATE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	DIMETHYL PHTHALATE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	FLUORANTHENE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	FLUORENE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	HEXACHLOROBENZENE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	HEXACHLOROBUTADIENE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	HEXACHLOROCYCLOPENTADIENE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	HEXACHLOROETHANE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	INDENO(1,2,3-CD)PYRENE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	ISOPHORONE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	N-NITROSODI-N-PROPYLAMINE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	N-NITROSODIPHENYLAMINE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	NAPHTHALENE	J	07A	15		
H4E070134	DF3000	SEMIVOLATILES	NITROBENZENE	UJ	07A			
H4E070134	DF3000	SEMIVOLATILES	PHENANTHRENE	J	07A	15		
H4E070134	DF3000	SEMIVOLATILES	PHENOL	J	15			
H4E070134	DF3000	SEMIVOLATILES	PYRENE	UJ	07A			
H4E070134	DF3000	VOLATILES	1,1,2-TRICHLOROETHANE	UJ	05B			
H4E070134	DF3000	VOLATILES	2-BUTANONE	J	04A	05A	15	
H4E070134	DF3000	VOLATILES	4-METHYL-2-PENTANONE	R	04A	05A		
H4E070134	DF3000	VOLATILES	ACETONE	B	06A			
H4E070134	DF3000	VOLATILES	BENZENE	J	15			
H4E070134	DF3000	VOLATILES	CHLOROBENZENE	J	15			
H4E070134	DF3000	VOLATILES	CHLOROMETHANE	UJ	05B			
H4E070134	DF3000	VOLATILES	ETHYLBENZENE	J	15			
H4E070134	DF3000	VOLATILES	METHYLENE CHLORIDE	J	15			
H4E070134	DF3000	VOLATILES	TRANS-1,3-DICHLOROPROPENE	UJ	05B			
H4E080113	DF3003	EXPLOSIVES	TETRYL	UJ	08A			
H4E080113	DF3003	METALS	ALUMINUM	B	06B	15		
H4E080113	DF3003	METALS	ARSENIC	B	06B	15		
H4E080113	DF3003	METALS	ARSENIC	B	06B			

Table K-5

Summary of Data Validation Qualifiers Assigned and Reason Codes for Qualification
Former Plum Brook Ordnance Works
Sandusky, Ohio

SAMPLE DELIVERY GROUP	SAMPLE NUMBER	ANALYSIS	PARAMETER	VQ	Reason Codes (1,2) R1	R2	R3	R4
H4E080113	DF3003	METALS	BARIUM	J	15			
H4E080113	DF3003	METALS	NICKEL	J	15			
H4E080113	DF3003	METALS	THALLIUM	B	06A	06B	15	
H4E080113	DF3003	METALS	ZINC	J	15			
H4E080113	DF3003	SEMIVOLATILES	2,4-DINITROPHENOL	UJ	05B			
H4E080113	DF3003	SEMIVOLATILES	2-METHYLNAPHTHALENE	J	15			
H4E080113	DF3003	SEMIVOLATILES	4,6-DINITRO-2-METHYLPHENOL	UJ	05B			
H4E080113	DF3003	VOLATILES	1,1,2-TRICHLOROETHANE	UJ	05B			
H4E080113	DF3003	VOLATILES	2-BUTANONE	R	04A	05A		
H4E080113	DF3003	VOLATILES	4-METHYL-2-PENTANONE	R	04A	05A		
H4E080113	DF3003	VOLATILES	BENZENE	J	15			
H4E080113	DF3003	VOLATILES	CARBON DISULFIDE	J	15			
H4E080113	DF3003	VOLATILES	TRANS-1,3-DICHLOROPROPENE	UJ	05B			
H4E080113	DF3004	EXPLOSIVES	TETRYL	UJ	08A			
H4E080113	DF3004	METALS	ALUMINUM	B	06B	15		
H4E080113	DF3004	METALS	COBALT	J	15			
H4E080113	DF3004	METALS	COPPER	J	15			
H4E080113	DF3004	METALS	LEAD	J	15			
H4E080113	DF3004	METALS	NICKEL	J	15			
H4E080113	DF3004	METALS	SELENIUM	J	15			
H4E080113	DF3004	METALS	THALLIUM	B	06A	06B	15	
H4E080113	DF3004	METALS	VANADIUM	J	15			
H4E080113	DF3004	METALS	ZINC	J	15			
H4E080113	DF3004	VOLATILES	1,1,2-TRICHLOROETHANE	UJ	05B			
H4E080113	DF3004	VOLATILES	2-BUTANONE	J	04A	05A	15	
H4E080113	DF3004	VOLATILES	4-METHYL-2-PENTANONE	R	04A	05A	05B	
H4E080113	DF3004	VOLATILES	ACETONE	J	15			
H4E080113	DF3004	VOLATILES	BENZENE	J	15			
H4E080113	DF3004	VOLATILES	CARBON DISULFIDE	J	15			
H4E080113	DF3004	VOLATILES	ETHYLBENZENE	J	15			
H4E080113	DF3004	VOLATILES	METHYLENE CHLORIDE	J	15			
H4E080113	DF3004	VOLATILES	TOLUENE	J	15			
H4E080113	DF3004	VOLATILES	TRANS-1,3-DICHLOROPROPENE	UJ	05B			

Footnotes:

(1) Table K-4 defines all reason codes.

(2) Reason codes are assigned in order of their importance to the validation qualifiers with R1 being most important.

Definitions:

VQ = validation qualifier

Table K-6

Laboratory and Validation Qualifier Definitions
Former Plum Brook Ordnance Works
Sandusky, Ohio

Qualifier	Definition
Laboratory - Organic	
B	The compound was detected in the sample and in an associated method blank.
J	The compound was positively identified; the reported value is an estimated concentration between the method detection limit and the reporting limit.
I	Matrix interference.
U	Not detected. The compound was analyzed for, but not detected above the associated reporting limit.
Laboratory - Inorganic	
B	The analyte was positively identified; the reported value is an estimated concentration between the method detection limit and the reporting limit.
J	The compound was detected in the sample and in an associated method blank.
G	Elevated reporting limit due to matrix interference.
U	Not detected. The analyte was analyzed for, but not detected above the associated reporting limit.
Validation - All	
B	The analyte was not detected significantly above the levels found in the associated method blank or field blanks
J	The compound/analyte was positively identified; the reported value is an estimated concentration.
R	Rejected due to severe deficiencies in the analytical process or supporting quality control data. The presence or absence of the compound/analyte cannot be verified.
U	Not detected. The compound/analyte was analyzed for, but not detected above the associated reporting limit.
UJ	Not detected. The associated reporting limit may be inaccurate or imprecise.

JUNE 2004 DOWNGRADIENT WELL SAMPLING DATA QUALITY EVALUATION

Table of Contents

Page

List of Tables ..... K-ii
List of Acronyms ..... K-iii
K.1.0 Introduction K-1
K.2.0 Field Sampling and QC Activities K-2
K.2.1 Trip Blanks K-2
K.2.2 Field Duplicates K-3
K.2.3 Field Split Samples K-4
K.3.0 Analytical Program and QC Activities K-5
K.3.1 Laboratory QA/QC Procedures K-5
K.3.1.1 Method/Calibration Blanks K-6
K.3.1.2 Matrix Spikes and Laboratory Control Spikes K-6
K.3.1.3 Calibration K-7
K.3.1.4 Column Agreement K-8
K.3.1.5 Surrogate Recoveries K-8
K.3.2 Reporting Limits K-9
K.3.3 Holding Times/Preservation K-10
K.4.0 Data Evaluation and Usability K-11
K.5.0 References K-14

List of Tables

Table	Title
K-1	Sample Cross-reference
K-2	Summary of Analytes Detected in Blanks
K-3	Summary of Original, Field Duplicate, and Field Split Results and RPD Calculations
K-4	Summary of Data Validation Reason Codes
K-5	Summary of Data Validation Qualifiers Assigned and Reason Codes for Qualification
K-6	Laboratory and Validation Qualifier Definitions

List of Acronyms

AR/COC	analysis request/chain of custody
CCAL	continuing calibration
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
DI	deionized
DQE	data quality evaluation
DQO	data quality objectives
EPA	U.S. Environmental Protection Agency
HPLC	high-performance liquid chromatography
ICAL	initial calibration
LCS	laboratory control sample
MB	material blank or method blank
MDL	method detection limit
MQL	method quantitation limit
MRL	method reporting limit
MS	matrix spike
MSD	matrix spike duplicate
%D	percent difference
%RSD	percent relative standard deviation
PQL	practical quantitation limit
PBOW	Plum Brook Ordnance Works
QA/QC	quality assurance/quality control
RL	reporting limit
RPD	relative percent difference
RRF	relative response factor
SAP	sampling and analysis plan
SDG	sample delivery group
SOP	standard operating procedures
STL	Severn Trent Laboratory
TDS	total dissolved solids
TOC	total organic compounds
TSS	total suspended solids
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound

K.1.0 Introduction

This appendix of the Tenth Quarterly Background Report presents results of the quality assurance/quality control (QA/QC) measures implemented for the sampling and analysis activities at the Plum Brook Ordnance Works (PBOW) – Sandusky, Ohio. The quality indicators from every aspect of the data collection have been reviewed, and an assessment of the data with regard to project-specific objectives is presented. Successful execution of project-specific objectives and procedures provides strong support for the acceptance of the data generated as adequate for the purpose of evaluating the analytical results from this assessment at PBOW.

Shaw Environmental, Inc. (Formerly IT Corporation) conducted field-sampling activities at PBOW in June 2004. Severn Trent Laboratories (STL) in Knoxville, Tennessee, and North Canton, Ohio, analyzed the project samples. Accutest Laboratories of Orlando, Florida, analyzed the field split samples. All data analyzed were reviewed for accuracy and completeness. One hundred percent of the data analyzed were subjected to data validation following Unites States Environmental Protection Agency (USEPA) guidelines in the *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review*, (EPA, 1999) and *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review*, (EPA, 2002). The criteria for blank evaluation were based on those detailed in *Region III Modifications to National Functional Guidelines for Organic Data Review* (EPA, 1994b) and *Region III Modifications to the Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses* (EPA, 1993). Since these documents specify procedures for Contract Laboratory Program (CLP) data, they are used as guidelines only. Method and laboratory quality assurance and quality control requirements supercede these guidelines, where applicable. Laboratory criteria are provided in Attachment A of Appendix H. Data were evaluated against specific criteria to verify the achievement of precision, accuracy, representativeness, completeness, and comparability goals established to meet the project data quality objectives (DQO). To verify that these DQOs were met, field measurements, sampling and handling procedures, laboratory analysis and reporting, and all nonconformances and discrepancies in the data were examined to determine compliance with the appropriate and applicable procedures defined in the site-wide sampling and analysis plan (SAP). The results of this review are presented in the following sections, with all analytical outliers or nonconformances discussed where they occurred.

K.2.0 Field Sampling and QC Activities

Shaw was retained by the U. S. Army Corps of Engineers (USACE), Nashville District, to conduct investigation and sampling activities at PBOW. Field activities at this site included collection of the background groundwater samples. The collection of these samples along with their associated QA and QC samples are discussed in this section of the Data Quality Evaluation (DQE).

All project and field duplicate samples collected were submitted to STL. Sample shipments from the field were performed under custody and documented using standard Shaw Analysis Request/Chain of Custody (AR/COC) forms. These forms provided project-specific analytical specifications and QC instructions to the laboratory. A formal COC transfer record was prepared and included with these forms to document custody during sample transportation, storage, and disposition by the laboratory. Table K-1 summarizes the field sample number, location, sample type, date of collection, and sample delivery group for each sample collected. Table K-2 summarizes the detected compounds in the method blank and trip blanks associated with the PBOW samples.

K.2.1 Trip Blanks

Aqueous samples designated for volatile organic compound (VOC) analysis may be susceptible to contamination by diffusion of organic compounds into the sample container. Trip blanks are analyzed in order to assess the potential for contamination to be introduced to an aqueous volatile sample during transport and handling procedures. A trip blank is a sample of analyte-free deionized (DI) water that is prepared at the laboratory, shipped to the field with sample containers, and returned to the laboratory with the water matrix samples receiving VOC analysis. A trip blank is then analyzed for volatile organics using the same sample preparation and analysis procedures used for the actual field samples. Three trip blank samples were collected. Three trip blanks contained target analytes and five samples were qualified.

The data validator applied the 5X-10X rule to the samples for the analytes detected. The 10-times limit is applicable only for common laboratory contaminants such as acetone, methylene chloride, and 2-butanone. The following samples were qualified "B" by the data validator, indicating that sample results are indicative of blank contamination:

Lot Number	Sample Affected	Blank Contaminant	Validation Qualifier
PB047	DG3000, DG3001, DG3003, DG3005, DG3006	Acetone	B

K.2.2 Field Duplicates

Field duplicate samples are collected and submitted to the laboratory for analysis along with their corresponding original samples. The data generated from the analysis of field duplicate samples are used to evaluate the precision of the sample collection and analysis procedures. High relative percent difference (RPD) between an original sample and its field duplicate may indicate a difference in sample matrix or sample collection rather than true problems with precision of sample analysis. Also, when estimated "J," blank-contaminated "B," or nondetected "U" results are reported, there is a potential for increased variability between the primary and duplicate sample results.

Field duplicate samples were collected at a frequency of approximately one for every ten samples collected (10 percent). One field duplicate sample was collected during this sampling event. Table K-3 compares the original and field duplicate results and shows the RPDs calculated for those detected compounds. Compounds not presented in the table were not detected in either the original or field duplicate samples. In cases where duplicates were performed and one result is less than the reporting limit, but greater than the method detection limit (MDL), the RPD is reported, but should be considered an estimated value.

The acceptance criterion of 30 percent RPD was used to evaluate these sample results. Data was qualified only if the analyte was detected in both samples. Iron and carbon disulfide were qualified "J." In most cases, original and field duplicate data compared well as demonstrated by the RPDs calculated. The instances where they do not compare well involve estimated or blank-contaminated data. RPD is calculated by using the following formula:

$$RPD = \left| \frac{A - B}{(A + B)/2} \right| \quad x \quad 100$$

where:

RPD = relative percent difference
A = original result
B = field duplicate result.

K.2.3 Field Split Samples

Split samples were collected in conjunction with field duplicate samples and sent to Accutest Laboratories. The split samples were submitted to the laboratory for the same analysis as their corresponding field duplicates and original field samples. The split samples are used to determine if data results are reproducible when analyzed by two different laboratories. Results are also evaluated to determine if a contracted laboratory's preparation and analysis procedures are in control and meet the approved method criteria.

Field split samples were collected at a frequency of approximately one for every ten regular samples. One split sample was collected during this sampling event.

Table K-3 compares the original and field split results and shows the RPDs calculated for those detected compounds. Compounds not presented in the table were not detected in either the original or field split samples. The analytes compare well when both labs reported above their reporting limits and there was no blank contamination.

K.3.0 Analytical Program and QC Activities

The project QA/QC program described in the SAP was followed for the collection and laboratory analysis of samples. Each of the analytical methods used require that method-specific QA/QC protocols be followed during sample analysis. These protocols are a critical part of the methods employed and were followed by the laboratory during sample analysis. Specific measures included detailed record keeping procedures, instrument calibrations, and analysis of method blanks, blank spikes, matrix spikes/matrix spike duplicates (MS/MSD), surrogates, and internal standards. The following SW-846 and USEPA methods were used to analyze PBOW samples:

Parameter	Method
Volatiles	SW-846 5030/8260B
Semivolatiles	SW-846 3510/8270C
Nitroaromatic Compounds	SW-846 8330M
Metals	SW-846 3005A/6010B/7470A
Turbidity	EPA 180.1
Alkalinity	EPA 310.1
Total Organic Carbon (TOC)	SW-846 9060
Hardness	EPA 130.2
Total Dissolved Solids (TDS)	EPA 160.1
Total Suspended Solids (TSS)	EPA 160.2
Chloride	EPA 325.2
Total Cyanide	SW-846 9012A
Nitrate	EPA 353.2
Sulfate	EPA 375.4

Appendix I contains validated analytical data summaries for the samples collected during this field investigation. The validator used the QA/QC criteria defined in the SAP to evaluate the data for all parameters for which criteria were provided. If acceptance criteria were not provided in the SAP, the validator used the laboratory-derived acceptance criteria or analytical method criteria to qualify data. Any qualifiers added to these data by the data validator are included in the summaries.

K.3.1 Laboratory QA/QC Procedures

The following sections discuss specific QA/QC protocols required and performed by the laboratory during this investigation.

K.3.1.1 Method/Calibration Blanks

Method blanks are analyzed with each analytical "batch" processed on a per matrix (i.e., soil and water) basis. Method blanks are carried step-wise through the same analytical procedure as their associated field samples, including the addition of solvents, surrogate and standard spikes, and reagents as required in the analysis process. The purpose of a method blank is to identify any possible contaminants that may be introduced to the sample as a result of any part of the analytical process. The data validator evaluated all blank data associated with each sample. When estimated or positive concentrations of compounds/analytes were reported in the corresponding field samples, associated samples were evaluated and qualified using the 5X-10X rule. The 10-times limit is applicable for common laboratory contaminants such as acetone, methylene chloride, 2-butanone, and certain phthalates.

For some analyses, initial and continuing calibration blanks are performed throughout the run sequence. These blanks verify the presence of carry over contamination for the analytes of interest.

Qualifiers applied to samples based on detections in the calibration and/or method blanks are summarized below:

SDG Number	Sample Number Affected	Blank Contaminant	Blank	Validation Qualifier
PB047	DG3000	Zinc (dissolved/total)	Method	B
	DG3000, DG3001, DG3003, DG3006	Thallium (total)	Calibration, Method	B
	DG3001	Arsenic (dissolved/total)	Calibration	B
	DG3001	Copper (total)	Calibration	B
	DG3002, DG3003, DG3004, DG3005, DG3006	Zinc (total)	Method	B
	DG3003	Selenium (total)	Calibration	B
	DG3003	Mercury (dissolved)	Calibration	B
	DG3004, DG3005, DG3006	Thallium (dissolved)	Method	B
	DG3005, DG3005	Zinc (dissolved)	Method	B
	DG3004, DG3005	Thallium (total)	Method	B
	DG3004	Mercury (total)	Calibration	B
	DG3006	Thallium (dissolved)	Calibration	B
	DG3000, DG3001, DG3003, DG3005, DG3006	Acetone	Method	B

B - blank contamination SDG – sample delivery group

K.3.1.2 Matrix Spikes and Laboratory Control Spikes

Two types of spikes were generally performed for all analyses: MS and laboratory control samples (LCS). MS compounds are spiked into an aliquot of a field sample. LCS compounds

are spiked into a blank matrix. The spiked compounds are representative compounds that are quantified during performance of the method. Recovery of the spiked compound is used as an assessment of analytical accuracy for the sample matrix analyzed. These results are useful in distinguishing sample matrix interferences from analysis interferences through a comparison of MS and LCS recovery data. Often, spikes are performed in duplicate (as an MSD or LCS duplicate). In this manner, the precision of the assessment can be quantified as the RPD of the original and duplicate spike.

Matrix spikes were assigned at a frequency of 1 for every 20 field samples collected. An MS and MSD were assigned in the field to sample DG3003. This sample corresponds to location PB-BED-MW25. Additional sample volume was provided to the laboratory for the MS/MSD analyses. This sampling frequency meets the collection criteria for this program as specified in the SAP. In addition to the overall collection frequency, the analytical method requires that the laboratory analyze 1 set of spikes per analytical batch. To comply with this method requirement, the laboratory may have to analyze batch QC with a work order. The validator evaluated the batch QC. The laboratory statistically determined target acceptance limits were used to assess the spike recovery and RPD.

The MS/MSD criteria were met with a few exceptions. The following samples were qualified:

SDG Number	Sample Number Affected	Analyte(s)	Validation Qualifier
Explosives			
PB047	DG3000, DG3001, DG3002, DG3003, DG3005, DG3006	Tetryl	UJ
Wet Chemistry			
PB047	DG3000, DG3001, DG3002, DG3003, DG3004, DG3005	Cyanide	UJ

UJ - undetected, estimated

LCS results are used to evaluate lab method performance in the same manner as the MS/MSD results except the LCS is not performed on an actual field sample matrix. An LCS is prepared for each analytical "batch" for each parameter and matrix analyzed. All LCS recoveries met the established QC criteria.

K.3.1.3 Calibration

A few compounds exhibited unacceptable performances in the calibration standards. The relative response factors (RRF) of 4-methyl-2-pentanone and 2-butanone were less than 0.1. 4-Methyl-2-pentanone and 2-butanone were rejected in all samples except the field split.

The following compounds exhibited individual initial calibration (ICAL) percent relative standard deviation (%RSD) greater than 30 and/or continuing calibration (CCAL) percent differences (%D) greater than 20.

SDG Number	Analysis	Samples	Compounds	Validation Qualifier
F24891	Volatiles	DG3007	Chloroethane	UJ
PB047	Semivolatiles	DG3000, DG3001, DG3002, DG3003, DG3004, DG3005, DG3006	2,4-Dinitophenol, 4,6-Dinitro-2-Methyphenol	UJ
	Volatiles	DG3000, DG3001, DG3002, DG3003, DG3004, DG3005, DG3006	2-Butanone, 4-Methyl-2-Pentanone	R
		DG3000, DG3001, DG3002, DG3003, DG3004, DG3005, DG3006	2-Hexanone, Carbon Disulfide, Trans-1,3-Dichloropropene	J/UJ
		DG3000, DG3001, DG3003, DG3005, DG3006	Acetone	B
		DG3001, DG3003, DG3006	1,1,2-Trichloroethane, Dibromochlormethane, Tetrachloroethene	UJ
		DG3001	Bromodichloromethane	R
		DG3002, DG3004	Acetone	UJ
		DG3004	1,1,2-Trichloroethane, 1,1-Dichloroethane	UJ

B – blank contamination; J – estimated; R- rejected; UJ - undetected, estimated

K.3.1.4 Column Agreement

For high-performance liquid chromatography (HPLC) analyses, sample results are confirmed using two dissimilar columns. In order for an analyte to be reported, it must be detected on both columns. Results differing by greater than 40 percent are qualified estimated, "J." All detections were in agreement. No data were qualified.

K.3.1.5 Surrogate Recoveries

Surrogate standards are non-target compounds that are added to all samples prior to extraction or purging. They are used in organic analyses to monitor the percent recovery efficiencies of the sample preparation and analytical procedures. Volatile surrogate recoveries for sample DG3001were below laboratory established QC limits. Volatile results for DG3001 should be considered biased low.

DG3001 was qualified as follows:

SDG Number	Samples Affected	Compound(s)	Validation Qualifier
PB047	DG3001	All VOC Compounds	J/B/R/UJ

"B" qualifiers for blank contamination and "R" qualifiers for calibration problems take precedence over estimating qualifiers (UJ/J).

K.3.2 Reporting Limits

Limits have been established to describe project sensitivity requirements. Each laboratory is required to demonstrate method performance through MDL studies for every method employed. These studies are required to be laboratory-specific so that individual laboratory variables such as equipment brands, reagent suppliers, and chemist technique are factored into the performance study. MDLs are established using controlled matrices (i.e., DI water). Practical quantitation limits (PQL) or method quantitation limits (MQL) used for this project are those statistically determined by the laboratories. The analytical program executed for this project required the use of SW-846 methods, which specify the procedure for calculating the MDLs. The PQL/MQL calculation adjusts the limit by a predetermined mathematical factor for the analysis of actual environmental sample matrices (i.e., soil, groundwater, etc.). Method reporting limits (MRL) are based on the project action or decision levels.

These limits are generally defined as follows:

- ***MDL.*** The minimum concentration of an analyte that can be measured and reported with 99 percent confidence that the concentration is greater than zero.
- ***MQL/PQL.*** The lowest level that the laboratory has demonstrated its ability to reliably quantitate target analytes within the criteria required for a given method. It is the lowest concentration at which the data are reported without qualification.
- ***MRL.*** A threshold value below which the laboratory reports a result as non-detected. Ideally, the MRL will be established anywhere between the MDL and 1/2 the project action levels.

An MDL is the lower limit at which the laboratory can differentiate a measurement from background. The MDL is determined in accordance with the procedures in 40 CFR Part 136. If project action levels are near or below the MDL, it is unlikely the sensitivity of the method will be achievable. A compromise must be reached. The PQL/MQL is the lower limit at which a measurement becomes meaningful. This measurement (the PQL or the reporting limit [RL]) is generally a multiple of three to five times the MDL.

Most samples were handled and analyzed as expected without significant changes to the anticipated project MQLs.

K.3.3 Holding Times/Preservation

All laboratory results submitted for this investigation have been reviewed with respect to laboratory adherence to extraction and analysis holding times. Maximum sample extraction and analysis hold times were those specified in USACE document EM200-1-3 (USACE, 2001). All other holding time criteria were acceptable for the samples collected.

K.4.0 Data Evaluation and Usability

The analytical data review process identified a few analytical nonconformance issues that were noted during this analytical program. These anomalies have been discussed in the previous sections of this appendix. Table K-5 summarizes all compounds requiring qualifier application due to anomalies discovered during data validation. Table K-4 defines the reason codes for qualification, and Table K-6 defines the data validation qualifiers.

The following definitions are used for defining precision, accuracy, representativeness, completeness, and comparability as they have been applied to this evaluation.

Precision. Precision is a measurement of mutual agreement among individual measurements of the same property, usually under prescribed similar conditions. Precision data were obtained through the analysis and evaluation of duplicate QA samples. Accuracy was determined through the analysis and evaluation of method blanks, LCSs, trip blanks, equipment rinsates, and MS samples.

Accuracy. Accuracy is a measurement of bias in a system and is expressed as a percent recovery. These QA samples were collected and/or analyzed at the frequency established in the SAP, verifying the completeness element of the DQOs along with the evaluation of holding times and reporting limits. Percent recovery is calculated as follows:

$$Percent\ Recovery = \left(\frac{(x - s)}{T} \right) * 100$$

Where:

X = the lab determined concentration of a spiked sample
S = the sample native concentration prior to spike
T = the true concentration of the spike.

Relative Percent Difference is calculated as follows:

$$Relative\ Percent\ Difference = \left[\frac{|D1 - D2|}{\frac{D1 + D2}{2}} \right] * 100$$

Where:

D1 and D2 = the results of duplicate measurements

Representativeness. Representativeness is a qualitative parameter that expresses the degree to which sample data actually represent the matrix and site conditions. For example, in conducting groundwater monitoring, representativeness requires proper location of wells and the collection of samples under consistent, documented procedures. Wells are located based upon the results of the hydrological study in progress and are designed to provide maximum coverage of the flow conditions. Requirements and procedures for sample collection and handling are designed to maximize sample representativeness. Representativeness also can be monitored by reviewing field documentation and performing field audits.

The samples were collected using Shaw standard operating procedures (SOP) and were fully documented through the use of standard Shaw field forms. Samples are representative of the matrix and site sampled.

Completeness. Completeness is a measure of the amount of valid data that are obtained during a sampling event as compared to the amount of data expected under optimum conditions. No data points were qualified "R," rejected, in the validation process because of QC criteria as described in the previous sections of this report. Completeness is calculated as follows:

$$Completeness\ \% = \left(\frac{D_r}{D_c}\right) X\ 100$$

Where:

D_r = the number of data points for which valid results are reported
D_c = the number of valid samples/data points that are collected and reach the laboratory for analysis.

During this task, 5 monitoring wells were sampled resulting in approximately 1444 targeted analytical records, including duplicate and split records. Fourteen data points were rejected due to anomalies discovered during the validation process. Using the above calculation, greater than 99 percent completeness is achieved for the task.

Comparability. Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. Comparability ensures that results for the sampling event can be compared with data from other past and/or future sampling programs. Compar-

ability for this sampling event was achieved through the use of established and recognized techniques and accepted standard USEPA methods. All samples collected and analyzed were subjected to the same sampling, handling, preparation, analysis, reporting, and validation criteria for the purpose of achieving comparability goals within the data set. Only data of known quality (i.e., precision and bias) can be compared.

Statement of Data Usability. The overall results of the analyses, as discussed in this evaluation, suggest that representative samples were collected and analyzed, and the results are indicative of the media analyzed, with the exception of the few anomalies noted. The data do reflect expected site conditions and are usable for their intended purpose.

Tables K-1 through K-6 summarize the analytical program and the results for the data validation effort for all samples collected by Shaw at PBOW.

K.5.0 References

U.S. Army Corps of Engineers (USACE), 2001, ***Engineering Design – Requirements for the Preparation of Sampling and Analysis Plans***, EM200-1-3, February.

U.S Environmental Protection Agency (USEPA), 1999, ***USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review***, October.

U.S Environmental Protection Agency (USEPA), 2002, ***USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review***, February.

U.S Environmental Protection Agency (USEPA), 1994, ***Region III Modifications to National Functional Guidelines for Organic Data Review,*** September.

U.S Environmental Protection Agency (USEPA), 1993, ***Region III Modifications to the Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses,*** April.

Table K-1

Sample Cross-reference
Background Wells
Former Plum Brook Ordnance Works
Sandusky, Ohio

Sample Type	Sample Location	Sample Number	Sample Date	Sample Purpose	SDG Number
GW	IT-BG8-BEDGW-001	DG3000	16-Jun-04	REG	PB047
GW	PB-BED-MW20	DG3001	17-Jun-04	REG	PB047
GW	PB-BED-MW24	DG3002	16-Jun-04	REG	PB047
GW	PB-BED-MW25	DG3003	17-Jun-04	REG	PB047
GW	PB-BED-MW25	DG3006	17-Jun-04	FD	PB047
GW	PB-BED-MW25	DG3007	17-Jun-04	FS	F24891
GW	PB-BED-MW28	DG3004	15-Jun-04	REG	PB047
GW	PB-BED-MW29	DG3005	16-Jun-04	REG	PB047

SDG - Sample delivery group.
GW - Groundwater.
REG - Regular.
FD - Field duplicate.
FS - Field split.

Table K-2

Summary of Analytes Detected in Blanks
Former Plum Brook Ordnance Works
Sandusky, Ohio

Sample Delivery Group	Sample Number	Analysis Date	Sample Purpose	Parameter	Result	Units	Lab Qualifier
PB047	DG5000	16-Jun-04	TB	ACETONE	5	µg/L	J B
PB047	DG5001	17-Jun-04	TB	ACETONE	5.6	µg/L	J B
PB047	DG5001	17-Jun-04	TB	CHLOROFORM	0.1	µg/L	J
PB047	DG5001	17-Jun-04	TB	METHYLENE CHLORIDE	0.25	µg/L	J
PB047	DG5002	21-Jun-04	TB	ACETONE	4.1	µg/L	J B
PB047	DG5002	21-Jun-04	TB	METHYLENE CHLORIDE	0.46	µg/L	J
PB047	GJDG8BW	16-Jun-04	BLK	ACETONE	3.6	µg/L	J
PB047	GJF4LBW	17-Jun-04	BLK	ACETONE	3	µg/L	J
PB047	GJNHABW	23-Jun-04	BLK	POTASSIUM	97.1	µg/L	B
PB047	GJNHABW	23-Jun-04	BLK	THALLIUM	5.9	µg/L	B
PB047	GJNHABW	23-Jun-04	BLK	ZINC	7	µg/L	B
PB047	GJNWFBW	21-Jun-04	BLK	ACETONE	3.7	µg/L	J

µg/L - Micrograms per liter.

Table K-3

Summary of Original, Field Duplicate, and Field Split Results and RPD Calculations
Former Plum Brook Ordnance Works
Sandusky, Ohio

			PB-BED-MW25 DG3003 17-Jun-04 REG		PB-BED-MW25 DG3006 17-Jun-04 FD		PB-BED-MW25 DG3007 17-Jun-04 FS		Relative Percent Difference between	Relative Percent Difference between
Parameter	**Units**	**Filtered**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**	**REG and FD**	**REG and FS**
Aluminum	µg/L	N	84.8	J	77.1	J	43	J	9.51	65.41
Aluminum	µg/L	Y	200	U	200	U	69.5	J	0.00	96.85
Antimony	µg/L	Y	60	U	60	U	5		0.00	169.23
Arsenic	µg/L	N	10	U	10	U	6.1	J	0.00	48.45
Arsenic	µg/L	Y	10	U	10	U	5.1	J	0.00	64.90
Barium	µg/L	N	112	J	111	J	106	J	0.90	5.50
Barium	µg/L	Y	117	J	118	J	116	J	0.85	0.86
Calcium	µg/L	N	194000		192000		194000		1.04	0.00
Calcium	µg/L	Y	193000		195000		197000		1.03	2.05
Iron	µg/L	N	104		98.4	J	300	U	5.53	97.03
Magnesium	µg/L	N	70400		69600		71700		1.14	1.83
Magnesium	µg/L	Y	70200		70900		72300		0.99	2.95
Manganese	µg/L	N	105		104		103		0.96	1.92
Manganese	µg/L	Y	103		104		101		0.97	1.96
Mercury	µg/L	Y	0.06	B	0.2	U	1	U	107.69	177.36
Potassium	µg/L	N	10800	J	10700	J	13100	J	0.93	19.25
Potassium	µg/L	Y	10900	J	10900	J	13100	J	0.00	18.33
Selenium	µg/L	N	1.5	B	5	U	40	U	107.69	185.54
Sodium	µg/L	N	67000		66300		68300	J	1.05	1.92
Sodium	µg/L	Y	67700		68400		70200	J	1.03	3.63
Thallium	µg/L	N	5.2	B	4.4	B	10	U	16.67	63.16
Thallium	µg/L	Y	10	U	5.8	B	10	U	53.16	0.00
Zinc	µg/L	N	5.1	B	3.6	B	8.8	J	34.48	53.24
Acetone	µg/L	N	4.9	B	4	B	50	U	20.22	164.30
Carbon disulfide	µg/L	N	1.9	J	1.9	J	2		0.00	5.13

RPD > 30%
µg/L - Micrograms per liter.
N - No.
Y - Yes.
Qual - Qualifier.
REG - Regular.
FD - Field duplicate.
FS - Field split.

Table K-4

Summary of Data Validation Reason Codes
Plum Brook Ordnance Works
Sandusky, Ohio

Reason Code	Description
01	Sample received outside of 4+/-2 degrees Celsius
01A	Improper sample preservation
02	Holding Time Exceeded
02A	Extraction
02B	Analysis
03	Instrument Performance - Outside Criteria
03A	BFB
03B	DFTPP
03C	DDT and/or Endrin % breakdown exceeds criteria
03D	retention time windows
03E	Resolution
04	Initial Calibration results outside specified criteria
04A	Compound mean RRF<0.05
04B	Compound %RSD>30
04C	Correlation Coefficient<0.995
05	Continuing Calibration results outside specified criteria
05A	Compound mean RRF<0.05
05B	Compound %D>25
06	Result qualified as a result of the 5x/10x blank correction
06A	Method or Preparation Blank
06B	ICB or CCB
06C	ER
06D	TB
06E	FB
07	Surrogate Recoveries outside control limits
07A	Sample
07B	Associated method blank or LCS
08	MS/MSD/Duplicate results outside criteria
08A	MS and/or MSD recovery not within control limits (accuracy)
08B	%RPD outside acceptance criteria (precision)
09	Post Digestion Spike outside criteria (GFAA)
10	Internal Standards outside specified control limits
10A	Recovery
10B	Retention Time
11	Laboratory Control Sample recoveries outside specified control limits
11A	Recovery
11B	%RPD (if run in duplicate)
12	Interference Check Standard
13	Serial Dilution
14	Tentatively Identified Compounds
15	Quantitation
16	Multiple results available; alternate analysis preferred
17	Field duplicate RPD criteria exceeded
18	Percent difference between original and second column > 25%
19	Professional judgement was used to qualify the data
20	Pesticide clean-up checks
21	Target compound identification
22	Radiological calibration
23	Radiological quantitation
24	Reported result and/or lab qualifier revised to reflect validation findings
999	See hard copy for details.

Table K-5

Summary of Data Validation Qualifiers Assigned amd Reason Codes for Qualification
Former Plum Brook Ordnance Works
Sandusky, Ohio

SAMPLE DELIVERY GROUP	SAMPLE NUMBER	ANALYSIS	PARAMETER	Reason Codes (1,2)				
				VQ	R1	R2	R3	R4
F24891	DG3007	METALS	ALUMINUM	J	15			
F24891	DG3007	METALS	ARSENIC	J	15			
F24891	DG3007	METALS	BARIUM	J	15			
F24891	DG3007	METALS	POTASSIUM	J	13			
F24891	DG3007	METALS	SODIUM	J	13			
F24891	DG3007	METALS	ZINC	J	15			
F24891	DG3007	VOLATILES	CHLOROETHANE	UJ	05B			
PB047	DG3000	CYANIDE	CYANIDE, TOTAL	UJ	08A			
PB047	DG3000	EXPLOSIVES	TETRYL	UJ	08A			
PB047	DG3000	METALS	ALUMINUM	J	15			
PB047	DG3000	METALS	BARIUM	J	15			
PB047	DG3000	METALS	NICKEL	J	15			
PB047	DG3000	METALS	POTASSIUM	J	13	15		
PB047	DG3000	METALS	THALLIUM	B	06A	06B	15	
PB047	DG3000	METALS	ZINC	B	06A	15		
PB047	DG3000	SEMIVOLATILES	2,4-DINITROPHENOL	UJ	05B			
PB047	DG3000	SEMIVOLATILES	4,6-DINITRO-2-METHYLPHENOL	UJ	05B			
PB047	DG3000	VOLATILES	2-BUTANONE	R	04A	05A	05B	
PB047	DG3000	VOLATILES	2-HEXANONE	UJ	05B			
PB047	DG3000	VOLATILES	4-METHYL-2-PENTANONE	R	04A	05A	05B	
PB047	DG3000	VOLATILES	ACETONE	B	05B	06A	06D	15
PB047	DG3000	VOLATILES	CARBON DISULFIDE	J	05B	15		
PB047	DG3000	VOLATILES	TRANS-1,3-DICHLOROPROPENE	UJ	05B			
PB047	DG3001	CYANIDE	CYANIDE, TOTAL	UJ	08A			
PB047	DG3001	EXPLOSIVES	TETRYL	UJ	08A			
PB047	DG3001	METALS	ALUMINUM	J	15			
PB047	DG3001	METALS	ARSENIC	B	06B	15		
PB047	DG3001	METALS	COBALT	J	15			
PB047	DG3001	METALS	COPPER	B	06B	15		
PB047	DG3001	METALS	NICKEL	J	15			
PB047	DG3001	METALS	POTASSIUM	J	13			
PB047	DG3001	METALS	THALLIUM	B	06A	06B	15	
PB047	DG3001	SEMIVOLATILES	2,4-DINITROPHENOL	UJ	05B			
PB047	DG3001	SEMIVOLATILES	4,6-DINITRO-2-METHYLPHENOL	UJ	05B			
PB047	DG3001	VOLATILES	1,1,1-TRICHLOROETHANE	UJ	07A			
PB047	DG3001	VOLATILES	1,1,2,2-TETRACHLOROETHANE	UJ	07A			
PB047	DG3001	VOLATILES	1,1,2-TRICHLOROETHANE	UJ	05B	07A		
PB047	DG3001	VOLATILES	1,1-DICHLOROETHANE	UJ	07A			
PB047	DG3001	VOLATILES	1,1-DICHLOROETHENE	UJ	07A			
PB047	DG3001	VOLATILES	1,2-DICHLOROETHANE	UJ	07A			
PB047	DG3001	VOLATILES	1,2-DICHLOROETHENE (TOTAL)	UJ	07A			
PB047	DG3001	VOLATILES	1,2-DICHLOROPROPANE	UJ	07A			
PB047	DG3001	VOLATILES	2-BUTANONE	R	04A	05A	07A	
PB047	DG3001	VOLATILES	2-HEXANONE	UJ	05B	07A		
PB047	DG3001	VOLATILES	4-METHYL-2-PENTANONE	R	04A	05A	07A	
PB047	DG3001	VOLATILES	ACETONE	B	05B	06A	06D	07A
PB047	DG3001	VOLATILES	BENZENE	J	07A	15		
PB047	DG3001	VOLATILES	BROMODICHLOROMETHANE	R	04A	05A	07A	
PB047	DG3001	VOLATILES	BROMOFORM	UJ	07A			

Table K-5

Summary of Data Validation Qualifiers Assigned amd Reason Codes for Qualification
Former Plum Brook Ordnance Works
Sandusky, Ohio

SAMPLE DELIVERY GROUP	SAMPLE NUMBER	ANALYSIS	PARAMETER	Reason Codes (1,2)				
				VQ	R1	R2	R3	R4
PB047	DG3001	VOLATILES	BROMOMETHANE	UJ	07A			
PB047	DG3001	VOLATILES	CARBON DISULFIDE	UJ	05B	07A		
PB047	DG3001	VOLATILES	CARBON TETRACHLORIDE	UJ	07A			
PB047	DG3001	VOLATILES	CHLOROBENZENE	UJ	07A			
PB047	DG3001	VOLATILES	CHLOROETHANE	UJ	07A			
PB047	DG3001	VOLATILES	CHLOROFORM	UJ	07A			
PB047	DG3001	VOLATILES	CHLOROMETHANE	UJ	07A			
PB047	DG3001	VOLATILES	CIS-1,3-DICHLOROPROPENE	UJ	07A			
PB047	DG3001	VOLATILES	DIBROMOCHLOROMETHANE	UJ	05B	07A		
PB047	DG3001	VOLATILES	ETHYLBENZENE	UJ	07A			
PB047	DG3001	VOLATILES	METHYLENE CHLORIDE	UJ	07A			
PB047	DG3001	VOLATILES	STYRENE	UJ	07A			
PB047	DG3001	VOLATILES	TETRACHLOROETHENE	UJ	05B	07A		
PB047	DG3001	VOLATILES	TOLUENE	UJ	07A			
PB047	DG3001	VOLATILES	TRANS-1,3-DICHLOROPROPENE	UJ	05B	07A		
PB047	DG3001	VOLATILES	TRICHLOROETHENE	UJ	07A			
PB047	DG3001	VOLATILES	VINYL CHLORIDE	UJ	07A			
PB047	DG3001	VOLATILES	XYLENES (TOTAL)	UJ	07A			
PB047	DG3002	CYANIDE	CYANIDE, TOTAL	UJ	08A			
PB047	DG3002	EXPLOSIVES	TETRYL	UJ	08A			
PB047	DG3002	METALS	ALUMINUM	J	15			
PB047	DG3002	METALS	POTASSIUM	J	13			
PB047	DG3002	METALS	ZINC	B	06A	15		
PB047	DG3002	SEMIVOLATILES	2,4-DINITROPHENOL	UJ	05B			
PB047	DG3002	SEMIVOLATILES	2-METHYLNAPHTHALENE	J	15			
PB047	DG3002	SEMIVOLATILES	4,6-DINITRO-2-METHYLPHENOL	UJ	05B			
PB047	DG3002	SEMIVOLATILES	NAPHTHALENE	J	15			
PB047	DG3002	VOLATILES	2-BUTANONE	R	04A	05A	05B	
PB047	DG3002	VOLATILES	2-HEXANONE	UJ	05B			
PB047	DG3002	VOLATILES	4-METHYL-2-PENTANONE	R	04A	05A	05B	
PB047	DG3002	VOLATILES	ACETONE	UJ	05B			
PB047	DG3002	VOLATILES	CARBON DISULFIDE	J	05B	15		
PB047	DG3002	VOLATILES	TRANS-1,3-DICHLOROPROPENE	UJ	05B			
PB047	DG3003	CYANIDE	CYANIDE, TOTAL	UJ	08A			
PB047	DG3003	EXPLOSIVES	TETRYL	UJ	08A			
PB047	DG3003	METALS	ALUMINUM	J	15			
PB047	DG3003	METALS	BARIUM	J	15			
PB047	DG3003	METALS	MERCURY	B	06B	15		
PB047	DG3003	METALS	POTASSIUM	J	13			
PB047	DG3003	METALS	SELENIUM	B	06B	15		
PB047	DG3003	METALS	THALLIUM	B	06A	06B	15	
PB047	DG3003	METALS	ZINC	B	06A	15		
PB047	DG3003	SEMIVOLATILES	2,4-DINITROPHENOL	UJ	05B			
PB047	DG3003	SEMIVOLATILES	4,6-DINITRO-2-METHYLPHENOL	UJ	05B			
PB047	DG3003	VOLATILES	1,1,2-TRICHLOROETHANE	UJ	05B			
PB047	DG3003	VOLATILES	2-BUTANONE	R	04A	05A		
PB047	DG3003	VOLATILES	2-HEXANONE	UJ	05B			
PB047	DG3003	VOLATILES	4-METHYL-2-PENTANONE	R	04A	05A		
PB047	DG3003	VOLATILES	ACETONE	B	05B	06A	06D	15

Table K-5

Summary of Data Validation Qualifiers Assigned amd Reason Codes for Qualification
Former Plum Brook Ordnance Works
Sandusky, Ohio

SAMPLE DELIVERY GROUP	SAMPLE NUMBER	ANALYSIS	PARAMETER	Reason Codes (1,2)				
				VQ	R1	R2	R3	R4
PB047	DG3003	VOLATILES	CARBON DISULFIDE	J	05B			
PB047	DG3003	VOLATILES	DIBROMOCHLOROMETHANE	UJ	05B			
PB047	DG3003	VOLATILES	TETRACHLOROETHENE	UJ	05B			
PB047	DG3003	VOLATILES	TRANS-1,3-DICHLOROPROPENE	UJ	05B			
PB047	DG3004	CYANIDE	CYANIDE, TOTAL	UJ	08A			
PB047	DG3004	METALS	ALUMINUM	J	15			
PB047	DG3004	METALS	MANGANESE	J	15			
PB047	DG3004	METALS	MERCURY	B	06B	15		
PB047	DG3004	METALS	POTASSIUM	J	13			
PB047	DG3004	METALS	THALLIUM	B	06A	15		
PB047	DG3004	METALS	ZINC	B	06A	15		
PB047	DG3004	SEMIVOLATILES	2,4-DINITROPHENOL	UJ	05B			
PB047	DG3004	SEMIVOLATILES	4,6-DINITRO-2-METHYLPHENOL	UJ	05B			
PB047	DG3004	VOLATILES	1,1,2-TRICHLOROETHANE	UJ	05B			
PB047	DG3004	VOLATILES	1,1-DICHLOROETHANE	UJ	05B			
PB047	DG3004	VOLATILES	2-BUTANONE	R	04A	05A	05B	
PB047	DG3004	VOLATILES	2-HEXANONE	UJ	05B			
PB047	DG3004	VOLATILES	4-METHYL-2-PENTANONE	R	04A	05A	05B	
PB047	DG3004	VOLATILES	ACETONE	UJ	05B			
PB047	DG3004	VOLATILES	CARBON DISULFIDE	J	05B	15		
PB047	DG3004	VOLATILES	TOLUENE	J	15			
PB047	DG3004	VOLATILES	TRANS-1,3-DICHLOROPROPENE	UJ	05B			
PB047	DG3005	CYANIDE	CYANIDE, TOTAL	UJ	08A			
PB047	DG3005	EXPLOSIVES	TETRYL	UJ	08A			
PB047	DG3005	METALS	ALUMINUM	J	15			
PB047	DG3005	METALS	COBALT	J	15			
PB047	DG3005	METALS	COPPER	J	15			
PB047	DG3005	METALS	POTASSIUM	J	13			
PB047	DG3005	METALS	THALLIUM	B	06A	15		
PB047	DG3005	METALS	ZINC	B	06A	15		
PB047	DG3005	METALS	ZINC	B	06A			
PB047	DG3005	SEMIVOLATILES	2,4-DICHLOROPHENOL	UJ	05B			
PB047	DG3005	SEMIVOLATILES	4,6-DINITRO-2-METHYLPHENOL	UJ	05B			
PB047	DG3005	VOLATILES	2-BUTANONE	R	04A	05A	05B	
PB047	DG3005	VOLATILES	2-HEXANONE	UJ	05B			
PB047	DG3005	VOLATILES	4-METHYL-2-PENTANONE	R	04A	05A	05B	
PB047	DG3005	VOLATILES	ACETONE	B	05B	06A	06D	15
PB047	DG3005	VOLATILES	BENZENE	J	15			
PB047	DG3005	VOLATILES	CARBON DISULFIDE	UJ	05B			
PB047	DG3005	VOLATILES	ETHYLBENZENE	J	15			
PB047	DG3005	VOLATILES	TRANS-1,3-DICHLOROPROPENE	UJ	05B			
PB047	DG3006	EXPLOSIVES	TETRYL	UJ	08A			
PB047	DG3006	METALS	ALUMINUM	J	15			
PB047	DG3006	METALS	BARIUM	J	15			
PB047	DG3006	METALS	IRON	J	15			
PB047	DG3006	METALS	POTASSIUM	J	13			
PB047	DG3006	METALS	THALLIUM	B	06A	06B	15	
PB047	DG3006	METALS	ZINC	B	06A	15		
PB047	DG3006	SEMIVOLATILES	2,4-DINITROPHENOL	UJ	05B			

Table K-5

Summary of Data Validation Qualifiers Assigned amd Reason Codes for Qualification
Former Plum Brook Ordnance Works
Sandusky, Ohio

SAMPLE DELIVERY GROUP	SAMPLE NUMBER	ANALYSIS	PARAMETER	Reason Codes (1,2)				
				VQ	R1	R2	R3	R4
PB047	DG3006	SEMIVOLATILES	4,6-DINITRO-2-METHYLPHENOL	UJ	05B			
PB047	DG3006	VOLATILES	1,1,2-TRICHLOROETHANE	UJ	05B			
PB047	DG3006	VOLATILES	2-BUTANONE	R	04A	05A		
PB047	DG3006	VOLATILES	2-HEXANONE	UJ	05B			
PB047	DG3006	VOLATILES	4-METHYL-2-PENTANONE	R	04A	05A		
PB047	DG3006	VOLATILES	ACETONE	B	05B	06A	06D	15
PB047	DG3006	VOLATILES	CARBON DISULFIDE	J	05B			
PB047	DG3006	VOLATILES	DIBROMOCHLOROMETHANE	UJ	05B			
PB047	DG3006	VOLATILES	TETRACHLOROETHENE	UJ	05B			
PB047	DG3006	VOLATILES	TRANS-1,3-DICHLOROPROPENE	UJ	05B			

Footnotes:

(1) Table K-4 defines all reason codes.

(2) Reason codes are assigned in order of their importance to the validation qualifiers with R1 being most important.

Definitions:

VQ = validation qualifier

Table K-6

Laboratory and Validation Qualifier Definitions
Former Plum Brook Ordnance Works
Sandusky, Ohio

Qualifier	Definition
Laboratory - Organic	
B	The compound was detected in the sample and in an associated method blank.
J	The compound was positively identified; the reported value is an estimated concentration between the method detection limit and the reporting limit.
U	Not detected. The compound was analyzed for, but not detected above the associated reporting limit.
Laboratory - Inorganic	
B	The analyte was positively identified; the reported value is an estimated concentration between the method detection limit and the reporting limit.
J	The compound was detected in the sample and in an associated method blank.
G	Elevated reporting limit due to matrix interference.
U	Not detected. The analyte was analyzed for, but not detected above the associated reporting limit.
Validation - All	
B	The analyte was not detected significantly above the levels found in the associated method blank or field blanks
J	The compound/analyte was positively identified; the reported value is an estimated concentration.
R	Rejected due to severe deficiencies in the analytical process or supporting quality control data. The presence or absence of the compound/analyte cannot be verified.
U	Not detected. The compound/analyte was analyzed for, but not detected above the associated reporting limit.
UJ	Not detected. The associated reporting limit may be inaccurate or imprecise.

AUGUST 2004 DOWNGRADIENT WELL SAMPLING DATA QUALITY EVALUATION

Table of Contents

Page

List of Tables ..... K-ii
List of Acronyms ..... K-iii
K.1.0 Introduction K-1
K.2.0 Field Sampling and QC Activities K-2
K.2.1 Trip Blanks K-2
K.2.2 Field Duplicates K-3
K.2.3 Field Split Samples K-4
K.3.0 Analytical Program and QC Activities K-5
K.3.1 Laboratory QA/QC Procedures K-5
K.3.1.1 Method/Calibration Blanks K-5
K.3.1.2 Matrix Spikes and Laboratory Control Spikes K-6
K.3.1.3 Calibration K-7
K.3.1.4 Column Agreement K-8
K.3.1.5 Surrogate Recoveries K-8
K.3.2 Reporting Limits K-8
K.3.3 Holding Times/Preservation K-9
K.4.0 Data Evaluation and Usability K-10
K.5.0 References K-13

List of Tables

Table	Title
K-1	Sample Cross-reference
K-2	Summary of Analytes Detected in Blanks
K-3	Summary of Original, Field Duplicate, and Field Split Results and RPD Calculations
K-4	Summary of Data Validation Reason Codes
K-5	Summary of Data Validation Qualifiers Assigned and Reason Codes for Qualification
K-6	Laboratory and Validation Qualifier Definitions

List of Acronyms

AR/COC	analysis request/chain of custody
CCAL	continuing calibration
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
DI	deionized
DQE	data quality evaluation
DQO	data quality objectives
EPA	U.S. Environmental Protection Agency
HPLC	high-performance liquid chromatography
ICAL	initial calibration
LCS	laboratory control sample
MDL	method detection limit
MQL	method quantitation limit
MRL	method reporting limit
MS	matrix spike
MSD	matrix spike duplicate
%D	percent difference
%RSD	percent relative standard deviation
PQL	practical quantitation limit
PBOW	Plum Brook Ordnance Works
QA/QC	quality assurance/quality control
SAP	sampling and analysis plan
SDG	sample delivery group
STL	Severn Trent Laboratory
RL	reporting limit
RPD	relative percent difference
RRF	relative response factor
SOP	standard operating procedures
STL	Severn Trent Laboratory
TDS	total dissolved solids
TOC	total organic compounds
TSS	total suspended solids
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound

K.1.0 Introduction

This appendix presents results of the quality assurance/quality control (QA/QC) measures implemented for the sampling and analysis activities at the Plum Brook Ordnance Works (PBOW) – Sandusky, Ohio. The quality indicators from every aspect of the data collection have been reviewed, and an assessment of the data with regard to project-specific objectives is presented. Successful execution of project-specific objectives and procedures provides strong support for the acceptance of the data generated as adequate for the purpose of evaluating the analytical results from this assessment at PBOW.

Shaw Environmental, Inc. (Formerly IT Corporation) conducted field-sampling activities at PBOW in August 2004. Severn Trent Laboratories (STL) in Knoxville, Tennessee, and North Canton, Ohio, analyzed the project samples. Accutest Laboratories of Orlando, Florida, analyzed the field split samples. All data analyzed were reviewed for accuracy and completeness. One hundred percent of the data analyzed were subjected to data validation following Unites States Environmental Protection Agency (USEPA) guidelines in the *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review*, (EPA, 1999) and *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review*, (EPA, 2002). The criteria for blank evaluation were based on those detailed in *Region III Modifications to National Functional Guidelines for Organic Data Review* (EPA, 1994b) and *Region III Modifications to the Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses* (EPA, 1993). Since these documents specify procedures for Contract Laboratory Program (CLP) data, they are used as guidelines only. Method and laboratory quality assurance and quality control requirements supercede these guidelines, where applicable. Laboratory criteria are provided in Attachment A of Appendix H. Data were evaluated against specific criteria to verify the achievement of precision, accuracy, representativeness, completeness, and comparability goals established to meet the project data quality objectives (DQO). To verify that these DQOs were met, field measurements, sampling and handling procedures, laboratory analysis and reporting, and all nonconformances and discrepancies in the data were examined to determine compliance with the appropriate and applicable procedures defined in the site-wide sampling and analysis plan (SAP). The results of this review are presented in the following sections, with all analytical outliers or nonconformances discussed where they occurred.

K.2.0 Field Sampling and QC Activities

Shaw was retained by the U. S. Army Corps of Engineers (USACE), Nashville District, to conduct investigation and sampling activities at PBOW. Field activities at this site included collection of the downgradient groundwater samples. The collection of these samples along with their associated QA and QC samples are discussed in this section of the Data Quality Evaluation (DQE).

All project and field duplicate samples collected were submitted to STL. Sample shipments from the field were performed under custody and documented using standard Shaw Analysis Request/Chain of Custody (AR/COC) forms. These forms provided project-specific analytical specifications and QC instructions to the laboratory. A formal COC transfer record was prepared and included with these forms to document custody during sample transportation, storage, and disposition by the laboratory. Table K-1 summarizes the field sample number, location, sample type, date of collection, and sample delivery group for each sample collected. Table K-2 summarizes the detected compounds in the method blank and trip blanks associated with the PBOW samples.

K.2.1 Trip Blanks

Aqueous samples designated for volatile organic compound (VOC) analysis may be susceptible to contamination by diffusion of organic compounds into the sample container. Trip blanks are analyzed in order to assess the potential for contamination to be introduced to an aqueous volatile sample during transport and handling procedures. A trip blank is a sample of analyte-free deionized (DI) water that is prepared at the laboratory, shipped to the field with sample containers, and returned to the laboratory with the water matrix samples receiving VOC analysis. A trip blank is then analyzed for volatile organics using the same sample preparation and analysis procedures used for the actual field samples. Four trip blank samples were collected. Four trip blanks contained target analytes and three samples were qualified.

The data validator applied the 5X-10X rule to the samples for the analytes detected. The 10-times limit is applicable for common laboratory contaminants such as acetone, methylene chloride, and 2-butanone. The following samples were qualified "B" by the data validator, indicating that sample results are indicative of blank contamination:

SDG Number	Sample Affected	Blank Contaminant	Validation Qualifier
H4H270215	DH3002, DH3005	Carbon Disulfide	B
	DH3002	Toluene	B

SDG – Sample delivery group.

K.2.2 Field Duplicates

Field duplicate samples are collected and submitted to the laboratory for analysis along with their corresponding original samples. The data generated from the analysis of field duplicate samples are used to evaluate the precision of the sample collection and analysis procedures. High relative percent difference (RPD) between an original sample and its field duplicate may indicate a difference in sample matrix or sample collection rather than true problems with precision of sample analysis. Also, when estimated "J," blank-contaminated "B," or nondetected "U" results are reported, there is a potential for increased variability between the primary and duplicate sample results.

Field duplicate samples were collected at a frequency of approximately one for every ten samples collected (10 percent). One field duplicate sample was collected during this sampling event. Table K-3 compares the original and field duplicate results and shows the RPDs calculated for those detected compounds. Compounds not presented in the table were not detected in either the original or field duplicate samples. In cases where duplicates were performed and one result is less than the reporting limit, but greater than the method detection limit (MDL), the RPD is reported, but should be considered an estimated value.

The acceptance criterion of 30 percent RPD was used to evaluate these sample results. Data was qualified only if the analyte was detected in both samples. Iron and carbon disulfide were qualified "J." In most cases, original and field duplicate data compared well as demonstrated by the RPDs calculated. The instances where they do not compare well involve estimated or blank-contaminated data. RPD is calculated by using the following formula:

$$RPD = \left| \frac{A - B}{(A + B)/2} \right| \quad x \quad 100$$

where:

RPD = relative percent difference
A = original result
B = field duplicate result.

K.2.3 Field Split Samples

Split samples were collected in conjunction with field duplicate samples and sent to Accutest Laboratories. The split samples were submitted to the laboratory for the same analysis as their corresponding field duplicates and original field samples. The split samples are used to determine if data results are reproducible when analyzed by two different laboratories. Results are also evaluated to determine if a contracted laboratory's preparation and analysis procedures are in control and meet the approved method criteria.

Field split samples were collected at a frequency of approximately one for every ten regular samples. One split sample was collected during this sampling event.

Table K-3 compares the original and field split results and shows the RPDs calculated for those detected compounds. Compounds not presented in the table were not detected in either the original or field split samples. The analytes compare well when both labs reported above their reporting limits and there was no blank contamination.

K.3.0 Analytical Program and QC Activities

The project QA/QC program described in the SAP was followed for the collection and laboratory analysis of samples. Each of the analytical methods used require that method-specific QA/QC protocols be followed during sample analysis. These protocols are a critical part of the methods employed and were followed by the laboratory during sample analysis. Specific measures included detailed record keeping procedures, instrument calibrations, and analysis of method blanks, blank spikes, matrix spikes/matrix spike duplicates (MS/MSD), surrogates, and internal standards. The following SW-846 and USEPA methods were used to analyze PBOW samples:

Parameter	Method
Volatiles	SW-846 5030/8260B
Semivolatiles	SW-846 3510/8270C
Nitroaromatic Compounds	SW-846 8330M
Metals	SW-846 3005A/6010B/7470A
Turbidity	EPA 180.1
Alkalinity	EPA 310.1
Total Organic Carbon (TOC)	SW-846 9060
Hardness	EPA 130.2
Total Dissolved Solids (TDS)	EPA 160.1
Total Suspended Solids (TSS)	EPA 160.2
Chloride	EPA 325.2
Total Cyanide	SW-846 9012A
Nitrate	EPA 353.2
Sulfate	EPA 375.4

Appendix I contains validated analytical data summaries for the samples collected during this field investigation. The validator used the QA/QC criteria defined in the SAP to evaluate the data for all parameters for which criteria were provided. If acceptance criteria were not provided in the SAP, the validator used the laboratory-derived acceptance criteria or analytical method criteria to qualify data. Any qualifiers added to these data by the data validator are included in the summaries.

K.3.1 Laboratory QA/QC Procedures

The following sections discuss specific QA/QC protocols required and performed by the laboratory during this investigation.

K.3.1.1 Method/Calibration Blanks

Method blanks are analyzed with each analytical "batch" processed on a per matrix (i.e., soil and water) basis. Method blanks are carried step-wise through the same analytical procedure as their

associated field samples, including the addition of solvents, surrogate and standard spikes, and reagents as required in the analysis process. The purpose of a method blank is to identify any possible contaminants that may be introduced to the sample as a result of any part of the analytical process. The data validator evaluated all blank data associated with each sample. When estimated or positive concentrations of compounds/analytes were reported in the corresponding field samples, associated samples were evaluated and qualified using the 5X-10X rule. The 10-times limit is applicable for common laboratory contaminants such as acetone, methylene chloride, 2-butanone, and certain phthalates.

For some analyses, initial and continuing calibration blanks are performed throughout the run sequence. These blanks verify the presence of carry over contamination for the analytes of interest.

Qualifiers applied to samples based on detections in the calibration and/or method blanks are summarized below:

SDG Number	Sample Number Affected	Blank Contaminant	Blank	Validation Qualifier
H4H260300	DH3003	Arsenic (dissolved)	Calibration	B
H4H270215	DH3000, DH3002, DH3005	Aluminum (dissolved)	Calibration	B
	DH3000	Aluminum (total), Selenium (total)	Calibration	B
	DH3005	Nickel (total)	Calibration	B
H4H280124	DH3004	Aluminum (dissolved)	Calibration	B
F26367	DH3006	Aluminum (dissolved)	Calibration	B

B - blank contamination

K.3.1.2 Matrix Spikes and Laboratory Control Spikes

Two types of spikes were generally performed for all analyses: MS and laboratory control samples (LCS). MS compounds are spiked into an aliquot of a field sample. LCS compounds are spiked into a blank matrix. The spiked compounds are representative compounds that are quantified during performance of the method. Recovery of the spiked compound is used as an assessment of analytical accuracy for the sample matrix analyzed. These results are useful in distinguishing sample matrix interferences from analysis interferences through a comparison of MS and LCS recovery data. Often, spikes are performed in duplicate (as an MSD or LCS duplicate). In this manner, the precision of the assessment can be quantified as the RPD of the original and duplicate spike.

Matrix spikes were assigned at a frequency of 1 for every 20 field samples collected. An MS and MSD were assigned in the field to sample DH3002. This sample corresponds to location PB-

BED-MW22. Additional sample volume was provided to the laboratory for the MS/MSD analyses. This sampling frequency meets the collection criteria for this program as specified in the SAP. In addition to the overall collection frequency, the analytical method requires that the laboratory analyze 1 set of spikes per analytical batch. To comply with this method requirement, the laboratory may have to analyze batch QC with a work order. The validator evaluated the batch QC. The laboratory statistically determined target acceptance limits were used to assess the spike recovery and RPD.

The MS/MSD criteria were met with a few exceptions. The following samples were qualified:

SDG Number	Sample Number Affected	Analyte(s)	Validation Qualifier
Metals			
H4H260300	DH3003	Aluminum (total)	J
H4H270215	DH3000, DH3002, DH3005	Aluminum (total)	J/B
H4H280124	DH3004	Aluminum (total)	J
Wet Chemistry			
H4H260300	DH3003	Nitrate, Cyanide (total)	UJ
H4H270215	DH3000, DH3002	Nitrate, Cyanide (total)	UJ
H4H280124	DH3007	Cyanide (total)	UJ
Volatiles			
F26367	DH3006	Trans-1,3-Dichloropropene, Styrene	UJ

UJ - undetected, estimated
B – associated blank contamination (Blank qualifiers take precedence over estimating qualifiers.)

LCS results are used to evaluate lab method performance in the same manner as the MS/MSD results except the LCS is not performed on an actual field sample matrix. An LCS is prepared for each analytical "batch" for each parameter and matrix analyzed. All LCS recoveries met the established QC criteria.

K.3.1.3 Calibration

A few compounds exhibited unacceptable performances in the calibration standards. The relative response factor (RRF) of 4-methyl-2-pentanone and 2-butanone were less than 0.1. 4-Methyl-2-pentanone and 2-butanone were rejected in all samples except the field split and DF3000. Acetone was rejected in samples was rejected in the field split.

The following compounds exhibited individual initial calibration (ICAL) percent relative standard deviation (%RSD) greater than 30 and/or continuing calibration (CCAL) percent differences (%D) greater than 20.

SDG Number	Analysis	Samples	Compounds	Validation Qualifier
H4H260300	Volatiles	DH3003	Acetone, 2-Butanone, 4-Methyl-2-pentanone	R
		DH3003	2-Hexanone	UJ
H4H270215	Volatiles	DH3000, DH3002, DH3005	2-Butanone, 4-Methyl-2-Pentanone	R
		DH3000, DH3002	Acetone	R
		DH3005	Xylenes (Total)	UJ
	Semivolatiles	DH3005	2,4-Dinitrophenol, 4,6-Dinitro-2-Methylphenol	UJ
H4H280124	Volatiles	DH3004	Acetone, 2-Butanone, 4-Methyl-2-Pentanone	R/J

R- rejected
J - estimated
UJ - undetected, estimated

K.3.1.4 Column Agreement

For high-performance liquid chromatography (HPLC) analyses, sample results are confirmed using two dissimilar columns. In order for an analyte to be reported, it must be detected on both columns. Results differing by greater than 40 percent are qualified estimated, "J." All detections were in agreement. No data were qualified.

K.3.1.5 Surrogate Recoveries

Surrogate standards are defined as non-target compounds added to standards, blanks, and samples prior to extraction or purging for organic analysis used to monitor the percent recovery efficiencies of the sample preparation and analytical procedures on a sample-by-sample basis. All surrogate recoveries were within laboratory established QC limits. No data were qualified.

K.3.2 Reporting Limits

Limits have been established to describe project sensitivity requirements. Each laboratory is required to demonstrate method performance through MDL studies for every method employed. These studies are required to be laboratory-specific so that individual laboratory variables such as equipment brands, reagent suppliers, and chemist technique are factored into the performance study. MDLs are established using controlled matrices (i.e., DI water). Practical quantitation limits (PQL) or method quantitation limits (MQL) used for this project are those statistically determined by the laboratories. The analytical program executed for this project required the use of SW-846 methods, which specify the procedure for calculating the MDLs. The PQL/MQL calculation adjusts the limit by a predetermined mathematical factor for the analysis of actual environmental sample matrices (i.e., soil, groundwater, etc.). Method reporting limits (MRL) are based on the project action or decision levels.

These limits are generally defined as follows:

- ***MDL.*** The minimum concentration of an analyte that can be measured and reported with 99 percent confidence that the concentration is greater than zero.

- ***MQL/PQL.*** The lowest level that the laboratory has demonstrated its ability to reliably quantitate target analytes within the criteria required for a given method. It is the lowest concentration at which data are reported without qualification.

- ***MRL.*** A threshold value below which the laboratory reports a result as non-detected. Ideally, the MRL will be established anywhere between the MDL and 1/2 the project action levels.

An MDL is the lower limit at which the laboratory can differentiate a measurement from background. The MDL is determined in accordance with the procedures in 40 Code of Federal Regulations (CFR) Part 136. If project action levels are near or below the MDL, it is unlikely the sensitivity of the method will be achievable. A compromise must be reached. The PQL/MQL is the lower limit at which a measurement becomes meaningful. This measurement (the PQL or the reporting limit [RL]) is generally a multiple of three to five times the MDL.

Most samples were handled and analyzed as expected without significant changes to the anticipated project MQLs.

K.3.3 Holding Times/Preservation

All laboratory results submitted for this investigation have been reviewed with respect to laboratory adherence to extraction and analysis holding times. Maximum sample extraction and analysis hold times were those specified in USACE document EM200-1-3 (USACE, 2001). All holding time criteria were acceptable for the samples collected with the exception of cyanide for sample DH3000. The cyanide result for sample DH3000 is estimated, qualified 'UJ', due to hold time exceeded.

K.4.0 Data Evaluation and Usability

The analytical data review process identified a few analytical nonconformance issues that were noted during this analytical program. These anomalies have been discussed in the previous sections of this appendix. Table K-5 summarizes all compounds requiring qualifier application due to anomalies discovered during data validation. Table K-4 defines the reason codes for qualification, and Table K-6 defines the data validation qualifiers.

The following definitions are used for defining precision, accuracy, representativeness, completeness, and comparability as they have been applied to this evaluation.

Precision. Precision is a measurement of mutual agreement among individual measurements of the same property, usually under prescribed similar conditions. Precision data were obtained through the analysis and evaluation of duplicate QA samples. Accuracy was determined through the analysis and evaluation of method blanks, LCSs, trip blanks, equipment rinsates, and MS samples.

Accuracy. Accuracy is a measurement of bias in a system and is expressed as a percent recovery. These QA samples were collected and/or analyzed at the frequency established in the SAP, verifying the completeness element of the DQOs along with the evaluation of holding times and reporting limits. Percent recovery is calculated as follows:

$$Percent\ Recovery = \left(\frac{(x-s)}{T}\right) * 100$$

Where:

X = the lab determined concentration of a spiked sample
S = the sample native concentration prior to spike
T = the true concentration of the spike.

Relative Percent Difference is calculated as follows:

$$Relative\ Percent\ Difference = \left[\frac{|D1-D2|}{\frac{D1+D2}{2}}\right] * 100$$

Where:

D1 and D2 = the results of duplicate measurements

Representativeness. Representativeness is a qualitative parameter that expresses the degree to which sample data actually represent the matrix and site conditions. For example, in conducting groundwater monitoring, representativeness requires proper location of wells and the collection of samples under consistent, documented procedures. Wells are located based upon the results of the hydrological study in progress and are designed to provide maximum coverage of the flow conditions. Requirements and procedures for sample collection and handling are designed to maximize sample representativeness. Representativeness also can be monitored by reviewing field documentation and performing field audits.

The samples were collected using Shaw SOPs and were fully documented through the use of standard Shaw field forms. Samples are representative of the matrix and site sampled.

Completeness. Completeness is a measure of the amount of valid data that are obtained during a sampling event as compared to the amount of data expected under optimum conditions. No data points were qualified "R," rejected, in the validation process because of QC criteria as described in the previous sections of this report. Completeness is calculated as follows:

$$Completeness\ \% = \left(\frac{D_r}{D_c}\right) X\ 100$$

Where:

D_r = the number of data points for which valid results are reported
D_c = the number of valid samples/data points that are collected and reach the laboratory for analysis.

During this task, 5 monitoring wells were sampled resulting in approximately 1040 targeted analytical records, including duplicate and split records. Nineteen data points were rejected due to anomalies discovered during the validation process. Using the above calculation, greater than 98 percent completeness is achieved for the task.

Comparability. Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. Comparability ensures that results for the sampling event can be compared with data from other past and/or future sampling programs. Comparability for this sampling event was achieved through the use of established and recognized

techniques and accepted standard USEPA methods. All samples collected and analyzed were subjected to the same sampling, handling, preparation, analysis, reporting, and validation criteria for the purpose of achieving comparability goals within the data set. Only data of known quality (i.e., precision and bias) can be compared.

Statement of Data Usability. The overall results of the analyses, as discussed in this evaluation, suggest that representative samples were collected and analyzed, and the results are indicative of the media analyzed, with the exception of the few anomalies noted. The data do reflect expected site conditions and are usable for their intended purpose.

Tables K-1 through K-6 summarize the analytical program and the results for the data validation effort for all samples collected by Shaw at PBOW.

K.5.0 References

U.S. Army Corps of Engineers, 2001, ***Engineering Design – Requirements for the Preparation of Sampling and Analysis Plans***, EM200-1-3, February.

U.S Environmental Protection Agency (USEPA), 1999, ***USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review***, October.

U.S Environmental Protection Agency (USEPA), 2002, ***USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review***, February.

U.S Environmental Protection Agency (USEPA), 1994, ***Region III Modifications to National Functional Guidelines for Organic Data Review,*** September.

U.S Environmental Protection Agency (USEPA), 1993, ***Region III Modifications to the Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses,*** April.

Table K-1

Sample Cross-reference Downgradient Wells
Former Plum Brook Ordnance Works
Sandusky, Ohio

Sample Type	Sample Location	Sample Number	Sample Date	Sample Purpose	SDG Number
GW	PB-BED-MW17	DH3000	26-Aug-04	REG	H4H270215
GW	PB-BED-MW19	DH3001	25-Aug-04	REG	H4H260300
GW	PB-BED-MW22	DH3002	26-Aug-04	REG	H4H270215
GW	PB-BED-MW22	DH3002-MS	26-Aug-04	MS	H4H270215
GW	PB-BED-MW22	DH3002-MSD	26-Aug-04	MSD	H4H270215
GW	PB-BED-MW22	DH3005	26-Aug-04	FD	H4H270215
GW	PB-BED-MW22	DH3006	26-Aug-04	FS	F26367
GW	PB-BED-MW30	DH3003	25-Aug-04	REG	H4H260300
GW	PB-BED-MW33	DH3004	27-Aug-04	REG	H4H280124
GW	PT-5912	DH3007	27-Aug-04	REG	H4H280124

GW - Groundwater.
SDG - Sample delivery group.
MS - Matrix spike.
MSD - Matrix spike duplicate.
REG - Regular.
FS - Field split.

Table K-2

Summary of Analytes Detected in Blanks
Former Plum Brook Ordnance Works
Sandusky, Ohio

Sample Delivery Group	Sample Number	Sample Date	Analysis Date	Sample Purpose	PARAMETER	RESULT	RL	MDL	UNITS	LQ
H4H260300	DH5000	25-Aug-04	28-Aug-04	TB	ACETONE	2.4	10	1.4	µg/L	J B
H4H260300	DH5000	25-Aug-04	28-Aug-04	TB	CHLOROFORM	0.17	1	0.1	µg/L	J
H4H260300	DH5000	25-Aug-04	28-Aug-04	TB	TOLUENE	0.14	1	0.1	µg/L	J
H4H260300	GN6EVBW	25-Aug-04	28-Aug-04	BLK	2-BUTANONE	3.2	5	0.75	µg/L	J
H4H260300	GN6EVBW	25-Aug-04	28-Aug-04	BLK	2-HEXANONE	1.2	5	0.76	µg/L	J
H4H260300	GN6EVBW	25-Aug-04	28-Aug-04	BLK	4-METHYL-2-PENTANONE	0.69	5	0.4	µg/L	J
H4H260300	GN6EVBW	25-Aug-04	28-Aug-04	BLK	ACETONE	4.7	10	1.4	µg/L	J
H4H260300	GN7A8BW	25-Aug-04	9-Sep-04	BLK	POTASSIUM	73.8	5000	66.8	µg/L	B
H4H270215	DH5001	26-Aug-04	31-Aug-04	TB	ACETONE	2.4	10	1.4	µg/L	J B
H4H270215	DH5001	26-Aug-04	31-Aug-04	TB	CARBON DISULFIDE	0.12	1	0.1	µg/L	J
H4H270215	DH5001	26-Aug-04	31-Aug-04	TB	CHLOROFORM	0.18	1	0.1	µg/L	J
H4H270215	DH5001	26-Aug-04	31-Aug-04	TB	TOLUENE	0.13	1	0.1	µg/L	J
H4H280124	DH5003	27-Aug-04	31-Aug-04	TB	2-BUTANONE	5.6	5	0.75	µg/L	
H4H280124	DH5003	27-Aug-04	31-Aug-04	TB	2-HEXANONE	1.7	5	0.76	µg/L	J
H4H280124	DH5003	27-Aug-04	31-Aug-04	TB	4-METHYL-2-PENTANONE	1	5	0.4	µg/L	J
H4H280124	DH5003	27-Aug-04	31-Aug-04	TB	ACETONE	7.1	10	1.4	µg/L	J B
H4H280124	DH5003	27-Aug-04	31-Aug-04	TB	CARBON DISULFIDE	0.19	1	0.1	µg/L	J
H4H280124	DH5003	27-Aug-04	31-Aug-04	TB	CHLOROFORM	0.2	1	0.1	µg/L	J
H4H280124	DH5003	27-Aug-04	31-Aug-04	TB	CHLOROMETHANE	0.2	2	0.12	µg/L	J B
H4H280124	DH5003	27-Aug-04	31-Aug-04	TB	TOLUENE	0.16	1	0.1	µg/L	J
H4H280124	GN9RHBW	27-Aug-04	31-Aug-04	BLK	ACETONE	1.7	10	1.4	µg/L	J
H4H280124	GN9RHBW	27-Aug-04	31-Aug-04	BLK	CHLOROMETHANE	0.21	2	0.12	µg/L	J

BLK - Blank.
LQ - Laboratory qualifier.
MDL - Method detection limit.
µg/L - Micrograms per liter.
RL - Reporting limit.
TB - Trip blank.

Table K-3

Summary of Original, Field Duplicate, and Field Split Results and RPD Calculations
Former Plum Brook Ordnance Works
Sandusky, Ohio

Location Code			PB-BED-MW22			PB-BED-MW22			PB-BED-MW22			Relative Percent Difference	Relative Percent Difference
Samnple Number			DH3002			DH3005			DH3006			between	between
Sample Date			26-Aug-04			26-Aug-04			26-Aug-04				
Sample Purpose			REG			FD			FS				
Parameter	**Units**	**Filtered**	**Result**	**Qual**	**ValQual**	**Result**	**Qual**	**ValQual**	**Result**	**Qual**	**ValQual**	**REG and FD**	**REG and FS**
Aluminum	µg/L	N	717		J	1080		J	368			40.40	98.34
Aluminum	µg/L	Y	63.6	B	B	64.1	B	B	33	B	B	0.78	64.06
Barium	µg/L	N	695			701			679			0.86	3.19
Barium	µg/L	Y	700			694			641			0.86	7.94
Calcium	µg/L	N	118000			117000			122000			0.85	4.18
Calcium	µg/L	Y	117000			115000			113000			1.72	1.75
Iron	µg/L	N	593			620			111	B	J	4.45	139.26
Magnesium	µg/L	N	36600			37100			38100			1.36	2.66
Magnesium	µg/L	Y	37000			36400			35800			1.63	1.66
Manganese	µg/L	N	57.5			56			56.6			2.64	1.07
Manganese	µg/L	Y	47			46.2			45.5			1.72	1.53
Nickel	µg/L	N	3.1	B	B	40	U	U	1.1	B	J	171.23	189.29
Potassium	µg/L	N	3980	B J	J	4410	B J	J	4610	B	J	10.25	4.43
Potassium	µg/L	Y	3730	B J	J	3750	B J	J	4280	B	J	0.53	13.20
Sodium	µg/L	N	18500			18700			16900			1.08	10.11
Sodium	µg/L	Y	18700			18500			16000			1.08	14.49
Thallium	µg/L	N	3.3	B	J	4.1	B	J	10	U	U	21.62	83.69
Thallium	µg/L	Y	10	U	U	5.8	B	J	10	U	U	53.16	53.16
Vanadium	µg/L	N	50	U	U	50	U	U	0.79	B	J	0.00	193.78
Zinc	µg/L	N	4.5	B	J	5.2	B	J	20	U	U	14.43	117.46
Zinc	µg/L	Y	4.2	B	J	20	U	U	20	U	U	130.58	0.00
Bis(2-ethylhexyl)phthalate	µg/L	N	10	U	U	2.5	J	J	5.1	U	U	120.00	68.42
Benzene	µg/L	N	0.21	J	J	0.18	J	J	1	U	U	15.38	138.98
Carbon disulfide	µg/L	N	0.19	J	B	0.22	J	B	2	U	U	14.63	160.36
Toluene	µg/L	N	0.11	J	B	1	U	U	2	U	U	160.36	66.67

RPD > 30%
FD - Field duplicate.
FS - Field split.
µg/L - Micrograms per liter.
N - No.
Y - Yes.
Qual - Qualifier.
REG - Regular.
ValQual - Validation qualifier.

Table K-4

Summary of Data Validation Reason Codes
Plum Brook Ordnance Works
Sandusky, Ohio

Reason Code	Description
01	Sample received outside of 4+/-2 degrees Celsius
01A	Improper sample preservation
02	Holding Time Exceeded
02A	Extraction
02B	Analysis
03	Instrument Performance - Outside Criteria
03A	BFB
03B	DFTPP
03C	DDT and/or Endrin % breakdown exceeds criteria
03D	retention time windows
03E	Resolution
04	Initial Calibration results outside specified criteria
04A	Compound mean RRF<0.05
04B	Compound %RSD>30
04C	Correlation Coefficient<0.995
05	Continuing Calibration results outside specified criteria
05A	Compound mean RRF<0.05
05B	Compound %D>25
06	Result qualified as a result of the 5x/10x blank correction
06A	Method or Preparation Blank
06B	ICB or CCB
06C	ER
06D	TB
06E	FB
07	Surrogate Recoveries outside control limits
07A	Sample
07B	Associated method blank or LCS
08	MS/MSD/Duplicate results outside criteria
08A	MS and/or MSD recovery not within control limits (accuracy)
08B	%RPD outside acceptance criteria (precision)
09	Post Digestion Spike outside criteria (GFAA)
10	Internal Standards outside specified control limits
10A	Recovery
10B	Retention Time
11	Laboratory Control Sample recoveries outside specified control limits
11A	Recovery
11B	%RPD (if run in duplicate)
12	Interference Check Standard
13	Serial Dilution
14	Tentatively Identified Compounds
15	Quantitation
16	Multiple results available; alternate analysis preferred
17	Field duplicate RPD criteria exceeded
18	Percent difference between original and second column > 25%
19	Professional judgement was used to qualify the data
20	Pesticide clean-up checks
21	Target compound identification
22	Radiological calibration
23	Radiological quantitation
24	Reported result and/or lab qualifier revised to reflect validation findings
999	See hard copy for details.

Table K-5

Summary of Data Validation Qualifiers Assigned and Reason Codes for Qualification
Former Plum Brook Ordnance Works
Sandusky, Ohio

Sample Delivery Group	Sanple Number	Filtered	Analysis	Parameter	Reason Codes (1,2)			
					VQ	R1	R2	R3
H4H270215	DH3000	N	Cyanide	Cyanide, total	UJ	01A	08A	
H4H270215	DH3000	N	Metals	Aluminum	B	06B	08A	15
H4H270215	DH3000	N	Metals	Manganese	J	15		
H4H270215	DH3000	N	Metals	Selenium	B	06B	15	
H4H270215	DH3000	N	Metals	Zinc	J	15		
H4H270215	DH3000	N	Nitrate	Nitrate	UJ	08A		
H4H270215	DH3000	N	Semivolatiles	Phenanthrene	J	15		
H4H270215	DH3000	N	Semivolatiles	Phenol	J	15		
H4H270215	DH3000	N	Volatiles	Acetone	R	04A	05A	
H4H270215	DH3000	N	Volatiles	Benzene	J	15		
H4H270215	DH3000	N	Volatiles	Butanone, 2-	R	04A	05A	
H4H270215	DH3000	N	Volatiles	Carbon disulfide	J	15		
H4H270215	DH3000	N	Volatiles	Methyl-2-pentanone, 4-	R	04A	05A	
H4H270215	DH3000	Y	Metals	Aluminum	B	06B	15	
H4H270215	DH3000	Y	Metals	Manganese	J	15		
H4H270215	DH3000	Y	Metals	Potassium	J	13		
H4H270215	DH3000	Y	Metals	Thallium	J	15		
H4H270215	DH3000	Y	Metals	Zinc	J	15		
H4H260300	DH3001	N	Cyanide	Cyanide, total	UJ	08A		
H4H260300	DH3001	N	Metals	Aluminum	B	06B	08A	15
H4H260300	DH3001	N	Metals	Manganese	J	15		
H4H260300	DH3001	N	Metals	Nickel	B	06B	15	
H4H260300	DH3001	N	Nitrate	Nitrate	UJ	08A		
H4H260300	DH3001	N	Semivolatiles	Naphthalene	J	15		
H4H260300	DH3001	N	Semivolatiles	Phenanthrene	J	15		
H4H260300	DH3001	N	Volatiles	Acetone	R	04A	05A	05B
H4H260300	DH3001	N	Volatiles	Butanone, 2-	R	04A	05A	05B
H4H260300	DH3001	N	Volatiles	Carbon disulfide	J	15		
H4H260300	DH3001	N	Volatiles	Hexanone, 2-	UJ	05B		
H4H260300	DH3001	N	Volatiles	Methyl-2-pentanone, 4-	R	04A	05A	
H4H260300	DH3001	Y	Metals	Aluminum	B	06B	15	
H4H260300	DH3001	Y	Metals	Copper	J	15		
H4H260300	DH3001	Y	Metals	Manganese	J	15		
H4H260300	DH3001	Y	Metals	Nickel	B	06B	15	
H4H260300	DH3001	Y	Metals	Potassium	J	13		
H4H260300	DH3001	Y	Metals	Selenium	J	15		
H4H260300	DH3001	Y	Metals	Thallium	J	15		
H4H270215	DH3002	N	Cyanide	Cyanide, total	UJ	08A		
H4H270215	DH3002	N	Metals	Aluminum	J	08A		
H4H270215	DH3002	N	Metals	Nickel	B	06B	15	
H4H270215	DH3002	N	Metals	Potassium	J	15		
H4H270215	DH3002	N	Metals	Thallium	J	15		
H4H270215	DH3002	N	Metals	Zinc	J	15		
H4H270215	DH3002	N	Nitrate	Nitrate	UJ	08A		
H4H270215	DH3002	N	Volatiles	Acetone	R	04A	05A	
H4H270215	DH3002	N	Volatiles	Benzene	J	15		

Table K-5

Summary of Data Validation Qualifiers Assigned and Reason Codes for Qualification
Former Plum Brook Ordnance Works
Sandusky, Ohio

Sample Delivery Group	Sanple Number	Filtered	Analysis	Parameter	Reason Codes (1,2)			
					VQ	R1	R2	R3
H4H270215	DH3002	N	Volatiles	Butanone, 2-	R	04A	05A	
H4H270215	DH3002	N	Volatiles	Carbon disulfide	B	06D	15	
H4H270215	DH3002	N	Volatiles	Methyl-2-pentanone, 4-	R	04A	05A	
H4H270215	DH3002	N	Volatiles	Toluene	B	06D	15	
H4H270215	DH3002	Y	Metals	Aluminum	B	06B	15	
H4H270215	DH3002	Y	Metals	Potassium	J	13	15	
H4H270215	DH3002	Y	Metals	Zinc	J	15		
H4H260300	DH3003	N	Cyanide	Cyanide, total	UJ	08A		
H4H260300	DH3003	N	Explosives	Nitrotoluene, 2-	J	15		
H4H260300	DH3003	N	Metals	Aluminum	J	08A		
H4H260300	DH3003	N	Metals	Arsenic	J	15		
H4H260300	DH3003	N	Metals	Barium	J	15		
H4H260300	DH3003	N	Metals	Zinc	J	15		
H4H260300	DH3003	N	Nitrate	Nitrate	UJ	08A		
H4H260300	DH3003	N	Semivolatiles	Methylnaphthalene, 2-	J	15		
H4H260300	DH3003	N	Semivolatiles	Naphthalene	J	15		
H4H260300	DH3003	N	Volatiles	Acetone	R	04A	05A	05B
H4H260300	DH3003	N	Volatiles	Benzene	J	15		
H4H260300	DH3003	N	Volatiles	Butanone, 2-	R	04A	05A	05B
H4H260300	DH3003	N	Volatiles	Carbon disulfide	J	15		
H4H260300	DH3003	N	Volatiles	Hexanone, 2-	UJ	05B		
H4H260300	DH3003	N	Volatiles	Methyl-2-pentanone, 4-	R	04A	05A	
H4H260300	DH3003	Y	Metals	Arsenic	B	06B	15	
H4H260300	DH3003	Y	Metals	Barium	J	15		
H4H260300	DH3003	Y	Metals	Potassium	J	13		
H4H260300	DH3003	Y	Metals	Thallium	J	15		
H4H260300	DH3003	Y	Metals	Zinc	J	15		
H4H280124	DH3004	N	Metals	Aluminum	J	08A		
H4H280124	DH3004	N	Metals	Barium	J	15		
H4H280124	DH3004	N	Metals	Thallium	J	15		
H4H280124	DH3004	N	Metals	Vanadium	J	15		
H4H280124	DH3004	N	Metals	Zinc	J	15		
H4H280124	DH3004	N	Volatiles	Acetone	J	04A	05A	15
H4H280124	DH3004	N	Volatiles	Benzene	J	15		
H4H280124	DH3004	N	Volatiles	Butanone, 2-	R	04A	05A	
H4H280124	DH3004	N	Volatiles	Carbon disulfide	J	15		
H4H280124	DH3004	N	Volatiles	Ethylbenzene	J	15		
H4H280124	DH3004	N	Volatiles	Methyl-2-pentanone, 4-	R	04A	05A	
H4H280124	DH3004	N	Volatiles	Toluene	J	15		
H4H280124	DH3004	Y	Metals	Aluminum	B	06B	15	
H4H280124	DH3004	Y	Metals	Barium	J	15		
H4H280124	DH3004	Y	Metals	Potassium	J	13		
H4H280124	DH3004	Y	Metals	Vanadium	J	15		
H4H280124	DH3004	Y	Metals	Zinc	J	15		
H4H270215	DH3005	N	Metals	Aluminum	J	08A		
H4H270215	DH3005	N	Metals	Potassium	J	15		

Table K-5

Summary of Data Validation Qualifiers Assigned and Reason Codes for Qualification
Former Plum Brook Ordnance Works
Sandusky, Ohio

Sample Delivery Group	Sanple Number	Filtered	Analysis	Parameter	Reason Codes (1,2)			
					VQ	R1	R2	R3
H4H270215	DH3005	N	Metals	Thallium	J	15		
H4H270215	DH3005	N	Metals	Zinc	J	15		
H4H270215	DH3005	N	Semivolatiles	Bis(2-ethylhexyl)phthalat	J	15		
H4H270215	DH3005	N	Semivolatiles	Dinitro-2-methylphenol, 4	UJ	05B		
H4H270215	DH3005	N	Semivolatiles	Dinitrophenol, 2,4-	UJ	05B		
H4H270215	DH3005	N	Volatiles	Benzene	J	15		
H4H270215	DH3005	N	Volatiles	Butanone, 2-	R	04A	05A	
H4H270215	DH3005	N	Volatiles	Carbon disulfide	B	06D	15	
H4H270215	DH3005	N	Volatiles	Methyl-2-pentanone, 4-	R	04A	05A	
H4H270215	DH3005	N	Volatiles	Xylenes, total	UJ	05B		
H4H270215	DH3005	Y	Metals	Aluminum	B	06B	15	
H4H270215	DH3005	Y	Metals	Potassium	J	13	15	
H4H270215	DH3005	Y	Metals	Thallium	J	15		
F26367	DH3006	N	Metals	Iron	J	15		
F26367	DH3006	N	Metals	Nickel	J	15		
F26367	DH3006	N	Metals	Potassium	J	15		
F26367	DH3006	N	Metals	Vanadium	J	15		
F26367	DH3006	N	Volatiles	Dichloropropene, trans-1	UJ	08A		
F26367	DH3006	N	Volatiles	Styrene	UJ	08B		
F26367	DH3006	Y	Metals	Aluminum	B	06B	15	
F26367	DH3006	Y	Metals	Potassium	J	15		
H4H280124	DH3007	N	Cyanide	Cyanide, total	UJ	08A		
H4H280124	DH3007	N	Metals	Aluminum	J	08A		
H4H280124	DH3007	N	Metals	Barium	J	15		
H4H280124	DH3007	N	Metals	Potassium	J	15		
H4H280124	DH3007	N	Metals	Selenium	B	06B	15	
H4H280124	DH3007	N	Volatiles	Acetone	R	04A	05A	
H4H280124	DH3007	N	Volatiles	Butanone, 2-	R	04A	05A	
H4H280124	DH3007	N	Volatiles	Carbon disulfide	J	15		
H4H280124	DH3007	N	Volatiles	Ethylbenzene	J	15		
H4H280124	DH3007	N	Volatiles	Methyl-2-pentanone, 4-	R	04A	05A	
H4H280124	DH3007	N	Volatiles	Toluene	J	15		
H4H280124	DH3007	N	Volatiles	Xylenes, total	J	15		
H4H280124	DH3007	Y	Metals	Aluminum	B	06B	15	
H4H280124	DH3007	Y	Metals	Barium	J	15		
H4H280124	DH3007	Y	Metals	Iron	J	15		
H4H280124	DH3007	Y	Metals	Potassium	J	13	15	
H4H280124	DH3007	Y	Metals	Zinc	J	15		

Footnotes:

(1) Table K-4 defines all reason codes.

(2) Reason codes are assigned in order of their importance to the validation qualifiers with R1 being most important.

Definitions:

VQ = validation qualifier

Table K-6

Laboratory and Validation Qualifier Definitions
Former Plum Brook Ordnance Works
Sandusky, Ohio

Qualifier	Definition
Laboratory - Organic	
B	The compound was detected in the sample and in an associated method blank.
G	Elevated reporting limit due to matrix interference.
I	Matrix interference.
J	The compound was positively identified; the reported value is an estimated concentration between the method detection limit and the reporting limit.
U	Not detected. The compound was analyzed for, but not detected above the associated reporting limit.
Laboratory - Inorganic	
B	The analyte was positively identified; the reported value is an estimated concentration between the method detection limit and the reporting limit.
J	The compound was detected in the sample and in an associated method blank.
G	Elevated reporting limit due to matrix interference.
U	Not detected. The analyte was analyzed for, but not detected above the associated reporting limit.
Validation - All	
B	The analyte was not detected significantly above the levels found in the associated method blank or field blanks
J	The compound/analyte was positively identified; the reported value is an estimated concentration.
R	Rejected due to severe deficiencies in the analytical process or supporting quality control data. The presence or absence of the compound/analyte cannot be verified.
U	Not detected. The compound/analyte was analyzed for, but not detected above the associated reporting limit.
UJ	Not detected. The associated reporting limit may be inaccurate or imprecise.

APPENDIX L

CHAINS-OF-CUSTODY

H4C100133

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ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB03 09 04STL-K

PAGE 1 OF 1

Project Name/No: PBOW
Sample Team Member: David Kessler
Profit Center: Knoxville
Project Manager: Steve Downey
Project No.: 843656
Required Report Date: 21 DAYS

Sample Shipment Date: 3/9/04
Laboratory Destination: STL- Knoxville
Laboratory Contact: Jamie McKinney
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: 833154266841

Bill To: Accounting
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Report To: Maureen McMyler
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DE3004	WATER	3/9/04 1410	2 - Amber	1 L	Cool	Explosives by 8330		
			1 - HDPE	250 mL	HNO3 ph2	Total TAL Metals by 6010B/7470A		
			1 - HDPE	250 mL	HNO3 ph2	Dissolved TAL Metals by 6010B/7470A		
			2 - Amber	1 L	Cool	TCL SVOCs by 8270C		
			3 - Glass	40 mL	HCL	TCL VOCs by 8260B		
			1 - HDPE	1 L	NaOH ph12	Cyanide by 9010/9012		
	WATER		2 - Amber	1 L	Cool	Explosives by 8330		
			1 - HDPE	250 mL	HNO3	Total TAL Metals by 6010B/7470A		
			1 - HDPE	250 mL	HNO3	Dissolved TAL Metals by 6010B/7470A	DKK	
			2 - Amber	1 L	Cool	TCL SVOCs by 8270C		
			3 - Glass	40 mL	HCL	TCL VOCs by 8260B		
			1 - HDPE	1 L	NaOH	Cyanide by 9010/9012		
	WATER		2 - Amber	1 L	Cool	Explosives by 8330		
			1 - HDPE	250 mL	HNO3	Total TAL Metals by 6010B/7470A		
			1 - HDPE	250 mL	HNO3	Dissolved TAL Metals by 6010B/7470A		
			2 - Amber	1 L	Cool	TCL SVOCs by 8270C	DKK	
			3 - Glass	40 mL	HCL	TCL VOCs by 8260B		
			1 - HDPE	1 L	NaOH	Cyanide by 9010/9012		
DE5003	WATER	3/9/04	2 - Glass	40 mL	HCL	TCL VOCs by 8260B		

Special Instructions:

Possible Hazard Identification:
Non-haz: X Flammable: ___ Poison B: ___ Unknown: ___

Sample Disposal:
Return to Client: ___ Disposal by Lab: X Archive: ___

Turnaround Time:
Normal: X Rush: ___

Level of QC Required:
Definitive: X Project Specific: ___

1. Relinquished by: David Kessler	Date: 3/9/04 Time: 1800	1. Received by: Andrew D. Flora	Date: 03-10-04 Time: 09:00
2. Relinquished by:	Date: Time:	2. Received by:	Date: Time:
3. Relinquished by:	Date: Time:	2. Received by:	Date: Time:

Comments: Custody Seals Intact Received Temp. 2°C 1 COOLER/ FEDEX TH 833154266841 ADF 03-10-04

Shaw™
Shaw E & I, Inc.

ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB03 09 04STL-NC ~~KK~~

PAGE 1 OF 1

Project Name/No: PBOW/843656
Sample Team Member: David Kessler
Profit Center: Knoxville
Project Manager: Steve Downey
Project No.: 843656
Required Report Date: 21 days

Sample Shipment Date: 3/9/04
Laboratory Destination: STL-North Canton
Laboratory Contact: Ken Kuzior
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: ~~823154266211~~ DKK
827069095332

Bill To: Accounting
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Report To: Maureen McMyler
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DE3004	WATER	3/9/04 1410	2 - Glass	40 mL	H2SO4	TOC by 9060		
			1 - HDPE	1000 mL	Cool	Alkalinity by 310.1; Chloride by 325.2		
						Nitrate by 353.2; Sulfate by 375.4		
						TDS by 160.1; TSS by 160.2		
						Turbidity by 180.1		
			1 - HDPE	250 mL	HNO3	Hardness by 130.2		
	WATER		2 - Glass	40 mL	H2SO4	TOC by 9060		
			1 - HDPE	1000 mL	Cool	Alkalinity by 310.1; Chloride by 325.2		
						Nitrate by 353.2; Sulfate by 375.4	DKK	
						~~TDS by 160.1; TSS by 160.2~~		
						Turbidity by 180.1		
			1 - HDPE	250 mL	HNO3	Hardness by 130.2		
	WATER		2 - Glass	40 mL	H2SO4	TOC by 9060		
			1 - HDPE	1000 mL	Cool	Alkalinity by 310.1; Chloride by 325.2		
						Nitrate by 353.2; Sulfate by 375.4	DKK	
						TDS by 160.1; TSS by 160.2		
						Turbidity by 180.1		
			1 - HDPE	250 mL	HNO3	Hardness by 130.2		
							DKK	

Special Instructions:

Possible Hazard Identification:
Non-haz: X Flammable: ___ Poison B: ___ Unknown: ___

Sample Disposal:
Return to Client: ___ Disposal by Lab: X Archive: ___

Turnaround Time:
Normal: X Rush: ___

Level of QC Required:
Definitive: X Project Specific: ___

1. Relinquished by: David Kessler	Date: 3/9/04 Time: 1800	1. Received by:	Date: 3/10/04 Time: 0745
2. Relinquished by:	Date: Time:	2. Received by:	Date: Time:
3. Relinquished by:	Date: Time:	2. Received by:	Date: Time:

Comments:

HHC110113

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ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB03 10 04STL-K

PAGE 1 OF 1

Project Name/No: PBOW
Sample Team Member: David Kessler
Profit Center: Knoxville
Project Manager: Steve Downey
Project No.: 843656
Required Report Date: 21 DAYS

Sample Shipment Date: 3.10.04
Laboratory Destination: STL- Knoxville
Laboratory Contact: Jamie McKinney
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: 835302112909

Bill To: Accounting
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Report To: Maureen McMyler
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DE3005	WATER	3.10.04 1015	1 - Amber	1 L	Cool	Explosives by 8830	Custody Seals Intact	
			1 - HDPE	250 mL	HNO3 pH2	Total TAL Metals by 6010B/7470A	Received Temp. 2°C	
			1 - HDPE	250 mL	HNO3 pH2	Dissolved TAL Metals by 6010B/7470A	1 COOLER / Fedex	
			2 - Amber	1 L	Cool	TCL SVOCs by 8270C	T#835302112909	
			3 - Glass	40 mL	HCL	TCL VOCs by 8260B	~~ADF 03-11-04~~ ADF 03-11-04	
			1 - HDPE	1 L	NaOH pH12	Cyanide by 9010/9012	ADF	03-11-04
DE3002	WATER	3.10.04 1305	1 - Amber	1 L	Cool	Explosives by 8830		
			1 - HDPE	250 mL	HNO3 pH2	Total TAL Metals by 6010B/7470A		
			1 - HDPE	250 mL	HNO3 pH2	Dissolved TAL Metals by 6010B/7470A		
			2 - Amber	1 L	Cool	TCL SVOCs by 8270C		
			3 - Glass	40 mL	HCL	TCL VOCs by 8260B		
			1 - HDPE	1 L	NaOH pH12	Cyanide by 9010/9012		
DE3001	WATER	3.10.04 1525	1 - Amber	1 L	Cool	Explosives by 8830	3/4 full	
			1 - HDPE	250 mL	HNO3 pH2	Total TAL Metals by 6010B/7470A		
			1 - HDPE	250 mL	HNO3 pH2	Dissolved TAL Metals by 6010B/7470A		
			1 - Amber	1 L	Cool	TCL SVOCs by 8270C		
			3'- Glass	40 mL	HCL	TCL VOCs by 8260B		
			1 - HDPE	1 L	NaOH pH12	Cyanide by 9010/9012	3/4 full	
DE3004	WATER	NA	2 - Glass	40 mL	HCL	TCL VOCs by 8260B		

Special Instructions:

Possible Hazard Identification:
Non-haz: X Flammable: ___ Poison B: ___ Unknown: ___

Sample Disposal:
Return to Client: ___ Disposal by Lab: X Archive: ___

Turnaround Time:
Normal: X Rush: ___

Level of QC Required:
Definitive: X Project Specific: ___

1. Relinquished by: David Kessler	Date: 3/10/04 Time: 1800	1. Received by: Andrew D. Flores	Date: 03-11-04 Time: 09:00
2. Relinquished by:	Date: Time:	2. Received by:	Date: Time:
3. Relinquished by:	Date: Time:	2. Received by:	Date: Time:

Comments:

200

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Shaw E & I, Inc.

ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB03 10 04STL-NC

PAGE 1 OF 1

Project Name/No: PBOW/843656
Sample Team Member: David Kessler
Profit Center: Knoxville
Project Manager: Steve Downey
Project No.: 843656
Required Report Date: 21 days

Sample Shipment Date: 3.10.04
Laboratory Destination: STL-North Canton
Laboratory Contact: Ken Kuzior
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: 835302112894

Bill To: Accounting
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Report To: Maureen McMyler
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DE3005	WATER	3.10.04 1015	2 - Glass	40 mL	H2SO4	TOC by 9060		
			1 - HDPE	1000 mL	Cool	Alkalinity by 310.1; Chloride by 325.2 Nitrate by 353.2; Sulfate by 375.4 TDS by 160.1; TSS by 160.2 Turbidity by 180.1		
			1 - HDPE	250 mL	HNO3	Hardness by 130.2		
DE3002	WATER	3.10.04 1305	2 - Glass	40 mL	H2SO4	TOC by 9060		
			1 - HDPE	1000 mL	Cool	Alkalinity by 310.1; Chloride by 325.2 Nitrate by 353.2; Sulfate by 375.4 TDS by 160.1; TSS by 160.2 Turbidity by 180.1		
			1 - HDPE	250 mL	HNO3	Hardness by 130.2		
DE3001	WATER	3.10.04 1525	2 - Glass	40 mL	H2SO4	TOC by 9060		
			1 - HDPE	1000 mL	Cool	Alkalinity by 310.1; Chloride by 325.2 Nitrate by 353.2; Sulfate by 375.4 TDS by 160.1; TSS by 160.2 Turbidity by 180.1		
			1 - HDPE	250 mL	HNO3	Hardness by 130.2		
						DKK		

Special Instructions:

Possible Hazard Identification:
Non-haz: X Flammable: ___ Poison B: ___ Unknown: ___

Sample Disposal:
Return to Client: ___ Disposal by Lab: X Archive: ___

Turnaround Time:
Normal: X Rush: ___

Level of QC Required:
Definitive: X Project Specific: ___

1. Relinquished by: David Kessler	Date: 3/10/04 Time: 1800	1. Received by: Danny Burns	Date: 3/11/04 Time: 9:30
2. Relinquished by:	Date: Time:	2. Received by:	Date: Time:
3. Relinquished by:	Date: Time:	2. Received by:	Date: Time:

Comments:

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ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD #4C120129

REFERENCE COC NO.: PB03 11 04STL-K

PAGE 1 OF 2

Project Name/No: PBOW
Sample Team Member: David Kessler
Profit Center: Knoxville
Project Manager: Steve Downey
Project No.: 843656
Required Report Date: 21 DAYS

Sample Shipment Date: 3/11/04
Laboratory Destination: STL- Knoxville
Laboratory Contact: Jamie McKinney
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: 835302112861

Bill To: Accounting
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Report To: Maureen McMyler
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DE3003	WATER	3.11.04 0915	1 - Amber	1 L	Cool	Explosives by 8330	Custody Seals Intact	
			1 - HDPE	250 mL pH2	HNO3	Total TAL Metals by 6010B/7470A	Received Temp. 2°c	
			1 - HDPE	250 mL pH2	HNO3	Dissolved TAL Metals by 6010B/7470A	3 COOLERS / FEDEX	
			2 - Amber	1 L	Cool	TCL SVOCs by 8270C	T#835302112861	
			3 - Glass	40 mL	HCL	TCL VOCs by 8260B	ADF 03-12-04	
			1 - HDPE	1 L pH12	NaOH	Cyanide by 9010/9012		
DE3003-MS	WATER	3.11.04 0915	1 - Amber	1 L	Cool	Explosives by 8330		
			1 - HDPE	250 mL pH2	HNO3	Total TAL Metals by 6010B/7470A		
			1 - HDPE	250 mL pH2	HNO3	Dissolved TAL Metals by 6010B/7470A		
			2 - Amber	1 L	Cool	TCL SVOCs by 8270C		
			3 - Glass	40 mL	HCL	TCL VOCs by 8260B		
			1 - HDPE	1 L pH12	NaOH	Cyanide by 9010/9012		
~~DE3003-MSD~~	~~WATER~~		~~2 - Glass~~	~~40 mL~~	~~HCL~~	~~TCL VOCs by 8260B~~	DLK 3/11/04	
DE3003-MSD	WATER	3/11/04 0915	1-Amber	1L	Cool	Explosives by 8330		
			1-HDPE	250ml pH2	HNO_3	Total TAL Metals by 6010B/7470A		
			1-HDPE	250ml pH2	HNO_3	Dissolved TAL Metals by 6010B/7470A		
			2-Amber	1L	Cool	TCL SVOCs by 8270C		
			3-Glass	40ml	HCL	TCL VOCs by 8260B		
DE5002	TRIP	3/11/04	2-Glass	40ml	HCL	TCL VOCs by 8260B		

Special Instructions:

Possible Hazard Identification: DE3003-MSD → 1-HDPE 1L pH12 NAOH Cyanide by 9010/9012

Sample Disposal:

Non-haz: X Flammable: ___ Poison B: ___ Unknown: ___

Return to Client ___ Disposal by Lab. X Archive: ___

Turnaround Time:

Normal: X Rush: ___

Level of QC Required:

Definitive: X Project Specific: ___

1. Relinquished by: David Kessler	Date: 3/11/04 Time: 1800	1. Received by: Andrew D. Flores	Date: 03-12-04 Time: 09:10
2. Relinquished by:	Date: Time:	2. Received by:	Date: Time:
3. Relinquished by:	Date: Time:	2. Received by:	Date: Time:

Comments:

page 2 of 2

~~HHCB~~ HHC120129
MFH 3-12-04

Shaw™
Shaw E & I, Inc.

ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB03 11 04STL-K

PAGE 2 OF 2

Project Name/No: PBOW
Sample Team Member: David Kessler
Profit Center: Knoxville
Project Manager: Steve Downey
Project No.: 843656
Required Report Date: 21 DAYS

Sample Shipment Date: 3/11/04
Laboratory Destination: STL- Knoxville
Laboratory Contact: Jamie McKinney
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: 853021128 61

Bill To: Accounting
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Report To: Maureen McMyler
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DE 3006	WATER	3/11/04 0915	2 - Amber	1 L	Cool	Explosives by 8830		
			1 - HDPE	250 mL pH2	HNO3	Total TAL Metals by 6010B/7470A		
			1 - HDPE	250 mL pH2	HNO3	Dissolved TAL Metals by 6010B/7470A		
			2 - Amber	1 L	Cool	TCL SVOCs by 8270C		
			3 - Glass	40 mL	HCL	TCL VOCs by 8260B		
			1 - HDPE	1 L	NaOH	Cyanide by 9010/9012		
DE 3000	WATER	3/11/04 1405	2 - Amber	1 L	Cool	Explosives by 8830		
			1 - HDPE	250 mL pH2	HNO3	Total TAL Metals by 6010B/7470A		
			1 - HDPE	250 mL pH2	HNO3	Dissolved TAL Metals by 6010B/7470A		
			2 - Amber	1 L	Cool	TCL SVOCs by 8270C		
			3 - Glass	40 mL	HCL	TCL VOCs by 8260B		
			1 - HDPE	1 L pH12	NaOH	Cyanide by 9010/9012		
	WATER		2 - Glass	40 mL	HCL	TCL VOCs by 8260B		
	DKK 3/11/04							

Special Instructions:

Possible Hazard Identification:
Non-haz: X Flammable: ___ Poison B: ___ Unknown: ___

Sample Disposal:
Return to Client: ___ Disposal by Lab: X Archive: ___

Turnaround Time:
Normal: X Rush: ___

Level of QC Required.
Definitive: X Project Specific: ___

1. Relinquished by: David Kessler	Date: 3/11/04 Time: 1600	1. Received by: Andrew D. Flores	Date: 03-12-04 Time: 09:10
2. Relinquished by:	Date: Time:	2. Received by:	Date: Time:
3. Relinquished by:	Date: Time:	2. Received by:	Date: Time:

Comments:

page 1 of 2

Shaw™
Shaw E & I, Inc.

ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB03 U 04STL-NC

PAGE 1 OF 2

Project Name/No: PBOW/843656
Sample Team Member: David Kessler
Profit Center: Knoxville
Project Manager: Steve Downey
Project No.: 843656
Required Report Date: 21 days

Sample Shipment Date: 3/11/04
Laboratory Destination: STL-North Canton
Laboratory Contact: Ken Kuzior
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: 835302112872

Bill To: Accounting
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Report To: Maureen McMyler
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DE3003	WATER	3.11.04 0915	2 - Glass	40 mL	H2SO4	TOC by 9060		
			1 - HDPE	1000 mL	Cool	Alkalinity by 310.1; Chloride by 325.2		
						Nitrate by 353.2; Sulfate by 375.4		
						TDS by 160.1; TSS by 160.2		
						Turbidity by 180.1		
			1 - HDPE	250 mL	HNO3	Hardness by 130.2		
DE3003-MS	WATER	3.11.04 0915	2 - Glass	40 mL	H2SO4	TOC by 9060		
			1 - HDPE	1000 mL	Cool	Alkalinity by 310.1; Chloride by 325.2		
						Nitrate by 353.2; Sulfate by 375.4		
						TDS by 160.1; TSS by 160.2		
						Turbidity by 180.1		
			1 - HDPE	250 mL	HNO3	Hardness by 130.2		
DE3003-MSD	water	3/11/04 0915	2-Glass	40mL	H_2SO_4	TOC by 9060		
			1-HDPE	1000mL	Cool	Alkalinity by 310.1; Chloride by 325.2		
						Nitrate by 353.2; Sulfate by 375.4		
						TDS by 160.1; TSS by 160.2		
						Turbidity by 180.1		
			1-HDPE	250mL	HNO_3	Hardness by 130.2		
							DLR 3/11/04	

Special Instructions:

Possible Hazard Identification:
Non-haz: X Flammable: ___ Poison B: ___ Unknown: ___

Sample Disposal:
Return to Client: ___ Disposal by Lab: X Archive: ___

Turnaround Time:
Normal: X Rush: ___

Level of QC Required:
Definitive: X Project Specific: ___

1. Relinquished by: David Kessler Date: 3/11/04 Time: 1800
2. Relinquished by: Date: Time:
3. Relinquished by: Date: Time:

1. Received by: Natalie J Bunker Date: 3-12-04 Time: 9:40
2. Received by: Date: Time:
2. Received by: Date: Time:

Comments:

Shaw™
Shaw E & I, Inc.

ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB03 11 04STL-NE 2

PAGE 2 OF 2

Project Name/No: PBOW/843656
Sample Team Member: David Kessler
Profit Center: Knoxville
Project Manager: Steve Downey
Project No.: 843656
Required Report Date: 21 days

Sample Shipment Date: 3/11/04
Laboratory Destination: STL-North Canton
Laboratory Contact: Ken Kuzior
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: 835302112872

Bill To: Accounting
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Report To: Maureen McMyler
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DE3006	WATER	3/11/04 0915	2 - Glass	40 mL	H2SO4	TOC by 9060		
			1 - HDPE	1000 mL	Cool	Alkalinity by 310.1; Chloride by 325.2		
						Nitrate by 353.2; Sulfate by 375.4		
						TDS by 160.1; TSS by 160.2		
						Turbidity by 180.1		
			1 - HDPE	250 mL	HNO3	Hardness by 130.2		
DE3000	WATER	3/11/04 1405	2 - Glass	40 mL	H2SO4	TOC by 9060		
			1 - HDPE	1000 mL	Cool	Alkalinity by 310.1; Chloride by 325.2		
						Nitrate by 353.2; Sulfate by 375.4		
						TDS by 160.1; TSS by 160.2		
						Turbidity by 180.1		
			1 - HDPE	250 mL	HNO3	Hardness by 130.2		
		DKK 3/11/04						

Special Instructions:

Possible Hazard Identification:
Non-haz: X Flammable: ___ Poison B: ___ Unknown: ___

Sample Disposal:
Return to Client: ___ Disposal by Lab: X Archive: ___

Turnaround Time:
Normal: X Rush: ___

Level of QC Required:
Definitive: X Project Specific: ___

1. Relinquished by: David Kessler Date: 3/11/04 Time: 1800
2. Relinquished by: Date: Time:
3. Relinquished by: Date: Time:

1. Received by: Natalie Burkhart Date: 3-12-04 Time: 0940
2. Received by: Date: Time:
2. Received by: Date: Time:

Comments:

F23936

Shaw
Shaw E & I, Inc.

ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: FB05 05 04ACC

PAGE 1 OF 1

Project Name/No: FBOW
Sample Team Member: David Kessler
Profit Center: Knoxville
Project Manager: Steve Downey
Project No.: 843656
Required Report Date: 21 days

Sample Shipment Date: 5/5/04
Laboratory Destination: Accutest
Laboratory Contact: Sue Bell
Project Contact/Phone: Maureen McMyler/865-560-5271
Carrier Waybill No.: 8436 4375 8650

Bill To: Accounting
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Report To: Maureen McMyler
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
(1) DF3006	WATER	5/5/04 1520	1 - Amber	1 L	Cool	Explosives by 8330		
			2 - Amber	1 L	Cool	Semivolatiles by 8270C		
			3 - Vial	40 mL	HCl	Volatiles by 8260B		
			1 - HDPE	250 mL	HNO3	TAL Metals (Total) by 6010B/7471A		
			1 - HDPE	250 mL	HNO3	TAL Metals (Diss) by 6010B/7471A		
(2) DF5001	WATER	5/5/04	2 - Vial	40 mL	HCl	Volatiles by 8260B		

Special Instructions:

Possible Hazard Identification:
Non-haz: ___ Flammable: ___ Poison B: ___ Unknown: X

Sample Disposal:
Return to Client: ___ Disposal by Lab: X Archive: ___

Turnaround Time:
Normal: X Rush: ___

Level of QC Required:
Definitive: X Project Specific: ___

1. Relinquished by: David Kessler	Date: 5/5/04 Time: 1800	1. Received by: FX	Date: 5/6/04 Time: 09:45
2. Relinquished by: FX	Date: Time:	2. Received by: Carlos R	Date: Time:
3. Relinquished by:	Date: Time:	2. Received by:	Date: Time:

Comments:

4.1
4

F23936: Chain of Custody
Page 1 of 2

H4F160108

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ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB06 15 04STL-K

PAGE 1 OF 1

Project Name/No: PBOW
Sample Team Member: David Kessler
Profit Center: Knoxville
Project Manager: Steve Downey
Project No.: 843656
Required Report Date: 21 DAYS

Sample Shipment Date: 6/15/04
Laboratory Destination: STL- Knoxville
Laboratory Contact: Jamie McKinney
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: 827069095321

Bill To: Accounting
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Report To: Maureen McMyler
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DG3004	WATER	6/15/04 1330	1 - Amber	1 L	Cool	Explosives by 8330	Custody Seals Intact Received Temp 2°C 1 cooler/ FEDEX T# 827069095321 ADF 06-16-04	
			1 - HDPE	~~250~~ mL 125	HNO3 ph2	Total TAL Metals by 6010B/7470A		
			1 - HDPE	~~250~~ mL 125	HNO3 ph2	Dissolved TAL Metals by 6010B/7470A		
			2 - Amber	1 L	Cool	TCL SVOCs by 8270C		
			3 - Glass	40 mL	HCL	TCL VOCs by 8260B		
			1 - HDPE	1 L	NaOH ph12	Cyanide by 9010/9012		
DG5000	WATER	6/15/04	2 - Glass	40 mL	HCL	TCL VOCs by 8260B		

Special Instructions:

Possible Hazard Identification:
Non-haz: ___ Flammable: ___ Poison B: ___ Unknown: ___

Sample Disposal:
Return to Client: ___ Disposal by Lab: X Archive: ___

Turnaround Time:
Normal: X Rush: ___

Level of QC Required:
Definitive: X

Project Specific: ___

1. Relinquished by: David Kessler - Shaw — Date: 6/15/04 — Time: 1800
2. Relinquished by: ___ — Date: ___ — Time: ___
3. Relinquished by: ___ — Date: ___ — Time: ___

1. Received by: Andrew D. Flores — Date: 06-16-04 — Time: 09:15
2. Received by: ___ — Date: ___ — Time: ___
2. Received by: ___ — Date: ___ — Time: ___

Comments:

Shaw
Shaw E & I, Inc.

ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB06 15 04STL-C

PAGE 1 OF 1

Project Name/No: PBOW/843656
Sample Team Member: David Kessler
Profit Center: Knoxville
Project Manager: Steve Downey
Project No.: 843656
Required Report Date: 21 days

Sample Shipment Date: 6/15/04
Laboratory Destination: STL-North Canton
Laboratory Contact: Ken Kuzior
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: 827069095310

Bill To: Accounting
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Report To: Maureen McMyler
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DG3004	WATER	6/15/04 1330	2 - Glass	40 mL	H2SO4	TOC by 9060		
			1 - HDPE	1000 mL	Cool	Alkalinity by 310.1; Chloride by 325.2		
						Nitrate by 353.2; Sulfate by 375.4		
						TDS by 160.1; TSS by 160.2		
						Turbidity by 180.1		
			1 - HDPE	250 mL	HNO3	Hardness by 130.2		
DCK 6/15/04								

Special Instructions:

Possible Hazard Identification:
Non-haz: X Flammable: ___ Poison B: ___ Unknown: ___

Sample Disposal:
Return to Client: ___ Disposal by Lab: X Archive: ___

Turnaround Time:
Normal: X Rush: ___

Level of QC Required:
Definitive: X Project Specific: ___

1. Relinquished by: David Kessler - Shaw Date: 6/15/04 Time: 1800
2. Relinquished by: Date: Time:
3. Relinquished by: Date: Time:

1. Received by: Gerry Burns - STL Date: 6/16/04 Time: 9:50
2. Received by: Date: Time:
2. Received by: Date: Time:

Comments:

H4F170114

Shaw™
Shaw E & I, Inc.

ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB06 16 04STL-K

PAGE 1 OF 1

Project Name/No: PBOW
Sample Team Member: David Kessler
Profit Center: Knoxville
Project Manager: Steve Downey
Project No.: 843656
Required Report Date: 21 DAYS

Sample Shipment Date: 6/16/04
Laboratory Destination: STL- Knoxville
Laboratory Contact: Jamie McKinney
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: 839702939557

Bill To: Accounting
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Report To: Maureen McMyler
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DG3005	WATER	6/16/04 0955	1 - Amber	1 L	Cool	Explosives by 8330		
			1 - HDPE	~~250~~ mL 125	HNO3 pH2	Total TAL Metals by 6010B/7470A		
			1 - HDPE	~~250~~ mL 125	HNO3 pH2	Dissolved TAL Metals by 6010B/7470A	Custody Seals Intact	
			2 - Amber	1 L	Cool	TCL SVOCs by 8270C	Received Temp. 2°C	
			3 - Glass	40 mL	HCL	TCL VOCs by 8260B	1 COOLER / FEDEX	
			1 - HDPE	1 L	NaOH pH12	Cyanide by 9010/9012	TH 839702939557	
DG3006 2 OK	WATER	6/16/04 1330	1 - Amber	1 L	Cool	Explosives by 8330	ADF 06-17-04	
			1 - HDPE	~~250~~ mL 125	HNO3 pH2	Total TAL Metals by 6010B/7470A		
			1 - HDPE	~~250~~ mL 125	HNO3 pH2	Dissolved TAL Metals by 6010B/7470A	Preserved in lab	
			2 - Amber	1 L	Cool	TCL SVOCs by 8270C	with 1ml NaOH (Lot#X28055)	
			3 - Glass	40 mL	HCL	TCL VOCs by 8260B	per pm	
			1 - HDPE	1 L	NaOH pH9	Cyanide by 9010/9012	ADF 06-17-04	
DG3000	WATER	6/16/04 1600	1 - Amber	1 L	Cool	Explosives by 8330		
			1 - HDPE	~~250~~ mL 125	HNO3 pH2	Total TAL Metals by 6010B/7470A		
			1 - HDPE	~~250~~ mL 125	HNO3 pH2	Dissolved TAL Metals by 6010B/7470A		
			2 - Amber	1 L	Cool	TCL SVOCs by 8270C		
			3 - Glass	40 mL	HCL	TCL VOCs by 8260B		
			1 - HDPE	1 L	NaOH pH12	Cyanide by 9010/9012		
DG5001	WATER	6/16/04 —	2 - Glass	40 mL	HCL	TCL VOCs by 8260B		

Special Instructions:

Possible Hazard Identification:
Non-haz: X Flammable: ___ Poison B: ___ Unknown: ___

Sample Disposal:
Return to Client: ___ Disposal by Lab: X Archive: ___

Turnaround Time:
Normal: X Rush: ___

Level of QC Required:
Definitive: X Project Specific: ___

1. Relinquished by: David Kessler-Shaw	Date: 6/16/04 Time: 1800	1. Received by: Andrew D. Flores	Date: 06-17-04 Time: 09:15
2. Relinquished by:	Date: Time:	2. Received by:	Date: Time:
3. Relinquished by:	Date: Time:	2. Received by:	Date: Time:

Comments:

Shaw™
Shaw E & I, Inc.

ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB06 16 04STL-C

PAGE 1 OF 1

Project Name/No: PBOW/843656
Sample Team Member: David Kessler
Profit Center: Knoxville
Project Manager: Steve Downey
Project No.: 843656
Required Report Date: 21 days

Sample Shipment Date: 6/16/04
Laboratory Destination: STL-North Canton
Laboratory Contact: Ken Kuzior
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: 827069095300

Bill To: Accounting
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Report To: Maureen McMyler
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DG3005	WATER	6/16/04 0955	2 - Glass	40 mL	H2SO4	TOC by 9060		
			1 - HDPE	1000 mL	Cool	Alkalinity by 310.1; Chloride by 325.2 Nitrate by 353.2; Sulfate by 375.4 TDS by 160.1; TSS by 160.2 Turbidity by 180.1		
			1 - HDPE	250 mL	HNO3	Hardness by 130.2		
DG3002 DKK	WATER	6/16/04 1330	2 - Glass	40 mL	H2SO4	TOC by 9060		
			1 - HDPE	1000 mL	Cool	Alkalinity by 310.1; Chloride by 325.2 Nitrate by 353.2; Sulfate by 375.4 TDS by 160.1; TSS by 160.2 Turbidity by 180.1		
			1 - HDPE	250 mL	HNO3	Hardness by 130.2		
DG3000	WATER	6/16/04 1600	2 - Glass	40 mL	H2SO4	TOC by 9060		
			1 - HDPE	1000 mL	Cool	Alkalinity by 310.1; Chloride by 325.2 Nitrate by 353.2; Sulfate by 375.4 TDS by 160.1; TSS by 160.2 Turbidity by 180.1		
			1 - HDPE	250 mL	HNO3	Hardness by 130.2		

Special Instructions:

Possible Hazard Identification:
Non-haz: X Flammable: ___ Poison B: ___ Unknown: ___

Sample Disposal:
Return to Client: ___ Disposal by Lab: X Archive: ___

Turnaround Time:
Normal: X Rush: ___

Level of QC Required:
Definitive: X Project Specific: ___

1. Relinquished by: David Kessler - Shaw Date: 6/16/04 Time: 1800
2. Relinquished by: Date: Time:
3. Relinquished by: Date: Time:

1. Received by: Terry Bunn Date: 6/17/04 Time: 9:45
2. Received by: Date: Time:
2. Received by: Date: Time:

Comments:

H4F190139

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ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB06 17 04STL-K

PAGE 1 OF 2

Project Name/No: PBOW
Sample Team Member: David Kessler
Profit Center: Knoxville
Project Manager: Steve Downey
Project No.: 843656
Required Report Date: 21 DAYS

Sample Shipment Date: 6/17/04
Laboratory Destination: STL- Knoxville
Laboratory Contact: Jamie McKinney
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: 839702939568

Bill To: Accounting
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Report To: Maureen McMyler
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DG3003	WATER	6/17/04 0945	1 - Amber	1 L	Cool	Explosives by 8330		
			1 - HDPE	~~250 mL~~ DUP 125	HNO3	Total TAL Metals by 6010B/7470A PH<2		
			1 - HDPE	~~250 mL~~ DUP 125	HNO3	Dissolved TAL Metals by 6010B/7470A ↓	Custody Seals Intact	
			2 - Amber	1 L	Cool	TCL SVOCs by 8270C	Received Temp. 2°c	
			3 - Glass	40 mL	HCL	TCL VOCs by 8260B	1 cooler / FedEx	
			1 - HDPE	1 L	NaOH	Cyanide by 9010/9012 PH>12	T#839702939568	
DG3003-MS	WATER	6/17/04 0945	1 - Amber	1 L	Cool	Explosives by 8330	ADF 06-18-04	
			1 - HDPE	~~250 mL~~ MS 125	HNO3	Total TAL Metals by 6010B/7470A PH<2		
			1 - HDPE	~~250 mL~~ MS 125	HNO3	Dissolved TAL Metals by 6010B/7470A ↓	RECEIVED MISSING CONTAINERS	
			2 - Amber	1 L	Cool	TCL SVOCs by 8270C	ON 6-19-04 11:15 EXCEPT FOR	
			3 - Glass	40 mL	HCL	TCL VOCs by 8260B	DG3006 9012 BOTTLE	
			1 - HDPE	1 L	NaOH	Cyanide by 9010/9012 PH>12	RECEIVED AT 2°C	
DG3003-MSD	WATER	6/17/04 0945	1 - Amber	1 L	Cool	Explosives by 8330	CUSTODY SEALS INTACT	
			1 - HDPE	~~250 mL~~ MSD 125	HNO3	Total TAL Metals by 6010B/7470A PH<2	OKD 6-19-04	
			1 - HDPE	~~250 mL~~ MSD 125	HNO3	Dissolved TAL Metals by 6010B/7470A ↓	1 COOLER FEDEX #	
			2 - Amber	1 L	Cool	TCL SVOCs by 8270C	839702939568	
			3 - Glass	40 mL	HCL	TCL VOCs by 8260B		
DG5002	WATER	6/17/04	1 - HDPE	1 L	NaOH	Cyanide by 9010/9012 PH>12		
			2 - Glass	40 mL	HCL	TCL VOCs by 8260B		

Special Instructions:

Possible Hazard Identification:
Non-haz: X Flammable: ___ Poison B: ___ Unknown: ___

Sample Disposal:
Return to Client: ___ Disposal by Lab: X Archive: ___

Turnaround Time:
Normal: X Rush: ___

Level of QC Required:
Definitive: X Project Specific: ___

1. Relinquished by: David Kessler-Shaw Date: 6/17/04 Time: 1800
2. Relinquished by: Date: Time:
3. Relinquished by: Date: Time:

1. Received by: Andrew D. Flores Date: 6-18-04 Time: 09:15
2. Received by: Bryan Landrum Date: 6-19-04 Time: 11:15
2. Received by: Date: Time:

Comments:

H4F170139

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Shaw E & I, Inc.

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ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB06 17 04STL-K

PAGE 2 OF 2

Project Name/No: PBOW
Sample Team Member: David Kessler
Profit Center: Knoxville
Project Manager: Steve Downey
Project No.: 843656
Required Report Date: 21 DAYS

Sample Shipment Date: 6/17/04
Laboratory Destination: STL- Knoxville
Laboratory Contact: Jamie McKinney
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: 839702939568

Bill To: Accounting
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Report To: Maureen McMyler
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DG3006	WATER	6/17/04 0945	1 - Amber	1 L	Cool	Explosives by 8330		
			1 - HDPE	~~250 mL~~ 125	HNO3	Total TAL Metals by 6010B/7470A PH<2		
			1 - HDPE	~~250 mL~~ 125 DLK	HNO3	Dissolved TAL Metals by 6010B/7470A ↓		
			2 - Amber	1 L	Cool	TCL SVOCs by 8270C		
			3 - Glass	40 mL	HCL	TCL VOCs by 8260B		
			1 - HDPE	1 L	NaOH	Cyanide by 9010/9012		
DG 3001	WATER	6/17/04 1515 DLK	1 - Amber	1 L	Cool	Explosives by 8330		
			1 - HDPE	~~250 mL~~ 125	HNO3	Total TAL Metals by 6010B/7470A PH<2		
			1 - HDPE	~~250 mL~~ 125 DLK	HNO3	Dissolved TAL Metals by 6010B/7470A ↓		
			2 - Amber	1 L	Cool	TCL SVOCs by 8270C		
			3 - Glass	40 mL	HCL	TCL VOCs by 8260B		
			1 - HDPE	1 L	NaOH	Cyanide by 9010/9012 PH>12		
~~DLK~~	~~WATER~~		~~2 - Glass~~	~~40 mL~~	~~HCL~~	~~TCL VOCs by 8260B~~		
DLK								

Special Instructions: *T@L bottles for SVOC DG 3001

Possible Hazard Identification:
Non-haz: X Flammable: ___ Poison B: ___ Unknown: ___

Sample Disposal:
Return to Client: ___ Disposal by Lab: X Archive: ___

Turnaround Time:
Normal: X Rush: ___

Level of QC Required:
Definitive: X Project Specific: ___

1. Relinquished by: David Kessler-Shaw	Date: 6/17/04 Time: 1800	1. Received by: Andrew D. Flores	Date: 06-18-04 Time: 09:15
2. Relinquished by:	Date: Time:	2. Received by:	Date: Time:
3. Relinquished by:	Date: Time:	2. Received by:	Date: Time:

Comments:

Shaw
Shaw E & I, Inc.

original

ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB06 17 04STL-K

Project Name/No: PBOW/843656
Sample Team Member: David Kessler
Profit Center: Knoxville
Project Manager: Steve Downey
Project No.: 843656
Required Report Date: 21 days

Sample Shipment Date: 6/17/04
Laboratory Destination: STL-North Canton
Laboratory Contact: Ken Kuzior
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: 842255358622

Bill To: Accounting
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Report To: Maureen McMyler
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DG 3003	WATER	6/17/04 0945	2 - Glass	40 mL	H2SO4	TOC by 9060		
			1 - HDPE	1000 mL	Cool	Alkalinity by 310.1; Chloride by 325.2 Nitrate by 353.2; Sulfate by 375.4 TDS by 160.1; TSS by 160.2 Turbidity by 180.1		
			1 - HDPE	250 mL	HNO3	Hardness by 130.2		
DG-3003-MS	WATER	6/17/04 0945	2 - Glass	40 mL	H2SO4	TOC by 9060		
			1 - HDPE	1000 mL	Cool	Alkalinity by 310.1; Chloride by 325.2 Nitrate by 353.2; Sulfate by 375.4 TDS by 160.1; TSS by 160.2 Turbidity by 180.1		
			1 - HDPE	250 mL	HNO3	Hardness by 130.2		
DG 3003-MSD	WATER	6/17/04 0945	2 - Glass	40 mL	H2SO4	TOC by 9060		
			1 - HDPE	1000 mL	Cool	Alkalinity by 310.1; Chloride by 325.2 Nitrate by 353.2; Sulfate by 375.4 TDS by 160.1; TSS by 160.2 Turbidity by 180.1		
			1 - HDPE	250 mL	HNO3	Hardness by 130.2		

Special Instructions:

Possible Hazard Identification:
Non-haz: X Flammable: ___ Poison B: ___ Unknown: ___

Sample Disposal:
Return to Client: ___ Disposal by Lab: X Archive: ___

Turnaround Time:
Normal: X Rush: ___

Level of QC Required:
Definitive: X Project Specific: ___

1. Relinquished by: David Kessler-Shaw	Date: 6/17/04 Time: 1800	1. Received by:	Date: 6/18/04 Time: 0950
2. Relinquished by:	Date: Time:	2. Received by:	Date: Time:
3. Relinquished by:	Date: Time:	2. Received by:	Date: Time:

Comments:

original

Shaw™
Shaw E & I, Inc.

ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB06 17 04STL-1C

PAGE X2 OF 2

Project Name/No: PBOW/843656
Sample Team Member: David Kessler
Profit Center: Knoxville
Project Manager: Steve Downey
Project No.: 843656
Required Report Date: 21 days

Sample Shipment Date: 6/17/04
Laboratory Destination: STL-North Canton
Laboratory Contact: Ken Kuzior
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: 842255358622

Bill To: Accounting
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Report To: Maureen McMyler
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DG3001	WATER	6/17/04 1515	2 - Glass	40 mL	H2SO4	TOC by 9060		
			1 - HDPE	1000 mL	Cool	Alkalinity by 310.1; Chloride by 325.2 Nitrate by 353.2; Sulfate by 375.4 TDS by 160.1; TSS by 160.2 Turbidity by 180.1		
			1 - HDPE	250 mL	HNO3	Hardness by 130.2		
DKK	WATER		2 - Glass	40 mL	H2SO4	TOC by 9060		
			1 - HDPE	1000 mL	Cool	Alkalinity by 310.1; Chloride by 325.2 Nitrate by 353.2; Sulfate by 375.4 TDS by 160.1; TSS by 160.2 Turbidity by 180.1		
			1 - HDPE	250 mL	HNO3	Hardness by 130.2		
DKK								

Special Instructions:

Possible Hazard Identification:
Non-haz: X Flammable: ___ Poison B: ___ Unknown: ___

Sample Disposal:
Return to Client: ___ Disposal by Lab: X Archive: ___

Turnaround Time:
Normal: X Rush: ___

Level of QC Required:
Definitive: X Project Specific: ___

1. Relinquished by: David Kessler - Shaw Date: 6/17/04 Time: 1800
2. Relinquished by: Date: Time:
3. Relinquished by: Date: Time:

1. Received by: Date: 6/18/04 Time: 0950
2. Received by: Date: Time:
2. Received by: Date: Time:

Comments:

Shaw™
Shaw E & I, Inc.

F24891

ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB06 17 04ACC

PAGE 1 OF 1

Bill To: Accounting
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Report To: Maureen McMyler
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Project Name/No: PBOW
Sample Team Member: David Kessler
Profit Center: Knoxville
Project Manager: Steve Downey
Project No.: 843656
Required Report Date: 21 days

Sample Shipment Date: 6/17/04
Laboratory Destination: Accutest
Laboratory Contact: Sue Bell
Project Contact/Phone: Maureen McMyler/865-560-5271
Carrier Waybill No.: 827069095295

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DG3007	WATER	6/17/04 0945	1 - Amber	1 L	Cool	Explosives by 8330		
		6/17/04 0945	2 - Amber	1 L	Cool	Semivolatiles by 8270C		
		6/17/04 0945	3 - Vial	40 mL	HCl	Volatiles by 8260B		
		6/17/04 0945	1 - HDPE	500 250 mL bkk	HNO3	TAL Metals (Total) by 6010B/7471A		
		6/17/04 0945	1 - HDPE	500 250 mL bkk	HNO3	TAL Metals (Diss) by 6010B/7471A		
DG5003	WATER	6/17/04	2 - Vial	40 mL	HCl	Volatiles by 8260B		

Special Instructions:

Possible Hazard Identification:
Non-haz: X Flammable: ___ Poison B: ___ Unknown: ___

Sample Disposal:
Return to Client: ___ Disposal by Lab: X Archive: ___

Turnaround Time:
Normal: X Rush: ___

Level of QC Required:
Definitive: X Project Specific: ___

1. Relinquished by: David Kessler-Shaw	Date: 6/17/04 Time: 1800	1. Received by: FX	Date: 6/18/04 Time: —
2. Relinquished by: FX	Date: 6/18/04 Time: 9:00	2. Received by:	Date: 6/18/04 Time: 9:00
3. Relinquished by:	Date: Time:	2. Received by:	Date: Time:

Comments:

F24891: Chain of Custody
Page 1 of 2

ACCUTEST Laboratories

HHH260300

Shaw
Shaw E & I, Inc.

ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB08 25 04STL-K

PAGE 1 OF 1

Project Name/No: PBOW
Sample Team Member: David Kessler
Profit Center: Knoxville
Project Manager: Steve Downey
Project No.: 843656
Required Report Date: 21 DAYS

Sample Shipment Date: 8/25/04
Laboratory Destination: STL- Knoxville
Laboratory Contact: Jamie McKinney
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: 842255353642

Bill To: Accounting
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Report To: Maureen McMyler
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DH3003	WATER	8/25/04 1355	1 - Amber	1 L	Cool	Explosives by 8330		
			1 - HDPE	250 mL	HNO3	Total TAL Metals by 6010B/7470A pH 2		
			1 - HDPE	250 mL	HNO3	Dissolved TAL Metals by 6010B/7470A ↓		
			2 - Amber	1 L	Cool	TCL SVOCs by 8270C		
			3 - Glass	40 mL	HCL	TCL VOCs by 8260B	Rec'd temp. 4 °C	
			1 - HDPE	1 L	NaOH	Cyanide by 9010/9012 pH 12	custody seal intact	
DH3001	WATER	8/25/04 1700	1 - Amber	1 L	Cool	Explosives by 8330	1 cooler broken	
			1 - HDPE	250 mL	HNO3	Total TAL Metals by 6010B/7470A pH 2	842255353642	
			1 - HDPE	250 mL	HNO3	Dissolved TAL Metals by 6010B/7470A ↓	MP 8-26-04	
			2 - Amber	1 L	Cool	TCL SVOCs by 8270C		
			3 - Glass	40 mL	HCL	TCL VOCs by 8260B		
			1 - HDPE	1 L	NaOH	Cyanide by 9010/9012 pH 12		
DH5000	WATER	8/25/04 —	2 - Glass	40 mL	HCL	TCL VOCs by 8260B		

Special Instructions: only 1 @ SVOC bottle for DH3001

Possible Hazard Identification:

Non-haz: ___ Flammable: ___ Poison B: ___ Unknown: X

Sample Disposal:

Return to Client: ___ Disposal by Lab: X Archive: ___

Turnaround Time:

Normal: X Rush: ___

Level of QC Required:

Definitive: X Project Specific: ___

1. Relinquished by: David Kessler - Shaw	Date: 8/25/04 Time: 1800	1. Received by: Matthew Hocum	Date: 8-26-04 Time: 09:00
2. Relinquished by:	Date: Time:	2. Received by:	Date: Time:
3. Relinquished by:	Date: Time:	2. Received by:	Date: Time:

Comments:

Shaw™
Shaw E & I, Inc.

ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB08 25 04STL-C

PAGE 1 OF 1

Project Name/No: PBOW/843656
Sample Team Member: David Kessler
Profit Center: Knoxville
Project Manager: Steve Downey
Project No.: 843656
Required Report Date: 21 days

Sample Shipment Date: 8/25/04
Laboratory Destination: STL-North Canton
Laboratory Contact: Ken Kuzior
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: 842255353631

Bill To: Accounting
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Report To: Maureen McMyler
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DW3003	WATER	8/25/04 1355	2 - Glass	40 mL	H2SO4	TOC by 9060		
			1 - HDPE	1000 mL	Cool	Alkalinity by 310.1; Chloride by 325.2		
						Nitrate by 353.2; Sulfate by 375.4		
						TDS by 160.1; TSS by 160.2		
						Turbidity by 180.1		
			1 - HDPE	250 mL	HNO3	Hardness by 130.2		
DW3001	WATER	8/25/04 1700	2 - Glass	40 mL	H2SO4	TOC by 9060		
			1 - HDPE	1000 mL	Cool	Alkalinity by 310.1; Chloride by 325.2		
						Nitrate by 353.2; Sulfate by 375.4		
						TDS by 160.1; TSS by 160.2		
						Turbidity by 180.1		
			1 - HDPE	250 mL	HNO3	Hardness by 130.2		

Special Instructions:

Possible Hazard Identification:
Non-haz: ___ Flammable: ___ Poison B: ___ Unknown: X

Sample Disposal:
Return to Client: ___ Disposal by Lab: X Archive: ___

Turnaround Time:
Normal: X Rush: ___

Level of QC Required:
Definitive: X Project Specific: ___

1. Relinquished by: David Kessler-Shaw	Date: 8/25/04	1. Received by:	Date: 8/26/04
	Time: 1800		Time: 0945
2. Relinquished by:	Date:	2. Received by:	Date:
	Time:		Time:
3. Relinquished by:	Date:	2. Received by:	Date:
	Time:		Time:

Comments:

H4H270 mfd 8-27-04.
H4H270215

Shaw™
Shaw E & I, Inc.

ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB08 26 04STL-K

PAGE 1 OF 2

Bill To: Accounting
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Report To: Maureen McMyler
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Project Name/No: PBOW
Sample Team Member: David Kessler
Profit Center: Knoxville
Project Manager: Steve Downey
Project No.: 843656
Required Report Date: 21 DAYS

Sample Shipment Date: 8/26/04
Laboratory Destination: STL- Knoxville
Laboratory Contact: Jamie McKinney
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: 842255353610

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DH-3002	WATER	8/26/04 1110	1 - Amber	1 L	Cool	Explosives by 8330		
			1 - HDPE	250 mL	HNO3	Total TAL Metals by 6010B/7470A ph2	Custody Seals Intact	
			1 - HDPE	250 mL	HNO3	Dissolved TAL Metals by 6010B/7470A ph2	Receipt Temp. 2°C.	
			2 - Amber	1 L	Cool	TCL SVOCs by 8270C	2 COOLERS/ FEDEX	
			3 - Glass	40 mL	HCL	TCL VOCs by 8260B	~~1#~~ ADF 082704	
			1 - HDPE	1 L	NaOH	Cyanide by 9010/9012 ph12	1# 842255353610	
DH-3002-MS	WATER	8/26/04 1110	1 - Amber	1 L	Cool	Explosives by 8330	ADF 08-27-04	
			1 - HDPE	250 mL	HNO3	Total TAL Metals by 6010B/7470A ph2		
			1 - HDPE	250 mL	HNO3	Dissolved TAL Metals by 6010B/7470A ph2		
			2 - Amber	1 L	Cool	TCL SVOCs by 8270C		
			3 - Glass	40 mL	HCL	TCL VOCs by 8260B		
			1 - HDPE	1 L	NaOH	Cyanide by 9010/9012 ph12		
DH-3002-MSD	WATER	8/26/04 1110	1 - Amber	1 L	Cool	Explosives by 8330		
			1 - HDPE	250 mL	HNO3	Total TAL Metals by 6010B/7470A ph2		
			1 - HDPE	250 mL	HNO3	Dissolved TAL Metals by 6010B/7470A ph2		
			2 - Amber	1 L	Cool	TCL SVOCs by 8270C		
			3 - Glass	40 mL	HCL	TCL VOCs by 8260B		
			1 - HDPE	1 L	NaOH	Cyanide by 9010/9012 ph12		
DH-3001	WATER	8/26/04 —	2 - Glass	40 mL	HCL	TCL VOCs by 8260B		

Special Instructions: Only 1 amber for SVOC for samples DH-3002 and DH-3002-MS.

Possible Hazard Identification:

Non-haz: ___ Flammable: ___ Poison B: ___ Unknown: X

Sample Disposal:

Return to Client: ___ Disposal by Lab: X Archive: ___

Turnaround Time:

Normal: X Rush: ___

Level of QC Required:

Definitive: X Project Specific: ___

1. Relinquished by: David Kessler - Shaw	Date: 8/26/04 Time: 1800	1. Received by: Andrew D. Flores STL	Date: 08-27-04 Time: 09:00
2. Relinquished by:	Date: Time:	2. Received by:	Date: Time:
3. Relinquished by:	Date: Time:	2. Received by:	Date: Time:

Comments:

HHH260300

Shaw
Shaw E & I, Inc.

ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB08 25 04STL-K

PAGE 1 OF 1

Project Name/No: PBOW
Sample Team Member: David Kessler
Profit Center: Knoxville
Project Manager: Steve Downey
Project No.: 843656
Required Report Date: 21 DAYS

Sample Shipment Date: 8/25/04
Laboratory Destination: STL- Knoxville
Laboratory Contact: Jamie McKinney
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: 842255353642

Bill To: Accounting
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Report To: Maureen McMyler
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DH3003	WATER	8/25/04 1355	1 - Amber	1 L	Cool	Explosives by 8330		
			1 - HDPE	250 mL	HNO3	Total TAL Metals by 6010B/7470A pH 2		
			1 - HDPE	250 mL	HNO3	Dissolved TAL Metals by 6010B/7470A ↓		
			2 - Amber	1 L	Cool	TCL SVOCs by 8270C		
			3 - Glass	40 mL	HCL	TCL VOCs by 8260B	Rec'd temp. 4 °C	
			1 - HDPE	1 L	NaOH	Cyanide by 9010/9012 pH 12	custody seal intact	
DH3001	WATER	8/25/04 1700	1 - Amber	1 L	Cool	Explosives by 8330	1 cooler broken	
			1 - HDPE	250 mL	HNO3	Total TAL Metals by 6010B/7470A pH 2	842255353642	
			1 - HDPE	250 mL	HNO3	Dissolved TAL Metals by 6010B/7470A ↓	MP 8-26-04	
			2 - Amber	1 L	Cool	TCL SVOCs by 8270C		
			3 - Glass	40 mL	HCL	TCL VOCs by 8260B		
			1 - HDPE	1 L	NaOH	Cyanide by 9010/9012 pH 12		
DH5000	WATER	8/25/04 —	2 - Glass	40 mL	HCL	TCL VOCs by 8260B		

Special Instructions: only 1 @ SVOC bottle for DH3001

Possible Hazard Identification:

Non-haz: ___ Flammable: ___ Poison B: ___ Unknown: X

Sample Disposal:

Return to Client: ___ Disposal by Lab: X Archive: ___

Turnaround Time:

Normal: X Rush: ___

Level of QC Required:

Definitive: X Project Specific: ___

1. Relinquished by: David Kessler - Shaw	Date: 8/25/04 Time: 1800	1. Received by: Matthew Hocum	Date: 8-26-04 Time: 09:00
2. Relinquished by:	Date: Time:	2. Received by:	Date: Time:
3. Relinquished by:	Date: Time:	2. Received by:	Date: Time:

Comments:

Shaw™
Shaw E & I, Inc.

ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB08 25 04STL-C

PAGE 1 OF 1

Project Name/No: PBOW/843656
Sample Team Member: David Kessler
Profit Center: Knoxville
Project Manager: Steve Downey
Project No.: 843656
Required Report Date: 21 days

Sample Shipment Date: 8/25/04
Laboratory Destination: STL-North Canton
Laboratory Contact: Ken Kuzior
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: 842255353631

Bill To: Accounting
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Report To: Maureen McMyler
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DW3003	WATER	8/25/04 1355	2 - Glass	40 mL	H2SO4	TOC by 9060		
			1 - HDPE	1000 mL	Cool	Alkalinity by 310.1; Chloride by 325.2		
						Nitrate by 353.2; Sulfate by 375.4		
						TDS by 160.1; TSS by 160.2		
						Turbidity by 180.1		
			1 - HDPE	250 mL	HNO3	Hardness by 130.2		
DW3001	WATER	8/25/04 1700	2 - Glass	40 mL	H2SO4	TOC by 9060		
			1 - HDPE	1000 mL	Cool	Alkalinity by 310.1; Chloride by 325.2		
						Nitrate by 353.2; Sulfate by 375.4		
						TDS by 160.1; TSS by 160.2		
						Turbidity by 180.1		
			1 - HDPE	250 mL	HNO3	Hardness by 130.2		

Special Instructions:

Possible Hazard Identification:
Non-haz: ___ Flammable: ___ Poison B: ___ Unknown: X

Sample Disposal:
Return to Client: ___ Disposal by Lab: X Archive: ___

Turnaround Time:
Normal: X Rush: ___

Level of QC Required:
Definitive: X Project Specific: ___

1. Relinquished by: David Kessler-Shaw	Date: 8/25/04	1. Received by:	Date: 8/26/04
	Time: 1800		Time: 0945
2. Relinquished by:	Date:	2. Received by:	Date:
	Time:		Time:
3. Relinquished by:	Date:	2. Received by:	Date:
	Time:		Time:

Comments:

H4H270 mfd 8-27-04.
H4H270215

Shaw™
Shaw E & I, Inc.

ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB08 26 04STL-K

PAGE 1 OF 2

Bill To: Accounting
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Report To: Maureen McMyler
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Project Name/No: PBOW
Sample Team Member: David Kessler
Profit Center: Knoxville
Project Manager: Steve Downey
Project No.: 843656
Required Report Date: 21 DAYS

Sample Shipment Date: 8/26/04
Laboratory Destination: STL- Knoxville
Laboratory Contact: Jamie McKinney
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: 842255353610

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DH-3002	WATER	8/26/04 1110	1 - Amber	1 L	Cool	Explosives by 8330		
			1 - HDPE	250 mL	HNO3	Total TAL Metals by 6010B/7470A ph2	Custody Seals Intact	
			1 - HDPE	250 mL	HNO3	Dissolved TAL Metals by 6010B/7470A ph2	Receipt Temp. 2°C.	
			2 - Amber	1 L	Cool	TCL SVOCs by 8270C	2 COOLERS/ FEDEX	
			3 - Glass	40 mL	HCL	TCL VOCs by 8260B	~~1#~~ ADF 082704	
			1 - HDPE	1 L	NaOH	Cyanide by 9010/9012 ph12	1# 842255353610	
DH-3002-MS	WATER	8/26/04 1110	1 - Amber	1 L	Cool	Explosives by 8330	ADF 08-27-04	
			1 - HDPE	250 mL	HNO3	Total TAL Metals by 6010B/7470A ph2		
			1 - HDPE	250 mL	HNO3	Dissolved TAL Metals by 6010B/7470A ph2		
			2 - Amber	1 L	Cool	TCL SVOCs by 8270C		
			3 - Glass	40 mL	HCL	TCL VOCs by 8260B		
			1 - HDPE	1 L	NaOH	Cyanide by 9010/9012 ph12		
DH-3002-MSD	WATER	8/26/04 1110	1 - Amber	1 L	Cool	Explosives by 8330		
			1 - HDPE	250 mL	HNO3	Total TAL Metals by 6010B/7470A ph2		
			1 - HDPE	250 mL	HNO3	Dissolved TAL Metals by 6010B/7470A ph2		
			2 - Amber	1 L	Cool	TCL SVOCs by 8270C		
			3 - Glass	40 mL	HCL	TCL VOCs by 8260B		
			1 - HDPE	1 L	NaOH	Cyanide by 9010/9012 ph12		
DH-3001	WATER	8/26/04 —	2 - Glass	40 mL	HCL	TCL VOCs by 8260B		

Special Instructions: Only 1 amber for SVOC for samples DH-3002 and DH-3002-MS.

Possible Hazard Identification:

Non-haz: ___ Flammable: ___ Poison B: ___ Unknown: X

Sample Disposal:

Return to Client: ___ Disposal by Lab: X Archive: ___

Turnaround Time:

Normal: X Rush: ___

Level of QC Required:

Definitive: X Project Specific: ___

1. Relinquished by: David Kessler - Shaw	Date: 8/26/04 Time: 1800	1. Received by: Andrew D. Flores STL	Date: 08-27-04 Time: 09:00
2. Relinquished by:	Date: Time:	2. Received by:	Date: Time:
3. Relinquished by:	Date: Time:	2. Received by:	Date: Time:

Comments:

Shaw
Shaw E & I, Inc.

ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB08 26 04STL-K

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DH3005	WATER	8/26/04 1110	1 - Amber	1 L	Cool	Explosives by 8330		
			1 - HDPE	250 mL	HNO3	Total Metals by 6010B/7470A ph2		
			1 - HDPE	250 mL	HNO3	Dissolved Metals by 6010B/7470A ph2		
			2 - Amber	1 L	Cool	SVOCs by 8270C		
			3 - Glass	40 mL	HCL	VOCs by 8260B		
			1 - HDPE	1000 mL	NaOH	Cyanide by 9010A		
DH3000	WATER	8/26/04 1715	1 - Amber	1 L	Cool	Explosives by 8330		
			1 - HDPE	250 mL	HNO3	Total Metals by 6010B/7470A ph2		
			1 - HDPE	250 mL	HNO3	Dissolved Metals by 6010B/7470A ph2		
			2 - Amber	1 L	Cool	SVOCs by 8270C		
			3 - Glass	40 mL	HCL	VOCs by 8260B		
			1 - HDPE	1000 mL	NaOH	Cyanide by 9010A ph7		
	WATER		1 - Amber	1 L	Cool	Explosives by 8330		
			1 - HDPE	250 mL	HNO3	Total Metals by 6010B/7470A		
			1 - HDPE	250 mL	HNO3	Dissolved Metals by 6010B/7470A		
			2 - Amber	1 L	Cool	SVOCs by 8270C		
			3 - Glass	40 mL	HCL	VOCs by 8260B		
			1 - HDPE	1000 mL	NaOH	Cyanide by 9010A		
	DKK 8/26/04							

Shaw™
Shaw E & I, Inc.

ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB08 26 04STL-C

Project Name/No: PBOW/843656
Sample Team Member: David Kessler
Profit Center: Knoxville
Project Manager: Steve Downey
Project No.: 843656
Required Report Date: 21 days

Sample Shipment Date: 8/26/04
Laboratory Destination: STL-North Canton
Laboratory Contact: Ken Kuzior
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: 842255353609

Bill To: Accounting
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Report To: Maureen McMyler
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DH3002	WATER	8/26/04 1110	2 - Glass	40 mL	H2SO4	TOC by 9060		
			1 - HDPE	1000 mL	Cool	Alkalinity by 310.1; Chloride by 325.2 Nitrate by 353.2; Sulfate by 375.4 TDS by 160.1; TSS by 160.2 Turbidity by 180.1		
			1 - HDPE	250 mL	HNO3	Hardness by 130.2		
DH3002-MS	WATER	8/26/04 1110	2 - Glass	40 mL	H2SO4	TOC by 9060		
			1 - HDPE	1000 mL	Cool	Alkalinity by 310.1; Chloride by 325.2 Nitrate by 353.2; Sulfate by 375.4 TDS by 160.1; TSS by 160.2 Turbidity by 180.1		
			1 - HDPE	250 mL	HNO3	Hardness by 130.2		
DH3002-MSD	WATER	8/26/04 1110	2 - Glass	40 mL	H2SO4	TOC by 9060		
			1 - HDPE	1000 mL	Cool	Alkalinity by 310.1; Chloride by 325.2 Nitrate by 353.2; Sulfate by 375.4 TDS by 160.1; TSS by 160.2 Turbidity by 180.1		
			1 - HDPE	250 mL	HNO3	Hardness by 130.2		

Special Instructions:

Possible Hazard Identification:
Non-haz: ___ Flammable: ___ Poison B: ___ Unknown: X

Sample Disposal:
Return to Client: ___ Disposal by Lab: X Archive: ___

Turnaround Time:
Normal: X Rush: ___

Level of QC Required:
Definitive: X Project Specific: ___

1. Relinquished by: David Kessler-Shaw — Date: 8/26/04 Time: 1800
2. Relinquished by: ___ — Date: ___ Time: ___
3. Relinquished by: ___ — Date: ___ Time: ___

1. Received by: [signature] — Date: 8-27-04 Time: 9:45
2. Received by: ___ — Date: ___ Time: ___
2. Received by: ___ — Date: ___ Time: ___

Comments:

Shaw™
Shaw E & I, Inc.

ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB08 26 04STL-N

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DH3000	WATER	8/26/04 1715	2 - Glass	40 mL	H2SO4	TOC by 9060		
			1 - HDPE	1000 mL	Cool	Alkalinity by 310.1; Chloride by 325.2		
						Nitrate by 353.2; Sulfate by 375.4		
						TDS by 160.1; TSS by 160.2		
						Turbidity by 180.1		
			1 - HDPE	250 mL	HNO3	Hardness by 130.2		
	WATER	DKF 8/26/04	2 - Glass	40 mL	H2SO4	TOC by 9060		
			1 - HDPE	1000 mL	Cool	Alkalinity by 310.1; Chloride by 325.2		
						Nitrate by 353.2; Sulfate by 375.4		
						TDS by 160.1; TSS by 160.2		
						Turbidity by 180.1		
			1 - HDPE	250 mL	HNO3	Hardness by 130.2		

H4H280124

Shaw™
Shaw E & I, Inc.

ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB08 27 04STL-K

PAGE 1 OF 1

Project Name/No: PBOW
Sample Team Member: David Kessler
Profit Center: Knoxville
Project Manager: Steve Downey
Project No.: 843656
Required Report Date: 21 DAYS

Sample Shipment Date: 8/27/04
Laboratory Destination: STL Knoxville
Laboratory Contact: Jamie McKinney
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: 842255353620

Bill To: Accounting
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Report To: Maureen McMyler
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DH3007	WATER	8/27/04 1030	1 - Amber	1 L	Cool	Explosives by 8330		
			1 - HDPE	250 mL	HNO3	Total TAL Metals by 6010B/7470A PMZ		
			1 - HDPE	250 mL	HNO3	Dissolved TAL Metals by 6010B/7470A ↓	Rec'd w/ 3°C	
			2 - Amber	1 L	Cool	TCL SVOCs by 8270C	custody seals intact	
			3 - Glass	40 mL	HCL	TCL VOCs by 8260B	1 cooler Fedex	
			1 - HDPE	1 L	NaOH	Cyanide by 9010/9012 PMZ	842255353620	
DH3004	WATER	8/27/04 1140	1 - Amber	1 L	Cool	Explosives by 8330	MFH 8-28-04	
			1 - HDPE	250 mL	HNO3	Total TAL Metals by 6010B/7470A PMZ		
			1 - HDPE	250 mL	HNO3	Dissolved TAL Metals by 6010B/7470A PMZ		
			~~2 - Amber~~	~~1 L~~	~~Cool~~	~~TCL SVOCs by 8270C~~ DKK		
			~~3 - Glass~~	~~40 mL~~	~~HCL~~	~~TCL VOCs by 8260B~~ DKK		
			~~1 - HDPE~~	~~1 L~~	~~NaOH~~	~~Cyanide by 9010/9012~~ DKK		
DH5003	WATER	8/27/04 DKK	2 - Glass	40 mL	HCL	TCL VOCs by 8260B		

Special Instructions:

Possible Hazard Identification:
Non-haz: X Flammable: ___ Poison B: ___ Unknown: ___

Sample Disposal:
Return to Client: ___ Disposal by Lab: X Archive: ___

Turnaround Time:
Normal: X Rush: ___

Level of QC Required:
Definitive: X Project Specific: ___

1. Relinquished by: David Kessler-Shaw	Date: 8/27/04 Time: 1803	1. Received by: Maureen McMyler	Date: 8-28-04 Time: 11:20
2. Relinquished by:	Date: Time:	2. Received by:	Date: Time:
3. Relinquished by:	Date: Time:	2. Received by:	Date: Time:

Comments:

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ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB08 27 04STL

PAGE 1 OF 1

Project Name/No: PBOW/843656
Sample Team Member: David Kessler
Profit Center: Knoxville
Project Manager: Steve Downey
Project No.: 843656
Required Report Date: 21 days

Sample Shipment Date: 8/27/04
Laboratory Destination: STL-North Canton
Laboratory Contact: Ken Kuzior
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: 842255358563

Bill To: Accounting
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Report To: Maureen McMyler
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DH 3007	WATER	8/27/04 1030	2 - Glass	40 mL	H2SO4	TOC by 9060		
			1 - HDPE	1000 mL	Cool	Alkalinity by 310.1; Chloride by 325.2		
						Nitrate by 353.2; Sulfate by 375.4		
						TDS by 160.1; TSS by 160.2		
						Turbidity by 180.1		
			1 - HDPE	250 mL	HNO3	Hardness by 130.2		
		DKK 8/27/04						

Special Instructions:

Possible Hazard Identification:
Non-haz: ___ Flammable: ___ Poison B: ___ Unknown: X

Sample Disposal:
Return to Client: ___ Disposal by Lab: X Archive: ___

Turnaround Time:
Normal: X Rush: ___

Level of QC Required:
Definitive: X Project Specific: ___

1. Relinquished by: David Kessler - Shaw	Date: 8/27/04	1. Received by: Natalie J Buhler	Date: 8-28-04
	Time: 1800		Time: 10:00
2. Relinquished by:	Date:	2. Received by:	Date:
	Time:		Time:
3. Relinquished by:	Date:	2. Received by:	Date:
	Time:		Time:

Comments:

F26367

Shaw
Shaw E & I, Inc.

ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB08 26 04ACC

PAGE 1 OF 1

Project Name/No:	PBOW	Sample Shipment Date:	8/26/04
Sample Team Member:	David Kessler	Laboratory Destination:	Accutest
Profit Center:	Knoxville	Laboratory Contact:	Sue Bell
Project Manager:	Steve Downey	Project Contact/Phone:	Maureen McMyler/865-560-5271
Project No.:	843656	Carrier Waybill No.:	842255353594
Required Report Date:	21 days		

Bill To: Accounting
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Report To: Maureen McMyler
Shaw E & I
312 Directors Drive
Knoxville, TN 37923

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
(1) DH3006	WATER	8/26/04 1110	1 - Amber	1 L	Cool	Explosives by 8330		
			2 - Amber	1 L	Cool	Semivolatiles by 8270C		
			3 - Vial	40 mL	HCl	Volatiles by 8260B		
			1 - HDPE	250 mL	HNO3	TAL Metals (Total) by 6010B/7471A		
			1 - HDPE	250 mL	HNO3	TAL Metals (Diss) by 6010B/7471A		
(2) DH5002	WATER	8/26/04	2 - Vial	40 mL	HCl	Volatiles by 8260B		

DKK 8/26/04

Special Instructions:

Possible Hazard Identification:
Non-haz: ___ Flammable: ___ Poison B: ___ Unknown: X

Sample Disposal:
Return to Client: ___ Disposal by Lab: X Archive: ___

Turnaround Time:
Normal: X Rush:

Level of QC Required:
Definitive: X Project Specific: ___

1. Relinquished by: David Kessler - Shaw FR	Date: 8/26/04	1. Received by: FedEx	Date:
	Time: 1800		Time:
2. Relinquished by:	Date:	2. Received by: Carlos D	Date: 8-27-04
	Time:		Time: 09:00
3. Relinquished by:	Date:	3. Received by:	Date:
	Time:		Time:

Comments:

3-2

F26367: Chain of Custody
Page 1 of 2

Appendix M

APPENDIX M

METHODS RELATED TO THE EVALUATION OF BACKGROUND

Appendix M

Methods Related to the Evaluation of Background Former Plum Brook Ordnance Works

This appendix describes the methods to be used in the evaluation of potentially background-related contributions to site groundwater, as referenced in Section 5.4.2 of the 2004 Groundwater Data Evaluation and Summary Report. Section M1.0 identifies the wells and samples used for the background data set. Section M2.0 describes the methodology used to derive Plum Brook Ordnance Works (PBOW) background screening concentrations (BSC). Section M3.0 discusses the use of statistical population testing. Various aspects of geochemical analysis are described in Section M4.0, and spatial evaluation is discussed in Section M5.0. The treatment of potentially background-related organics are discussed in Section M6.0. Note that Sections M3.0 through M5.0 may potentially apply to organics as well as inorganics.

Analytical data may have associated validation qualifiers. The selection of data use in the derivation of BSCs, as well as that to be used in statistical population testing or other comparisons to background described in this appendix, is consistent with the protocol used in the baseline human health risk assessments (BHHRA) that have been performed for PBOW sites (IT, 2001; 2000a,b). Nonqualified and estimated (i.e., "J") values were used directly in the evaluation of background. Rejected (i.e., "R") and blank contaminated (i.e., "B") were not used. For samples which are nondetects (i.e., "U"), the chemical is assumed to be present at one-half the detection limit, unless the chemical was not detected in any of the site samples in which case it is regarded as not present in background. The analytical results of field duplicate sets were averaged, with one exception: where one of the duplicate samples was reported as a nondetect and the other was detected at a concentration less than the detection limit, the detected concentration was used. In all cases where one duplicate was reported as a detection and the other was not, the sample was included as a detection for data summary purposes.

M1.0 Selection of Background Data Set

Seven wells were installed as potential upgradient bedrock background wells for PBOW. Based on a review of all available site data, the following wells are recommended for inclusion in the PBOW background data set that will be used in determining the background concentrations of inorganics in bedrock groundwater (Shaw, 2004a):

- BG8-BEDGW-001 (10 samples)
- BED-MW25 (10 samples)
- BED-MW28 (4 samples)
- BED-MW29 (4 samples).

Only samples from the above wells collected using low-flow (minimal drawdown) sampling were used in the derivation of BSCs, and only these samples should be used in statistical population testing (Section M3.0) or other evaluations (Section M4.0 and M5.0), as needed, in the groundwater BHHRA (Shaw 2004b).

The following wells were excluded from the PBOW background well data set, with the reasons for exclusion provided in parentheses:

- BED-MW20 (excluded due to the presence of methane)
- BED-MW24 (excluded because location is now interpreted as being downgradient from a contamination source; also, presence of multiple nitroaromatics)
- BED-MW26 (insufficient well yield).

It is noted that well BED-MW20 might be useful as a background well for qualitative comparison for any on-site wells that are impacted by natural gas.

M2.0 Derivation of Background Screening Concentrations

The use of BSC for inorganics is referenced in Section 5.4.2 of the 2004 Groundwater Data Evaluation and Summary Report. BSCs were derived using the 28 samples from the four background monitoring wells identified in Section M.1. BSCs are designed as a quick screening tool to be used for inorganics in the BHHRA. It is understood that if an inorganic analyte's maximum detected concentration (MDC) in groundwater at a PBOW area of concern does not exceed the BSC, then that analyte is regarded as being attributable to background conditions without any further evaluation (Shaw, 2004b).

As agreed by the U.S. Army Corps of Engineers (USACE) and the Ohio Environmental Protection Agency (OEPA) during the November 20, 2002 PBOW project team meeting (USACE, 2002), PBOW BSCs were derived from the background MDC or the upper tolerance limit on the 95th percentile (UTL), whichever is less. The UTL was derived from the Chebychev

inequality (EPA, 1997) which is shown in Equation M.1. This inequality holds over all distributions with finite mean and variance.

$$\Pr\left(\left|\frac{X-\mu}{\sigma}\right| \geq b\right) \leq \frac{1}{b^2} \qquad \text{Eq. M.1}$$

Where:

Pr = probability
X = random sample from a population
μ = population mean
σ = standard deviation
b = function of the probability.

The Chebychev UTL is calculated based on the mean and standard deviation of the sample as shown in Equation M.1. Let μ denote the mean and σ the standard deviation of the distribution from which the X observations are taken. By the Chebychev inequality: setting $1/b^2 = 0.05$, then $b = \sqrt{20}$, which is approximated by 4.47. This indicates that the interval $[\mu - 4.47\sigma, \mu + 4.47]$ holds at least 95 percent of the probability of the distribution. Therefore, $\mu + 4.47$ is an upper bound for the 95th percentile. The calculated 95th UTL may be larger than the MDC, especially if relatively few background samples (e.g., < 30) are in the data set and/or the upper end of the distribution is not well defined by the data. Nearly all of the BSC values for PBOW (Table M-1) are based on the MDC, rather than the UTL, because the MDC values are generally less than the UTLs for the PBOW data sets.

It is noted that BSC values are used for screening and are only a preliminary determination as to the classification of site-relatedness for an inorganic constituent; the exceedance of a BSC indicates only that further evaluation is warranted in the BHHRA. The first step of this further evaluation is the generally population testing as described in Section M3.0. Note that the BSC values shown in Table M-1 for potentially site-related BTEX compounds (benzene, toluene, ethylbenzene, and xylenes) will not be used for screening in the BHHRA, but are included in this report as points of reference (see Section M6.0).

M3.0 Statistical Population Testing

Statistical population testing may be performed in cases where the site MDC for an inorganic exceeds the BSC. Population testing is not necessary for site data sets whose results indicate obvious site-related contamination; such data sets may be judged as exceeding background without needlessly expending the effort to perform a statistical analysis. Also, population testing

may not be necessary for those data sets whose MDC very marginally exceeds the MDC, but whose analytical data (as evidenced by a data summary information including mean, standard deveiation, and frequency of detection) do not exceed those of background.

The Wilcoxon rank-sum test (WRS), also known as the Mann-Whitney U test, will be used for population testing because it is independent of distribution type and in many cases has greater statistical power than parametric tests such as the t-test for independent samples, which can be run only on two normally or two lognormally distributed populations (StatSoft, 1998). Further statistical population comparison may be performed on a case-by-case basis, depending on specific data set characteristics such as the detection frequencies of the two data sets (i.e., site and background), magnitude of site detections versus background, and spatial variability (Section M5.0) of the two data sets.

M4.0 Geochemical Analysis

Geochemical characteristics of the site groundwater are evaluated as a matter of course in the remedial investigation. If judged appropriate for a given well or data set, pertinent geochemical characteristics of site groundwater may be evaluated with respect to background groundwater. These include parameters such as total dissolved solids, total suspended solids, pH, and dissolved oxygen. Also, filtered versus unfiltered analytical results may be compared to differentiate between the inorganic analytes that are likely to be transported with groundwater flow through the aquifer material and those that may not. Geochemical analysis is generally more applicable for inorganics than organics, but groundwater impact of organics may affect aquifer conditions (e.g., pH, dissolved oxygen [DO]) that result in changes in concentrations of inorganics dissolved in groundwater. Also, as mentioned in Section M6.0, petroliferous shale may be a source of polynuclear aromatic hydrocarbons (PAH), benzene, toluene, ethylbenzene, and xylene (BTEX) in groundwater. Natural reducing conditions associated with the petroliferous shale could also result in higher concentrations of certain inorganics.

A geochemical analysis may also consider the impact of sorption of certain trace inorganics to suspended "clays" (i.e., clay minerals, hydrous aluminum oxides, and aluminum hydroxides) and "iron oxides" (i.e., iron oxide, iron hydroxide, and iron oxyhydroxide). The presence of suspended clays or iron oxides in groundwater samples has particular importance in the interpretation of trace element concentrations. Most clay particles maintain a negative surface charge under neutral pH conditions, and have a strong tendency to adsorb positively charged (cationic) aqueous species, such as barium, lead, and zinc. Iron oxides display the opposite behavior, maintaining a positive surface charge under neutral pH conditions, and have a strong tendency to adsorb negatively charged (anionic) aqueous species, such as arsenic, selenium, and

vanadium. Under neutral pH, aluminum concentrations exceeding approximately 1 milligram per liter (mg/L) (1,000 micrograms per liter [µg/L]) indicate the presence of suspended clays. Likewise, under neutral pH and moderate-to-oxidizing redox conditions, aluminum and iron concentrations exceeding approximately 1 mg/L (1,000 µg/L) are indicative of suspended iron oxides.

M5.0 Spatial Evaluation

Spatial evaluation of groundwater should be considered for the evaluation of both organic and inorganic chemicals, as appropriate, and may be performed in conjunction with a statistical and/or geochemical evaluation. A spatial evaluation may be performed where specific areas of chemicals of potential concern exhibit relatively high concentrations and may be necessary even when the WRS statistical test (which) indicates that site concentrations do not exceed background; note that the WRS is nonparametric and does not consider absolute magnitude on the detected concentrations. With respect to background, a spatial evaluation may provide information to indicate whether an apparently elevated concentration on site might in fact be related to background. Also, the spatial evaluation may suggest the presence of a hot spot; it may be expedient to perform some of the above comparisons to background (e.g., statistical) excluding the hot spot, presuming that remediation or an informed site management decision is made regarding the hot spot.

M6.0 Potentially Background-Related Organics

BTEX compounds and PAHs detected in site groundwater may be at least partially attributable to background sources. Petroliferous shale formations, including the Delaware Limestone, underlie the site. In the general vicinity of PBOW, quarries mine limestone from the Delaware; traces of natural petroleum-derived BTEX and hydrogen sulfide (indicative of reducing conditions associated with petroleum) are common in these quarries. Further, actively producing in Erie County oil wells are reportedly pumping from the Delaware Limestone and Columbus Limestone (Swinford, 2002).

As stated in Section M2.0, BTEX compounds will not be screened out of the BHHRA on the basis of BSCs. Instead, compounds with concentrations exceeding risk-based screening concentrations (RBSC) will be carried through the BHHRA. Further evaluation will be performed if the presence of these compounds is shown to contribute significantly to risk. BSC values were not developed for PAHs because no PAHs were detected in the background groundwater data set.

As part of the remedial investigation (RI), an evaluation of BTEX and PAHs was performed for site and background groundwater with respect to lithologic unit. Vertical correlation—especially with regard to lithologic unit—was considered as well as horizontal correlation, utilizing multiple lines of evidence. Existing information was gathered, as available, concerning regional variations, again, with respect to lithologic units. As part of this evaluation, the monitoring wells were evaluated for hydrogen sulfide content, which may indicative of the presence of naturally occurring petroleum.

It is anticipated that the results of the study will have to be evaluated qualitatively as well as quantitatively, and that it will yield no unequivocably interpretation as to the contribution of background sources. Instead, the intent is that information from this background evaluation of PAHs and BTEX be used to facilitate informed site management agreements.

M7.0 References

IT Corporation (IT), 2001, ***TNT Areas A and C Remedial Investigation, Volume II – Human Health Risk Assessment, Final, Former Plum Book Ordnance Works, Sandusky, Ohio,*** November.

IT Corporation (IT), 2000a, ***Risk Assessment and Direct-Push Investigation of Red Water Pond Areas, Final, Former Plum Book Ordnance Works, Sandusky, Ohio,*** August.

IT Corporation (IT), 2000b, ***Final TNT Area B Remedial Investigation, Volume II – Baseline Human Health Risk Assessment and Volume III – Ecological Risk Assessment, Final, Former Plum Book Ordnance Works, Sandusky, Ohio,*** August.

Shaw Environmental, Inc., (Shaw), 2004a, ***Background Monitoring Well Selection for the Phase II Groundwater Remedial Investigation***, Former Plum Brook Ordnance Works, Sandusky, Ohio, 19 October.

Shaw Environmental, Inc., (Shaw), 2004b, ***Baseline Human Health Risk Assessment for Groundwater Work Plan***, Draft, Former Plum Brook Ordnance Works, Sandusky, Ohio, December.

StatSoft, Inc., 1998, ***Statistica for Windows***, Version 5.1, Tulsa, Oklahoma.

Swinford, M., 2002, email correspondence from M. Swinford (Geologist and Supervisor, Ohio Department of Natural Resources) to D. Kessler (Geologist, Shaw), 29 August.

U.S. Army Corps of Engineers (USACE), 2002, ***Plum Brook Ordnance Works Team Meeting, Meeting Minutes, OEPA Southwest Office, Dayton, Ohio***, 20 November.

U.S. Environmental Protection Agency (EPA), 1997, ***The Lognormal Distribution in Environmental Applications***, Technology Support Center Issue Paper, EPA/600/R-97/006, December.

Table M-1

Background Screening Concentrations for Inorganics and BTEX Compounds in Groundwater 2004 Groundwater Data Summary and Evaluation Report Former Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of Values, ug/L: Detected Concentrations Minimum	Detected Concentrations Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Mean ug/L	Standard Deviation	UTL [a] ug/L	BSC [b] ug/L
Metals - Unfiltered										
Aluminum	11 / 13	85	3.15E+01	3.09E+02	2.00E+02	2.00E+02	1.05E+02	6.98E+01	4.17E+02	309
Arsenic	4 / 26	15	3.30E+00	7.40E+00	1.00E+01	1.00E+01	4.99E+00	6.56E-01	7.92E+00	7.4
Barium	28 / 28	100	2.58E+01	1.18E+04	2.00E+02	2.00E+03	1.73E+03	3.77E+03	1.86E+04	11800
Calcium	28 / 28	100	1.74E+04	3.16E+05	5.00E+03	5.00E+03	1.38E+05	8.31E+04	5.09E+05	316000
Cobalt	6 / 27	22	1.00E+00	1.21E+01	5.00E+01	5.00E+01	2.05E+01	8.75E+00	5.96E+01	12.1
Copper	2 / 28	7	3.30E+00	1.98E+01	2.50E+01	2.50E+01	1.24E+01	2.26E+00	2.25E+01	19.8
Iron	24 / 27	89	3.82E+01	1.55E+03	1.00E+02	1.00E+02	4.15E+02	4.87E+02	2.59E+03	1550
Magnesium	28 / 28	100	7.28E+03	2.17E+05	5.00E+03	5.00E+03	7.17E+04	5.85E+04	3.33E+05	217000
Manganese	28 / 28	100	3.60E+00	6.88E+02	1.50E+01	1.50E+01	8.12E+01	1.24E+02	6.36E+02	636
Nickel	4 / 27	15	4.80E+00	8.60E+00	4.00E+01	4.00E+01	1.81E+01	4.67E+00	3.90E+01	8.6
Potassium	28 / 28	100	2.53E+03	1.16E+05	5.00E+03	5.00E+04	2.70E+04	3.06E+04	1.64E+05	116000
Sodium	28 / 28	100	1.33E+04	1.39E+06	5.00E+03	5.00E+04	3.55E+05	4.36E+05	2.30E+06	1390000
Zinc	14 / 19	74	8.30E-01	5.07E+02	2.00E+01	2.00E+01	5.55E+01	1.23E+02	6.06E+02	507
Volatile Organic Compounds										
Benzene	9 / 28	32	1.45E-01	2.40E+00	1.00E+00	5.00E+00	6.73E-01	5.43E-01	3.10E+00	2.4
Ethylbenzene	6 / 28	21	1.30E-01	8.70E-01	1.00E+00	5.00E+00	5.82E-01	4.00E-01	2.37E+00	0.87
Toluene	8 / 28	29	1.20E-01	1.70E+00	1.00E+00	5.00E+00	4.99E-01	2.83E-01	1.76E+00	1.7
Xylenes, total	8 / 28	29	3.60E-01	5.50E+00	1.00E+00	5.00E+00	1.22E+00	1.53E+00	8.07E+00	5.5

[a] The UTL (upper tolerance limit) is calculated using the Cheby Chev equation (mean + 4.47 * standard deviation).

[b] The BSC (background screening criterion) is the calculated UTL or the maximum detected concentration, whichever is less.

ug/L = microgram per Liter

mg/L = milligram per Liter

BTEX = benzene, toluene, ethylbenzene, and xylenes

ATTACHMENT M1

BACKGROUND MONITORING WELL SELECTION FOR THE PHASE II GROUNDWATER INVESTIGATION

Shaw Environmental, Inc.

312 Directors Drive
Knoxville, TN 37923
865.690.3211
Fax 865.690.3626

Shaw™ Shaw Environmental, Inc.

October 19, 2004

Commander
U.S. Army Engineer District, Nashville
ATTN: CELRN-EC-R-M (Mrs. Linda Ingram)
110 Ninth Avenue South, Room 682
U.S. Court House Annex
Nashville, Tennessee 37203

Background Monitoring Well Selection
For the Phase II Groundwater Remedial Investigation
Former Plum Brook Ordnance Works, Sandusky, Ohio

Dear Mrs. Ingram:

Seven possible background bedrock groundwater monitoring wells at the above noted facility, have been sampled on a quarterly basis beginning in September-October 2001, to determine the background concentration of inorganics in bedrock groundwater. Shaw is providing this technical memorandum for review and approval from PBOW Team Members of wells that were selected, prior to report preparation. Prior review and approval of this background monitoring well data set will reduce subsequent comments and revisions to the 2004 Groundwater Data Summary and Evaluation Report, scheduled for November 2004.

Please submit any external comments within **2 weeks or by November 1, 2004** to Mrs. Linda Ingram at the USACE office in Nashville, Tennessee. Use email address Linda.Ingram@lrn02.usace.army.mil or you may send a written response to the following address:

Department of the Army
Nashville District, Corps of Engineers
ATTN: CELRN-EC-R-M (Mr. Linda Ingram)
P.O. Box 1070
Nashville, Tennessee 37202-1070

Should you have any questions or require additional information regarding this submittal, please do not hesitate to call me at (865) 694-7496.

Sincerely,

Steven T. Downey, P.E.
Project Manager

Enclosures

Copy Distribution List

Name	Copies
U.S. Army Engineer District, Nashville ATTN: CELRN-EC-R-M (Mrs. Linda Ingram) 110 Ninth Avenue South, Room 682 U.S. Court House Annex Nashville, TN 37203	2
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Mr. Ron Nabors Site Coordinator Division of Emergency and Remedial Response (DERR) Ohio Environmental Protection Agency 347 North Dunbridge Road Bowling Green, Ohio 43402-0466	2
Mrs. Laurie Moore Eggert Risk Assessment Coordinator Ohio EPA - Southwest District Office Office of Federal Facilities Oversight (OFFO) 401 E. Fifth Street Dayton, Ohio 45402	1

Evaluation and Selection of Background Groundwater Monitoring Wells
Former Plum Brook Ordnance Works, Sandusky, Ohio
September 2004

1.0 Introduction

Seven new and existing monitoring wells have been sampled to determine the background concentrations of inorganics in bedrock groundwater at the Former Plum Brook Ordnance Works (PBOW), Sandusky, Ohio. The purpose of this technical memorandum is to qualitatively evaluate the suitability of these wells for determining background concentrations and to obtain approval from PBOW Team Members prior to report preparation. Prior review and approval of a background data set will reduce subsequent comments and revisions to the Draft 2004 Groundwater Data Summary and Evaluation Report, scheduled for November 2004.

Data from the following 5existing wells (installed prior to November 2001) and 2 newly installed wells (installed in August 2003) were evaluated to determine whether groundwater data collected from these wells was representative of background conditions. Evaluation criteria included well yield, groundwater flow direction, water quality parameters, and the presence of groundwater contamination.

2.0 Potential Background Monitoring Well Locations

For evaluating background bedrock groundwater, monitoring wells furthest upgradient of known PBOW contaminant sources is required. In general, bedrock groundwater flow at the PBOW site is in the northeast direction, toward Lake Erie. This interpretation is based on consistent observations of quarterly groundwater elevation data collected over the past 2 years. Potential upgradient background monitoring wells include those installed as part of historical site investigations and those installed as part of the focused background investigation. In all, the following wells were evaluated:

- BG8-BEDGW-001
- PB-BED-MW24
- PB-BED-MW25
- PB-BED-MW26
- PB-BED-MW28
- PB-BED-MW29.

Locations of all potential background wells evaluated in this document are shown on Figure 1.

Wells BG8-BEDGW-001 and PB-BED-MW20 have been used for previous groundwater investigations and are upgradient of known PBOW contaminant sources. Bedrock monitoring well BG8-BEDGW-001 is located in the extreme western part of the PBOW facility, south of the G-8 Burning Ground Area and TNT Manufacturing Area C. Monitoring well PB-BED-MW20 is located in the extreme southern portion of the PBOW facility west of the intersection of Taft and Patrol Roads.

To supplement these existing background wells and better provide for site-wide bedrock groundwater coverage, monitoring wells PB-BED-MW24, PB-BED-MW25, and PB-BED-MW26 were installed in August 2001. Bedrock monitoring well PB-BED-MW24 is located in the extreme western part of the PBOW facility, southwest of Acid Area No. 2 and west of the West Area Red Water Ponds. Bedrock well PB-BED-MW25 is located in the extreme southwest part of the PBOW facility, southeast of the Lower Toluene Tanks Area and well PB-BED-MW26 is located in the extreme southwest part of the PBOW facility.

Evaluation of background PBOW bedrock groundwater from the identified wells began in the fall of 2001. Groundwater samples were attempted to be collected by the low-flow (minimal drawdown) sampling methodology if recharge of bedrock groundwater allowed, and if not, were collected by bailer. Groundwater sampling was performed on a quarterly basis in relation to a calculated "wet" and "dry" climatological season for the PBOW site. Based on historical rainfall records and evapotranspiration rates, the wet season (time the greatest volume of groundwater potentially present) for the Sandusky area was determined to be during the months of January through June and the dry season (time the least amount of groundwater potentially present) was identified as July through December. After the first year (4 quarters) of groundwater sampling, analytical data was reviewed. Low levels of nitroaromatics in the bedrock groundwater were intermittently detected in wells PB-BED-MW20 (nitrobenzene-April 2002), PB-BED-MW24 (nitrobenzene, RDX, and 2,6-DNT-April 2002), and PB-BED-MW25 (nitrobenzene-April 2002). Since these wells were located on PBOW property, it was thought the low levels of nitroaromatics may be site related. Based on discussions with the Ohio Environmental Protection Agency, two additional rounds of groundwater sampling were conducted in October 2002 and April 2003 to verify the detection of nitroaromatics in these wells. Nitroaromatics (nitrobenzene, TNT and RDX) were again detected in the groundwater from these three wells. Monitoring well PB-BED-MW20 detected RDX in the groundwater in April 2003, PB-BED-MW24 detected TNT in April 2003, and PB-BED-MW25 detected nitrobenzene in October 2002. With the additional groundwater

elevation data from these wells, the data was used to refine the groundwater flow maps for the site. These flow maps indicated that well PB-BED-MW24 was potentially downgradient of the West Area Red Water Pond.

To determine if these wells were truly background and upgradient of the PBOW site, off-site monitoring wells PB-BED-MW28 and PB-BED-MW29 were installed in August 2003 hydraulically upgradient (south) of PBOW. Monitoring well PB-BED-MW28 is located south of the PBOW facility on property owned by NASA, near the intersection of Taft and Mason Roads. This well is upgradient of well PB-BED-MW20. Monitoring well PB-BED-MW29 is situated southwest of the PBOW facility on private property, located west of Ransom Road and south of West Scheid Road. This well is located upgradient of PB-BED-MW25. Following installation of these new bedrock wells, four (4) additional rounds of groundwater sampling were conducted from all potential background wells.

As part of the investigation to determine off-site groundwater quality, monitoring well PB-BED-MW30 was installed in March 2004 northwest of PB-BED-MW24, east of the intersection of Bouy and Patten Tract Roads. Water level from this well in addition to one private well further to the north, confirmed that well PB-BED-MW24 is indeed downgradient of the West Area Redwater Pond.

3.0 Review Criteria

New and existing background bedrock monitoring wells were evaluated using site data to determine whether groundwater samples collected from these wells is representative of background bedrock concentrations of inorganic compounds entering the PBOW facility. This data included criteria such as well yield, groundwater flow direction, water quality parameters, and the presence of groundwater contamination. A brief description of these review criteria are presented in the following paragraphs.

3.1 Well Yield

Well yield is an important factor in determining whether the fracture encountered during drilling is providing groundwater in sufficient quantities that would be available for transport of any potential groundwater contamination. More importantly, the yield dictates whether the well can be sampled using low-low (minimal drawdown) methods, thus providing more representative groundwater sample results. Well yield was evaluated during drilling to determine the interval to install the well screen and during well sampling.

3.2 Groundwater Flow Direction

Groundwater flow maps were completed to determine the overall groundwater flow regime at PBOW. Current groundwater flow directions are depicted on the August 2004 overburden/shale bedrock contour map (Figure 1). Flow directions of the bedrock groundwater in the Delaware Limestone are shown on the August 2004 Delaware Limestone groundwater contour map (Figure 2). These maps were reviewed to determine whether each well used in the evaluation was upgradient of potential groundwater contamination.

3.3 Water Quality Parameters

Water quality parameters, collected during purging and sampling using a flow-through cell, were evaluated to determine if there were anomalous data or indicators of potential sampling problems. A summary of water quality measurements is shown on Table 1.

3.4 Presence of Groundwater Contamination

The presence of groundwater contamination, particularly site-related contaminants (i.e., nitroaromatics), may alter groundwater geochemistry. For example, anaerobic degradation of organic compounds may lead to lower dissolved oxygen and more negative oxidation-reduction potential, leading to higher dissolved inorganics. A summary of the background groundwater analytical results is provided as Table 2.

4.0 Results

The following sections summarize all available data for each of the potential background wells.

4.1 BG8-BEDGW-001

Monitoring well BG8-BEDGW-001 is screened within the Olentangy Shale bedrock at a depth of 4.75 to 19.75 feet bgs. Based on groundwater elevation data collected and corresponding flow maps, groundwater flow in this area of PBOW is to the north-northwest (Figure 1), indicating this well is upgradient of known PBOW areas of potential contamination. A total of 12 groundwater sampling events (10 by low-flow [minimal drawdown] and 2 by bailer) have been conducted at the well beginning in November 1997 (dry season) and ending in June 2004 (wet season). Nitroaromatics have never been detected in any of the groundwater samples from the well. Sporadic detections of acetone, 2-butanone, carbon disulfide, chloromethane, methylene chloride, xylenes and bis(2-ethylhexyl)phthalate have been reported. Approximately half of these organic compounds were "B" qualified, indicating the compound was also detected in the associated laboratory blank, suggesting these reported detections are not site related. The remaining detected

organic compound concentrations were less than 1 microgram per liter (µg/l). The analytical data does not indicate that this well has been impacted by PBOW-related activities.

Review of groundwater quality data indicates anomalous readings for three sampling events. An elevated pH of 13.03 S.U. was observed on September 27, 2001. The pH range for all other sampling events from this well was 5.97 to 7.80 S.U. At a pH of 13.03 S.U., concentrations of iron and manganese would be expected to be low. Review of the data does not indicate these to be anomalously low compared to other results from this well. Elevated pH readings were also observed in other wells sampled during this time period, suggesting that these readings are due to equipment error and are not indicative of geochemical changes in groundwater. Elevated Eh and dissolved oxygen readings were recorded on April 3, 2002 and March 11, 2004. Redox values recorded for all other sampling periods are negative for this well, indicating reducing conditions. Corresponding dissolved oxygen readings are also typically low, ranging from 0.0 ppm to 1.92 ppm. Conversely, the Eh values for April 3, 2004 and March 11, 2004 were 220 mV and 42.8 mV, and DO values were 6.74 ppm and 5.51 ppm, respectively. Note that the DO value for April 3, 2003 was obtained from the purging log. The DO meter malfunctioned during sampling, and the reading was the last recorded. Regardless, the data suggest a possible seasonal effect occurring. Review of the dissolved inorganics data indicate lower concentrations of redox-sensitive compounds, specifically iron and manganese. Even though some anomalies of groundwater quality criteria are noted and some organics were reported at low concentrations, the observed values do not appear to indicate site-related conditions. Therefore, well BG8-BEDGW-001 is recommended to be included in the background data set. Further evaluation of the seasonal trends will be completed as part of the 2004 Groundwater Data Summary and Evaluation Report.

4.2 PB-BED-MW20

Monitoring well PB-BED-MW20 is screened within the Ohio Shale at a depth of 28.5 to 48.5 bgs. Based on groundwater elevation data collected and corresponding flow maps, groundwater flow in this area of PBOW is to the east (Figure 1), indicating this well is upgradient of known PBOW areas of potential contamination. A total of 12 groundwater sampling events (8 by low-flow [minimal drawdown], and 4 by bailer) have been conducted at the well beginning in November 1997 (dry season) and ending in June 2004 (wet season). Low concentrations of nitrobenzene (0.088J µg/l), RDX (0.17J µg/l), and 4-amino-2,6-DNT (0.19J µg/l) were each detected in 1 of 12 sampling events. These three nitroaromatics were detected in groundwater samples collected during the months of April 2002 (wet season), April 2003 (wet season), and September 2003 (dry season), respectively. The RDX detection is interpreted to be false positive result based on the following information. RDX has only been detected sporadically in PBOW soil and groundwater

samples. In total, RDX has been detected in 4 of 880 soil samples and 11 of 421 groundwater samples collected at the site from 1996 through 2004. There is no information to indicate that RDX was ever used or was otherwise present at the site. RDX is not known to be a contaminant of any reactants used in TNT manufacturing, a by-product of TNT manufacturing, or a degradation product of any compounds formerly used or manufactured at PBOW. RDX is not a nitroaromatic and is structurally quite dissimilar from nitroaromatics such as TNT and related compounds, some of which are substrates or breakdown products of TNT (e.g., di- and mono- substituted nitroaromatics and aminonitroaromatics). Similar sporadic detections of RDX have been reported at the West Virginia Ordnance Works, a TNT manufacturing facility similar to PBOW. Confirmation sampling and analysis at that site verified that RDX was not present.

Natural gas was encountered in well PB-BED-MW20 during nearly every sampling event. During groundwater purging of the well when the water table was lowered, escaping gas was evident. The 2-inch riser would sometimes violently shake, gurgling and bubbling of water could be heard, and the explosive meter would measure maximum limits. Also, based on discussions with NASA personnel, an abandoned natural gas well is located nearby at Taft Road and the security fence. While hydrogen sulfide is common in nearly all the bedrock wells, natural gas (presumably methane), has not been observed in any other wells onsite.

Other organic compounds sporadically detected include acetone, bromomethane, 2-butanone, chloromethane, ethyl benzene, methylene chloride, xylenes, bis(2-ethylhexyl)phthalate, and 2-methylnaphthalene. Of these detections, acetone and methylene chloride were commonly "B" qualified, indicating the compound was also detected in the associated laboratory blank. This suggests the reported values may not be site related. In addition, 2-butanone and BEHP, although not "B" qualified, are also common laboratory contaminants. Other organic compounds benzene, carbon disulfide, and toluene were detected in the groundwater in more than half of the sampling events. As previously discussed, these detections are likely the result of natural petroleum hydrocarbons present in the bedrock at PBOW. All of the detected organic compounds exhibited concentrations slightly above or less than 1 µg/l, except acetone (5.3 µg/l in April 2002) and 2-butanone (9.8 µg/l in July 2002).

Review of water quality parameter data indicate that two anomalous results for Eh and/or DO. The positive Eh readings were observed in April of 2002 and 2003. Review of the redox-sensitive inorganics (i.e., iron) indicate much lower concentrations of iron during these two periods. In addition, dissolved oxygen was elevated during April 2003. These readings, coupled with the lower concentration of iron, suggest a possible seasonal trend in this well. Samples collected in

May 1998 also show a lower concentration of iron, supporting this seasonal trend. It should be noted however that Eh data was not available for this sample.

As noted above, the well exhibited high concentrations of natural gas. Review of the inorganic analytical data indicate that the dissolved iron concentrations were approximately one to two orders of magnitude higher than other background wells. In addition, manganese was also elevated by a factor of two over other wells.

In summation, most of the organic groundwater detections are interpreted to be influenced by the presence of natural gas in the rock formation or are common laboratory contaminants. The low levels of nitroaromatics were detected sporadically and were not reproducible over the quarterly sampling. In addition, the low concentrations of the nitroaromatics likely will not have a significant impact on the inorganic data. However, the presence of natural gas (methane), atypical for the PBOW site, likely influences the concentration of inorganics. Therefore, monitoring well PB-BED-MW20 should not be used to determine background groundwater concentrations for PBOW in general, even though the presence of methane is associated with natural geologic conditions. Should any other bedrock wells exhibit the presence of natural gas, the data from PB-BED-MW20 could be used for comparison purposes for that well only. Further, only those samples collected by low-flow should be used to determine the range in background concentrations.

4.3 PB-BED-MW24

Monitoring well PB-BED-MW24 is screened within the Delaware Limestone at a depth of 25.5 to 40.5 feet below ground surface (bgs). Based on groundwater elevation data collected and corresponding flow maps, groundwater flow in this area of PBOW is to the west-northwest (Figure 2). A total of 10 groundwater sampling events (9 by low-flow [minimal drawdown] and 1 by bailer) have been conducted at the well beginning in October 2001 (dry season) and ending in June 2004 (wet season). Nitroaromatics 2,6-DNT (µg/l), nitrobenzene (0.33 µg/l), RDX (0.22J µg/l), and 2,4,6-TNT (0.081J µg/L) were each detected in 1 of the 10 groundwater sampling events for this well. 2,6-DNT, nitrobenzene, and RDX were reported only in the sample taken during April 2002, and 2,4,6-TNT (0.081J µg/l) was reported only in the sample collected during April 2003. After installation of off-site monitoring well PB-BED-MW30 and review of potentiometric flow map data, it was concluded that well PB-BED-MW24 was actually downgradient of a known contamination source, the West Area Red Water Pond. Therefore, monitoring well PB-BED-MW24 is not considered a background well. Groundwater analytical results from this well will be evaluated with other site-related wells in the upcoming data summary report.

4.4 PB-BED-MW25

Monitoring well PB-BED-MW25 is screened within the Olentangy Shale bedrock at a depth of 27.5 to 37.5 feet bgs. Based on groundwater elevation data collected and corresponding flow maps, groundwater flow in this area of PBOW is to the northeast (Figure 1), indicating this well is upgradient of known PBOW areas of potential contamination. A total of 10 low-flow (minimal drawdown) groundwater sampling events have been conducted at the well beginning in October 2001 (dry season) and ending in June 2004 (wet season).

The nitroaromatic compound nitrobenzene has been detected in 2 of the 10 PB-BED-MW25 groundwater samples. During April 2002 it was detected at a concentration of 0.076J µg/l and in October 2002 at a concentration of 0.12J µg/l. The source of the nitrobenzene is unclear, but nitrobenzene has wide industrial use and is present in numerous consumer products; perhaps, its presence may be associated with the application of pesticides or fertilizer on local farm fields. Sporadic detections of acetone, carbon disulfide, chloroform, 4-methyl-2-pentanone, methylene chloride, benzene, ethyl benzene, toluene, xylenes (BTEX) and bis(2-ethylhexyl)phthalate have been reported. Three of these organic compounds (acetone, methylene chloride, and bis[2-ethylhexyl]phthalate) exhibited analytical results that were "B" qualified, indicating the compound was also detected in the associated laboratory blank. This suggests that these reported concentrations are not site related. Natural petroleum hydrocarbon (oil) and natural gas are known to be associated with the limestone and shale bedrock in northern Ohio. The low levels of BTEX and carbon disulfide (less than 1.5 µg/l) are believed to be related to the natural petroleum and gas. The remaining detected organic compounds (chloroform and 4-methyl-2-pentanone) were only detected during one sampling event and exhibited analytical results 1.1 and 0.3 µg/l, respectively. A potential source of chloroform is from release of chlorinated tap water into the environment through surface discharge or through septic systems. Although there are low levels of organics, the analytical data does not indicate that this well has been impacted by PBOW-related activities.

Review of groundwater quality data indicates an anomalous pH reading for one sampling event. An elevated pH of 10.58 S.U. was observed on October 5, 2001 with the pH for all other sampling events from this well ranging from 6.56 to 8.46 S.U. At an elevated pH (i.e., greater than 10 S.U.), the solubility of iron and manganese is low. Review of the data indicates iron at a concentration of 795 µg/l (unfiltered) and 713 µg/l (filtered) and manganese at a concentration of 89 µg/l (filtered) and 87 µg/l (filtered). The iron concentrations from the October 2002 sampling were anomalously high compared to the other sampling events for this well while manganese concentrations were within the range of those detected during other events. Elevated pH readings were also observed in

other wells sampled during the fall 2001 groundwater sampling, suggesting that these readings are due to equipment error and are not indicative of geochemical changes in groundwater.

With the exception of turbidity, the remaining water quality parameter readings were relatively consistent over the sampling intervals and do not indicate any possible errors. Field recorded turbidity readings were less than 6 NTUs for all samples collected. However, laboratory measured turbidity (Table 2) for these same samples ranged from 2 to 112 NTUs. The reason for this discrepancy is unclear.

The sporadic detections of nitrobenzene should not preclude this well from being used to determine background conditions in bedrock groundwater. While the source of the nitrobenzene could be from PBOW, the lack of other nitroaromatics (TNT or DNT) in samples from this well suggests that nitrobenzene is not site-related (note also, as mentioned above, that nitrobenzene has wide industrial applications and is present in numerous consumer products). Further, the low reported concentrations likely do not have a significant impact to groundwater geochemistry. The primary effects of organics in groundwater are lower dissolved oxygen and more reducing conditions. The bedrock groundwater is naturally under reducing conditions due to the presence of naturally occurring petroleum hydrocarbons, and thus, these sporadic nitrobenzene detections likely would not significantly change the geochemistry.

4.5 PB-BED-MW26

Monitoring well PB-BED-MW26 is screened within the Ohio Shale bedrock at a depth of 42.75 to 57.75 feet bgs. This well has insufficient yield for use in background monitoring. A single sample was collected by bailer only in January 2002,with sufficient volume to analyze only for unfiltered metals. Results of the unfiltered metals sample exhibited very high analytical results when compared to the results from other background wells. Since January 2002, sufficient water has not been available for further analysis. During a September 2002 meeting between the USACE, OEPA, NASA, and Shaw, it was decided to eliminate monitoring well PB-BED-MW26 from the background data set due to insufficient yield, having never been properly developed, and showing unrepresentative groundwater analytical results caused by the high turbidity in the groundwater that accompanies attempts at sampling by bailer from a limited water column.

4.6 PB-BED-MW28

Monitoring well PB-BED-MW28 is screened within the Ohio Shale bedrock at a depth of 21.65 to 41.65 feet bgs. Based on information from potentiometric flow maps, the well monitors groundwater upgradient of the PBOW site with groundwater flow in a northeast-easterly direction

toward the site (Figure 1). A total of 4 groundwater sampling events performed by the low-flow (minimal drawdown) sampling methodology have been conducted at the well beginning in September 2003 (dry season) and ending in June 2004 (wet season). Nitroaromatics have never been detected in the groundwater from the well. Sporadic detections of acetone, carbon disulfide, chloromethane, ethyl benzene, methylene chloride, trichloroethene, and xylenes have been reported and benzene and toluene were detected during all four of the sampling events. The sporadic detection of methylene chloride was "B" qualified, indicating that it was also detected in the associated laboratory blank. All of the compounds except acetone, benzene, and toluene were detected at concentrations less than 1 µg/l. Acetone was detected at a concentration of 2.1 µg/l in March 2004, benzene was detected at concentrations of 2.4 µg/l, 2.2 µg/l, 1.7 µg/l, and 1.1 µg/l during the months of September 2003, December 2003, March 2004, and June 2004, respectively, and toluene was detected at a concentration of 1.7 µg/l in September 2003. Natural petroleum hydrocarbon (oil) and natural gas are known to be associated with the shale bedrock in northern Ohio. The low levels of BTEX and carbon disulfide (1.3 µg/l) are believed to be related to the natural petroleum and natural gas in the organic rich shale in which the well is screened. The detection of trichloroethene (TCE) (0.59J µg/l) in the September 2003 is most likely related to local farming operations in the area.

Review of groundwater quality data indicates anomalous readings for only the Eh measurements. Positive readings indicating oxidizing conditions were obtained in December 2003 (7.5 mV-dry season) and March 2004 (75.3 mV-wet season) while negative measurements indicating reducing conditions were obtained in September 2003 (-95.2 mV-dry season) and June 2004 (-131.9 mV-wet season). Corresponding dissolved oxygen readings for all 4 events were typically low, ranging from 0.00 to 0.45 ppm. The Eh data suggest a possible seasonal effect occurring. Review of the dissolved inorganics data indicate higher concentrations of redox-sensitive compounds, specifically iron and manganese, during the fall and winter with lower concentrations observed in the spring and summer results. This likely is due to additional groundwater recharge occurring during the spring. Further evaluation of the seasonal trends will be completed as part of the 2004 Groundwater Data Summary and Evaluation Report.

The purpose of the background evaluation is to determine the water quality entering the PBOW site, regardless of any impacts from offsite areas. Given that this well's location is approximately 1,200 feet upgradient of the site, there is no concern of impacts by PBOW site activities; this is corroborated by a lack of nitroaromatics detections. Therefore, well PB-BED-MW28 well is recommended for use in the background data set.

4.7 PB-BED-MW29

Monitoring well PB-BED-MW29 is screened within the Olentangy Shale bedrock at a depth of 27.65 to 37.65 feet bgs. Based on information from potentiometric flow maps, the well monitors groundwater upgradient of the PBOW site with groundwater flow in a north-northeastly direction toward the site (Figure 1). A total of 4 groundwater sampling events performed by the low-flow (minimal drawdown) sampling methodology have been conducted at the well beginning in September 2003 (dry season) and ending in June 2004 (wet season). Nitroaromatics have never been detected in the groundwater from the well. Sporadic detections of acetone, chloroform, chloromethane, methylene chloride, and toluene have been reported and benzene, carbon disulfide, ethyl benzene, and xylenes were each detected in at least three of the four sampling events. Sporadic hits acetone and methylene chloride were "B" qualified, indicating that they were also detected in the associated laboratory blank. All of the compounds except acetone, carbon disulfide, and total xylenes were detected at a concentration less than 1 µg/l. Acetone was detected at concentrations of 17 µg/l, 2.1 µg/l, and 9.1 µg/l in September 2003, March 2004, and June 2004 respectively, carbon disulfide was detected at a concentration of 13 µg/l during the month of December 2003, and total xylenes were detected at concentrations of 5.5 µg/l, 5.1 µg/l, 4.5 µg/l, and 3.7 µg/l during the months of September and December 2003 and March and June 2004, respectively. Natural petroleum hydrocarbon (oil) and natural gas are known to be associated with the shale bedrock in northern Ohio. The low levels of BTEX and carbon disulfide are believed to be related to the natural petroleum and natural gas in the organic rich shale in which the well is screened.

Review of groundwater quality data indicates no particular anomalous readings. The Eh measurement during the month of June 2004 was recorded as a negative reading compared to three positive measurement readings during the previous sampling months. As with PB-BEDGW-028, Eh shows a seasonal trend. Concentrations of redox-sensitive compounds, specifically iron also shows a seasonal trend.

The purpose of the background evaluation is to determine the water quality entering the PBOW site, regardless of any impacts from offsite areas. Given that this well's location is approximately 1,200 feet upgradient of the site, there is no concern of impacts by PBOW site activities, as corroborated by a lack of nitroaromatics detections. Therefore, well PB-BED-MW29 is recommended for use in the background data set.

5.0 Summary

Based on a review of all available site data, the following wells are recommended for inclusion in the PBOW background data set that will be used in determining the background concentrations of inorganics in bedrock groundwater:

- BG8-BEDGW-001 (10 samples)
- PB-BED-MW25 (10 samples)
- PB-BED-MW28 (4 samples)
- PB-BED-MW29 (4 samples)

It should be noted that only samples from the above wells collected using low-flow (minimal drawdown) will be used in the statistical evaluation of background analytical data. The number of samples shown in parenthesis represent only the samples collected using low-flow sampling. All other samples collected by bailer will not be used in determining the background concentration of inorganics.

The following wells are recommended for exclusion from the PBOW background well data set, with the reasons for exclusion provided in parentheses:

- PB-BED-MW20 (excluded due to the presence of methane)
- PB-BED-MW24 (excluded because location is now interpreted as being downgradient from a contamination source; also, presence of multiple nitroaromatics)
- PB-BED-MW26 (insufficient well yield).

It is noted that well PB-BED-MW20 might be useful as a background well for qualitative comparison for any on-site wells that are impacted by natural gas.

Table 1

Final Field Measurements of Groundwater Samples
Background Well Review
Former Plum Brook Ordnance Works, Sandusky, Ohio

Well Identification	Date	Time	Low-Flow Sampled	PID (ppm)	H_2S (ppm)	Eh (mV)	pH	Conductivity (µmhos/cm)	Turbidity (NTU)	Dissolved O_2 (ppm)	Temperature (°C)	Volume Purged (gal)
Background Bedrock Wells (1997 through March 2004)												
BG8-BEDGW-001	11/17/1997	NA	No	0	NM	-245.3	7.21	3.31	321	6.83	10.5	30
	5/15/1998	NA	No	0.1	NM	-36.2	7.80	151	10	8.00	13.0	27.73
	9/27/2001	1220	Yes	0.0	NM	-339	13.03	3.75	0.0	0.00	12.65	2.97
	1/16/2002	1450	Yes	0.0	0.0	-79	7.38	0.856	2.8	0.00	10.69	2.22
	7/12/2002	0920	Yes	0	0	-258	7.21	3.68	10.3	0.41	13.45	5
	10/18/2002	1050	Yes	0.0	0.0	-307	5.97	3.88	16.5	1.73	14.2	4.0
	4/10/2003	1545	Yes	1.1	0.0	-64.5	7.79	0.656	2.3	NM	8.61	3
	9/18/2003	1550	Yes	0.0	0	-307.9	6.84	3.429	0.0	1.92	15.72	2
	12/10/2003	1620	Yes	0.0	0	-50.8	7.23	0.988	0.0	0.31	11.11	3
	3/11/2004	1405	Yes	0.0	0	42.8	7.16	0.983	0.0	5.51	9.21	2.7
	6/16/2004	1600	Yes	0.0	0.0	-102.8	7.18	0.648	0.0	1.90	15.82	1.8
PB-BED-MW20	11/17/1997	NA	No	0	NM	-24.7	6.74	48.5	563	4.14	9.4	27
	5/28/1998	NA	No	0.1	NM	NM	6.65	38.1	999	12.80	13.0	58
	9/26/2001	1415	No	0.0	NM	-73	8.95	53.60	53.5	0.00	10.54	10.33
	1/15/2002	1415	Yes	1.6	0.0	-55	6.83	52.60	15.0	0.00	7.22	1
	4/4/2002	1013	Yes	0.0	NM	51	7.07	53	0.0	0.00	10.37	1.9
	7/10/2002	1600	Yes	0	0	-57	6.73	52.9	NR	0.00	13.85	3.5
	10/17/2002	1510	No	0.0	0.0	-32	5.69	56.3	10.8	3.38	11.60	24
	4/11/2003	1050	Yes	0.9	0.0	64.3	6.96	49.75	3.7	9.23	10.17	2.8
	9/18/2003	0845	Yes	0.0	0	-9.6	6.43	49.71	0.0	0.38	11.97	1.8
	12/10/2003	1200	Yes	0.0	0	-30.2	6.68	51.46	0.1	0.46	8.86	1.5
	3/10/2004	1525	Yes	0.0	0	-55.7	6.70	48.57	0.0	0.00	10.91	0.75
	6/17/2004	1515	Yes	0	0.0	-53.5	6.68	48.96	0.0	0.54	25.98	1.5
PB-BED-MW24	10/9/2001	0935	Yes	NM	NM	-144	9.38	1.81	73.3	5.32	11.20	2.99
	1/17/2002	1005	Yes	114	0.0	-333	6.82	1.99	2.5	0.00	9.69	2.11
	4/3/2002	1730	Yes	76.0	0.0	-318	7.06	1.98	0.0	NM	10.71	1.8
	7/12/2002	1405	Yes	84.1	>500	-358	6.66	1.88	350	0.00	12.93	4.5
	10/19/2002	1110	No	58.2	>50	-297	6.30	1.85	22.3	5.52	12.20	4.5
	4/9/2003	1530	Yes	5.6	>200	-337.7	6.64	1.753	0.0	0.00	9.98	3.3
	9/17/2003	1320	Yes	62.9	>500	-323.0	6.14	1.637	0.0	4.88	13.00	3.25
	12/10/2003	1035	Yes	58.3	>50	-331.7	6.61	1.408	0.0	-1.99	10.06	3.2
	3/10/2004	1305	Yes	56.8	156	-310.3	6.54	1.700	3.4	0.00	10.84	2.1
	6/16/2004	1330	Yes	47.5	>200	-321.9	6.63	1.334	0.0	0.00	14.65	3.3

Table 1

Final Field Measurements of Groundwater Samples
Background Well Review
Former Plum Brook Ordnance Works, Sandusky, Ohio

Well Identification	Date	Time	Low-Flow Sampled	PID (ppm)	H_2S (ppm)	Eh (mV)	pH	Conductivity (µmhos/cm)	Turbidity (NTU)	Dissolved O_2 (ppm)	Temperature (°C)	Volume Purged (gal)
Background Bedrock Wells (1997 through March 2004), continued												
PB-BED-MW25	10/5/2001	0920	Yes	0.0	0.01	-237	10.58	1.89	5.7	2.41	11.90	3.67
	1/16/2002	1030	Yes	0.0	0.0	-291	7.23	2.42	5.8	0.00	10.54	4.44
	4/3/2002	1120	Yes	NM	NM	-333	8.46	2.62	2.7	0.01	10.90	8
	7/11/2002	1115	Yes	0	0	-302	7.19	1.86	1.9	0.00	12.92	8
	10/17/2002	1035	Yes	0.0	0.0	-290	6.56	2.96	2.1	1.69	12.00	6.0
	4/10/2003	1035	Yes	0.0	0.0	-333.8	7.22	2.817	3.7	NM	10.93	5.5
	9/18/2003	1220	Yes	0.3	0.0	-296.2	6.98	1.707	0.0	0.22	13.91	5.5
	12/11/2003	1355	Yes	0.0	0	-325.6	7.11	1.509	0.0	0.10	10.82	3.6
	3/11/2004	0915	Yes	0.0	0.0	-303.4	7.01	1.605	0.0	0.00	10.85	5.2
	6/17/2004	0945	Yes	0.0	0.0	-275.5	7.09	1.672	0.0	0.26	13.59	4.8
PB-BED-MW26	10/10/2001	NA	NA	3.6	NM	No sample collected due to insufficient water volume.						
	1/15/02[a]	1030	No	2.2	0.21	-59	6.87	31.0	999	8.04	8.69	0.5
	4/9/2002	NA	NA	NM	NM	No sample collected due to insufficient water volume.						
	7/12/2002	NA	NA	3.1	0	No sample collected due to insufficient water volume.						
	10/16/2002	NA	NA	6.0	0.0	No sample collected due to insufficient water volume.						
	4/8/2003	NA	NA	NM	NM	No sample collected due to insufficient water volume.						
	9/3/2003	NA	NA	NM	NM	No sample collected due to insufficient water volume.						
	12/10/2003	NA	NA	NM	NM	No sample collected due to insufficient water volume.						
	3/10/2004	NA	NA	15.6	0.00	No sample collected due to insufficient water volume.						
	6/17/2004	NA	NA	14.6	20	No sample collected due to insufficient water volume.						
PB-BED-MW28	9/17/2003	0915	Yes	0.0	0	-95.2	7.50	1.408	0.0	0.21	13.88	1.50
	12/9/2003	1320	Yes	0.0	0	7.5	7.54	1.391	0.0	0.45	10.28	1.5
	3/9/2004	1410	Yes	0.0	0	75.3	8.50	1.739	0.0	0.00	10.01	2.5
	6/15/2004	1330	Yes	0.0	0	-131.9	7.89	1.228	0.4	0.33	15.01	4
PB-BED-MW29	9/16/2003	1520	Yes	0.0	0	6.5	6.66	10.30	25.0	0.22	15.80	3.9
	12/9/2003	1535	Yes	8.0	0	3.0	6.82	8.490	1.9	0.39	10.00	1.37
	3/10/2004	1015	Yes	0.0	0	34.4	6.73	9.207	10.2	0.0	9.13	1.8
	6/16/2004	0955	Yes	0.0	0	-52.9	6.78	9.125	0.3	0.19	13.65	3

Table 1

Final Field Measurements of Groundwater Samples
Background Well Review
Former Plum Brook Ordnance Works, Sandusky, Ohio

Notes:

Water quality measurements were recorded immediately before sample collection. PID and H_2S readings taken as monitoring well lid removed.

O_2 - Oxygen.

[a]Water quality reading collected from last purged groundwater due to a limited water volume. Reading was not recorded in a flow through cell. Well was purged on 1/15/02 and sample was collected on 1/17/02 at 0820.

Table 2

Summary of Background Bedrock Groundwater Analytical Results
Former Plum Brook Ordnance Works
Sandusky, Ohio

Location:				IT-BG8-BEDGW-001																							
Sample Number:				5410		5415		BD3007		CA3006		CB3007		CC3001		CD3001		DA3001		DC3000		DD3001		DE3000		DG3000	
Sample Date:				17-Nov-97		15-May-98		27-Sep-01		16-Jan-02		3-Apr-02		12-Jul-02		18-Oct-02		10-Apr-03		18-Sep-03		10-Dec-03		11-Mar-04		16-Jun-04	
Low-Flow Sample:				No		No		Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes	
Parameter	Units	MDC	BSC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																											
Amino-2,6-dinitrotoluene, 4-	ug/L	0.19	NE																								
Dinitrotoluene, 2,6-	ug/L	0.43	NE																								
Nitrobenzene	ug/L	0.33	NE																								
RDX	ug/L	0.22	NE																								
Trinitrotoluene, 2,4,6-	ug/L	0.081	NE																								
Volatiles																											
Acetone	ug/L	170	NE									3.5	J	2.6	B	3.4	J	1.9	B							5.6	B
Benzene	ug/L	110	NE																								
Bromomethane	ug/L	0.27	NE																								
Butanone, 2-	ug/L	17	NE											3.2	B			0.53	J								
Carbon disulfide	ug/L	29	NE	0.65	J											0.43	J					0.3	J	0.19	J	0.16	J
Chloroform	ug/L	1.1	NE																								
Chloromethane	ug/L	1.3	NE																			0.26	J				
Ethylbenzene	ug/L	45	NE																								
Methyl-2-pentanone, 4-	ug/L	0.3	NE																								
Methylene chloride	ug/L	21	NE	0.37	B																						
Toluene	ug/L	100	NE																								
Trichloroethene	ug/L	0.59	NE																								
Xylenes, total	ug/L	240	NE	0.38	B							1															
Semivolatiles																											
Bis(2-ethylhexyl)phthalate	ug/L	5.4	NE	1.7	J	4	B							4.3	B												
Diethyl phthalate	ug/L	1.5	NE																								
Dimethylphenol, 2,4-	ug/L	1.1	NE																								
Methylnaphthalene, 2-	ug/L	10	NE																								
Naphthalene	ug/L	8.7	NE																								
Phenol	ug/L	1.4	NE																								
Metals - Unfiltered																											
Aluminum	ug/L	10200	TBD	9020		307		51.6	B	78.7	B	31.5	J	65.2	B	83.6	B	141	B	101	B					71.8	J
Antimony	ug/L	8	TBD																								
Arsenic	ug/L	52.6	TBD	17.6										3.6	J												
Barium	ug/L	26900	TBD	520				285		68	J	29.9	J	229		279		43.5	J	292		73.2	J	25.8	J	27.6	J
Beryllium	ug/L	4.6	TBD							1.2	B																
Cadmium	ug/L	1.5	TBD																								
Calcium	ug/L	2290000	TBD	161000		57700		124000	J	91300		81500		134000		122000		66600		131000		86200		66800		81800	
Chromium	ug/L	18.2	TBD	18.2				1.4	B																		
Cobalt	ug/L	35.8	TBD											12.1	J			1	J								
Copper	ug/L	72.2	TBD	59.5								3.3	J														
Iron	ug/L	52100	TBD	22600		1230	J	204		118	B	38.2	J	1490		74.5	J			218		908					
Lead	ug/L	101	TBD	26.3		6.8																					
Magnesium	ug/L	1040000	TBD	79500		19300		77300		38400		31700		73500		77000		29000		81900		37100		25000		29000	
Manganese	ug/L	2240	TBD	2240		130		71.6		107		29		688		51.1		35		63.8		166		3.6	J	40.9	
Mercury	ug/L	0.1	TBD																								
Nickel	ug/L	74.9	TBD									6.8	J	8.6	J			8.6	J			4.8	J	3.6	B		
Potassium	ug/L	174000	TBD	32900				41100		13300		2530	J	30500		41200	J	5290	J	42700	J	7630		2530	J	4310	J
Selenium	ug/L	5	TBD																								
Sodium	ug/L	9130000	TBD	399000				459000		93200		23600		395000		462000		48900		471000		86300		21300		13300	
Thallium	ug/L	7.1	TBD							3.3	B									3.8	B	2.5	B	3.1	B	4	B
Vanadium	ug/L	35.9	TBD																								
Zinc	ug/L	612	TBD	126		49.7	B			12.6	J	15.6	J	10		0.83	J	2.5	B			30.1		4.3	B	16.6	B
Metals - Filtered																											
Aluminum	ug/L	1470	TBD					56.6	B	83.6	B	52	B	113	B	86.7	B	113	B	75	B			61.6	B	74.3	J
Antimony	ug/L	0	TBD																								
Arsenic	ug/L	6.9	TBD																								
Barium	ug/L	26200	TBD	366				279		83.6	J	30.6	J	236		285		47.6	J	292		81.8	J	27.8	J	29.8	J
Beryllium	ug/L	1.5	TBD							1.5	B																
Cadmium	ug/L	1.2	TBD																			1.2	J				
Calcium	ug/L	2570000	TBD	121000	J	92100		125000		98300		82900		133000		127000		70000		131000		89900	J	66100		81300	
Chromium	ug/L	0	TBD																								
Cobalt	ug/L	34.8	TBD											8.2	J			2.5	J								
Copper	ug/L	49.2	TBD																								
Iron	ug/L	6180	TBD	563				169		216				1160		53.4	J			195		856					
Lead	ug/L	8.7	TBD																								
Magnesium	ug/L	1090000	TBD	72400		41000		77600		43300		32300		76000		79800		30400		81900		40000		24800		29400	
Manganese	ug/L	1300	TBD	1300		658		73.5		117		23.6		728		52.2		73.8		64		164		3.6	J	47.5	
Mercury	ug/L	0.24	TBD																								
Nickel	ug/L	82.9	TBD									7	J	8.5	J			9.8	J			4.8	J	4.8	J	2.8	J
Potassium	ug/L	173000	TBD	32000		14400		40700		16700		2470	J	31000		43200	J	5930	J	42100	J	9690	J	2620	J	4770	J
Selenium	ug/L	0	TBD																								
Sodium	ug/L	9110000	TBD	398000		139000		459000		121000	J	24400		392000		472000		62800		472000		112000	J	22400		17600	
Thallium	ug/L	7.3	TBD							4.6	B							6.9	B	4.7	B	2.7	B	5.1	J		
Vanadium	ug/L	0	TBD																								
Zinc	ug/L	673	TBD			44.9	B			13.5	J	17.3	J	7.3	J	1.2	B	5.8	J			35.9		3.9	B	17.5	B
Water VQity Parameters																											
Alkalinity	ppm	979	NE	350		180		357	J	200		157		367		332		168		355		255		189		317	
Chloride	ppm	34600	NE	780		34		932		78		63.2	J	896		999		77.7		1000		132		24.5		9.6	
Cyanide, total	ppm	0.004	NE																								
Hardness	ppm	20000	NE	1000		340		719		380		314		647		687		320		710		313		340		312	
Nitrate	ppm	22	NE			7.3				22		10.4						8.6				0.58		16	R	1.5	
Nitrate-Nitrite	ppm	0.2	NE	0.2																							
Sulfate	ppm	514	NE	70		45		28.3		68		63.3		9.2		11.2		57.5		23.3		54.4		46.4		36	
Total dissolved solids	ppm	43800	NE	1800		300		1990		500		458		2040		1870		174		1880		584		352		383	
Total organic carbon	ppm	9.9	NE			1								1.9		1.3				1.2		1.2		1.1			
Total suspended solids	ppm	760	NE	10		280		4				3	J	21				4		7		4					
Turbidity	NTU	742	NE					104	J			0.61		39		44.2		0.56		78.5		5.2	J				

Table 2

Summary of Background Bedrock Groundwater Analytical Results
Former Plum Brook Ordnance Works
Sandusky, Ohio

(2 of 6)

Location:				PB-BED-MW20																					
Sample Number:				5960		5965		BD3026		CA3005		CB3001		CC3003		CD3003		DA3003		DC3001		DD3002		DE3001		DG3001	
Sample Date:				17-Nov-97		28-May-98		26-Sep-01		15-Jan-02		4-Apr-02		10-Jul-02		17-Oct-02		11-Apr-03		18-Sep-03		9-Dec-03		10-Mar-04		17-Jun-04	
Low-Flow Sample:				No		No		No		Yes		Yes		Yes		No		Yes		Yes		Yes		Yes		Yes	
Parameter	Units	MDC	BSC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																											
Amino-2,6-dinitrotoluene, 4-	ug/L	0.19	NE																	0.19	J						
Dinitrotoluene, 2,6-	ug/L	0.43	NE																								
Nitrobenzene	ug/L	0.33	NE									0.088	J							-							
RDX	ug/L	0.22	NE															0.17	J								
Trinitrotoluene, 2,4,6-	ug/L	0.081	NE																								
Volatiles																											
Acetone	ug/L	170	NE					1.2	J			5.3	J	10	B									2.1	J	5.7	B
Benzene	ug/L	110	NE	0.93	J	1.6		0.25	J					3.2		1.3	J	0.23	J	1.4	J	1.2		1.1		0.34	J
Bromomethane	ug/L	0.27	NE											0.27	J												
Butanone, 2-	ug/L	17	NE											9.8													
Carbon disulfide	ug/L	29	NE			0.17	J									1.1	J	0.21	J			0.16	J	0.21	J		
Chloroform	ug/L	1.1	NE																								
Chloromethane	ug/L	1.3	NE																	0.47	B						
Ethylbenzene	ug/L	45	NE	0.15	J																						
Methyl-2-pentanone, 4-	ug/L	0.3	NE																								
Methylene chloride	ug/L	21	NE	0.3	B	0.49	B											0.31	B					0.28	B		
Toluene	ug/L	100	NE	0.73	B	0.95	B			2.4	B			0.76	B	0.35	J			0.45	B	0.26	B	0.28	J		
Trichloroethene	ug/L	0.59	NE																								
Xylenes, total	ug/L	240	NE	2.6		0.91	J					0.67	J														
Semivolatiles																											
Bis(2-ethylhexyl)phthalate	ug/L	5.4	NE			5.4	B	2.9	J																		
Diethyl phthalate	ug/L	1.5	NE																								
Dimethylphenol, 2,4-	ug/L	1.1	NE																								
Methylnaphthalene, 2-	ug/L	10	NE	1.1	J																						
Naphthalene	ug/L	8.7	NE																								
Phenol	ug/L	1.4	NE																								
Metals - Unfiltered																											
Aluminum	ug/L	10200	TBD	3290		678	J	207	J			48.6	J	83.4	B	155	J	143	B	115	B	57.9	B	63.2	B	180	J
Antimony	ug/L	8	TBD																								
Arsenic	ug/L	52.6	TBD																	3.3	J			3.4	B	3	B
Barium	ug/L	26900	TBD	19000		16400		23900		22500		23700		24000		25700		26900		25200		26100		25500		22500	
Beryllium	ug/L	4.6	TBD													0.51	B										
Cadmium	ug/L	1.5	TBD																								
Calcium	ug/L	2290000	TBD	2140000		1960000	J	2060000	J	1860000		1890000		2000000		2050000		2180000		2180000		2290000		2100000		1880000	
Chromium	ug/L	18.2	TBD					7.6	B			1.7	J					1.3	B								
Cobalt	ug/L	35.8	TBD					7.1	J			6.1	J	8	J	8.1	J	8.5	J	8.6	J	6.8	J	7.1	J	11.4	J
Copper	ug/L	72.2	TBD	32.8				15.8	B	32.8		30.5														3.2	B
Iron	ug/L	52100	TBD	13200		6770		5920	J	6480		853		4970		5310		257		4120		2030		794		584	
Lead	ug/L	101	TBD																								
Magnesium	ug/L	1040000	TBD	920000		861000		943000	J	860000		884000		960000		941000		981000		1040000		1040000		992000		915000	
Manganese	ug/L	2240	TBD	180		153		189	J	128		156		190		185		162		192		202		183		170	
Mercury	ug/L	0.1	TBD																								
Nickel	ug/L	74.9	TBD					3.5	J			3.4	J					7.2	J	4	J					6.2	J
Potassium	ug/L	174000	TBD	92300		78600		85800	J	165000		86700	J	101000	J	91700	J	81700	J	104000	J	72600	J	174000	J	164000	J
Selenium	ug/L	5	TBD																								
Sodium	ug/L	9130000	TBD	7660000		7300000		7980000	J	6830000		7770000		8380000		8190000		8430000		8540000		9130000		8600000		7930000	
Thallium	ug/L	7.1	TBD							7.1	B					4.1	B			4.6	B					4.2	B
Vanadium	ug/L	35.9	TBD																								
Zinc	ug/L	612	TBD	41.6		42.1	B	5.3		23.4		64.9		9.7	J	15.6	J	5.3	B	5.7	J	612		43.6		85.5	
Metals - Filtered																											
Aluminum	ug/L	1470	TBD					40.9	B			55.9	B	63.1	B	69.8	B	109	B	91.4	B			77.8	B	128	J
Antimony	ug/L	0	TBD																								
Arsenic	ug/L	6.9	TBD					2.8	J											4.8	J	4.1	J			2.8	B
Barium	ug/L	26200	TBD	21000		4950		24400		21300		23800		23900		24500		26200		25700		25700		24300		23100	
Beryllium	ug/L	1.5	TBD													0.24	B										
Cadmium	ug/L	1.2	TBD																								
Calcium	ug/L	2570000	TBD	2570000	J	491000	J	2110000		1720000		1910000		2020000		1990000		2120000		2270000		2240000	J	2000000		1940000	
Chromium	ug/L	0	TBD																								
Cobalt	ug/L	34.8	TBD					6.4	J			5.9	J	8	J	7.5	J	9.3	J	23.8	J	6.2	J	6.2	J	13	J
Copper	ug/L	49.2	TBD					2	B	5.7	J	26.5												5.3	B		
Iron	ug/L	6180	TBD	2310		1320		5350		6180		1130		5100		4940				3800		1830		510		636	
Lead	ug/L	8.7	TBD																								
Magnesium	ug/L	1090000	TBD	1090000		223000	J	965000		829000		888000		969000		911000		953000		1070000		1020000		944000		942000	
Manganese	ug/L	1300	TBD	162		47		188		129		156		193		182		160		220		200		178		178	
Mercury	ug/L	0.24	TBD			0.24												0.032	J								
Nickel	ug/L	82.9	TBD					2.9	J			3.2	J					6.5	J	6	J					7.2	J
Potassium	ug/L	173000	TBD	103000		21600		87400	J	170000		86900	J	102000	J	88400	J	79000	J	105000	J	70500	J	173000	J	170000	J
Selenium	ug/L	0	TBD																								
Sodium	ug/L	9110000	TBD	9110000		1870000		8100000		6870000		7830000		8120000		7750000		8210000		8710000		9000000	J	8220000		8240000	
Thallium	ug/L	7.3	TBD							7.3	B									4.1	B					3.8	B
Vanadium	ug/L	0	TBD																								
Zinc	ug/L	673	TBD					3.3	J	21.6		59.2	J	3.2	J	78.3		4.8	J	6.4	J	673		31.4		102	
Water VQity Parameters																											
Alkalinity	ppm	979	NE	240		260		255	J	280		229		293		259		246		248		238		248		264	
Chloride	ppm	34600	NE	19000		21000		22400		18000		17300	J	19000		21100		34600		19100		21300		20800		24200	
Cyanide, total	ppm	0.004	NE																								
Hardness	ppm	20000	NE	20000		10000		9360		8200		8850		8140		9390		9200		9690		9940		9550		8900	
Nitrate	ppm	22	NE																							0.18	
Nitrate-Nitrite	ppm	0.2	NE																								
Sulfate	ppm	514	NE							3.2																	
Total dissolved solids	ppm	43800	NE	32000		24000		27400	J	26000		27800		35500		43800		32600		42700		33600		28700		36100	
Total organic carbon	ppm	9.9	NE					0.5	J	1.1	J	0.74	J													2.1	
Total suspended solids	ppm	760	NE	74		90		125		13		13		33		19		100		112		39		760		22	
Turbidity	NTU	742	NE					48.4	J	8.8		10.5		7.4		19.2		3.9		6.2		18.4	J	5.7		4	

Table 2

Summary of Background Bedrock Groundwater Analytical Results
Former Plum Brook Ordnance Works
Sandusky, Ohio

(3 of 6)

				Location:	PB-BED-MW24																			
				Sample Number:	BD3029		CA3001		CB3008		CC3004		CD3004		DA3004		DC3002		DD3003		DE3002		DG3002	
				Sample Date:	9-Oct-01		17-Jan-02		3-Apr-02		12-Jul-02		19-Oct-02		9-Apr-03		17-Sep-03		11-Dec-03		10-Mar-04		16-Jun-04	
				Low-Flow Sample:	Yes		Yes		Yes		Yes		No		Yes		Yes		Yes		Yes		Yes	
Parameter	Units	MDC	BSC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																								
Amino-2,6-dinitrotoluene, 4-	ug/L	0.19	NE																					
Dinitrotoluene, 2,6-	ug/L	0.43	NE						0.43															
Nitrobenzene	ug/L	0.33	NE						0.33															
RDX	ug/L	0.22	NE						0.22	J														
Trinitrotoluene, 2,4,6-	ug/L	0.081	NE												0.081	J								
Volatiles																								
Acetone	ug/L	170	NE		120	J			170	J	60				88	B								
Benzene	ug/L	110	NE		60		91		110		14	J	9.3	J	36	J	32		36		22		100	
Bromomethane	ug/L	0.27	NE																					
Butanone, 2-	ug/L	17	NE				8.1		17	J	12	B												
Carbon disulfide	ug/L	29	NE				1.2		0.59	J			29						3.4	J	9.1	J	7.3	J
Chloroform	ug/L	1.1	NE																					
Chloromethane	ug/L	1.3	NE				1.3	J																
Ethylbenzene	ug/L	45	NE		19	J	32		38		8	J	4.8	J	15	J	13	J	10		9	J	45	
Methyl-2-pentanone, 4-	ug/L	0.3	NE																					
Methylene chloride	ug/L	21	NE		21	J									14	J								
Toluene	ug/L	100	NE		58		90		100		17	J	14		43	J	37		31		14		57	
Trichloroethene	ug/L	0.59	NE																					
Xylenes, total	ug/L	240	NE		110		180		210		55		23		82		67		50	J	48	J	240	
Semivolatiles																								
Bis(2-ethylhexyl)phthalate	ug/L	5.4	NE								4.6	B												
Diethyl phthalate	ug/L	1.5	NE																					
Dimethylphenol, 2,4-	ug/L	1.1	NE		1.1	J					0.76	J												
Methylnaphthalene, 2-	ug/L	10	NE		3.6	J	5.6		4.6	J	10	J	1.4	J	5.5	J	4	J	2.9	J			2	J
Naphthalene	ug/L	8.7	NE		2.9	J	7		4	J	8.7	J			4.6	J	3.5	J	2.3	J			1.9	J
Phenol	ug/L	1.4	NE		1.4	J																		
Metals - Unfiltered																								
Aluminum	ug/L	10200	TBD		37.8	J	77.7	B	35.7	J	1150		115	J	141	B	78	B	194	J	61.5	B	78.4	J
Antimony	ug/L	8	TBD																					
Arsenic	ug/L	52.6	TBD								4.3													
Barium	ug/L	26900	TBD		932		938		1160		680		1080		1140		690		642		489		535	
Beryllium	ug/L	4.6	TBD				1.2	B																
Cadmium	ug/L	1.5	TBD																					
Calcium	ug/L	2290000	TBD		158000		157000		161000		346000		159000		167000		168000		151000		131000		125000	
Chromium	ug/L	18.2	TBD								9.4													
Cobalt	ug/L	35.8	TBD								2.9				1.2	J			7.7	J				
Copper	ug/L	72.2	TBD								8.6										18.5	J		
Iron	ug/L	52100	TBD		48.3	J	72.7	B			13400		403											
Lead	ug/L	101	TBD								5.2	B												
Magnesium	ug/L	1040000	TBD		78500		78900		82900		88800		75400		84500		80600		70800		69500		69900	
Manganese	ug/L	2240	TBD		24.8		19.2		14.8	J	420		23.6		14.1	J	27.4		25.8		26.3		19.6	
Mercury	ug/L	0.1	TBD												0.035	J								
Nickel	ug/L	74.9	TBD								7.9													
Potassium	ug/L	174000	TBD		32100		46600		47600	J	41600		22900	J	26400	J	24100	J	24300		23700	J	21900	J
Selenium	ug/L	5	TBD																					
Sodium	ug/L	9130000	TBD		90800		90600		106000		101000		91800		104000		80400		67000		61800		64400	
Thallium	ug/L	7.1	TBD				4.2	B									3.8	B	2.5	B				
Vanadium	ug/L	35.9	TBD								6.1													
Zinc	ug/L	612	TBD								28.4		3.9	J	1.2	B			9.3	J	6.4	J		
Metals - Filtered																								
Aluminum	ug/L	1470	TBD		55.1	B	89.6	B	74	B	110	B	87	B	128	B	69.9	B	50.8	B	56.9	B	84	J
Antimony	ug/L	0	TBD																					
Arsenic	ug/L	6.9	TBD																					
Barium	ug/L	26200	TBD		942		962		1170		670		1140		1160		689		669		489		590	
Beryllium	ug/L	1.5	TBD				1.5	B																
Cadmium	ug/L	1.2	TBD																					
Calcium	ug/L	2570000	TBD		159000		158000		161000		147000		160000		168000		169000		152000	J	126000		135000	
Chromium	ug/L	0	TBD																					
Cobalt	ug/L	34.8	TBD										1.4	J	1.5	J	3.7	J						
Copper	ug/L	49.2	TBD																					
Iron	ug/L	6180	TBD				40.7	B																
Lead	ug/L	8.7	TBD																					
Magnesium	ug/L	1090000	TBD		78500		78800		82800		79400		77600		83600		79900		71100		67300		72000	
Manganese	ug/L	1300	TBD		22.1		18.7		16.6		44.2		15.5		13.7	J	35		25.5		26		22.6	
Mercury	ug/L	0.24	TBD																					
Nickel	ug/L	82.9	TBD																					
Potassium	ug/L	173000	TBD		30700	J	43300		44400	J	38300		24000	J	25800	J	23200	J	24500	J	23900	J	22300	J
Selenium	ug/L	0	TBD																					
Sodium	ug/L	9110000	TBD		90500		87800	J	105000		98500		92500		105000		79600		67900	J	61200		66400	
Thallium	ug/L	7.3	TBD				4.1	B													2.8	J		
Vanadium	ug/L	0	TBD																					
Zinc	ug/L	673	TBD						3.4	J			5.7	B	0.97	J	2.9	B					4.2	B
Water VQity Parameters																								
Alkalinity	ppm	979	NE		697	J	810		157		979		757		803		846		726		700		769	
Chloride	ppm	34600	NE		149		140		175	J	155		126		105		98		48.7		79.7		79	
Cyanide, total	ppm	0.004	NE												0.004	B								
Hardness	ppm	20000	NE		566		710		715		1370		808		820		761		130		670		584	
Nitrate	ppm	22	NE																					
Nitrate-Nitrite	ppm	0.2	NE																					
Sulfate	ppm	514	NE		21.4		150		23.6		32.3				20.3		24.6		32.6		40.5		25.5	
Total dissolved solids	ppm	43800	NE		948		1000		2200		1020		990		949		988		779		755		824	
Total organic carbon	ppm	9.9	NE		3		1.8		2.4		3.7		3.7		2.4		1.9		1.6		1.5			
Total suspended solids	ppm	760	NE						14		124		62		5				4					
Turbidity	NTU	742	NE		266		61		116		742		49.6		68.8		138		74		23.5		56.6	

Table 2

Summary of Background Bedrock Groundwater Analytical Results
Former Plum Brook Ordnance Works
Sandusky, Ohio

(4 of 6)

				PB-BED-MW25																			
Location:				BD3030		CA3002		CB3004		CC3005		CD3005		DA3005		DC3003		DD3004		DE3003		DG3003	
Sample Number:				5-Oct-01		16-Jan-02		3-Apr-02		11-Jul-02		17-Oct-02		10-Apr-03		18-Sep-03		11-Dec-03		11-Mar-04		17-Jun-04	
Sample Date:				Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes	
Low-Flow Sample:																							
Parameter	Units	MDC	BSC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
Explosives																							
Amino-2,6-dinitrotoluene, 4-	ug/L	0.19	NE																				
Dinitrotoluene, 2,6-	ug/L	0.43	NE																				
Nitrobenzene	ug/L	0.33	NE					0.076	J			0.12	J										
RDX	ug/L	0.22	NE																				
Trinitrotoluene, 2,4,6-	ug/L	0.081	NE																				
Volatiles																							
Acetone	ug/L	170	NE	1.7	B					1.4	B	1.6	J									4.9	B
Benzene	ug/L	110	NE	0.37	J							0.15	J										
Bromomethane	ug/L	0.27	NE																				
Butanone, 2-	ug/L	17	NE																				
Carbon disulfide	ug/L	29	NE	0.48	J	1.5		0.36	J	0.17	J	1.3	J	1.5	J			0.77	J	1.2		1.9	J
Chloroform	ug/L	1.1	NE	1.1																			
Chloromethane	ug/L	1.3	NE																				
Ethylbenzene	ug/L	45	NE	0.22	J																		
Methyl-2-pentanone, 4-	ug/L	0.3	NE	0.3	J																		
Methylene chloride	ug/L	21	NE	0.3	B			0.21	B														
Toluene	ug/L	100	NE	0.8	J			0.25	J											0.13	J		
Trichloroethene	ug/L	0.59	NE																				
Xylenes, total	ug/L	240	NE	1.5								0.37	J										
Semivolatiles																							
Bis(2-ethylhexyl)phthalate	ug/L	5.4	NE	0.86	J					3	B												
Diethyl phthalate	ug/L	1.5	NE																				
Dimethylphenol, 2,4-	ug/L	1.1	NE																				
Methylnaphthalene, 2-	ug/L	10	NE																				
Naphthalene	ug/L	8.7	NE																				
Phenol	ug/L	1.4	NE																				
Metals - Unfiltered																							
Aluminum	ug/L	10200	TBD	78.2	B	79.8	B	41.3	J	44.6	J	79.7	J	137	B	86.5	B	61.2	B	50.3	B	84.8	J
Antimony	ug/L	8	TBD																				
Arsenic	ug/L	52.6	TBD																				
Barium	ug/L	26900	TBD	226		247		434		164	J	277		558		177	J	187	J	233		112	J
Beryllium	ug/L	4.6	TBD			1.2	B																
Cadmium	ug/L	1.5	TBD																				
Calcium	ug/L	2290000	TBD	134000		158000		173000		183000		200000		194000		159000		141000		107000		194000	
Chromium	ug/L	18.2	TBD																				
Cobalt	ug/L	35.8	TBD																				
Copper	ug/L	72.2	TBD																				
Iron	ug/L	52100	TBD	795		357		91.1	J	103		207		102		156		140		82.1	J	104	
Lead	ug/L	101	TBD																				
Magnesium	ug/L	1040000	TBD	79500		80000		68000		69100		80200		81200		62000		54000		41900		70400	
Manganese	ug/L	2240	TBD	89		56.2		68.8		95.6		86.5		79.8		72.9		58.5		45.1		105	
Mercury	ug/L	0.1	TBD																				
Nickel	ug/L	74.9	TBD																				
Potassium	ug/L	174000	TBD	17600		21600		14500	J	11400	J	16200	J	19200	J	12100	J	11900		10800	J	10800	J
Selenium	ug/L	5	TBD																			1.5	B
Sodium	ug/L	9130000	TBD	112000		115000		196000		92300		187000		223000		120000		122000		114000		67000	
Thallium	ug/L	7.1	TBD			4.7	B									3.1	B	3	B			5.2	B
Vanadium	ug/L	35.9	TBD																				
Zinc	ug/L	612	TBD	7.7	J			79.5				1.7	J	1.4	B	4.8	J	74.4				5.1	B
Metals - Filtered																							
Aluminum	ug/L	1470	TBD	68.7	B			52.7	B	97.8	B	69.8	B	135	B	61.8	B			57.7	B		
Antimony	ug/L	0	TBD																				
Arsenic	ug/L	6.9	TBD																				
Barium	ug/L	26200	TBD	224		234		452		160	J	270		545		177	J	175	J	239		117	J
Beryllium	ug/L	1.5	TBD																				
Cadmium	ug/L	1.2	TBD																				
Calcium	ug/L	2570000	TBD	128000		146000		176000		187000		198000		188000		158000		135000	J	112000		193000	
Chromium	ug/L	0	TBD																				
Cobalt	ug/L	34.8	TBD											2	J								
Copper	ug/L	49.2	TBD																				
Iron	ug/L	6180	TBD	713		337				59.8	J	157		18.8	J	92.7	J	74.5	J				
Lead	ug/L	8.7	TBD																				
Magnesium	ug/L	1090000	TBD	76800		74400		69700		74100		78600		77900		61400		51400		43800		70200	
Manganese	ug/L	1300	TBD	87		52.2		65.6		94		84.2		75.7		71.5		55.2		46.8		103	
Mercury	ug/L	0.24	TBD											0.056	J							0.06	B
Nickel	ug/L	82.9	TBD																				
Potassium	ug/L	173000	TBD	17000		20200		14900	J	12100	J	15900	J	18400	J	11900	J	11100	J	11400	J	10900	J
Selenium	ug/L	0	TBD																				
Sodium	ug/L	9110000	TBD	109000		114000		196000		97600		180000		217000		118000		115000	J	119000		67700	
Thallium	ug/L	7.3	TBD							6.4	J												
Vanadium	ug/L	0	TBD																				
Zinc	ug/L	673	TBD	3	J			19.9	J			1.5	B	1	J	2.6	B	21.7					
Water VQity Parameters																							
Alkalinity	ppm	979	NE	278	J	320		337		329		314		344		313		316		331		294	
Chloride	ppm	34600	NE	404		460		558	J	219		631		615		257		221		199		95.4	
Cyanide, total	ppm	0.004	NE											0.004	B								
Hardness	ppm	20000	NE	627		720		611		772		848		820		700		540		510		760	
Nitrate	ppm	22	NE																				
Nitrate-Nitrite	ppm	0.2	NE																				
Sulfate	ppm	514	NE	121		79		36.2		416		79.5		38.6		264		136		142		514	
Total dissolved solids	ppm	43800	NE	1000		1100		1330		1180		1440		767		1100		834		808		1160	
Total organic carbon	ppm	9.9	NE	4	B	2		3		2.7		2.7		2		2.8		2.4		2.3		1.9	
Total suspended solids	ppm	760	NE	4				9		5				4		5		8				4	
Turbidity	NTU	742	NE	21.7	J	21		112		23.6		35.8		98		22.9		64.4		86.5		2	

Table 2

Summary of Background Bedrock Groundwater Analytical Results
Former Plum Brook Ordnance Works
Sandusky, Ohio

(5 of 6)

				Location:	PB-BED-MW26		PB-BED-MW28										PB-BED-MW29							
				Sample Number:	CA3004		DC3004		DD3007		DE3004		DG3004		DC3005		DD3008		DE3005		DG3005			
				Sample Date:	17-Jan-02		17-Sep-03		9-Dec-03		9-Mar-04		15-Jun-04		16-Sep-03		9-Dec-03		10-Mar-04		16-Jun-04			
				Low-Flow Sample:	No		Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes			
Parameter	Units	MDC	BSC		Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ		
Explosives																								
Amino-2,6-dinitrotoluene, 4-	ug/L	0.19	NE																					
Dinitrotoluene, 2,6-	ug/L	0.43	NE																					
Nitrobenzene	ug/L	0.33	NE																					
RDX	ug/L	0.22	NE																					
Trinitrotoluene, 2,4,6-	ug/L	0.081	NE																					
Volatiles																								
Acetone	ug/L	170	NE								2.1	J			17				2.1	J	9.1	B		
Benzene	ug/L	110	NE				2.4	J	2.2		1.7		1.1				0.96	J	0.22	J	0.23	J		
Bromomethane	ug/L	0.27	NE																					
Butanone, 2-	ug/L	17	NE																					
Carbon disulfide	ug/L	29	NE								1.3		0.1	J	0.44	J	13		1.9					
Chloroform	ug/L	1.1	NE												0.25	J								
Chloromethane	ug/L	1.3	NE						0.97	J	0.42	J					0.3	J						
Ethylbenzene	ug/L	45	NE						0.13	J					0.86	J	0.87	J	0.66	J	0.55	J		
Methyl-2-pentanone, 4-	ug/L	0.3	NE																					
Methylene chloride	ug/L	21	NE								2.1	B							0.59	B				
Toluene	ug/L	100	NE				1.7	J	0.62	J	0.18	J	0.13	J	0.12	J								
Trichloroethene	ug/L	0.59	NE				0.59	J																
Xylenes, total	ug/L	240	NE						0.41	J					5.5		5.1	J	4.5	J	3.7			
Semivolatiles																								
Bis(2-ethylhexyl)phthalate	ug/L	5.4	NE																					
Diethyl phthalate	ug/L	1.5	NE																					
Dimethylphenol, 2,4-	ug/L	1.1	NE																					
Methylnaphthalene, 2-	ug/L	10	NE																					
Naphthalene	ug/L	8.7	NE																					
Phenol	ug/L	1.4	NE																					
Metals - Unfiltered																								
Aluminum	ug/L	10200	TBD		93200		147	J	42.6	B	54.5	B	129	J	309		49.9	B	103	J	120	J		
Antimony	ug/L	8	TBD																					
Arsenic	ug/L	52.6	TBD		56.8		7.4	J	5.4	J	5.5	B					3.3	J	2.6	B				
Barium	ug/L	26900	TBD		1970		374		395		342		337		11300		11800		10800		9110			
Beryllium	ug/L	4.6	TBD		5.2																			
Cadmium	ug/L	1.5	TBD		3.3	J																		
Calcium	ug/L	2290000	TBD		2180000		20800		20000		17500		17400		316000		295000		274000		272000			
Chromium	ug/L	18.2	TBD		454																			
Cobalt	ug/L	35.8	TBD		82.8										3.9	J	3.6	J	3.5	B	2.6	J		
Copper	ug/L	72.2	TBD		293																19.8	J		
Iron	ug/L	52100	TBD		232000		235		398		219		184		932		1550		1480		1000			
Lead	ug/L	101	TBD		79.2																			
Magnesium	ug/L	1040000	TBD		958000		8320		7780		7370		7280		217000		198000		189000		188000			
Manganese	ug/L	2240	TBD		7470		20.3		16.6		10.6	J	10.6	J	62.7		50.7		46.4		43.6			
Mercury	ug/L	0.1	TBD		0.14	J							0.1	B										
Nickel	ug/L	74.9	TBD		457																			
Potassium	ug/L	174000	TBD		334000		7240	J	6050		18300	J	15900	J	75800	J	67800		112000	J	116000	J		
Selenium	ug/L	5	TBD																					
Sodium	ug/L	9130000	TBD		3790000		290000		285000		275000		269000		1390000		1350000		1350000		1320000			
Thallium	ug/L	7.1	TBD				4.2	B			6.7	B	3.9	B	5.1	B	2.4	B						
Vanadium	ug/L	35.9	TBD		142																			
Zinc	ug/L	612	TBD		789		2.5	B	247		2.8	B	15.4	B	6.9	J	507		9	J	27.4	B		
Metals - Filtered																								
Aluminum	ug/L	1470	TBD				152	J			74.6	B	78.1	J	83.1	B	66.9	B	85	B	107	J		
Antimony	ug/L	0	TBD																					
Arsenic	ug/L	6.9	TBD				6.9	J	5.6	J	5	B			2.6	J	3.1	J						
Barium	ug/L	26200	TBD				371		374		354		343		10500		10800		10800		9050			
Beryllium	ug/L	1.5	TBD																					
Cadmium	ug/L	1.2	TBD																					
Calcium	ug/L	2570000	TBD				20300		19700	J	17900		17300		316000		283000	J	274000		282000			
Chromium	ug/L	0	TBD																					
Cobalt	ug/L	34.8	TBD												6.1	J	3.4	J	3.4	J	2.6	J		
Copper	ug/L	49.2	TBD																		6.1	J		
Iron	ug/L	6180	TBD				242		354		186		125		350		1490		1060		892			
Lead	ug/L	8.7	TBD																					
Magnesium	ug/L	1090000	TBD				8120		7670		7540		7250		219000		189000		190000		196000			
Manganese	ug/L	1300	TBD				15.8		16.4		11.8	J	11.6	J	55.1		49.3		45.5		44.8			
Mercury	ug/L	0.24	TBD																					
Nickel	ug/L	82.9	TBD																					
Potassium	ug/L	173000	TBD				7140	J	5920	J	17300	J	14000	J	76500	J	60700	J	114000	J	120000	J		
Selenium	ug/L	0	TBD																					
Sodium	ug/L	9110000	TBD				289000		280000	J	282000		272000		1390000		1250000	J	1360000		1380000			
Thallium	ug/L	7.3	TBD				4.1	B	3.8	B	5.2	J	4	B	6.2	B	3.8	B			2.5	B		
Vanadium	ug/L	0	TBD																					
Zinc	ug/L	673	TBD				3.8	B	247		3	B	14.7	B	8.5	J	528		3.4	B	23.5	B		
Water VQity Parameters																								
Alkalinity	ppm	979	NE				474		444		468		481		443		432		448		467			
Chloride	ppm	34600	NE				171		148		168		162		3540		2930		3050		3340			
Cyanide, total	ppm	0.004	NE																					
Hardness	ppm	20000	NE				99.5		81.6		78		30.4		1750		1500		1540		1470			
Nitrate	ppm	22	NE												0.39									
Nitrate-Nitrite	ppm	0.2	NE																					
Sulfate	ppm	514	NE				35.2		13.1						5.7						7.5			
Total dissolved solids	ppm	43800	NE				833		697		774		746		6580		3880		5450		5720			
Total organic carbon	ppm	9.9	NE				5.9		5.3		5.2		4.7		2.6		3.9		2.2		4.5			
Total suspended solids	ppm	760	NE						4				8		46		7		105		14			
Turbidity	NTU	742	NE				3.3		1.6	J	1.4		0.72		14.7		7	J	8.1		7.5			

Table 2

Summary of Background Bedrock Groundwater Analytical Results
Former Plum Brook Ordnance Works
Sandusky, Ohio

(6 of 6)

Validation Qualifiers (VQ)

J - The analyte was positively identified; the reported value is an estimated concentration.

B - The analyte was not detected sigificantly above the levels found in the associated blanks.

ug/L - Micrograms per liter.

RDX - Cyclotrimethylenetrinitramine.

NTU - Nephelometric turbidity unit.

ppm - Parts per million.

Geochemical Data Analyses
2004 Groundater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Sample Location:			BG8-BEDGW-001																					
Sample No.:			5410		5415		BD3007		CA3006		CB3007		CC3001		CD3001		DA3001		DC3000		DD3001		DE3000		DG3000	
Sample Date:			17-Nov-97		15-May-98		27-Sep-01		16-Jan-02		3-Apr-02		12-Jul-02		18-Oct-02		10-Apr-03		18-Sep-03		10-Dec-03		11-Mar-04		16-Jun-04	
Parameter	Units																									
Calcium	ug/L	epm	121000	6.0379	92100	4.5958	125000	6.2375	98300	4.9052	82900	4.1367	133000	6.6367	127000	6.3373	70000	3.4930	131000	6.5369	89900	4.4860	66100	3.2984	81300	4.0569
Magnesium	ug/L	epm	72400	5.9578	41000	3.3739	77600	6.3857	43300	3.5632	32300	2.6580	76000	6.2540	79800	6.5667	30400	2.5016	81900	6.7396	40000	3.2916	24800	2.0408	29400	2.4193
Sodium	ug/L	epm	398000	17.3130	139000	6.0465	459000	19.9665	121000	5.2635	24400	1.0614	392000	17.0520	472000	20.5320	62800	2.7318	472000	20.5320	112000	4.8720	22400	0.9744	17600	0.7656
Potassium	ug/L	epm	32000	0.8186	14400	0.3684	40700	1.0411	16700	0.4272	2470	0.0632	31000	0.7930	43200	1.1051	5930	0.1517	42100	1.0769	9690	0.2479	2620	0.0670	4770	0.1220
		Total		30.1273		14.3845		33.6308		14.1590		7.9193		30.7357		34.5411		8.8781		34.8854		12.8975		6.3806		7.3638
Alkalinity	ppm	epm	350	5.7365	180	2.9502	357	5.8512	200	3.2780	157	2.5732	367	6.0151	332	5.4415	168	2.7535	355	5.8185	255	4.1795	189	3.0977	317	5.1956
Chloride	ppm	epm	780	22.0038	34	0.9591	932	26.2917	78	2.2004	63.2	1.7829	896	25.2762	999	28.1818	77.7	2.1919	1000	28.2100	132	3.7237	24.5	0.6911	9.6	0.2708
Sulfate	ppm	epm	70	1.4574	45	0.9369	28.3	0.5892	68	1.4158	63.3	1.3179	9.2	0.1915	11.2	0.2332	57.5	1.1972	23.3	0.4851	54.4	1.1326	46.4	0.9660	36	0.7495
		Total		29.1977		4.8462		32.7322		6.8941		5.6740		31.4828		33.8565		6.1426		34.5136		9.0358		4.7549		6.2160
epm difference		epm		0.0078		0.2480		0.0068		0.1725		0.0826		-0.0060		0.0050		0.0911		0.0027		0.0880		0.0730		0.0423
% difference		%		0.7834		24.7996		0.6771		17.2536		8.2587		-0.6004		0.5005		9.1058		0.2679		8.8033		7.2996		4.2263

Greater than the 7 percent epm charge balance criteria.
epm - Equivalents per million.
ug/L - Micrograms per liter.
ppm - Parts per million.

Sample Location:			BED- MW20																					
Sample No.:			5960		5965		BD3026		CA3005		CB3001		CC3003		CD3003		DA3003		DC3001		DD3002		DE3001		DG3001	
Sample Date:			17-Nov-97		28-May-98		26-Sep-01		15-Jan-02		4-Apr-02		10-Jul-02		17-Oct-02		11-Apr-03		18-Sep-03		9-Dec-03		10-Mar-04		17-Jun-04	
Parameter	Units																									
Calcium	ug/L	epm	2570000	128.2430	491000	24.5009	2110000	105.2890	1720000	85.8280	1910000	95.3090	2020000	100.7980	1990000	99.3010	2120000	105.7880	2270000	113.2730	2240000	111.7760	2000000	99.8000	1940000	96.8060
Magnesium	ug/L	epm	1090000	89.6961	223000	18.3507	965000	79.4099	829000	68.2184	888000	73.0735	969000	79.7390	911000	74.9662	953000	78.4224	1070000	88.0503	1020000	83.9358	944000	77.6818	942000	77.5172
Sodium	ug/L	epm	9110000	396.2850	1870000	81.3450	8100000	352.3500	6870000	298.8450	7830000	340.6050	8120000	353.2200	7750000	337.1250	8210000	357.1350	8710000	378.8850	9000000	391.5000	8220000	357.5700	8240000	358.4400
Potassium	ug/L	epm	103000	2.6347	21600	0.5525	87400	2.2357	170000	4.3486	86900	2.2229	102000	2.6092	88400	2.2613	79000	2.0208	105000	2.6859	70500	1.8034	173000	4.4253	170000	4.3486
		Total		616.8588		124.7491		539.2845		457.2400		511.2104		536.3662		513.6535		543.3662		582.8942		589.0152		539.4771		537.1118
Alkalinity	ppm	epm	240	3.9336	260	4.2614	255	4.1795	280	4.5892	229	3.7533	293	4.8023	259	4.2450	246	4.0319	248	4.0647	238	3.9008	248	4.0647	264	4.3270
Chloride	ppm	epm	19000	535.9900	21000	592.4100	22400	631.9040	18000	507.7800	17300	488.0330	19000	535.9900	21100	595.2310	34600	976.0660	19100	538.8110	21300	600.8730	20800	586.7680	24200	682.6820
Sulfate	ppm	epm	0	0.0000	0	0.0000	0	0.0000	3.2	0.0666	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000
		Total		539.9236		596.6714		636.0835		512.4358		491.7863		540.7923		599.4760		980.0979		542.8757		604.7738		590.8327		687.0090
epm difference		epm		0.0333		-0.3271		-0.0412		-0.0285		0.0097		-0.0021		-0.0386		-0.1433		0.0178		-0.0066		-0.0227		-0.0612
% difference		%		3.3254		-32.7079		-4.1178		-2.8461		0.9683		-0.2055		-3.8550		-14.3335		1.7774		-0.6600		-2.7717		-6.1226

Greater that the 7 percent epm charge balance criteria.
epm - Equivalents per million.
ug/L - Micrograms per liter.
ppm - Parts per million.

Sample Location:			BED-MW25																	
Sample No.:			BD3030		CA3002		CB3004		CC3005		CD3005		DA3005		DC3003		DD3004		DE3003		DG3003	
Sample Date:			5-Oct-01		16-Jan-02		3-Apr-02		11-Jul-02		17-Oct-02		10-Apr-03		18-Sep-03		11-Dec-03		11-Mar-04		17-Jun-04	
Parameter	Units																					
Calcium	ug/L	epm	128000	6.3872	146000	7.2854	176000	8.7824	187000	9.3313	198000	9.8802	188000	9.3812	158000	7.8842	135000	6.7365	112000	5.5888	193000	9.6307
Magnesium	ug/L	epm	76800	6.3199	74400	6.1224	69700	5.7356	74100	6.0977	78600	6.4680	77900	6.4104	61400	5.0526	51400	4.2297	43800	3.6043	70200	5.7768
Sodium	ug/L	epm	109000	4.7415	114000	4.9590	196000	8.5260	97600	4.2456	180000	7.8300	217000	9.4395	118000	5.1330	115000	5.0025	119000	5.1765	67700	2.9450
Potassium	ug/L	epm	17000	0.4349	20200	0.5167	14900	0.3811	12100	0.3095	15900	0.4067	18400	0.4707	11900	0.3044	11100	0.2839	11400	0.2916	10900	0.2788
		Total		17.8834		18.8835		23.4252		19.9841		24.5849		25.7018		18.3742		16.2526		14.6612		18.6312
Alkalinity	ppm	epm	278	4.5564	320	5.2448	337	5.5234	329	5.3923	314	5.1465	344	5.6382	313	5.1301	316	5.1792	331	5.4251	294	4.8187
Chloride	ppm	epm	404	11.3968	460	12.9766	558	15.7412	219	6.1780	631	17.8005	615	17.3492	257	7.2500	221	6.2344	199	5.6138	95.4	2.6912
Sulfate	ppm	epm	121	2.5192	79	1.6448	36.2	0.7537	416	8.6611	79.5	1.6552	38.6	0.8037	264	5.4965	136	2.8315	142	2.9564	514	10.7015
		Total		18.4725		19.8662		22.0183		20.2314		24.6022		23.7910		17.8765		14.2452		13.9953		18.2114
epm difference		epm		-0.0081		-0.0127		0.0155		-0.0031		-0.0002		0.0193		0.0069		0.0329		0.0116		0.0057
% difference		%		-0.8101		-1.2680		1.5479		-0.3075		-0.0175		1.9304		0.6865		3.2912		1.1619		0.5698

Greater that the 7 percent epm charge balance criteria.
epm - Equivalents per million.
ug/L - Micrograms per liter.
ppm - Parts per million.

Sample Location:			BED-MW28								BED-MW29							
Sample No.:			DC3004		DD3007		DE3004		DG3004		DC3005		DD3008		DE3005		DG3005	
Sample Date:			17-Sep-03		9-Dec-03		9-Mar-04		15-Jun-04		16-Sep-03		9-Dec-03		10-Mar-04		16-Jun-04	
Parameter	Units																	
Calcium	ug/L	epm	20300	1.0130	19700	0.9830	17900	0.8932	17300	0.8633	316000	15.7684	283000	14.1217	274000	13.6726	282000	14.0718
Magnesium	ug/L	epm	8120	0.6682	7670	0.6312	7540	0.6205	7250	0.5966	219000	18.0215	189000	15.5528	190000	15.6351	196000	16.1288
Sodium	ug/L	epm	289000	12.5715	280000	12.1800	282000	12.2670	272000	11.8320	1390000	60.4650	1250000	54.3750	1360000	59.1600	1380000	60.0300
Potassium	ug/L	epm	7140	0.1826	5920	0.1514	17300	0.4425	14000	0.3581	76500	1.9569	60700	1.5527	114000	2.9161	120000	3.0696
		Total		14.4353		13.9456		14.2232		13.6500		96.2118		85.6022		91.3838		93.3002
Alkalinity	ppm	epm	474	7.7689	444	7.2772	468	7.6705	481	7.8836	443	7.2608	432	7.0805	448	7.3427	467	7.6541
Chloride	ppm	epm	171	4.8239	148	4.1751	168	4.7393	162	4.5700	3540	99.8634	2930	82.6553	3050	86.0405	3340	94.2214
Sulfate	ppm	epm	35.2	0.7329	13.1	0.2727	0	0.0000	0	0.0000	5.7	0.1187	0	0.0000	0	0.0000	7.5	0.1562
		Total		13.3256		11.7250		12.4098		12.4536		107.2428		89.7358		93.3832		102.0317
epm difference		epm		0.0200		0.0433		0.0340		0.0229		-0.0271		-0.0118		-0.0054		-0.0224
% difference		%		1.9986		4.3253		3.4044		2.2916		-2.7109		-1.1787		-0.5411		-2.2350

Greater that the 7 percent epm charge balance criteria.
epm - Equivalents per million.
ug/L - Micrograms per liter.
ppm - Parts per million.

ATTACHMENT M2

GEOCHEMICAL EVALUATION OF THE ELEVATED INORGANIC CONCENTRATIONS IN BACKGROUND GROUNDWATER

Attachment M2

Geochemical Evaluation of Elevated Inorganic Concentrations in Background Groundwater

This attachment evaluates and describes the overall geochemistry of the groundwater in the background wells, by providing a chemical basis for the observations of the major and minor elements observed in the background groundwater. This is accomplished by first establishing quality criteria and evaluating the usability of the data, censoring data that fail to meet the criteria, describing the observed data in terms of established geochemical principles, and finally reviewing the data to determine if any long-term or seasonal trends are present.

Monitoring Well BG8-BEDGW-001. Background monitoring well BG8-BEDGW-001 is an overburden/shale well screened within the Olentangy Shale bedrock. This well has been sampled 12 times since November 1997. Results of these analyses are contained in Table 7-18 of the main document.

The first step in evaluating aqueous geochemical data pertaining to the major elements is to assess data acceptability. This is important because the anionic and cationic analyses are performed on separate bottles of sample, using different analysts and several different analytical methods. Additionally, precipitation and/or dissolution reactions may occur that could alter the chemical composition within the bottles to varying degrees based on holding times and storage conditions prior to analysis.

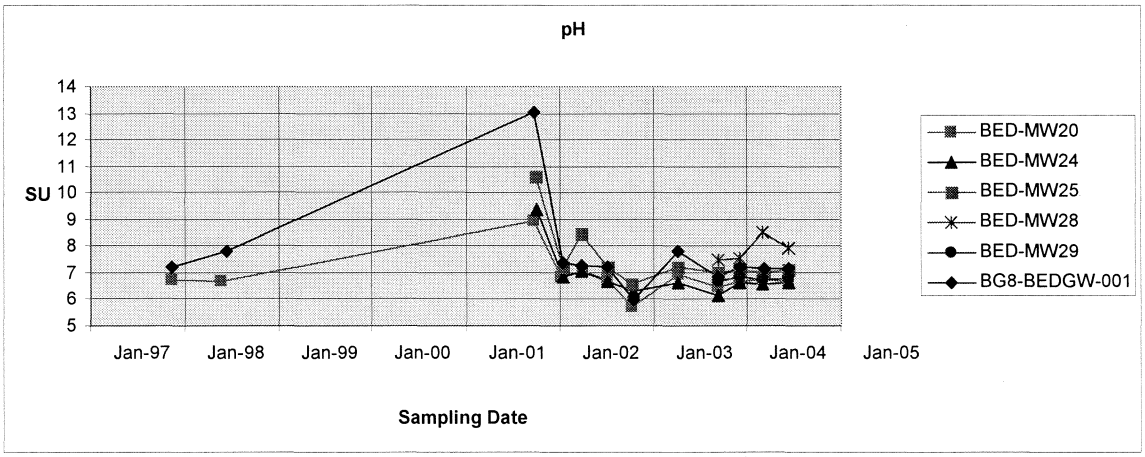
Water quality parameters total organic carbon, total suspended solids, and turbidity included in the background groundwater sampling are the equivalents per million (EPM) for cations, anions, and percent difference. These charge balance computations are commonly used to determine analytical acceptability. Because all waters must be electrically neutral, a complete water analysis should result in total positive charges equaling total negative charges; this absolute property is independent of seasonal or cyclical variations. It is generally established that an acceptable water analysis should not deviate more than plus or minus 7 percent for the four major cations and three major anions. Provided that analytical data are accurate, larger deviations indicate an overlooked charged species such as nitrate in certain waters. As indicated by cell shading

in Table M2-1, six of the analyses for well BG8-BEDGW-001 do not meet the acceptability criteria for major ions.

Pronounced seasonal trends were observed in samples from well BG8-BEDGW-001. The anion chloride exhibited the most pronounced seasonal trend. Concentrations of chloride anions tended to be relatively high during the dry season (i.e., July through December) and relatively lower during the other wet season (i.e., January through June). Similar seasonal trends were found in the cations calcium, magnesium, sodium, and potassium. This fluctuation in water type, together with the observations of concurrent trends in total dissolved solids concentrations and relatively shallow placement of the well screen, are interpreted to suggest meteorological influence.

Further evidence of a possible surface influence lies in the oxidation-reduction potential (Eh) values. The variation in the values between sampling events, plus the presence of dissolved oxygen suggests a mixture of recent and older water at this location. The extreme variation in Eh measurements suggests the system is not well poised and either oxygen reactions or some type of mixed potential is occurring at the electrode surface.

Field measured pH values generally lie within the neutral range, with the exception of the value 13.03 measured on September 27, 2001. Such exceptionally high alkaline conditions are found in nature in the surface waters of alkaline playa lakes. It is highly likely that this value is an error resulting from either an equipment problem or a calibration issue on this date. The graph below shows that all samples collected on this date showed anomalously high readings.



Explosives have not been detected in this well and detections of volatile organic compound (VOC) and semivolatile organic compound (SVOC) parameters are very low and either detected in the laboratory blank samples or estimated below the detection limit.

Filtered trace metal concentrations are low and for the most part sporadic in nature. Barium, iron, manganese, and zinc are the only trace metals consistently detected at concentrations above the detection limits.

Monitoring Well BED-MW20. Background monitoring well BED-MW20 is screened within the Ohio Shale and has been sampled twelve times since November 1997. Applying the EPM charge balance criteria for major element acceptability results in two samples falling outside the limits. The groundwater sample collected in May 1998 (Sample No. 5965) appears to have analytical problems with the major cations: all appear to be anomalously low. The groundwater sample collected during April 2003 (Sample No. DA3003) appears to have an anomalous result for the chloride ion.

Examination of the remaining twelve samples indicates that groundwater at this location is a strongly sodium chloride type water with high total dissolved solids; this water can be classified as brackish to saline. Drilling logs indicate the water was under confining pressure so that unlike well BG8-BEDGW-001, well BED-MW20 is not likely influenced by locally infiltrating surface water and most likely represents the mineralogy of the shale confining rock. Dissolved oxygen concentrations are at or near zero and, as expected in conditions of low oxygen, the measured Eh is negative and generally within the range of ferrous/ferric and sulfate/sulfide couples. Filtered iron and manganese concentrations are nearly as high as those of the unfiltered samples and are consistent with the reducing conditions where these metals are primarily dissolved and not associated with filterable microcrystalline hydroxides. Barium also is elevated and most likely is representative of the mineralogy of shales which contain barite.

Three nitroaromatic compounds were detected from this well at low estimated concentrations in three samples. Reported concentrations of VOCs and SVOCs were either also found in the laboratory blanks, or estimated at concentrations far below the reporting limits. These results indicate that this well has not been impacted by Plum Brook Ordnance Works activities. However, this water is unique among the background wells and most likely represents a very different aquifer environment.

Monitoring Well BED-MW25. Background monitoring well BED-MW25 is screened within the Olentangy Shale bedrock and, like well BED-MW20, is under confined conditions. The well was sampled ten times and each of the samples meet the charge balance criteria for major elements. The major element chemistry of this well is unique to the background wells in that it contains relatively equal equivalents of the three major cations (e.g., within a factor of about two). The principal cation is usually calcium with sodium and magnesium at comparable levels. In addition, an anion "shift" of was observed in well BED-MW25 where the water was observed to be chloride-dominant with during five of the first six sampling events (October 2001 through April 2003), and bicarbonate-dominant (i.e., alkalinity) during three of the last four sampling events (September 2003 through June 2004). The cause for this is not apparent but does not seem related to seasonal variation or wet versus dry periods. It does not appear to be related to local recharge, as large changes in total dissolved solids are not observed. In addition, the field Eh measurements are well poised and although dissolved oxygen was measured in several instances, the Eh readings do not confirm its presence.

The persistence of iron and manganese in the dissolved fraction at similar concentrations to the unfiltered samples support reducing conditions at this location. The other trace metals detected in the dissolved fraction (barium and zinc) are common to groundwater derived from shale.

The only nitroaromatic compound detected in this well was nitrobenzene, detected twice at very low estimated concentrations. Low concentrations of a few other organic compounds were reported in samples from this well; however, several were attributed to blank contamination, and the remaining at were at very low estimated concentrations. As stated in the teleconference messages (Appendix N), natural petroleum hydrocarbons are known to be associated with local limestone formations. The low levels of benzene, toluene, ethylbenzene and xylenes (BTEX) and carbon disulfide may have migrated from this source below or may be associated with the organic rich shale.

Monitoring Well BED-MW28. Background monitoring well BED-MW28 is screened for 15 feet within the Ohio Shale. The well was sampled four times and each sample meets the charge balance criteria. The water is dominated by sodium and bicarbonate species. Boring logs indicate that the screened interval is dominated by limey shale and calcite vugs which appear to control the major element chemistry. Bicarbonate results from the dissolution of carbonate minerals. The dominance of sodium over calcium most

likely results from ion exchange with the shaley mineralogy that is primarily layered silicate minerals exchange capacity.

Field Eh measurements and the presence of dissolved oxygen imply that the platinum electrode is measuring mixed potentials due to the oxygen. The relatively constant values of iron and manganese in both the unfiltered and filtered sample fractions suggests that while oxygen may be present, its concentration is probably low.

Unfiltered and filtered zinc and barium were detected in each of the four samples, and arsenic was reported in three samples in both the filtered and unfiltered fractions (though one in each was "B" qualified). Each of these elements is commonly present in shale and the mobility of zinc and arsenic is enhanced in more reducing environments.

Nitroaromatic and semivolatile constituents were not detected in any of the samples analyzed from well BED-MW28. Very low concentrations of acetone (a common laboratory contaminant), chloromethane, and trichloroethylene were each estimated below the detection limit in only one or two of the samples from this well. The remaining very low detections of BTEX are consistent with a local, naturally occurring hydrocarbon source and not indicative of former ordnance activities.

Monitoring Well BED-MW29. Background monitoring well BED-MW29 is located in the Olentangy Shale with a screened interval of 10 feet. The boring log indicates the presence of pyrite veins, vugs, and clay-filled partings. The well was sampled four times and each of the analyses met the charge balance criteria for major elements.

The groundwater at this location is a sodium chloride type with relatively high total dissolved solids. Field measured Eh and dissolved oxygen measurements indicate that the system has low concentrations of dissolved oxygen, and the variable Eh measurements reflect its presence.

The presence of dissolved zinc, iron, and copper are indicative of the sulfides that are observed in the groundwater. Barium, detected at relatively high concentrations in filter and unfiltered fractions from this well, is a common constituent of shale and its presence in this well is likely not the result of anthropogenic activities.

No nitroaromatic or SVOC compounds were detected in any of the samples. As was the case with well BED-MW28, the low levels of VOCs detected in these samples can be attributed to a natural hydrocarbon source that has been documented in the vicinity.

Trends Evaluation Conclusions. Data from wells, where sufficient information was available, were plotted against time to ascertain if any long-term or seasonal trends could be observed (Figures M2-1 through M2-8). This resulted in the portrayal of major elements plus dissolved iron and manganese. The major element plots only include those samples meeting the charge-balance criteria. The findings of this evaluation are summarized as follows:

- Pronounced seasonal trends were observed in well BG8-BEDGW-001. The anion chloride exhibited the most pronounced seasonal trend. Concentrations of chloride anions tended to be relatively high during the dry season (i.e., July through December) and relatively lower during the other wet season (i.e., January through June). Similar seasonal trends were found in the cations calcium, magnesium, sodium, and potassium. This fluctuation in water type, together with the observations of a large decrease in total dissolved solids and relatively shallow placement of the well screen, are interpreted to suggest meteorological influence.

- An anion "shift" of was observed in well BED-MW25 where the water was observed to be chloride-dominant with during five of the first six sampling events (October 2001 through April 2003), and bicarbonate-dominant (i.e., alkalinity) during three of the last four sampling events (September 2003 through June 2004). The well was sulfate-dominant with respect to anions in the remaining two sampling events.

- Overall seasonal trends common among the five background wells evaluated (including BED-MW20) were not observed. The only clearly evident seasonal trends were in well BG8-BEDGW-001, as described above.

Geochemical Data Analyses
2004 Groundater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Sample Location:			BG8-BEDGW-001																					
Sample No.:			5410		5415		BD3007		CA3006		CB3007		CC3001		CD3001		DA3001		DC3000		DD3001		DE3000		DG3000	
Sample Date:			17-Nov-97		15-May-98		27-Sep-01		16-Jan-02		3-Apr-02		12-Jul-02		18-Oct-02		10-Apr-03		18-Sep-03		10-Dec-03		11-Mar-04		16-Jun-04	
Parameter	Units																									
Calcium	ug/L	epm	121000	6.0379	92100	4.5958	125000	6.2375	98300	4.9052	82900	4.1367	133000	6.6367	127000	6.3373	70000	3.4930	131000	6.5369	89900	4.4860	66100	3.2984	81300	4.0569
Magnesium	ug/L	epm	72400	5.9578	41000	3.3739	77600	6.3857	43300	3.5632	32300	2.6580	76000	6.2540	79800	6.5667	30400	2.5016	81900	6.7396	40000	3.2916	24800	2.0408	29400	2.4193
Sodium	ug/L	epm	398000	17.3130	139000	6.0465	459000	19.9665	121000	5.2635	24400	1.0614	392000	17.0520	472000	20.5320	62800	2.7318	472000	20.5320	112000	4.8720	22400	0.9744	17600	0.7656
Potassium	ug/L	epm	32000	0.8186	14400	0.3684	40700	1.0411	16700	0.4272	2470	0.0632	31000	0.7930	43200	1.1051	5930	0.1517	42100	1.0769	9690	0.2479	2620	0.0670	4770	0.1220
		Total		30.1273		14.3845		33.6308		14.1590		7.9193		30.7357		34.5411		8.8781		34.8854		12.8975		6.3806		7.3638
Alkalinity	ppm	epm	350	5.7365	180	2.9502	357	5.8512	200	3.2780	157	2.5732	367	6.0151	332	5.4415	168	2.7535	355	5.8185	255	4.1795	189	3.0977	317	5.1956
Chloride	ppm	epm	780	22.0038	34	0.9591	932	26.2917	78	2.2004	63.2	1.7829	896	25.2762	999	28.1818	77.7	2.1919	1000	28.2100	132	3.7237	24.5	0.6911	9.6	0.2708
Sulfate	ppm	epm	70	1.4574	45	0.9369	28.3	0.5892	68	1.4158	63.3	1.3179	9.2	0.1915	11.2	0.2332	57.5	1.1972	23.3	0.4851	54.4	1.1326	46.4	0.9660	36	0.7495
		Total		29.1977		4.8462		32.7322		6.8941		5.6740		31.4828		33.8565		6.1426		34.5136		9.0358		4.7549		6.2160
epm difference		epm		0.0078		0.2480		0.0068		0.1725		0.0826		-0.0060		0.0050		0.0911		0.0027		0.0880		0.0730		0.0423
% difference		%		0.7834		24.7996		0.6771		17.2536		8.2587		-0.6004		0.5005		9.1058		0.2679		8.8033		7.2996		4.2263

Greater than the 7 percent epm charge balance criteria.
epm - Equivalents per million.
ug/L - Micrograms per liter.
ppm - Parts per million.

Sample Location:			BED- MW20																					
Sample No.:			5960		5965		BD3026		CA3005		CB3001		CC3003		CD3003		DA3003		DC3001		DD3002		DE3001		DG3001	
Sample Date:			17-Nov-97		28-May-98		26-Sep-01		15-Jan-02		4-Apr-02		10-Jul-02		17-Oct-02		11-Apr-03		18-Sep-03		9-Dec-03		10-Mar-04		17-Jun-04	
Parameter	Units																									
Calcium	ug/L	epm	2570000	128.2430	491000	24.5009	2110000	105.2890	1720000	85.8280	1910000	95.3090	2020000	100.7980	1990000	99.3010	2120000	105.7880	2270000	113.2730	2240000	111.7760	2000000	99.8000	1940000	96.8060
Magnesium	ug/L	epm	1090000	89.6961	223000	18.3507	965000	79.4099	829000	68.2184	888000	73.0735	969000	79.7390	911000	74.9662	953000	78.4224	1070000	88.0503	1020000	83.9358	944000	77.6818	942000	77.5172
Sodium	ug/L	epm	9110000	396.2850	1870000	81.3450	8100000	352.3500	6870000	298.8450	7830000	340.6050	8120000	353.2200	7750000	337.1250	8210000	357.1350	8710000	378.8850	9000000	391.5000	8220000	357.5700	8240000	358.4400
Potassium	ug/L	epm	103000	2.6347	21600	0.5525	87400	2.2357	170000	4.3486	86900	2.2229	102000	2.6092	88400	2.2613	79000	2.0208	105000	2.6859	70500	1.8034	173000	4.4253	170000	4.3486
		Total		616.8588		124.7491		539.2845		457.2400		511.2104		536.3662		513.6535		543.3662		582.8942		589.0152		539.4771		537.1118
Alkalinity	ppm	epm	240	3.9336	260	4.2614	255	4.1795	280	4.5892	229	3.7533	293	4.8023	259	4.2450	246	4.0319	248	4.0647	238	3.9008	248	4.0647	264	4.3270
Chloride	ppm	epm	19000	535.9900	21000	592.4100	22400	631.9040	18000	507.7800	17300	488.0330	19000	535.9900	21100	595.2310	34600	976.0660	19100	538.8110	21300	600.8730	20800	586.7680	24200	682.6820
Sulfate	ppm	epm	0	0.0000	0	0.0000	0	0.0000	3.2	0.0666	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000
		Total		539.9236		596.6714		636.0835		512.4358		491.7863		540.7923		599.4760		980.0979		542.8757		604.7738		590.8327		687.0090
epm difference		epm		0.0333		-0.3271		-0.0412		-0.0285		0.0097		-0.0021		-0.0386		-0.1433		0.0178		-0.0066		-0.0227		-0.0612
% difference		%		3.3254		-32.7079		-4.1178		-2.8461		0.9683		-0.2055		-3.8550		-14.3335		1.7774		-0.6600		-2.7717		-6.1226

Greater that the 7 percent epm charge balance criteria.
epm - Equivalents per million.
ug/L - Micrograms per liter.
ppm - Parts per million.

Sample Location:			BED-MW25																	
Sample No.:			BD3030		CA3002		CB3004		CC3005		CD3005		DA3005		DC3003		DD3004		DE3003		DG3003	
Sample Date:			5-Oct-01		16-Jan-02		3-Apr-02		11-Jul-02		17-Oct-02		10-Apr-03		18-Sep-03		11-Dec-03		11-Mar-04		17-Jun-04	
Parameter	Units																					
Calcium	ug/L	epm	128000	6.3872	146000	7.2854	176000	8.7824	187000	9.3313	198000	9.8802	188000	9.3812	158000	7.8842	135000	6.7365	112000	5.5888	193000	9.6307
Magnesium	ug/L	epm	76800	6.3199	74400	6.1224	69700	5.7356	74100	6.0977	78600	6.4680	77900	6.4104	61400	5.0526	51400	4.2297	43800	3.6043	70200	5.7768
Sodium	ug/L	epm	109000	4.7415	114000	4.9590	196000	8.5260	97600	4.2456	180000	7.8300	217000	9.4395	118000	5.1330	115000	5.0025	119000	5.1765	67700	2.9450
Potassium	ug/L	epm	17000	0.4349	20200	0.5167	14900	0.3811	12100	0.3095	15900	0.4067	18400	0.4707	11900	0.3044	11100	0.2839	11400	0.2916	10900	0.2788
		Total		17.8834		18.8835		23.4252		19.9841		24.5849		25.7018		18.3742		16.2526		14.6612		18.6312
Alkalinity	ppm	epm	278	4.5564	320	5.2448	337	5.5234	329	5.3923	314	5.1465	344	5.6382	313	5.1301	316	5.1792	331	5.4251	294	4.8187
Chloride	ppm	epm	404	11.3968	460	12.9766	558	15.7412	219	6.1780	631	17.8005	615	17.3492	257	7.2500	221	6.2344	199	5.6138	95.4	2.6912
Sulfate	ppm	epm	121	2.5192	79	1.6448	36.2	0.7537	416	8.6611	79.5	1.6552	38.6	0.8037	264	5.4965	136	2.8315	142	2.9564	514	10.7015
		Total		18.4725		19.8662		22.0183		20.2314		24.6022		23.7910		17.8765		14.2452		13.9953		18.2114
epm difference		epm		-0.0081		-0.0127		0.0155		-0.0031		-0.0002		0.0193		0.0069		0.0329		0.0116		0.0057
% difference		%		-0.8101		-1.2680		1.5479		-0.3075		-0.0175		1.9304		0.6865		3.2912		1.1619		0.5698

Greater that the 7 percent epm charge balance criteria.
epm - Equivalents per million.
ug/L - Micrograms per liter.
ppm - Parts per million.

Sample Location:			BED-MW28								BED-MW29							
Sample No.:			DC3004		DD3007		DE3004		DG3004		DC3005		DD3008		DE3005		DG3005	
Sample Date:			17-Sep-03		9-Dec-03		9-Mar-04		15-Jun-04		16-Sep-03		9-Dec-03		10-Mar-04		16-Jun-04	
Parameter	Units																	
Calcium	ug/L	epm	20300	1.0130	19700	0.9830	17900	0.8932	17300	0.8633	316000	15.7684	283000	14.1217	274000	13.6726	282000	14.0718
Magnesium	ug/L	epm	8120	0.6682	7670	0.6312	7540	0.6205	7250	0.5966	219000	18.0215	189000	15.5528	190000	15.6351	196000	16.1288
Sodium	ug/L	epm	289000	12.5715	280000	12.1800	282000	12.2670	272000	11.8320	1390000	60.4650	1250000	54.3750	1360000	59.1600	1380000	60.0300
Potassium	ug/L	epm	7140	0.1826	5920	0.1514	17300	0.4425	14000	0.3581	76500	1.9569	60700	1.5527	114000	2.9161	120000	3.0696
		Total		14.4353		13.9456		14.2232		13.6500		96.2118		85.6022		91.3838		93.3002
Alkalinity	ppm	epm	474	7.7689	444	7.2772	468	7.6705	481	7.8836	443	7.2608	432	7.0805	448	7.3427	467	7.6541
Chloride	ppm	epm	171	4.8239	148	4.1751	168	4.7393	162	4.5700	3540	99.8634	2930	82.6553	3050	86.0405	3340	94.2214
Sulfate	ppm	epm	35.2	0.7329	13.1	0.2727	0	0.0000	0	0.0000	5.7	0.1187	0	0.0000	0	0.0000	7.5	0.1562
		Total		13.3256		11.7250		12.4098		12.4536		107.2428		89.7358		93.3832		102.0317
epm difference		epm		0.0200		0.0433		0.0340		0.0229		-0.0271		-0.0118		-0.0054		-0.0224
% difference		%		1.9986		4.3253		3.4044		2.2916		-2.7109		-1.1787		-0.5411		-2.2350

Greater that the 7 percent epm charge balance criteria.
epm - Equivalents per million.
ug/L - Micrograms per liter.
ppm - Parts per million.

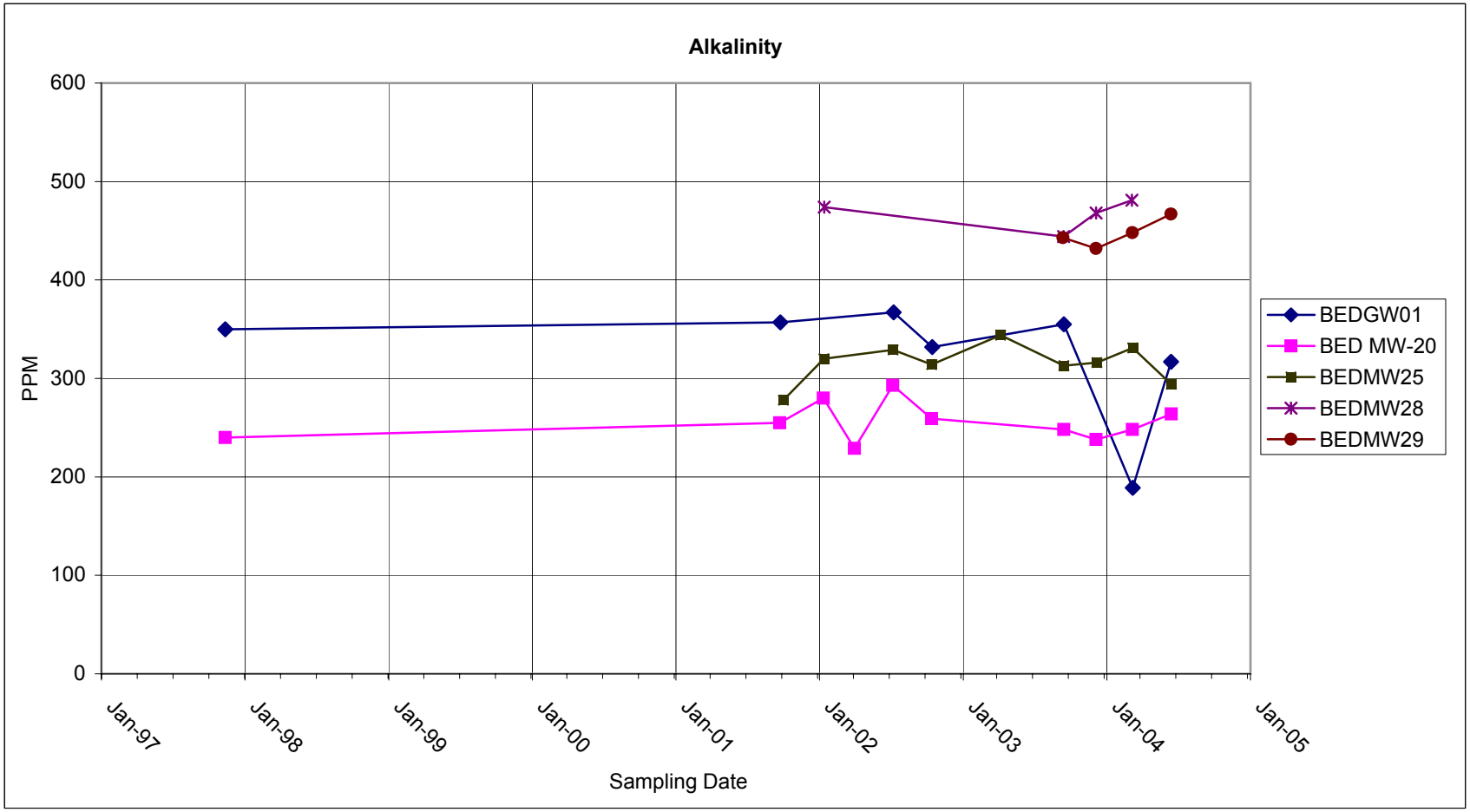


Figure M2-1

Alkalinity Concentration (ppm) versus Sampling Date
2004 Groundwater Data Summary
and Evaluation Report
Former Plum Brook Ordnance Works
NASA Plum Brook Station
Sandusky, Ohio

Shaw® Shaw Environmental, Inc.

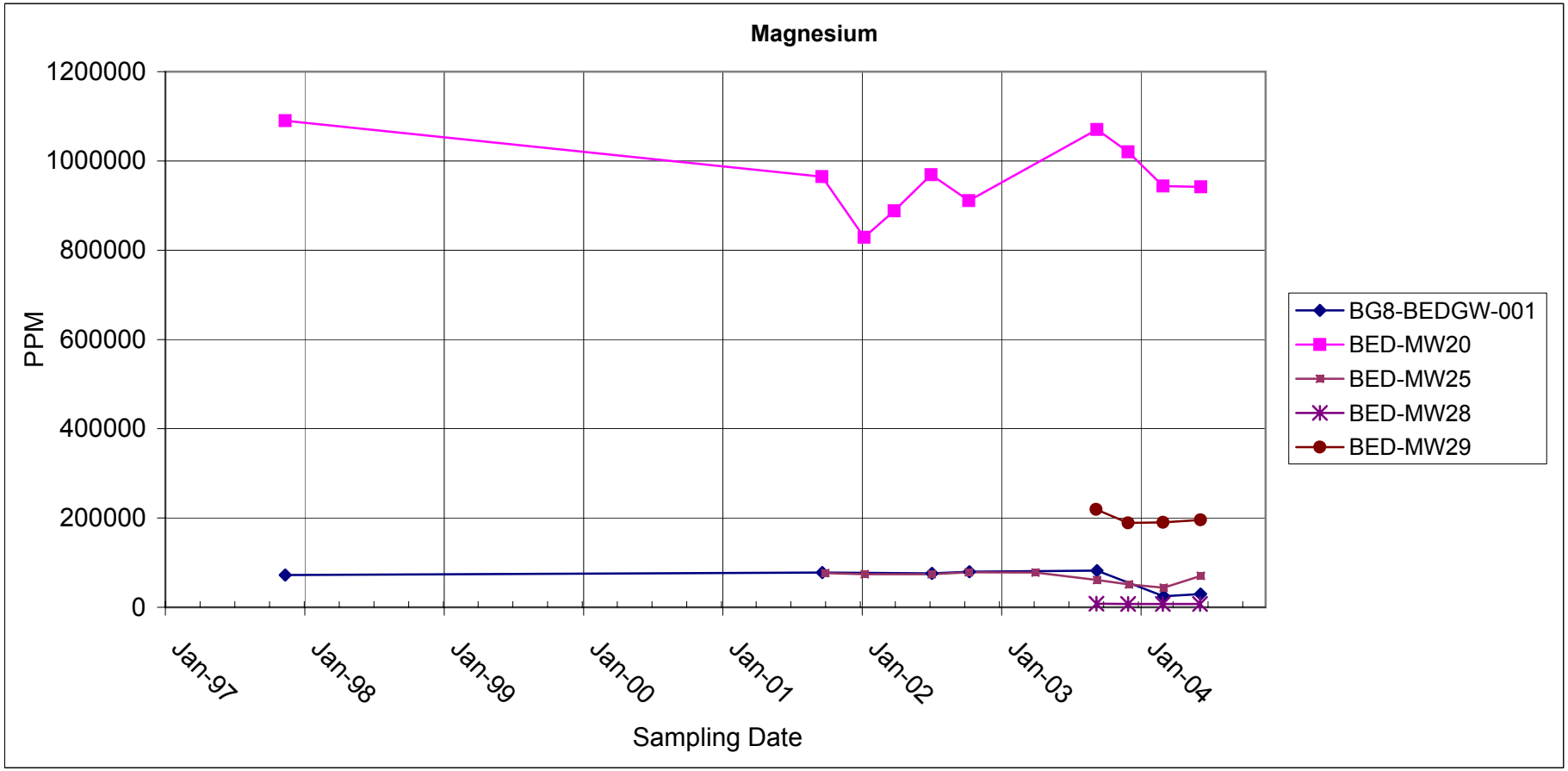


Figure M2-2

Magnesium Concentration (ppm) versus Sampling Date
2004 Groundwater Data Summary
and Evaluation Report
Former Plum Brook Ordnance Works
NASA Plum Brook Station
Sandusky, Ohio

Shaw® Shaw Environmental, Inc.

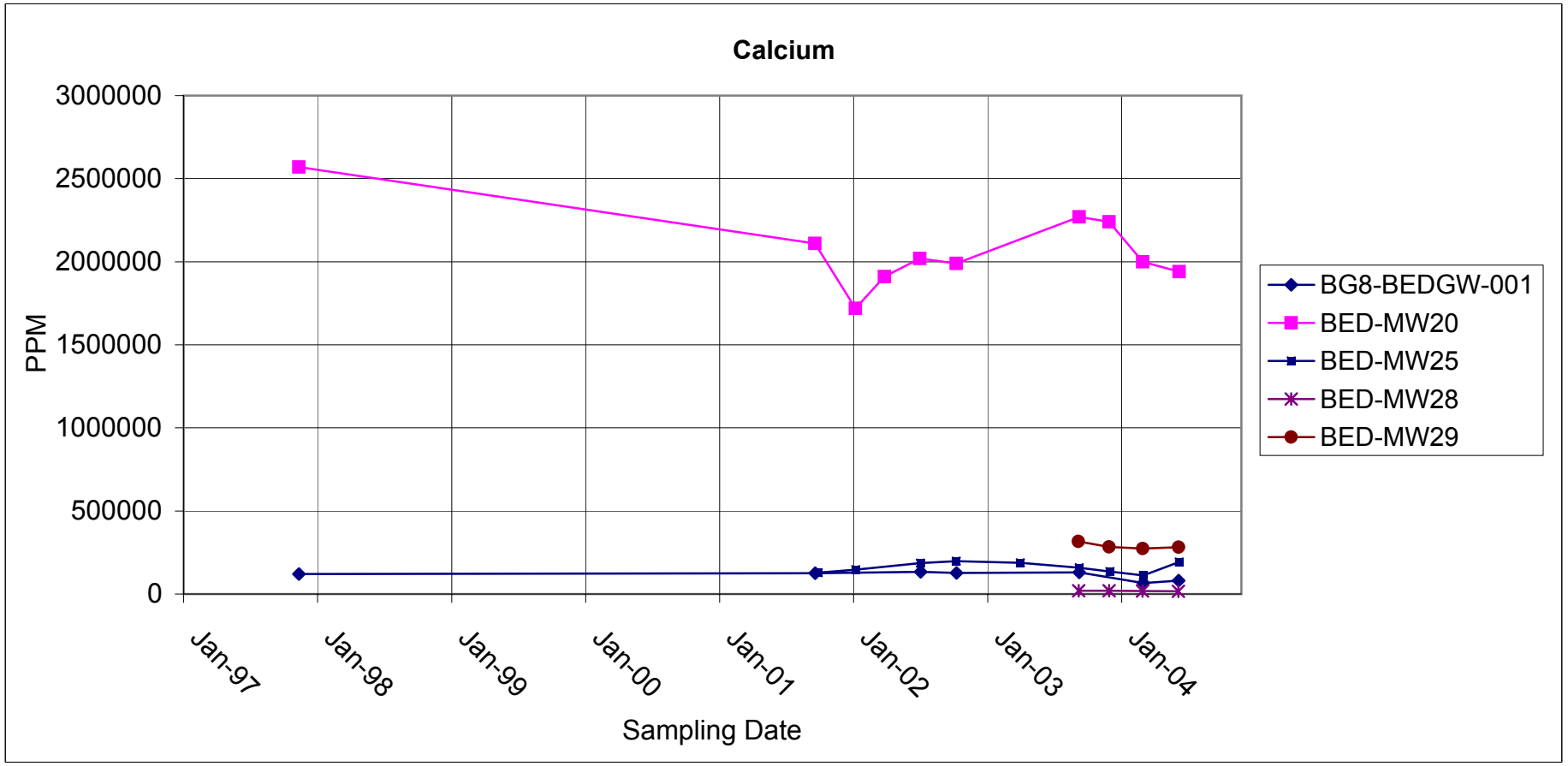


Figure M2-3

Calcium Concentration (ppm) versus Sampling Date)
2004 Groundwater Data Summary
and Evaluation Report
Former Plum Brook Ordnance Works
NASA Plum Brook Station
Sandusky, Ohio

Shaw® Shaw Environmental, Inc.

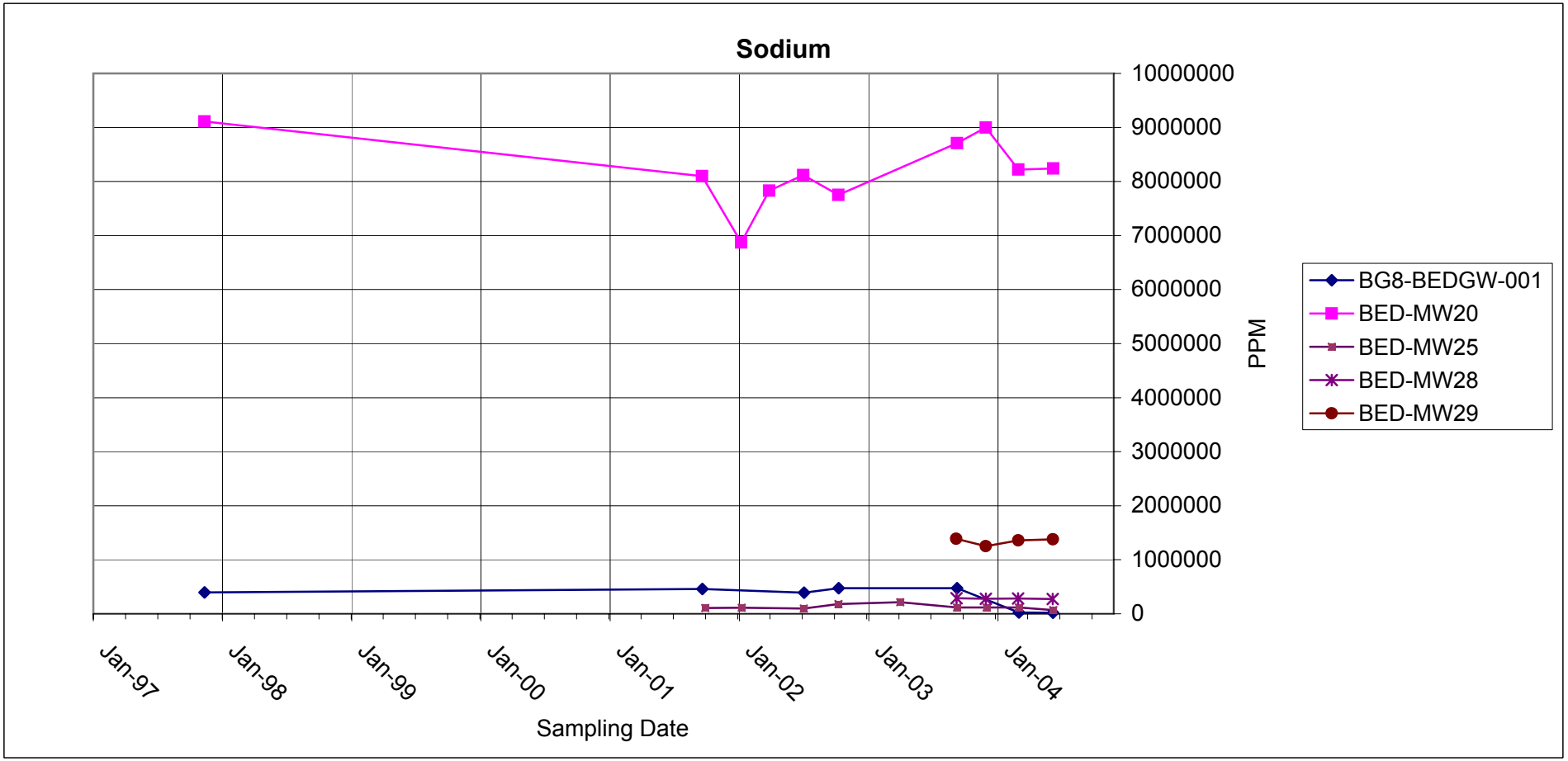


Figure M2-4

Sodium Concentration (ppm) versus Sampling Date
2004 Groundwater Data Summary
and Evaluation Report
Former Plum Brook Ordnance Works
NASA Plum Brook Station
Sandusky, Ohio

Shaw® Shaw Environmental, Inc.

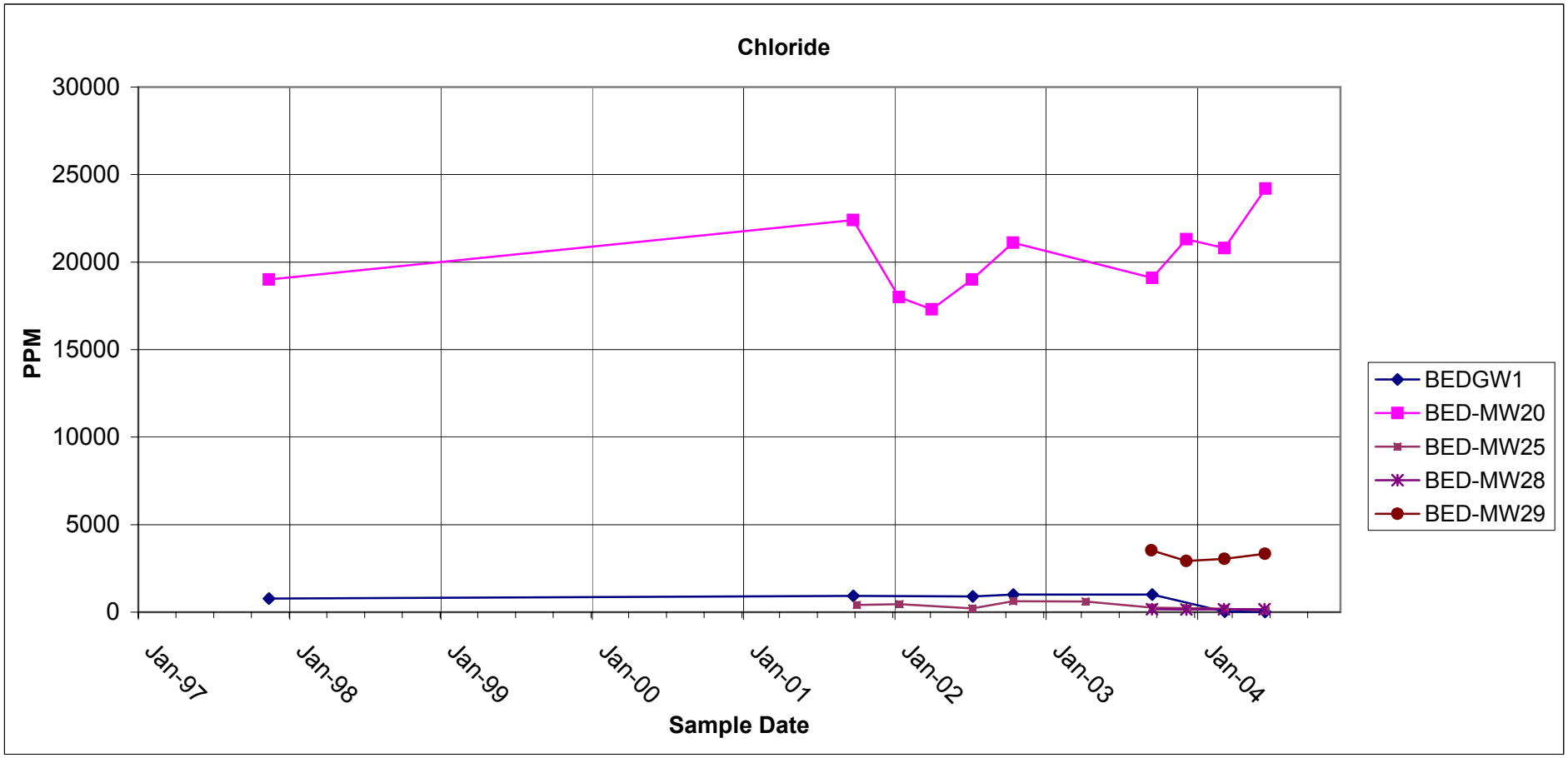


Figure M2-5

Chloride Concentration (ppm) versus Sampling Date
2004 Groundwater Data Summary
and Evaluation Report
Former Plum Brook Ordnance Works
NASA Plum Brook Station
Sandusky, Ohio

Shaw® Shaw Environmental, Inc.

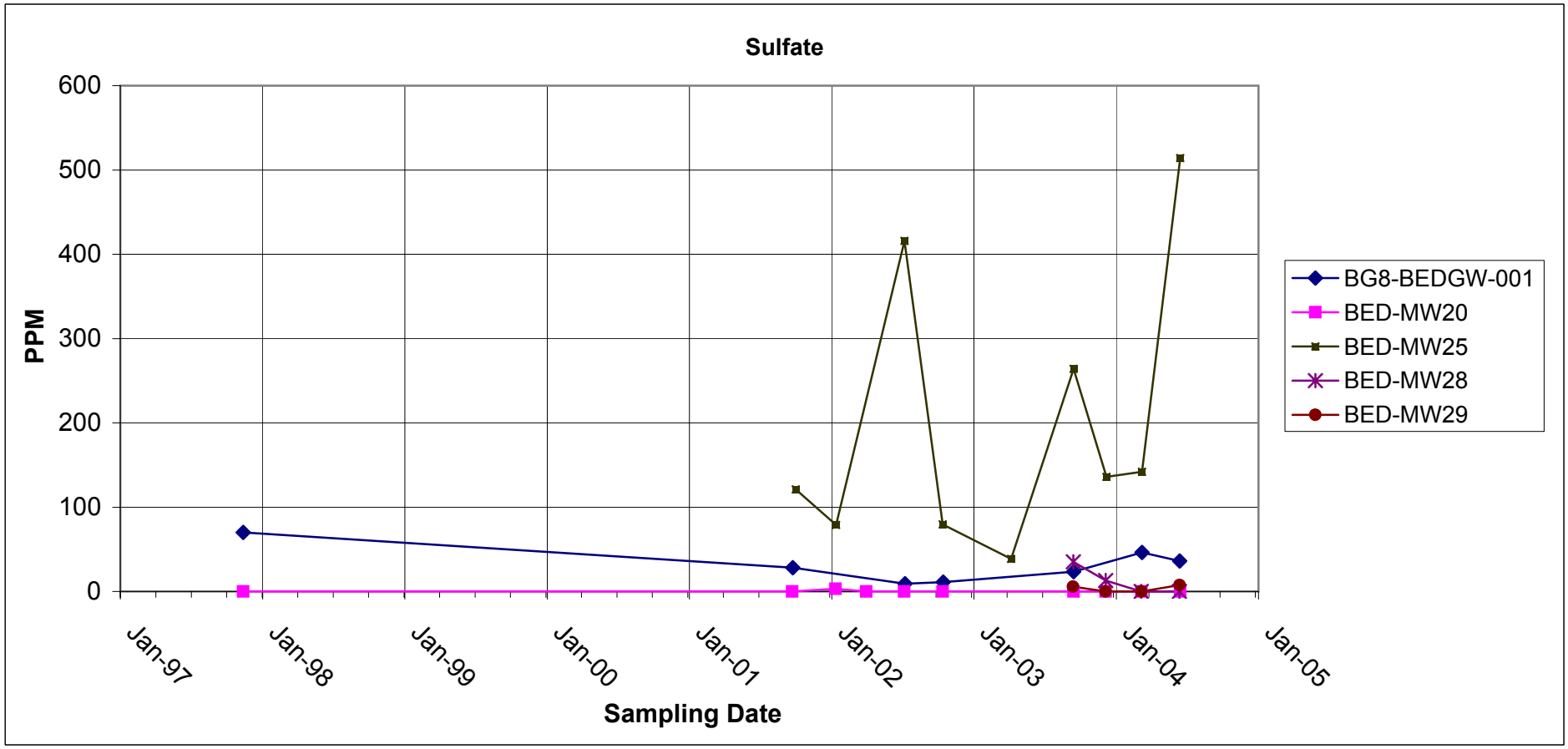


Figure M2-6

Sulfate Concentration (ppm) versus Sampling Date
2004 Groundwater Data Summary
and Evaluation Report
Former Plum Brook Ordnance Works
NASA Plum Brook Station
Sandusky, Ohio

Shaw® Shaw Environmental, Inc.

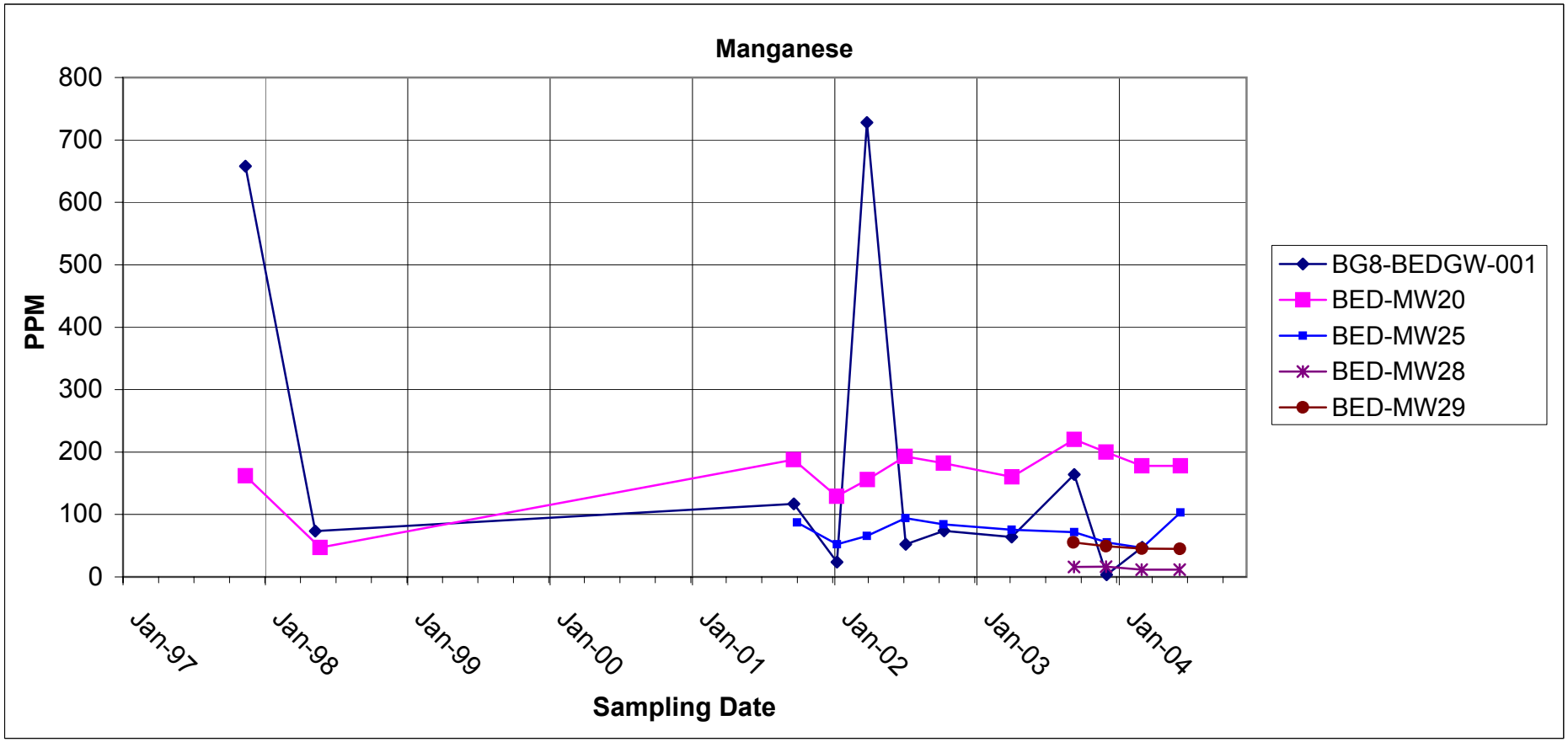


Figure M2-7

Manganese Concentration (ppm) versus Sampling Date
2004 Groundwater Data Summary
and Evaluation Report
Former Plum Brook Ordnance Works
NASA Plum Brook Station
Sandusky, Ohio

Shaw® Shaw Environmental, Inc.

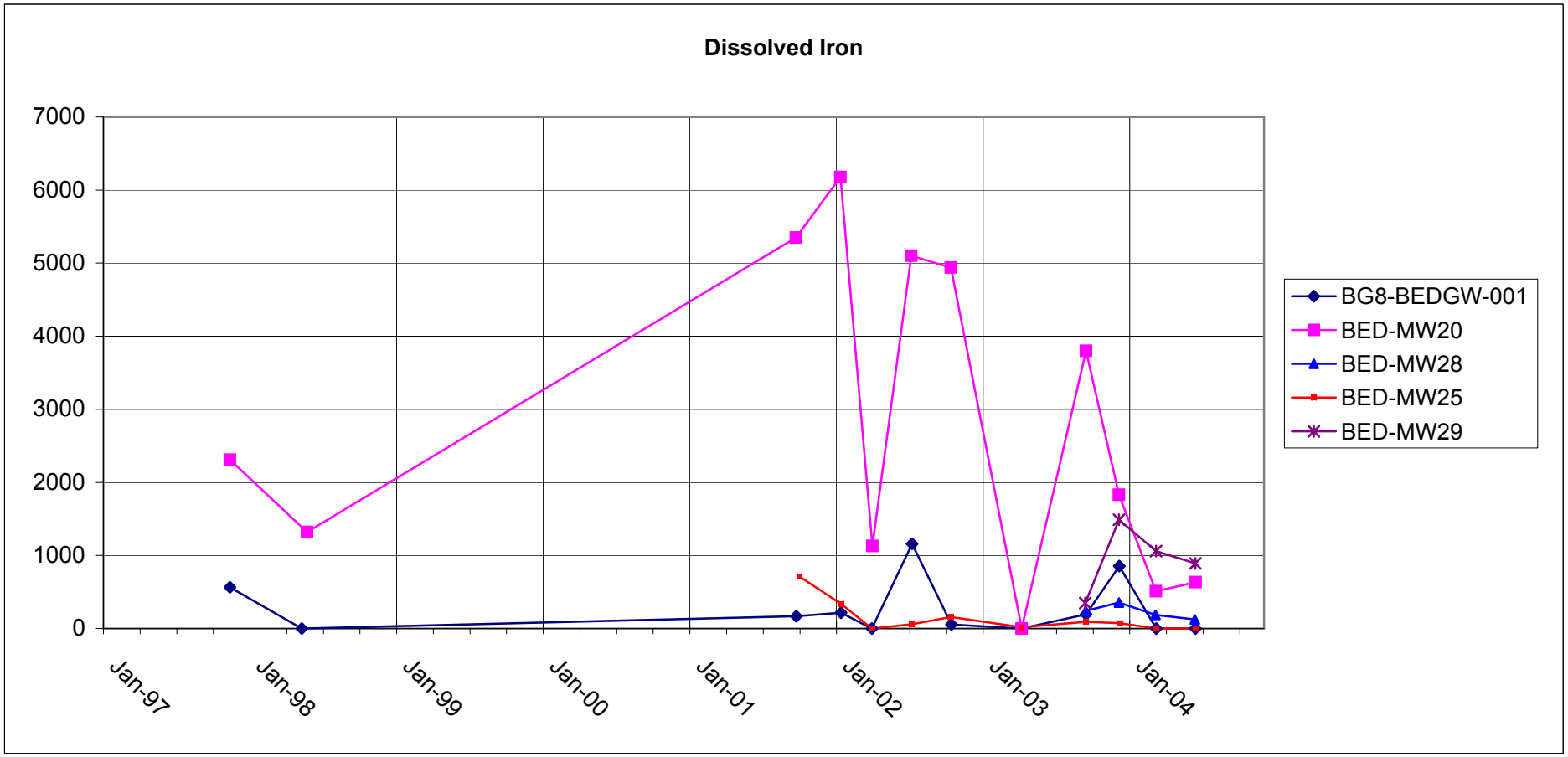


Figure M2-8

Dissolved Iron Concentration (ppm) versus Sampling Date
2004 Groundwater Data Summary
and Evaluation Report
Former Plum Brook Ordnance Works
NASA Plum Brook Station
Sandusky, Ohio

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APPENDIX N

TELECONFERENCE NOTES ON BTEX IN QUARRY/ E-MAIL MESSAGE ON ACTIVE OIL/GAS FIELD

INTERNATIONAL TECHNOLOGY CORPORATION

RECORD OF ☒ TELECON ☐ MEETING

Project Name	Number	Phase	Task	Subtask
PBOW				

Date: 11/18/98 Time: 1315

CALL FROM ☒ NAME: DAVID Kessler
CALL TO ☐

Other Participants — Name/Location/Representing:

CALL FROM ☐ NAME:
CALL TO ☒ Martin Jones (V.P.)

Telephone Number: 419-625-8141

Company Name: Wagner Quarry

Address:

City Sandusky

State OH Zip Code

Topic: BTEX in Bedrock

Summary (Decisions & Specific Actions Required by Named Persons):

Inquired about H_2S and BTEX in bedrock.

Martin Jones (VP - mechincal engineer) said that the BTEX and H_2S in the bedrock is all natural. Very common in the limestone in the area. Hydrogen Sulfide is particularly noticed from zones (in the quarry) around depths of ~90-120 Ft and 130-160 Ft. Oil can be found (in the area) in the limestone at the surface all the way to the base of the limestone. The Exgenics are very common throughout this entire region. Low levels are seen as far away as Sandusky Rocks Co. (near intersection of Rt 4 and Turnpike)

Required Action:

Prepared by (Signature): David Kessler

Distribution:
- Original to Project File
- Copy to Project Manager
- Copy to Preparer

☒ Other Distribution (By Preparer)
Mike Springberg, Rick Ellis
Mike Gunderson

PAGE ___ OF ___

Kessler, Dave

Subject: RE: Erie County limestone

From: "Swinford, Mac" <Mac.Swinford@dnr.state.oh.us>
To: "'djkessler1@juno.com'" <djkessler1@juno.com>
Date: Thu, 29 Aug 2002 09:55:04 -0400
Subject: Erie County limestone
Message-ID:
<83E473D76ECF8240B3F513CE308CA9E8C8156C@nrxchg2.dnr.state.oh.us>

David Kessler:

There is an actively producing oil and gas field producing from the Delaware
Limestone and the underlying Columbus Limestone in Florence and Berlin Townships, Erie County. Information on the individual wells are on file here at the Ohio Geological Survey. We also have maps depicting the general
outline of the fields in this area. Please call Ron Riley 614-265-6573 for
this information.

Regional, the Columbus and to a lesser extent the Delaware Limestone commonly can have a slight to moderate petroleum smell and may have a sulfur odor.

If you require additional information please contact me.

Thank you,
Mac Swinford
Geologist and Supervisor,
Geologic Mapping Group
ODNR, Division of Geological Survey
614-265-6473
e-mail: mac.swinford@dnr.state.oh.us

Shaw™
Shaw Environmental & Infrastructure, Inc.

RECORD OF TELEPHONE CALL

DATE: 2/3/04

TIME: 1000

Project Name: PBOW

Project Number: 843656

Call from: David Kessler

Call to: Mr. Rick Pavey, (614) 265-6599, Ohio Department of Natural Resources (ODNR).

Summary (Decisions/Specific Actions):

Attempted to contact Mr. Mac Swinford of ODNR for information of oil/gas wells found at the DNR website (www.ohiodnr.com/geosurvey/ogcim/petrol/ftpmap, URL: ftp://ftp/dnr.state.oh.us/Geological_Survey/well_db/erie.dbf) but was transferred to DNR representative Mr. Rick Pavey.

Informed Mr. Pavey of above listed website and inquired if he had any information of the wells found on the map. Mr. Pavey said that he would attempt to find specific information and return call. [Shaw faxed the map for his research that was found at the website but had the PBOW coordinates included with the well locations].

Return call from Mr. Pavey to David Kessler ~1300:

From his research into the purpose of the oil/gas wells, he found that the well on PBOW property was not listed in the records (must have been installed before records were kept). The next nearest well to the facility (well immediately to the west, as shown on the map) was drilled in 1957 as a stratigraphic test boring. From his review of the other active/inactive oil and gas wells shown on the figure and his recollection of petroleum hydrocarbon encountered at the Wagnor Quarries, he confirmed that there is "without a doubt petroleum hydrocarbon in the Delaware and Columbus bedrock units". There must not have been sufficient quantities of oil or gas for commercial production in this area (near PBOW), as indicated by the sporadic spacing, but in the southeast corner of the map, a good producing oil field is present. The well locations are very close to one another.

Required Action: Include information in response to Restoration Advisory Board comments received for the Seventh Quarterly Background Groundwater Report.

Prepared By: David Kessler

Distribution: Steve Downey, Mike Gunderson, Tom Siard

APPENDIX O

RECHARGE CALCULATIONS

CLIENT	JOB NUMBER
NASHVILLE C.O.E.	~~DLK 773256~~ ~~825636~~ DLK 843656

SUBJECT: CALCULATION OF MONTHLY RUNOFF @ PLUMBROOK ORDNANCE WORKS

BASED ON: SOIL CONSERVATION SERVICE TECH RELEASE #55, JUNE 1986 / ERIE COUNTY SOIL SURVEY REPORT OF PROGRESS, 1994 BY OHIO DEPT. OF NAT. RESOURCES

BY	CHECKED BY	APPROVED BY	DATE
LR ELLIS	Jane Li		1/12/99

* Information updated ~~February 2002~~ DKK 11/04 November 2004.

CALCULATION ASSUMPTIONS:

1. RUNOFF EQUATION FOR A STORM EVENT CAN BE USED FOR MONTHLY RUNOFF RATES

2. LAND USES CAN BE LARGELY DEFINED BY USING AN AERIAL PHOTO

3. THE SOIL NAMES IN THE 1994 ERIE COUNTY PROGRESS REPORT (FOR THE ERIE COUNTY SOIL SURVEY) CAN BE USED FOR CHARACTERIZATION OF THE ~~CN NUMBER~~ HYDROLOGIC SOIL GROUP (E.G. THE NAMES PEWAMO & BENNINGTON, [IN THE PEWAMO-BENNINGTON ASSOC] CAN BE LOOKED UP & THOSE TWO ARE CHARACTERISTIC OF THE WHOLE ASSOCIATION) – SEE ~~ATTACHED ERIE COUNTY REPORT~~ DKK Attachment 1

Eq.1 $$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)}$$

Eq.2 $$S = \frac{1000}{CN} - 10$$

Eq.3 $$I_a = 0.2S$$

Q = RUNOFF IN INCHES
P = RAINFALL IN INCHES
S = POTENTIAL MAXIMUM RETENTION AFTER RAINFALL BEGINS (INCHES)
I_a = INITIAL ABSTRACTION (INCHES) [WHICH IS ALL LOSSES BEFORE RUNOFF BEGINS]
CN = CURVE NUMBER [OBTAINED BY FIRST GETTING THE HYDROLOGIC NUMBER FOR EACH SOIL TYPE ON SCS TECH REPT TABLE 2.2a, THEN USING IT ON TABLE 2.2...

NOTES

* SEE CALC. SHEET 2 OF 5 FOR DERIVATION OF CN

* SEE ATTACHED EXCEL SPREADSHEET FOR MONTHLY RUNOFF CALCULATIONS USING $Q = \frac{(P - 0.2S)^2}{(P + 0.8S)}$

INTERNATIONAL TECHNOLOGY CORPORATION

By RICK ELLIS Date 1/8/99 Subject DETERMINING CN FOR PBOW SOIL FOR RUNOFF CALC. Sheet No. 2 of 5

Chkd. By J. Li Date 1/12/99 Proj. No. _____

USE TO YIELD TYPES w/ TECH RPT 55

SOIL NAME	GENERAL LOCATION	APPROX. PERCENTAGE PBOW OF SITE ASSOC	APPROX. PERCENTAGE PBOW OF SITE EACH	APPROX CURVE NO ROUNDED ASSOC	APPROX CURVE NO EACH	LAND USE	HYDROL. SOIL GROUP
PEWAMO-BENNINGTON ASSOC.	EXTREME SOUTHEAST & EXTREME NORTHEAST	1/5		75		THINLY WOODED	
PEWAMO					80		C/D
BENNINGTON					70		C
HORNELL-FRIES-COLWOOD ASSOC.	CENTRAL	1/2		75		1/2 (GOOD COVER) OPEN SPACES; 1/2 WOODED (GOOD COVER)	
HORNELL					80		D
FRIES					77		D
COLWOOD					66		B/D
CASTALIA-MILLSDALE-MILTON-RITCHEY ASSOC.	NORTH-CENTRAL (WEST TO EAST STRIP)	1/10		75		2/3 (GOOD COVER) OPEN SPACES; 1/3 WOODED (GOOD COVER)	
CASTALIA					74		C
MILLSDALE					70		B/D
MILTON					74		C
RITCHEY					80		D
KIBBIE-ELNORA-TUSCOLA-COLWOOD ASSOC.	NORTH-WESTERN PORTION OF SITE	1/5		58		WOODED (GOOD COVER)	
KIBBIE					55		B
ELNORA					55		B
TUSCOLA					55		B
COLWOOD					66		B/D
			TOTAL AVG CN	72			

Month	Rain (P)	*Ia*	*S*	*Curve Number (CN)*	Runoff (Q)	Evapo-transpiration (E)	Evapo*0.6 (E est.)	Monthly Rechge
	From Sandusky, OH rain gauge	*Ia=0.2S*	*S=1000/CN-10*	*(see Table in Appendix ??)*	Q=(P-0.2S)^2 /P+0.8S	(From National Weather Service (Cleveland)		R = P-Q- E est
Jan-94	2.33	0.78	3.89	72	0.44	0.6	0.36	**1.53**
Feb-94	1.09	0.78	3.89	72	0.02	1.5	0.90	**0.17**
Mar-94	1.48	0.78	3.89	72	0.11	2.3	1.38	**-0.01**
Apr-94	2.62	0.78	3.89	72	0.59	5	3.00	**-0.97**
May-94	1.92	0.78	3.89	72	0.26	5	3.00	**-1.34**
Jun-94	4.86	0.78	3.89	72	2.09	6	3.60	**-0.83**
Jul-94	1.38	0.78	3.89	72	0.08	5.9	3.54	**-2.24**
Aug-94	2.83	0.78	3.89	72	0.71	4.7	2.82	**-0.70**
Sep-94	2.83	0.78	3.89	72	0.71	4	2.40	**-0.28**
Oct-94	1.46	0.78	3.89	72	0.10	2.7	1.62	**-0.26**
Nov-94	2.38	0.78	3.89	72	0.47	2.1	1.26	**0.65**
Dec-94	2.1	0.78	3.89	72	0.34	0.6	0.36	**1.40**
Jan-95	3.22	0.78	3.89	72	0.94	0.6	0.36	**1.92**
Feb-95	0.82	0.78	3.89	72	0.00	1	0.60	**0.22**
Mar-95	1.39	0.78	3.89	72	0.08	2.3	1.38	**-0.07**
Apr-95	4.28	0.78	3.89	72	1.66	3.3	1.98	**0.64**
May-95	4.2	0.78	3.89	72	1.60	4.9	2.94	**-0.34**
Jun-95	2.48	0.78	3.89	72	0.52	5.2	3.12	**-1.16**
Jul-95	6.77	0.78	3.89	72	3.63	6.2	3.72	**-0.58**
Aug-95	3.68	0.78	3.89	72	1.24	5.1	3.06	**-0.62**
Sep-95	1.25	0.78	3.89	72	0.05	3.9	2.34	**-1.14**
Oct-95	3.84	0.78	3.89	72	1.35	2.9	1.74	**0.75**
Nov-95	2.6	0.78	3.89	72	0.58	1.4	0.84	**1.18**
Dec-95	1.09	0.78	3.89	72	0.02	NA		
Jan-96	1.27	0.78	3.89	72	0.06	0.7	0.42	**0.79**
Feb-96	1	0.78	3.89	72	0.01	0.7	0.42	**0.57**
Mar-96	2.04	0.78	3.89	72	0.31	1.7	1.02	**0.71**
Apr-96	4.39	0.78	3.89	72	1.74	3.3	1.98	**0.67**
May-96	2.25	0.78	3.89	72	0.40	4.3	2.58	**-0.73**
Jun-96	4.66	0.78	3.89	72	1.94	5.4	3.24	**-0.52**
Jul-96	3.72	0.78	3.89	72	1.27	5.6	3.36	**-0.91**
Aug-96	0.4	0.78	3.89	72	0.04	5.1	3.06	**-2.70**
Sep-96	6.5	0.78	3.89	72	3.41	3.1	1.86	**1.23**
Oct-96	2.37	0.78	3.89	72	0.46	2.1	1.26	**0.65**
Nov-96	1.94	0.78	3.89	72	0.27	0.8	0.48	**1.19**
Dec-96	3.35	0.78	3.89	72	1.02	0.5	0.30	**2.03**
Jan-97	1.65	0.78	3.89	72	0.16	0.6	0.36	**1.13**
Feb-97	3.29	0.78	3.89	72	0.99	1	0.60	**1.70**
Mar-97	3.04	0.78	3.89	72	0.83	1.6	0.96	**1.25**
Apr-97	1.62	0.78	3.89	72	0.15	3	1.80	**-0.33**
May-97	5.19	0.78	3.89	72	2.34	3.9	2.34	**0.51**
Jun-97	6.79	0.78	3.89	72	3.65	5.2	3.12	**0.02**
Jul-97	2.26	0.78	3.89	72	0.41	4.9	2.94	**-1.09**
Aug-97	4.23	0.78	3.89	72	1.62	3.2	1.92	**0.69**
Sep-97	4.11	0.78	3.89	72	1.54	2.8	1.68	**0.89**
Oct-97	1.58	0.78	3.89	72	0.14	2.3	1.38	**0.06**
Nov-97	2.24	0.78	3.89	72	0.40	0.9	0.54	**1.30**
Dec-97	1.95	0.78	3.89	72	0.27	0.3	0.18	**1.50**
Jan-98	3.85	0.78	3.89	72	1.36	0.4	0.24	**2.25**
Feb-98	2.67	0.78	3.89	72	0.62	0.5	0.30	**1.75**

Month	Rain (P)	*Ia*	*S*	*Curve Number (CN)*	Runoff (Q)	Evapo-transpiration (E)	Evapo*0.6 (E est.)	Monthly Rechge
	From Sandusky, OH rain gauge	*Ia=0.2S*	*S=1000/CN-10*	*(see Table in Appendix ??)*	Q=(P-0.2S)^2 /P+0.8S	(From National Weather Service (Cleveland)		R = P-Q- E est
Mar-98	3.45	0.78	3.89	72	1.09	1.9	1.14	**1.22**
Apr-98	1.62	0.78	3.89	72	0.15	2.6	1.56	**-0.09**
May-98	5.19	0.78	3.89	72	2.34	3.9	2.34	**0.51**
Jan-98	3.85	0.78	3.89	72	1.36	0.4	0.24	**2.25**
Feb-98	2.67	0.78	3.89	72	0.62	0.45	0.27	**1.78**
Mar-98	3.45	0.78	3.89	72	1.09	1.9	1.14	**1.22**
Apr-98	5.56	0.78	3.89	72	2.64	2.6	1.56	**1.36**
May-98	0.68	0.78	3.89	72	0.00	3.9	2.34	**-1.66**
Jun-98	3.71	0.78	3.89	72	1.26	4.1	2.46	**-0.01**
Jul-98	5.11	0.78	3.89	72	2.28	4.9	2.94	**-0.11**
Aug-98	4.91	0.78	3.89	72	2.13	4.2	2.52	**0.26**
Sep-98	1.18	0.78	3.89	72	0.04	3.6	2.16	**-1.02**
Oct-98	1.46	0.78	3.89	72	0.10	2.1	1.26	**0.10**
Nov-98	1.21	0.78	3.89	72	0.04	1.5	0.90	**0.27**
Dec-98	1.09	0.78	3.89	72	0.02	0.8	0.48	**0.59**
Jan-99	2.81	0.78	3.89	72	0.70	0.5	0.30	**1.81**
Feb-99	1.33	0.78	3.89	72	0.07	0.9	0.54	**0.72**
Mar-99	1.83	0.78	3.89	72	0.22	2	1.20	**0.41**
Apr-99	4.51	0.78	3.89	72	1.83	2.43	1.46	**1.22**
May-99	1.81	0.78	3.89	72	0.22	4.3	2.58	**-0.99**
Jun-99	1.72	0.78	3.89	72	0.18	4.8	2.88	**-1.34**
Jul-99	2.83	0.78	3.89	72	0.71	5.5	3.30	**-1.18**
Aug-99	2.48	0.78	3.89	72	0.52	4	2.40	**-0.44**
Sep-99	1.59	0.78	3.89	72	0.14	3.7	2.22	**-0.77**
Oct-99	2.2	0.78	3.89	72	0.38	2.5	1.50	**0.32**
Nov-99	2.84	0.78	3.89	72	0.71	1.7	1.02	**1.11**
Dec-99	2.11	0.78	3.89	72	0.34	0.8	0.48	**1.29**
Jan-00	1	0.78	3.89	72	0.01	0.6	0.36	**0.63**
Feb-00	1.21	0.78	3.89	72	0.04	0.9	0.54	**0.63**
Mar-00	2.26	0.78	3.89	72	0.41	2	1.20	**0.65**
Apr-00	2.4	0.78	3.89	72	0.48	2.1	1.26	**0.66**
May-00	6.12	0.78	3.89	72	3.09	3.5	2.10	**0.93**
Jun-00	8.32	0.78	3.89	72	4.98	3.7	2.22	**1.12**
Jul-00	5.31	0.78	3.89	72	2.44	3.5	2.10	**0.77**
Aug-00	4.69	0.78	3.89	72	1.96	3.5	2.10	**0.63**
Sep-00	5.05	0.78	3.89	72	2.24	3	1.80	**1.01**
Oct-00	1.93	0.78	3.89	72	0.26	1.8	1.08	**0.59**
Nov-00	1.23	0.78	3.89	72	0.05	0.7	0.42	**0.76**
Dec-00	1.81	0.78	3.89	72	0.22	0.3	0.18	**1.41**
Jan-01	0.48	0.78	3.89	72	0.02	0.2	0.12	**0.34**
Feb-01	1.09	0.78	3.89	72	0.02	0.8	0.48	**0.59**
Mar-01	0.69	0.78	3.89	72	0.00	1	0.60	**0.09**
Apr-01	2.23	0.78	3.89	72	0.39	2.7	1.62	**0.22**
May-01	1.88	0.78	3.89	72	0.24	2.8	1.68	**-0.04**
Jun-01	0.98	0.78	3.89	72	0.01	4	2.40	**-1.43**
Jul-01	1.37	0.78	3.89	72	0.08	5	3.00	**-1.71**
Aug-01	1.87	0.78	3.89	72	0.24	4.5	2.70	**-1.07**
Sep-01	1.58	0.78	3.89	72	0.14	3.2	1.92	**-0.48**
Oct-01	0.15	0.78	3.89	72	0.12	2.6	1.56	**-1.53**
Nov-01	2.65	0.78	3.89	72	0.61	1.3	0.78	**1.26**

Month	Rain (P)	*Ia*	*S*	*Curve Number (CN)*	Runoff (Q)	Evapo-transpiration (E)	Evapo*0.6 (E est.)	Monthly Rechge
	From Sandusky, OH rain gauge	*Ia=0.2S*	*S=1000/CN-10*	*(see Table in Appendix ??)*	Q=(P-0.2S)^2 /P+0.8S	(From National Weather Service (Cleveland)		R = P-Q- E est
Dec-01	1.88	0.78	3.89	72	0.24	0.6	0.36	**1.28**
Jan-02	1.95	0.78	3.89	72	0.27	0.8	0.48	**1.20**
Feb-02		0.78	3.89	72	0.19	1.2	0.72	
Mar-02	2.27	0.78	3.89	72	0.41	1.5	0.90	**0.96**
Apr-02	3.11	0.78	3.89	72	0.87	2.4	1.44	**0.80**
May-02	3.45	0.78	3.89	72	1.09	2.9	1.74	**0.62**
Jun-02	2.96	0.78	3.89	72	0.78	4.4	2.64	**-0.46**
Jul-02	0.68	0.78	3.89	72	0.00	5.4	3.24	**-2.56**
Aug-02	0.21	0.78	3.89	72	0.10	4.6	2.76	**-2.65**
Sep-02	0.81	0.78	3.89	72	0.00	3.6	2.16	**-1.35**
Oct-02		0.78	3.89	72	0.19	1.7	1.02	
Nov-02	2.65	0.78	3.89	72	0.61	1.1	0.66	**1.38**
Dec-02	1.33	0.78	3.89	72	0.07	0.5	0.30	**0.96**
Jan-03		0.78	3.89	72	0.19	0.4	0.24	
Feb-03	1.19	0.78	3.89	72	0.04	0.5	0.30	**0.85**
Mar-03	1.64	0.78	3.89	72	0.16	1.7	1.02	**0.46**
Apr-03	3.24	0.78	3.89	72	0.95	3.4	2.04	**0.25**
May-03	3.75	0.78	3.89	72	1.29	3.5	2.10	**0.36**
Jun-03	1.17	0.78	3.89	72	0.04	4.6	2.76	**-1.63**
Jul-03		0.78	3.89	72	0.19	5.3	3.18	
Aug-03		0.78	3.89	72	0.19	5.1	3.06	
Sep-03		0.78	3.89	72	0.19	3.6	2.16	
Oct-03		0.78	3.89	72	0.19	2.5	1.50	
Nov-03	2.48	0.78	3.89	72	0.52	1.7	1.02	**0.94**
Dec-03	2.42	0.78	3.89	72	0.49	0.8	0.48	**1.45**
Jan-04	1.04	0.78	3.89	72	0.02	0.4	0.24	**0.78**
Feb-04	0.41	0.78	3.89	72	0.04	0.7	0.42	**-0.05**
Mar-04	2.48	0.78	3.89	72	0.52	1.6	0.96	**1.00**
Apr-04	1.84	0.78	3.89	72	0.23	3	1.80	**-0.19**
May-04	5.35	0.78	3.89	72	2.47	3.9	2.34	**0.54**
Jun-04	2.85	0.78	3.89	72	0.72	4.7	2.82	**-0.69**
Jul-04		0.78	3.89	72	0.19	4.9	2.94	
Aug-04		0.78	3.89	72	0.19	4.5	2.70	
Sep-04		0.78	3.89	72	0.19	4.2	2.52	

Attachment 1

Table 2-2.--Runoff curve numbers for selected agricultural, suburban, and urban land use. (Antecedent moisture condition II, and $I_a = 0.2S$)

LAND USE DESCRIPTION		HYDROLOGIC SOIL GROUP			
		A	B	C	D
Cultivated land[1]: without conservation treatment		72	81	88	91
: with conservation treatment		62	71	78	81
Pasture or range land: poor condition		68	79	86	89
good condition		39	61	74	80
Meadow: good condition		30	58	71	78
Wood or Forest land: thin stand, poor cover, no mulch		45	66	77	83
good cover[2]		25	55	70	77
Open Spaces, lawns, parks, golf courses, cemeteries, etc.					
good condition: grass cover on 75% or more of the area		39	61	74	80
fair condition: grass cover on 50% to 75% of the area		49	69	79	84
Commercial and business areas (85% impervious)		89	92	94	95
Industrial districts (72% impervious)		81	88	91	93
Residential:[3]					
Average lot size	Average % Impervious[4]				
1/8 acre or less	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
Paved parking lots, roofs, driveways, etc.[5]		98	98	98	98
Streets and roads:					
paved with curbs and storm sewers[5]		98	98	98	98
gravel		76	85	89	91
dirt		72	82	87	89

[1] For a more detailed description of agricultural land use curve numbers refer to National Engineering Handbook, Section 4, Hydrology, Chapter 9, Aug. 1972.

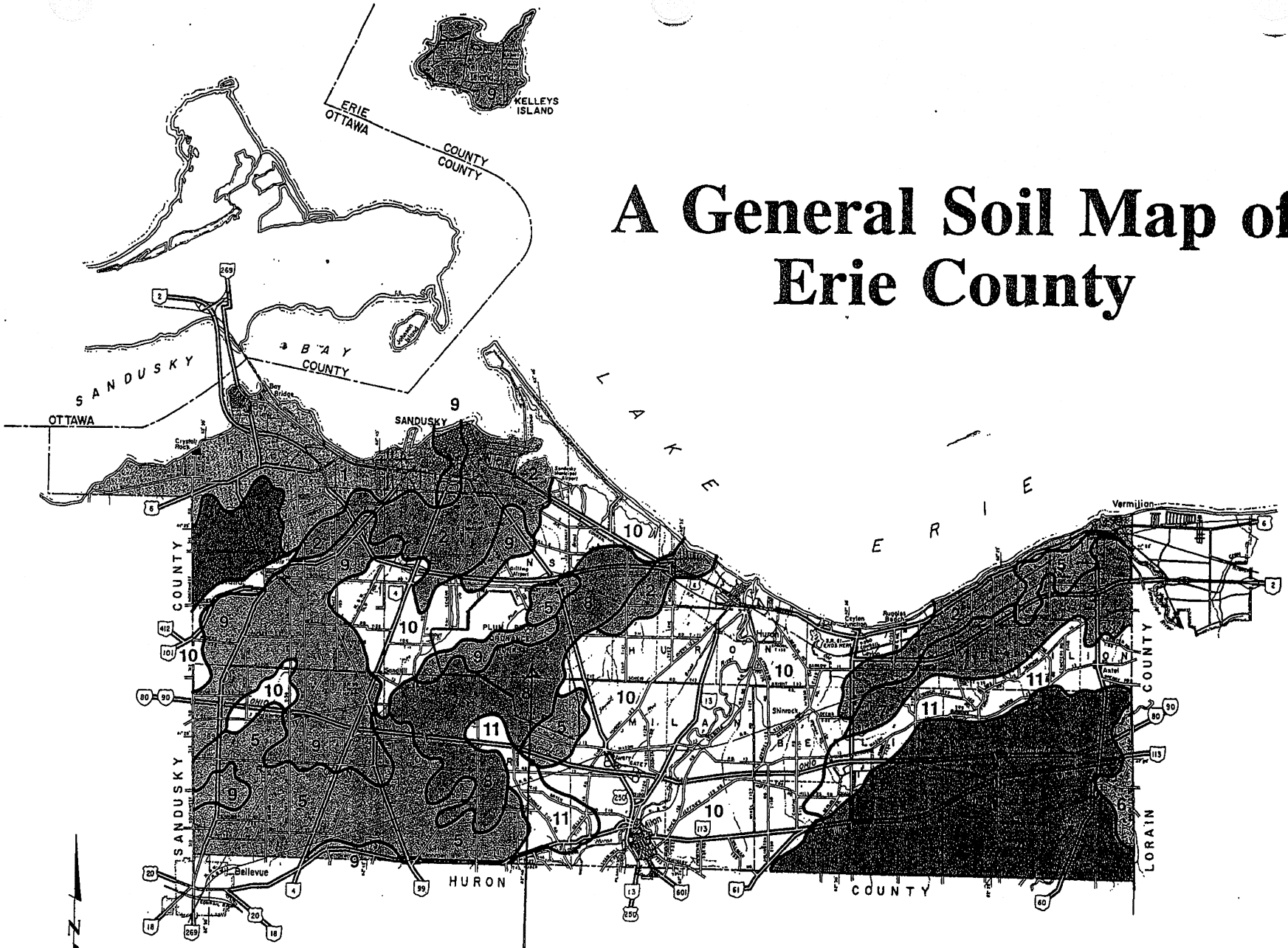
[2] Good cover is protected from grazing and litter and brush cover soil.

[3] Curve numbers are computed assuming the runoff from the house and driveway is directed towards the street with a minimum of roof water directed to lawns where additional infiltration could occur.

[4] The remaining pervious areas (lawn) are considered to be in good pasture condition for these curve numbers.

[5] In some warmer climates of the country a curve number of 95 may be used.

A General Soil Map of Erie County



PLUM BROOK ORDNANCE WORKS

Soil Legend

VERY DEEP SOILS ON LAKE PLAINS

1 Toledo-Fulton Association: Nearly level, very poorly drained and somewhat poorly drained soils formed in lacustrine sediments.

2 Del Rey-Milford Association: Nearly level, somewhat poorly drained and very poorly drained soils formed in lacustrine sediments.

3 Weyers-Haplaquents-Sandusky Association: Level, very poorly drained soils formed in calcareous tufa and marl over lacustrine sediments.

VERY DEEP SOILS PRIMARILY ON TILL PLAINS

4 Bennington-Cardington-Haskins Association: Nearly level to sloping, somewhat poorly drained and moderately well drained soils formed in glacial till and loamy outwash sediments over glacial till or lacustrine sediments.

5 Pewamo-Bennington Association: Nearly level to gently sloping, very poorly drained and somewhat poorly drained soils formed in glacial till and lacustrine sediments.

6 Mahoning-Rawson-Ellsworth Association: Nearly level to sloping, somewhat poorly drained and moderately well drained soils formed in glacial till and loamy outwash over glacial till or lacustrine sediments.

SHALLOW TO DEEP SOILS ON BEDROCK-CONTROLLED TILL PLAINS AND LAKE PLAINS

7 Allis-Fries Association: Moderately deep, nearly level, somewhat poorly drained to very poorly drained soils formed in glacial till or lacustrine sediments over shale bedrock.

8 Hornell-Fries-Colwood Association: Moderately deep and deep, nearly level to gently sloping, somewhat poorly drained and very poorly drained soils formed in glacial till and lacustrine sediments over shale bedrock.

9 Castalia-Millsdale-Milton-Ritchey Association: Shallow to moderately deep, nearly level to moderately steep, well drained and very poorly drained soils formed in glacial till, lacustrine sediments and limestone residuum.

VERY DEEP SOILS ON OUTWASH PLAINS, LAKE PLAINS, DELTAS AND BEACH RIDGES

10 Kibbie-Elnora-Tuscola-Colwood Association: Nearly level to gently sloping, somewhat poorly drained, moderately well drained and very poorly drained soils formed in outwash, lacustrine and deltaic sediments.

11 Jimtown-Oshtemo-Millgrove Association: Nearly level to gently sloping, somewhat poorly drained, well drained and very poorly drained soils formed in outwash and beach sediments.

The general soil map shows the location of the 11 soil associations or general soil areas in Erie County. Each association typically consists of two to four major soils for which it is named and some soils of minor extent. The soils in each association occur together in a distinct and repetitive landscape pattern.

The general soil map is most useful for providing generalized information about the soil resources of Erie County. It is **not** suitable for planning the management of a farm or for selection of a building site because of its small scale.

Information on how to obtain more detailed soil maps in the county is given elsewhere in this publication. The following information about the 28 soils identified on the General Soil Map plus 32 other soil series in the county can also be obtained by request:

- Slope range
- Drainage class
- Permeability
- Available water capacity
- Seasonal high water table depth
- Depth to bedrock
- Shrink-swell potential

Some of the more common management concerns that can be identified in places from the detailed soil maps are slope, erosion, shallowness to bedrock, slow permeability, seasonal wetness, ponding, droughtiness, poor filtration, and flooding. Information about recommended management practices can be obtained from the Erie SWCD.

APPENDIX P

COMMENTS AND RESPONSES

Response to Comments
U.S. Army Corps of Engineers (CELRN-EC-R-D)
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio
(Report dated December 2004)

Reference: Comments from Jim Beaujon, copied February 18, 2005 from Dr. Checks.

Comment 1: **Page ES-2 & ES-3: The "ug/L" in the tabular column heads are not underlined.**

Response 1: Agreed. The "ug/L" in the tabular column headings will be underlined.

Comment 2: **Page ES-5, 2nd paragraph, end of 2nd line: Delete "site" from the sentence.**

Response 2: Agreed. "Site" will be deleted from the sentence.

Comment 3: **Page 1-4, Section 1.2, 1st paragraph, 2nd to last line: Change "groundwater conclusions and recommendations" to "groundwater conclusions. Recommendations".**

Response 3: Agreed. The changes will be made as indicated.

Comment 4: **Page 3-6, paragraph at top of page: It states the total cost of the alternative for TNTA was estimated to be $7,815,000 but the parenthetical note indicates that cost includes TNTC. Is the $7,815,000 the estimate for TNTA alone or is it for both TNTA and TNTC? Please edit for clarity.**

Response 4: The total cost estimate for the recommended remedial alternative at TNTA is $7,688,000. The estimated cost for simultaneous remediation of TNTA with TNTC is $10,987,000. The text will be edited to reflect the correct costs along with clarification of the estimated costs.

Comment 5: **Page 3-6, Section 3.1.2, 3rd paragraph, 4th line: Appropriate portion should read "sediment, soil, and groundwater".**

Response 5: Agreed. Soil will be included in the referenced historical media.

Comment 6: **Page 3-11, Section 3.1.3, 3rd paragraph, 1st sentence: Some punctuation is needed between each of the listed investigations, perhaps semicolons. So it would read as "... by MK (1994); a 1994 ... by D&M (1997a); groundwater by Shaw ... and 2002 (Shaw 2003a); and a soil ...".**

Response 6: Agreed. Semicolons will be inserted as needed.

Comment 7: **Page 3-15, 6th line of 1st paragraph: Change "Delaware screened" to "Delaware Limestone screened".**

Response 7: Agreed. "Limestone" will be inserted following Delaware.

Comment 8: **Page 3-16, paragraph/sentence beginning with "Shaw was contracted in 1989": Is "near-surface sediment sampling" meant to be "near-surface soil sampling"?**

Response 8: The sentence will be adjusted to read, "Shaw was contracted in 1989 to conduct surface water, soil, and groundwater sampling ….".

Comment 9: **Page 4-1, 2nd paragraph, 2nd to last line: BED-MW29 is west of Ransom Road.**

Response 9: Correct. "East" will be replaced by "west" in the sentence.

Comment 10: **Page 4-1, 3rd paragraph, last sentence: Change to read "... north of PBOW on the east side of Columbus Avenue beneath the State Route 2 overpass ... area, north of Taylor Road near Botay Road.**

Response 10: Agree. The last sentence will be changed as indicated.

Comment 11: **Page 4-2, Section 4.2, 1st paragraph, 7th line: Change "prior to the ... perimeter respectively" to "from the ... perimeter areas respectively".**

Response 11: Agreed. The last part of the sentence will be changed as indicated.

Comment 12: **Page 4-2, last paragraph on page, 4th line: For clarity, change "located on government property" to "located on NASA property".**

Response 12: Agreed. The word "government" will be changed to "NASA" for clarity.

Comment 13: **Page 4-4, 1st line: Change "soil areas. During this phase of work, overburden" to "soil areas, thus overburden".**

Response 13: Agreed. The two sentences will be restructured as noted.

Comment 14: **Page 4-4: 4th line of 2nd full paragraph- change "desire depth" to "desired depth". End of 2nd to last paragraph- change "manhole" to "access hole".**

Response 14: Agreed. "Desire" will be changed to "desired" and "manhole" will be changed to "access hole".

Comment 15: **Page 4-5, last paragraph: Rewrite the first sentence for clarity. Change the next 4 sentences to read something like "As a result of using Driller Service Inc. size #1 sand rather than the appropriate size #2, quantities of filter pack sand passed through the screen slots and into the monitoring well during well development. This influx of sand decreased the total accessible depth of BED-MW30 by approximately 3 ft and BED-MW33 by approximately 4.5 ft. The change in total depth of BED-MW30 was ... The change in total depth of BED-MW33 was also noted prior to its development."**

Response 15: Agreed. The paragraph will be rewritten as suggested.

Comment 16: **Page 4-5, last paragraph, 5th sentence: This sentence is a bit confusing as it states a "final" determination was made at two points in time ("at this point and approximately 2 weeks later"). Generally a "final" determination is made at one point in time not two. Please edit the sentence.**

Response 16: Agreed. The sentence will be changed to "Approximately 2 weeks later, confirmation with the drilling firm was made that an incorrect sand size had been used for filter pack construction".

Comment 17: **Page 4-6, 2nd line: Change "suite is able to be collected" to "suite can be collected".**

Response 17: The change will be made as suggested.

Comment 18: **Page 4-7, last paragraph, 3rd line: Change "(i.e., with" to "(i.e., sampled with".**

Response 18: Agreed. "Sample" will be added prior to with.

Comment 19: **Page 6-3: First line- change "76 wells overburden wells" to "76 overburden wells". Third line- close the parentheses after "Shale".**

Response 19: Agreed. The changes will be made as suggested.

Comment 20: **Page 6-4, 1st full paragraph, last line: Change "less continuous that previously" to "less continuous than previously".**

Response 20: Agreed. "That" will be replaced by the word "than".

Comment 21: **Page 7-1, paragraph before bullet list of AOCs: Change "direct-put" to "direct-push".**

Response 21: Agreed. "Direct-push" will replace "direct-put".

Comment 22: **Page 7-3, 2nd paragraph, 3rd line: Change "Only samples ... was used" to "Only samples ... were used".**

Response 22: Agreed. Was will be changed to were.

Comment 23: **Page 7-3, Section 7.2, 2nd sentence: Change "compared RBSC" to "compared to RBSC".**

Response 23: Agreed. The word "to" will be inserted prior to RBSC.

Comment 24: **Page 7-4, 2000 Dry Season section: The 6th and 7th sentences both mention benzene and toluene in GW01 are above RBSC. Is the 7th sentence necessary?**

Response 24: No the 7th sentence is not necessary and will be deleted.

Comment 25: **Page 7-7, about the middle of the partial paragraph at top of page, sentence beginning with "In this well": Change both occurrences of "compounds above" to "compounds were above".**

Response 25: Agreed. "Were" will be inserted between "compounds" and "above" at both locations in the sentence.

Comment 26: **Page 7-10, Section 7.2.1.4, end 3rd line: Change "7 on 2001" to "7 in 2001".**

Response 26: Agreed. "On" will be changed to the word "in" as suggested.

Comment 27: **Page 7-14, 2002 Wet Season section, sentence on 4th and 5th lines from end of paragraph: Change "others metals" to "other metals" and "L), iron" to "L), and iron".**

Response 27: Agreed. The changes will be made as suggested.

Comment 28: **Page 7-17, 3rd line from end of 1st partial paragraph on page: Change "det3ected" to "detected".**

Response 28: Agreed. The misspelled word will be corrected.

Comment 29: **Page 7-48, 2002 Wet Season section, 2nd line: Change "detected above the at a" to "detected at a".**

Response 29: Agreed. The change will be made as suggested.

Comment 30: **Page 8-1, 1st paragraph, 2nd line from end: Change "were determined not to be used" to "were not used".**

Response 30: Agreed. The wording will be changed as indicated.

Comment 31: **Page 8-6, Section 8.2.1.2, 5th line from end of 1st paragraph: Remove "(" from between "value" and "ranged".**

Response 31: Agreed. "(" will be removed as suggested.

Comment 32: **Page 8-8, 1st 2 sentences on page: I believe there are several properties between Mr. Koch's property, which includes PT-5912, and PBOW thus please rewrite these sentences to something like- "Private well PT-5912 is northwest of PBOW downgradient of the WARWP and AA2. The owner of PT-5912 signed a ROE form to allow sampling for this investigation.**

Response 32: Agreed. The last two sentences will be rewritten as suggested.

Comment 33: **Page 8-10, 1st sentence: RDX was reported once in a groundwater sample from AA1 too and an explanation for the erroneous reporting of RDX was provided earlier in the document. Thus please replace "so its one time occurrence in the groundwater sample is unclear" with something incorporating the earlier explanation.**

Response 33: Agreed. The sentence will be replaced by the following sentence, "Nitroaromatic RDX is not known to have ever been used or manufactured at PBOW, and is not a degradation product of nitroaromatics formerly produced. Based on information and analyses at a similar site, the reported concentrations of RDX at PBOW are likely a laboratory artifact".

Comment 34: **Page 8-13, 2nd paragraph, 2nd sentence: Was there free-phase hydrocarbons in the soil from the borings for BED-MW31, 32, and 34 or was it in the rock cores from those holes? If it wasn't in the soil please rewrite the sentence accordingly.**

Response 34: Agreed. "Soil" in the second sentence will be replaced by "also on rock cores from the" to make the sentence clearer.

Comment 35: **Page 9-1, 1st recommendation: Section 7.2.8.3, pages 7-48 and 7-49, seems a bit more definite that the toluene is the result of former DOD activities rather than natural petroleum hydrocarbons in the area. If that is a valid assessment this recommendation should reflect Section 7.2.8.3's conclusion better.**

Response 35: Agreed. The recommendation will be revised as follows: "Toluene was detected at elevated concentrations in well MK-MW20 in the UTT area.

Based on the relative absence of other aromatic hydrocarbons, the source of the contamination is interpreted to be from toluene storage used in the production of nitroaromatics. Based on these findings, further evaluation is warranted".

Comment 36: **Table 3-16, Title: The second "W" is missing from "WARWP".**

Response 36: Agreed. The second "W" will be inserted into WARWP in the title.

Comment 37: **Table 4-1: Change column heading "Groundwater Level Conditions" to something like "Seasonal Period".**

Response 37: Agreed. The "Groundwater Level Conditions" column heading will be changed to "Season Period".

Comment 38: **Figure 3-4: Label Fox Road.**

Response 38: Fox Road will be identified on Figure 3-4.

Comment 39: **Well Construction Diagram for BED-MW30: What is meant by the hand written "unknown" beside the form's printed "20-40 Washed Silica Sand Pack"? Also, no elevation or depth is recorded for the groundwater encountered on "3/18/04". Relative to the note in the lower left of the form and so it will be clearly understood by future samplers please add a brief notation above the "57.3" to indicate the depth the sand has filled to (e.g. filter pack sand infiltration has filled to __ ft).**

Response 39: As indicated on Page 1 of the HTRW form for BED-MW30, the depth bedrock groundwater was encountered was not able to be identified. "Unknown" written beside 20-40 Washed Silica Sand Pack should have been written beside "Encountered groundwater at". "Unknown" will be moved to the proper location.

A note will be added on the BED-MW30 well construction diagram above the 57.3 foot depth to indicate filter pack sand has infiltrated the screen to a total depth of 54.3 feet.

Comment 40: **Well Construction Diagram for BED-MW31: What is meant by the hand written "unknown" beside "Encountered groundwater at"?**

Response 40: Groundwater was not encountered during drilling of BED-MW31 during the time period of March 16 through March 20, 2004. On March 21, 2004, a groundwater level measurement incorrectly recorded approximately 15 feet of water in the borehole. In thought of groundwater present in the borehole, PVC well construction material was installed. The well construction diagram form was completed on March 21, 2004 indicating the depth groundwater was

encountered was unknown. Since only a foot of groundwater could be measured after the well was installed, the PVC materials were removed and further well completion activities were not conducted. "Unknown" will be removed from the well construction diagram.

Comment 41: **Well Construction Diagram for BED-MW33: There is no indication on the diagram that sand has infiltrated the well. So it will be clearly understood by future samplers, above the "88.5" please add a brief notation (e.g. filter pack sand infiltration has filled to __ ft) indicating where the bottom of the well was at last measurement.**

Response 41: Agreed. A note will be added on the BED-MW33 well construction diagram above the 88.5 foot depth to indicate that filter pack sand has infiltrated the screen to a total depth of 83.7 feet.

Comment 42: **Photographs: For the most part good photos, much better than the ones taken during earlier investigations using disposable cameras.**

Response 42: Noted. Photographs of rock cores taken with a digital camera are now standard procedure.

Comment 43: **Appendix E: There are two attachments to this appendix but I didn't see where the text in the appendix refers to or explains the attachments. Section 2.0, 1st sentence- change "The methods ... was" to "The methods ... were". Section 6.0, 3rd paragraph, 1st line- change "well are range" to "well range".**

Response 43: The call outs for Attachments 1 and 2 will be included in Section 6.0 and grammatical changes will be made as indicated.

Comment 44: **Appendix E, Attachment 2: If the "f.aqt" in the Data Set name means it's data from a falling head run then two of the falling head runs are miss-titled "Rising Test Analysis".**

Response 44: Correct. The titles from the two falling head data sets will be identified correctly.

Comment 45: **Attachment M2, Table M2-1: The footnotes for the shading start with "Greater that" rather than "Greater than".**

Response 45: Agreed. "Greater that" will be changed to "Greater than".

Comment 46: **Attachment M2, Figures: The figure titles are not really correct. For example Figure M2-1 would be more correctly titled "Alkalinity Concentration (ppm)" or "Alkalinity Concentration (ppm) versus Sampling Date".**

Response 46: Agreed. The titles of all seven figures will be changed as suggested (i.e. Alkalinity Concentration (ppm) versus Sampling Date.

Reference: Comments from Lannae Long, copied February 28, 2005 from Dr. Checks.

Comment 1: **Section 3.2.1, page 3-17, last para.: Para. beginning with "A BERA was performed by Shaw for the WARWP (IT, 2001f; 2000c). The paragraph should be expanded to explain that a full ecological risk assessment including definitive toxicity testing was done for surface water and sediment and a brief description of results. This paragraph only touches on the Screening Level ERA which did indicate that further action (BERA) was needed.**

Response 1: The paragraph will be completely revised as follows: "A SLERA was initially performed for the WARWP (IT, 2000c). Based on the SLERA results which suggested the potential for ecological impact, a full BERA (IT, 2001g) was performed to more accurately determine whether ecological receptors may be adversely impacted by PBOW-related chemicals in WARWP soil, surface water or sediment. The BERA included revised food-web models based on site-specific bioconcentration factors (BCF) derived from tissue sample and site-specific aquatic and terrestrial toxicity testing. It was concluded from the BERA that PAH concentrations in one surface soil indicated some earthworm toxicity; however, survival was decreased by less than 30 percent. These PAHs may be generated by controlled burning which is practiced at PBOW. Food-chain modeling indicated some potential for ecological risk to the shrew associated with PAHs, but only under the most conservative assumptions. Given the weight of evidence, it is unlikely that WARWP Area soils represent an unacceptable ecological concern. Iron concentrations in one sediment sample indicated the potential for ecological risk to the raccoon and heron through food chain modeling under the most conservative assumptions; more typical central tendency. Toxicity study results suggested some toxicity to benthic invertebrates. However, the maximum iron concentration detected in the sediment samples (24,200 mg/kg) likely results from the native background soil which comprises the substrate of the pond. Iron concentrations in PBOW background soil range up to 234,000 mg/kg (mean of 40,100 mg/kg). Thus, there appear to be no site-related impacts to sediment with regard to ecological receptors in the WARWP Area."

Comment 2: **Section 3.2.2, page 3-20, 2nd para.: This paragraph should be expanded to briefly summarize both SLERA and BERA. The SLERA indicated further action based on ECO results, thus a BERA was conducted. The BERA included toxicity testing of media at the PRRWP, and a brief sentence or two should summarize the BERA findings.**

Response 2: The paragraph will be revised as follows: "A SLERA was initially performed for the PRRWP (IT, 2000c). Based on the SLERA results which suggested the potential for ecological impact, a full BERA (IT, 2001f) was performed to more accurately determine whether ecological receptors may be adversely impacted by PBOW-related chemicals in WARWP soil, surface water, or sediment. The BERA included revised food-web models based on site-specific BCFs. It was concluded from the BERA, using the most conservative exposure assumptions, only a low potential for adverse ecological effects exists upon exposure to PRRWP soil by terrestrial receptors. No site-related chemicals were identified as potentially impacting PRRWP surface water or sediment."

Comment 3: **Section 9 recommendations: One of the recommendations is to properly close 9 known manholes in TNT A and C. I found more manholes in Acids Area 3. Would it be appropriate to recommend that a general sweep of PBOW be conducted for open manholes, and other manholes also be appropriately closed as well?**

Response 3: Agreed. Identifying the location of former DOD open manholes across PBOW followed by proper abandonment will be recommended.

Comment 4: **Table 3-10, Historic: MDC were not included. Include the MDC in the left column for each chemical that was detected.**

Response 4: **Agreed. MDC's were inadvertently omitted and will be included.**

Reference: Comments from Douglas Mullendore, copied February 28, 2005 from Dr. Checks.

Comment 1: **Page ES-3, Nitroaromatic Contamination, 2nd Sentence. Suggest revising this sentence to state that only 2A-DNT and 4A-DNT suggest natural biological activity.**

Response 1: Agreed. The sentence will be revised. Also, under Delaware Limestone Water-Bearing Zone, page ES-5, last paragraph under Nitroaromatic Compounds, that information regarding the detection of 2A-4,6-DNT and 4A-2,6-DNT will be revised accordingly.

Comment 2: **ES-3, Organic Compounds, 1st Sentence. Add detected after consistently.**

Response 2: Agreed. Detected will be added to the sentence.

Comment 3: **General. In section 2.0 can a section titled "Geochemistry" be included to discuss the significance of chloride, sulfate, and nitrate dominated groundwaters.**

Response 3: Agreed. Text discussing the site-wide groundwater geochemistry will be included as the last paragraph in Section 2.4 Site Conceptual Model. This will consist of a brief synopsis of the basic differences in the water bearing zones (overburden/shale and limestone), including potential natural and anthropogenic sources of sulfate, chloride, and nitrate at PBOW. Upon further review of the data, other pertinent information may be added including discussions of basic water quality parameters (pH, Eh, dissolved oxygen, total dissolved solids, etc).

Comment 4: **Page 7-17, 1st Paragraph, Last Sentence. Detected is incorrectly spelled.**

Response 4: Agreed. Detected will be spelled correctly.

Comment 5: **Page 7-28, Section 7.2.4, 1st Paragraph. Suggest revising that PCE and TCE are indicative of anthropogenic activities, but may not be related to DoD operations.**

Response 5: Agreed. Because NASA and National Guard activities have taken place at the WARWP area, the detection of PCE and TCE in the overburden/shale groundwater may not be related to former DoD activities. The paragraph will be revised.

Comment 6: **Page 7-34, 1998 Wet Season Sampling Event (May), Next to Last Sentence. Check the reference.**

Response 6: The reference used for the detection of RDX as a laboratory artifact was obtained from the Background Monitoring Well Selection letter report. The correct reference will be included.

Comment 7: **Page 7-35, Delaware Limestone Bedrock, 2nd Sentence. Should the first parenthesis be for RDX? If so please correct.**

Response 7: Correct. RDX will be included before the analytical concentration.

Response to Comments
U.S. Army Corps of Engineers - Huntington (CELRH-EC-CE)
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio
(Report dated December 2004)

Reference: Comments from Eric Guy, received February 23, 2005.

Comment 1: **Executive summary, fifth paragraph, second sentence: after "well BED-MW30," and before "review of groundwater....", the word "and" should be inserted. Also, since BED-MW30 is downgradient of WARWP, the text should state that it is not part of the background data set either. As currently written one could assume that BED-MW30 replaced BED-MW24 in the background data set, and then become confused as they are both downgradient wells.**

Response 1: Agree with both comments. The paragraph will be revised to clarify the selection of the background wells.

Comment 2: **Executive summary, Organic Compounds section: it seems TNTB should be added to the list of "AOCs investigated" in parentheses.**

Response 2: Agreed. Benzene was detected above the RBSC in wells TNTB-BEDGW-003 and TNTB-BEDGW-004 during both sampling occasions from each well and toluene was detected above the BSC value on both sampling events from well TNTB-BEDGW-003. TNTB will be added to the AOC list.

Comment 3: **Section 3.1.1, last paragraph, second to last sentence: Delete "(combined remediation cost of TNTA and TNTC)" since $7.8 million is the individual cost given in (IT, 2003e) and not the combined cost.**

Response 3: A similar comment was also received from the Nashville USACE. The response provided and that will be inserted into the text is that the total cost estimate for the recommended remedial alternative at TNTA is $7,688,000. The estimated cost for simultaneous remediation of TNTA with TNTC is $10,987,000. The text will be edited to reflect the correct costs along with clarification of the estimated costs.

Comment 4: **Section 4.2, third to last paragraph: Replace "on private or property outside" with "on private property or property outside."**

Response 4: Agreed. The sentence will be revised as suggested.

Comment 5: **Section 4.3, third paragraph: its stated that "it was at this point and approximately 2 weeks later that the final determination was made." This is a confusing statement, and its suggested that it be stated**

something to the effect of "it was suspected at this point, and finally determined approximately 2 weeks later" instead.

Response 5: Agreed. A similar comment was also received from the Nashville USACE. The entire paragraph will be rewritten as recommended by J. Beaujon (comment #15).

Comment 6: **Section 6.2.1, first paragraph, fifth sentence: suggest revising "76 wells overburden wells" to "76 overburden wells."**

Response 6: Agreed. The change will be made as suggested.

Comment 7: **Section 7.1, last paragraph, second sentence: replace "was" with "were."**

Response 7: Agreed. The replacement will be made.

Comment 8: **Table 3-16: the title acronym "WARP" should be changed to "WARWP."**

Response 8: Agreed. The title will be corrected.

Comment 9: **Table 6-4: some of the average vertical gradient values are not calculated properly, e.g., it appears that the average value for pair 1 was calculated by dividing the sum of total measurements by 5 total measurements instead of by 7, which would be correct.**

Response 9: Agreed. All of the average vertical gradients will be rechecked. After recalculation, the division difference did not change the end result. All of the vertical gradients remained positive indicating a downward gradient.

Comment 10: **Appendix E: The signature block on the final report is not signed.**

Response 10: Believe comment is referring to Appendix F, land survey data. If so, comment is correct. A signed copy of the signature page will be included.

Response to Comments
Ohio Environmental Protection Agency
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio
(Report dated December 2004)

Reference: Comments from John Weaver through Ron Nabors, received March 30, 2005, dated March 15, 2005.

Introduction:

The Division of Emergency and Remedial Response (DERR) has requested that the Division of Drinking and Ground Waters (DDAGW) perform a review of the above referenced document.

The U.S. Army is conducting environmental investigations at previously owned U.S. Department of Defense (DOD) properties, of which the NASA Plum Brook Station (NPBS) is one such facility. The NPBS is comprised of approximately 6400 acres and is located 4 miles south of Sandusky, Ohio in Erie county. Investigatory work is being managed and technically overseen by the Nashville District of the U.S. Army Corps of Engineers (USACE) under the Defense Environmental Restoration Program (DERP) Formerly Used Defense Sites (FUDS). The USACE has contracted Shaw Environmental Inc. (Shaw) to provide engineering and consulting services for the NPBS investigation including the completion of a site-wide ground water investigation (GWI). The Shaw December 23, 2004 Draft 2004 Groundwater Data Summary and Evaluation Report represents those ground water-related activities completed at NPBS to date and is the subject of this review.

Comment 1: **The NASA Plum Brook Station (NPBS) and Shaw Environmental Inc. (Shaw) December 23, 2004 [Draft] 2004 Groundwater Data Summary and Evaluation Report (2004 Annual Report) is a compilation of data/information obtained from the following activities:**

a. 2003 offsite background monitoring well installation.

b. Four phases of 2004 field activities.

c. Tenth quarterly background ground water sampling event.

d. Two downgradient ground water sampling events. And,

e. Development of background screening concentrations (BSCs) for naturally-occurring benzene, toluene, ethylbenzene, and xylene in the background bedrock monitoring wells.

Ohio EPA DERR has requested that Ohio EPA DDAGW provide a relevant summary of the above activities in this inter-office communication (IOC).

2003 offsite background monitoring well installation

To further expand the ground water investigation at TNT Areas A, B, and C, and the Red Water Pond Areas (West Area and Pentolite Road), 2 additional bedrock background monitoring wells (BED-MW28 and BED-MW29) were installed outside (south) of the NPBS boundary. These wells were installed in August 2003 as two-inch PVC wells and to a depth ranging from approximately 38-42 feet below land surface (bls). The wells are screened in shale (Olentangy).

Also in 2003 (January), overburden/shale monitoring well PR-MW08 and downgradient bedrock well BED-MW27 were abandoned.

Four phases of 2004 field activities

To further expand the ground water investigation at TNT Areas A, B, and C, and the Red Water Pond Areas (West Area and Pentolite Road), 2 downgradient bedrock monitoring wells (BED-MW30 and BED-MW33) were installed outside (west and north, respectively) of the NPBS boundary. The wells were installed in March 2004 as two-inch PVC wells and to a depth ranging from approximately 57-88 feet bls. The wells are screened in massive limestone (Delaware) where naturally-occurring hydrocarbon was observed.

Hydraulic slug-testing was performed at newly installed background bedrock monitoring wells BED-MW28 and BED-MW29 and newly installed downgradient bedrock monitoring wells BED-MW30 and BED-MW33.

Tenth quarterly background ground water sampling event

A tenth quarterly background ground water sampling event was completed at existing background bedrock monitoring wells BG8-BEDGW-001, BED-MW20, BED-MW24, and BED-MW25, and at newly installed background bedrock monitoring wells BED-MW28 and BED-MW29 on June 15-17, 2004. During all 2003 and 2004 sampling events at the NPBS monitoring wells, ground water samples were obtained for analysis of VOCs, SVOCs, metals (filtered and unfiltered), nitroaromatics, and water quality parameters. Samples were analyzed by Severn Trent Laboratories, Inc. of Knoxville, Tennessee.

For clarification, Ohio EPA, U.S. Army Corps of Engineers (USACE), Shaw, and NPBS have agreed that the background bedrock monitoring well network shall consist of the following wells for the purpose of developing background concentrations.

Two downgradient ground water sampling events

Existing onsite downgradient wells BED-MW17, BED-MW19, and BED-MW22 and new offsite downgradient monitoring wells BED-MW30 and BED-MW33 were sampled on May 5-7 and August 24-27, 2004 to determine in part if ground water quality fluctuated on a seasonal basis.

During the August 2004 sampling event, an offsite private well (PT-5912) was sampled to provide additional downgradient analytical data.

Development of background screening concentrations (BSCs) for naturally-occurring benzene, toluene, ethylbenzene, and xylene in the background bedrock monitoring wells

BSCs for inorganic and selected organic constituents were developed using a total of 28 data points collected using low-flow sampling methodologies as follows: BG8-BEDGW-001 (10 samples), PB-BED-MW25 (10 samples), PB-BED-MW28 (4 samples), and PB-BED-MW29 (4 samples). The BSCs were calculated using maximum detected concentrations or a 95th upper tolerance limit, whichever was less (Appendix M of the 2004 Annual Report).

Response 1: The information above is correct. The last paragraph on the previous page (page 2) beginning with "For clarification, Ohio EPA…", background bedrock monitoring wells that the Ohio EPA, U.S. Army Corps of Engineers (USACE), Shaw, and NPBS have agreed upon for developing background bedrock groundwater concentrations, were not listed. As identified in the October 19, 2004 *Background Monitoring Well Selection* letter report, the wells are BG8-BEDGW-001, PB-BED-MW25, BED-MW28, and PB-BED-MW29.

Comment 2: **Provided in the table below is a summary of ground water quality in the monitored saturated zones at selected areas of concern (AOCs) at the NPBS.**

Constituent/ AOC	VOCs>BSCs a/o RBSCs	SVOCs>BSCs a/o RBSCs	Nitroaromatics> BSCs a/o RBSCs	Metals (unfiltered)> BSCs a/o RBSCs	Metals (filtered)> BSCs a/o RBSCs
TNT Area A					
overburden	x	o	x	x	x
overburden/	x	x	x	x	o

Constituent/ AOC	VOCs>BSCs a/o RBSCs	SVOCs>BSCs a/o RBSCs	Nitroaromatics> BSCs a/o RBSCs	Metals (unfiltered)> BSCs a/o RBSCs	Metals (filtered)> BSCs a/o RBSCs
shale					
limestone	x	x	x	x	x
TNT Area B					
overburden/ shale		x	x	x	x
shale	x	x		x	x
TNT Area C					
overburden	x	x	x	x	o
overburden/ shale				x	x
limestone	x	x		x	x
West Area Red Water Ponds Area					
overburden	x	x	x	x	x
limestone	x	x		x	x
Pentolite Road Red Water Ponds Area					
overburden	x	x	x	x	x
limestone	x	x	x	x	x

Constituent/ AOC	VOCs>BSCs a/o RBSCs	SVOCs>BSCs a/o RBSCs	Nitroaromatics> BSCs a/o RBSCs	Metals (unfiltered)> BSCs a/o RBSCs	Metals (filtered)> BSCs a/o RBSCs
Acid Area 1					
limestone	x	x	x	x	x
Acid Area 2					
limestone	x	x	x	x	x
Acid Area 3					
limestone	x	x		x	x
Maintenance Area					
limestone	x	x	x	x	x
Additional Burning Ground Area					
shale	x	x		x	o
Upper Toluene Tanks Area					
overburden/ shale	x				
limestone	x	x	x	x	x
Downgradient Perimeter Wells					
limestone	x	x	x	x	x

Notes:
BSCs -Background screening concentrations.
RBSCs -Risk-based screening concentrations.
a/o -And/or.
Metals under consideration in the table above are arsenic, barium, beryllium, cadmium, chromium, cobalt, lead, mercury, nickel, selenium, and thallium.
Downgradient perimeter wells are BED-MW17, BED-MW19, BED-MW22, BED-MW24, BED-MW30, and BED-MW33.

Response 2: Based on review of analytical data tables, 4 additional cells should be marked to indicate groundwater quality in the saturated zones of AOCs. Additional markings made by Shaw are indicated by "o".

Comment 3: **Ohio EPA concurs with all of the recommendations made by Shaw in Section 9.0 of the 2004 Annual Report. These recommendations consist of:**

a. Additional evaluation of the detection of toluene at the Upper Toluene Tank Area.

b. Consideration of the installation of monitoring wells at the Middle Toluene Tanks Area as none currently exist.

c. Installation of an additional bedrock well at the Pentolite Road Red Water Pond Area. And,

d. Surface water sample collection from Ransom Brook to evaluate any nitroaromatic contamination.

Response 3: Comment noted.

Response to Comments
HTRW Center of Expertise
2004 Groundwater Data Summary and Evaluation Report
Former Plum Brook Ordnance Works, Sandusky, Ohio
(Report dated December 2004)

Reference: Comments from Chung-Rei Mao, dated February 23, 2005.

Comment 1: **Page ES-1, 3rd paragraph: Normally BTEX would not be considered as naturally occurring contaminants and any detections of significant amounts would be considered as site related contaminations, instead of non-anthropogenic or anthropogenic background contaminants. If the BTEX are from naturally occurring petroleum hydrocarbons, recommend that it be stated early in the Executive Summary and also explain why BSCs were not determined for PAHs, which should also be considered as naturally occurring contaminants.**

Response 1: Agreed. A brief statement will be made in the third paragraph stating that the BTEX concentrations are interpreted to be from natural sources and are not site related. In addition, the text will refer readers to following sections on the Delaware Limestone where this information is discussed in detail. BSCs were not derived for PAHs because no PAHs were detected in the background groundwater samples. No change will be made in the Executive Summary.

Comment 2: **Page ES-2, last paragraph: The approach used to set the BSC value would give high biased BSC values, especially if the sample size is small and statistical outliers happen. In order for an effective comparison of site contamination with the background, recommend that the central tendencies of the site and background concentration data be compared. For example, if the background and site data sets were both normally distributed with equal variances, it would be appropriate to compare the mean concentration of the background data set with that for the site data set.**

Response 2: The protocol used to screen maximum detected background concentrations in the report was previously agreed upon by USACE and OEPA during a November 2002 team meeting. This meeting will be referenced in Appendix M. The BSC values will not exceed the maximum concentration of the background samples. The project team thoroughly discussed background sampling locations before deciding on the current background monitoring well set. Any statistical outliers from these locations likely reflect true background conditions.

Comment 3: **Pages 3-5, 3-10, 3-14: Please explain the different RGOs for same contaminants occurred at TNT Areas A, B, and C. For examples, the RGOs for 1-A-4,6-DNT are 1.3, 0.40, and 1.7 mg/kg for Areas A, B, and C, respectively.**

Response 3: First, an error in the RGOs listed on page 3-14 for TNTC will be corrected; the separate RGO for benzo(a)anthracene in this list will be removed because this

compound is included in the 1 mg/kg RGO for "total carcinogenic PAHs." The RGOs for each site were back-calculated from the baseline human health risk assessments as presented in the feasibility study (FS) reports. The TNTB FS was completed first. In that document, the RGOs are based on individual chemical hazard quotients (HQ) of 0.1 or incremental lifetime cancer risks (ILCR) of 1E-5, whichever resulted in a lower concentration for each chemical of concern. During discussions with USACE prior to submittal of the TNTA&C FS, the OEPA expressed that cleanup levels at these sites should be based on chemical-specific RGOs that resulted in a cumulative hazard index (HI) that does not exceed 1 and a cumulative ILCR that does not exceed 1E-5. Therefore, the RGO values for these latter two sites were derived on a site-specific basis, using a sum-of-ratios method and a review of all the RI samples in an attempt to minimize the excavation volumes (refer to Appendix B of the TNTA&C FS). The derivation of the soil RGO values is too detailed to include in the text of this report. However, the text will be revised, as mentioned, to correct the error concerning benzo(a)anthracene and to more clearly indicate, in the case of TNTA, that the RGOs are from the FS report.

Comment 4: **Page 3-21, Section 3.3.1: Because of the potential of losing volatile organics from surface soils of less than 12" depth, recommend that soil samples for volatile organic analysis be collected from depths of at least 12" below the ground surface in the future.**

Response 4: Comment noted.

Comment 5: **Page 3-22: Recommend that the exclusion of Well PB-BED-MW20 because of the presence of methane be further described, e.g., how much methane, source of methane, potential impacts on data quality, etc.**

Response 5: The volume of methane released from well BED-MW20 is not known. The other reasons for excluding the well because of the presence of methane are detailed in Appendix M, Attachment M1. Information for exclusion of BED-MW24 and BED-MW26 is also included in the attachment. A reference for detailed explanations for the exclusion of each of the wells will be inserted into the text.

Comment 6: **Page 4-7, Section 5.0, 2nd paragraph: Please clarify if the "4-gas" lower explosive limit (LEL) meter was for which 4 gases, i.e., was "methane" the missing 4th gas, which was used for the calibration of the LEL meter?**

Response 6: As stated in Section 5.0, page 4-7, 2nd paragraph, for health and safety purposes, a "4-gas" lower explosive meter was used to measure vapors in the monitoring well to determine if any possibly hazardous vapors would be encountered during purging activities. The LEL meter measures the lower explosive limit, carbon monoxide, oxygen, and hydrogen sulfide. The lower explosive limit is not a specific gas but a term that describes when any vapor or gas concentration is too lean to burn and therefore allowing the chance for immediate explosion. The 4-gas meter is calibrated with a single calibration bottle containing 5 gases. Methane and nitrogen are used for calibrating the LEL, carbon monoxide for carbon

monoxide, oxygen for oxygen, and hydrogen sulfide for hydrogen sulfide. No changes will be made to the paragraph except carbon dioxide will be changed to carbon monoxide.

Comment 7: **Page 4-7, last paragraph: Please clarify the inconsistent statement on sample filtration. The first sentence of this paragraph states that a high capacity 0.45-micrometer filter was used to filter groundwater; however, Sections 7.0 and 8.0 imply that both filtered and non-filtered groundwater samples were collected.**

Response 7: Information in Sections 7.0 and 8.0 are correct. Per contract requirements, both filtered and unfiltered groundwater samples were collected from the monitoring wells. The last paragraph on page 4-7 simply describes how the filtered groundwater sample was collected. The first sentence of the last paragraph will be revised to state "Filtered and unfiltered samples were collected for metals analysis.

Comment 8: **Page 5-1, Section 5.1.1, 2nd paragraph: EPA CLP protocols are EPA contract requirements, which may not meet project DQOs. Assessing analytical data based on NFGs may not be appropriate for performance-based SW-846 methods and meet project DQOs. It is not clear if the "specific criteria" described in the third sentence were the same as the generic NFGs or project-specific criteria based on DQO process. Recommend that the origins or procedures for the determination of the "specific criteria" be described.**

Response 8: Agreed. The paragraph will be updated to clarify that the documents listed, since they specify procedures for CLP protocol, are used as guidelines only. Method and lab quality assurance and quality control requirements supersede these guidelines where applicable.

Comment 9: **Page 5-2, Section 5.1.2: Please specify the "water quality parameters" and the analytical methods used.**

Response 9: Water quality parameters will be specified in the text but due to the length of the associated parameters, the reader will be referenced to Table 5-1.

Comment 10: **Page 5-2, Section 5.1.2, 2nd paragraph, 4th sentence: Because headspace and calibration problems (i.e., low bias) may give false negatives, "nondetects" do not relief the impact on analytical data.**

Response 10: Agreed. The paragraph will be updated.

Comment 11: **Page 5-2, Section 5.1.3: The data quality requirements in the SAP and QAPP (IT, 1996) should be revised based on the DoD QSM for future PBOW projects.**

Response 11: Comment noted.

Comment 12: **Page 5-2, Section 5.1.4: Please note that CLP CRQL may not meet project DQOs. Project reporting limits or quantitation limits should be determined based on project action levels, tolerable decision errors, and data uncertainty. In addition, the acceptance criteria for blank evaluations did not comply with SW-846 methodology (See Chapter One of SW-846). For inorganic analyses, calibration blanks should also be assessed with different acceptance criteria, e.g., metals analysis by Method 6010. Recommend that this comment be considered for the revision of the SAP and QAPP of future projects.**

Response 12: Comment noted.

Comment 13: **Page 5-4, Section 5.2.2: Although some approaches for comparing site concentrations to background concentrations may be intuitively appealing or may be consistent with current guidance, they can grossly over estimate the level of site contamination. One common strategy consists of establishing a threshold value for background and then comparing site contaminant concentrations, in a point wise manner, to the threshold value; the site is assumed contaminated if any detection exceeds the threshold value. The threshold value may be set equal to the mean background concentration, the maximum detected background concentration, or the 95 percentile of the background data set. However, this strategy will generally be inappropriate since it typically results in an unacceptable high frequency of false positives. In other words, there will be a high probability that a site will be classified as being contaminated when the concentrations of the analytes of concern are not significantly different from background.**

For the purposes of illustration, assume that the study area has not been impacted by site-related waste handling activities. In terms of a statistical approach, this is equivalent to assuming that the probability distributions of contamination for the site and background study areas are identical. Also assume that the threshold value or background is equal to the maximum detected concentration for the background samples. If the same numbers of samples were collected for the site and background study areas, then the probability that the target analyte will be incorrectly declared to be a potential contaminant of concern will be 50%. In essence, the high "false positive probability" of 50% occurs because the site data are being compared on a sample-by-sample basis to a threshold value. In order for an effective comparison to be performed, the entire set (i.e., distribution) of values for the site study area (rather than individual values) needs to be compared with the entire set of values for the background study area.

Response 13: Most of this comment focuses on the likelihood that a single screening value will result in analytes being classified as site-related when the concentrations are in reality associated with background conditions. However, the comparison of the maximum detected concentrations to the PBOW BSC is only a screening step that has been agreed to by the project team (see response to Comment 2). As stated in Section 5.2.2 and described in Appendix M, the comparison to BSC values is not a final determination of site-relatedness and population testing (suggested by the

reviewer) is specifically mentioned and described therein. In addition to population testing, Section 5.2.2 and Appendix M also identify other potential methods (e.g., geochemical analyses and spatial evaluations) that may be used following BSC screening to determine the contribution of background to samples collected on-site or downgradient.

Comment 14: **Page 7-1, Section 7.0: Because of the large amount of data, recommend that temporal plots for major target analytes be prepared to show the concentration changes versus time and the cause of the wide temporal changes in concentrations be discussed.**

Response 14: Temporal plots of groundwater analytical data are useful if the data set is sufficient. While there are multiple rounds of sampling are available, there are limited detections of site related contaminants (i.e., nitroaromatics) with the detected concentrations generally being low. A review of the data indicates that only one or two wells have sufficient data to provide useful plots. It should be noted that temporal plots were prepared for the background inorganic analytical data presented in Appendix M.

Comment 15: **Page 7-1, Section 7.1, 2nd paragraph: Please check if "direct-put" should read "direct-push".**

Response 15: Correct. "Direct-put" will be changed to "direct-push".

Comment 16: **Page 7-10, Section 7.2.1.4: Bis(2-ethylhexyl)phthalate, a plasticizer, is a common field or lab contaminant. The detection of bis(2-ethylhexyl)phthalate could be an artifact of field or lab contamination.**

Response 16: True but the analytical data were validated and were not found in the field or method blank samples. Since the well MK-MW23 was only sampled twice, once in November 1997 and again in May 1998, and the November 1997 revealed a non-detect, additional sampling from the overburden/shale well would need to be conducted to confirm or deny the analytical result.

Comment 17: **Page 7-29, Section 7.2.5: It is not clear if PETN was analyzed with what analytical methods from 1998 through 2004. Recommend that more technical details on PETN analysis be provided.**

Response 17: Although the Pentolite Road Red Water Ponds are nearest the Pentolite Manufacturing Area, groundwater at PBOW has not analyzed for PETN constituents 1998 through 2004 during any of the investigations.

Comment 18: **Appendix H, Page 1, Section 2.0, last sentence: "Specific QC criteria" for all target analytes should be listed or referred.**

Response 18: Tables will be inserted that list specific criteria for the methods and labs.

Comment 19: **Appendix H, Page 2, Section 2.0, 1st sentence: Attachment A is not available and should be.**

Response 19: Attachment A contains the work lists that the validators used in their review. They are not provided because all the information contained in them is presented in the summary report.

Comment 20: **Appendix K, Page K-9, Section K.3.2, 2nd bullet: The specified limits of precision and accuracy (bias) should be specified. In addition, please clarify how the concentration of the lowest standard was set to provide the "specified limits" of precision and bias.**

Response 20: Noted. Tables containing the limits of precision and accuracy will be provided. The definition will be modified to clarify the use of the lowest standard in determining the MQL/PQL.

Comment 21: **Appendix K, Section K.4.0, Page K-12, Comparability: Recommend that this section also state that only data of known data quality (i.e., precision and bias) could be compared.**

Response 21: The section will be updated.

APPENDIX B

BASELINE HUMAN HEALTH RISK ASSESSMENT OF GROUNDWATER (ELECTRONIC DELIVERABLE)

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September 26, 2006

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Submittal of the Final Baseline Human Health Risk Assessment for Groundwater
Former Plum Brook Ordnance Works, Sandusky, Ohio
Contract Number DACA62-00-D-0002; Shaw Project Number 833886

Dear Mrs. Ingram:

In accordance with the requirements of Delivery Order 0014 of Contract Number DACA62-00-D-002, Shaw is pleased to submit this Final Baseline Human Health Risk Assessment for Groundwater that underlies the TNT and Red Water Pond Areas at the Former Plum Brook Ordnance Works located in Sandusky, Ohio.

Enclosed are six (6) copies of the Final report, which was written consistent with the work plan submitted October 5, 2005. Comments received on the March 10, 2006 draft report were incorporated into this final report. Copies of this report have also been forwarded to those on the distribution list.

Should you have any questions or require additional information regarding this submittal, please do not hesitate to call me at (865) 694-7496.

Sincerely,

for

Steven T. Downey, P.E.
Project Manager

Enclosures

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Client Name: U.S. Army Engineer District, Nashville; CELRN-EP-R-M

Project Description: Baseline Human Health Risk Assessment for Groundwater, Former Plum Brook Ordnance Works

Contract No. DACA62-00-D-0002 Delivery Order No. 014

Project No. 833886 Task/Phase No. 05010000

Document Type

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☐	Technical / Cost Proposal	
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Document Origin

- X Originator Developed
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Document Status

- ☐ Preliminary
- ☐ Internal Draft
- ☐ Draft
- ☐ Draft Final
- X Final
- ☐ Other:

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NOTICE: By signature above, parties certify that the subject document has been prepared by and/or reviewed by them (as appropriate), that all review comments have been resolved, and that the document is ready for submittal.

Baseline Human Health Risk Assessment of Groundwater Former Plum Brook Ordnance Works Sandusky, Ohio

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September 2006

Table of Contents

Page

List of Appendices v
List of Tables vi
List of Figures x
List of Acronyms xi
Executive Summary ES-1
1.0 Introduction 1-1
1.1 Facility Description 1-2
1.2 Background 1-2
1.3 Site Use and Groundwater Use 1-4
1.4 Protocol for the Baseline Human Health Risk Assessment 1-5
1.5 Organization of the Baseline Human Health Risk Assessment 1-6
2.0 Data Evaluation 2-1
2.1 Selection of Analytical Data 2-1
2.1.1 Sampling Method Considerations 2-1
2.1.2 Evaluation of Data Quality 2-3
2.2 Identification of Chemicals of Potential Concern 2-4
2.2.1 Risk-Based Screening 2-4
2.2.2 Frequency of Detection 2-6
2.2.3 Comparison to Background 2-6
2.2.3.1 Background Screening of Inorganics 2-7
2.2.3.2 Statistical Data Set Testing of Inorganics 2-7
2.2.3.3 Treatment of Organics 2-8
2.2.4 Role of COPC Screening in the Risk Assessment Process 2-8
2.3 Data Evaluation Summary 2-8
3.0 Exposure Assessment 3-1
3.1 Conceptual Site Exposure Model 3-1
3.1.1 Physical Setting 3-2
3.1.2 Contaminant Sources, Release Mechanisms, and Migration Pathways Associated with Groundwater 3-5
3.1.3 Groundwater Receptors and Exposure Pathways 3-6
3.1.3.1 Overburden Groundwater 3-6
3.1.3.2 Bedrock Groundwater 3-6
3.1.3.3 Exposure to Lead 3-9

Table of Contents *(Continued)*

Page

3.2 Quantification of Exposure-Point Concentrations 3-9
3.2.1 Groundwater Concentrations 3-9
3.2.2 Concentrations in Household Air from Groundwater Use 3-12
3.2.3 Concentrations of VOCs in Groundwater: Resident Dermal Uptake 3-12
3.2.4 Modeled Future Groundwater Concentrations 3-13
3.3 Quantification of Chemical Intakes 3-14
3.3.1 Ingestion of COPCs in Groundwater 3-14
3.3.2 Inhalation of COPCs from Air 3-14
3.3.3 Dermal Contact with COPCs in Water 3-15
3.3.4 Inhalation of Air Containing VOCs from Groundwater 3-17
4.0 Toxicity Assessment 4-1
4.1 Evaluation of Carcinogenicity 4-1
4.2 Evaluation of Noncarcinogenic Effects 4-4
4.3 Dermal Toxicity Values 4-5
4.4 Target Organ Toxicity 4-5
4.5 Lead Toxicity 4-6
4.6 Sources of Toxicity Information Used in the Risk Assessment 4-7
5.0 Risk Characterization Methodology 5-1
5.1 Carcinogenic Effects of Chemicals 5-1
5.2 Noncancer Effects of Chemicals 5-3
6.0 Risk Characterization Results 6-1
6.1 Overall Groundwater Risk Results 6-1
6.1.1 Overall TNTA Groundwater Risk Results 6-1
6.1.2 Overall TNTB Groundwater Risk Results 6-3
6.1.3 Overall TNTC Groundwater Risk Results 6-4
6.1.4 Overall PRRWP Area Groundwater Risk Results 6-5
6.1.5 Overall WARWP Area Groundwater Risk Results 6-6
6.1.6 Overall Downgradient Areas Groundwater Risk Results 6-7
6.2 Site-Related Groundwater Risk Results 6-8
6.2.1 Site-Related TNTA Groundwater Risk Results 6-9
6.2.2 Site-Related TNTB Groundwater Risk Results 6-9

Table of Contents *(Continued)*

Page

6.2.3 Site-Related TNTC Groundwater Risk Results 6-10
6.2.4 Site-Related PRRWP Area Groundwater Risk Results 6-10
6.2.5 Site-Related WARWP Area Groundwater Risk Results 6-10
6.2.6 Site-Related Downgradient Areas Groundwater Risk Results 6-11
6.3 Modeled Future Groundwater Risk Results 6-12
6.3.1 Modeled TNTA Groundwater Risk Results 6-13
6.3.2 Modeled TNTB Groundwater Risk Results 6-14
6.3.3 Modeled TNTC Groundwater Risk Results 6-15
6.3.4 Modeled PRRWP Area Groundwater Risk Results 6-16
6.3.5 Modeled WARWP Area Groundwater Risk Results 6-17
6.3.6 Modeled Groundwater Risk Results – Area Downgradient from TNTA 6-18
6.3.7 Modeled Groundwater Risk Results – Area Downgradient from TNTB, TNTC, and the PRRWP Area 6-19
6.3.8 Modeled Groundwater Risk Results – Area Downgradient from the WARWP Area 6-20
6.4 Evaluation of Lead 6-20
6.5 Evaluation of Sulfate 6-22
7.0 Uncertainty Analysis 7-1
7.1 Types of Uncertainty 7-1
7.2 Sources of Uncertainty 7-2
7.2.1 Sample Selection 7-2
7.2.2 Exposure-Point Concentration Estimates 7-2
7.2.3 Site Relatedness of Risks 7-3
7.2.4 Land-Use Assumptions/Receptor Selection 7-6
7.2.5 Exposure Assumption Values 7-6
7.2.6 Groundwater-to-Air Household Model 7-8
7.2.7 Site Groundwater Model 7-8
7.2.8 Toxicity Assessment 7-10
7.2.9 Risk Characterization 7-12
8.0 Aggregate Risk Summary 8-1
8.1 TNTA Aggregate Risk Estimates 8-1

Table of Contents *(Continued)*

Page

8.2 TNTB Aggregate Risk Estimates 8-2
8.3 TNTC Aggregate Risk Estimates 8-3
8.4 PRRWP Aggregate Risk Estimates 8-4
8.5 WARWP Aggregate Risk Estimates 8-5
9.0 Development of Risk-Based Remediation Criteria for Groundwater 9-1
10.0 Summary, Conclusions, and Recommendations 10-1
10.1 Summary 10-1
10.2 Conclusions 10-4
10.3 Recommendations 10-5
11.0 References 11-1
Tables
Figures

List of Appendices

Appendix A – Residential Well Survey Summary
Appendix B – Technical Memorandum and Associated Response to Comments
Appendix C – Statistical Output for Comparisons to Background
Appendix D – Integrated Exposure Uptake Biokinetic Model Output for Lead
Appendix E – Plum Brook Ordnance Works Site Groundwater Model
Appendix F – Toxicological Profiles
Appendix G – Risk Characterization Spreadsheets
Appendix H – Evaluation of Site Relatedness

List of Tables

Table	Title	Follows Tab
2-1	Sampling Locations Used in the Baseline Human Health Risk Assessment of Groundwater	
2-2	Groundwater Samples Evaluated	
2-3	Background Screening Concentrations for Inorganics and BTEX Compounds in Groundwater	
2-4	Statistical Summary and COPC Selection of Chemicals Detected in Bedrock Groundwater, TNT Area A	
2-5	Statistical Summary and COPC Selection of Chemicals Detected in Bedrock Groundwater, TNT Area B	
2-6	Statistical Distribution and COPC Selection of Chemicals Detected in Bedrock Groundwater, TNT Area C	
2-7	Statistical Summary and COPC Selection of Chemicals Detected in Bedrock Groundwater, Pentolite Road Red Water Pond Area	
2-8	Statistical Summary and COPC Selection of Chemicals Detected in Bedrock Groundwater, West Area Red Water Ponds Area	
2-9	Statistical Summary and COPC Selection of Chemicals Detected in Bedrock Groundwater, Downgradient Areas at the Facility Boundary	
2-10	Statistical Summary and COPC Selection of Chemicals Detected in Overburden Groundwater, TNT Area A	
2-11	Statistical Summary and Screening of Chemicals Detected in Overburden Direct-Push Groundwater, TNT Area A	
2-12	Statistical Summary and Screening of Chemicals Detected in Overburden Groundwater, TNT Area B	
2-13	Statistical Summary and Screening of Chemicals Detected in Overburden Direct-Push Groundwater, TNT Area B	
2-14	Statistical Summary and Screening of Chemicals Detected in Overburden Groundwater, TNT Area C	
2-15	Statistical Summary and Screening of Chemicals Detected in Overburden Direct-Push Groundwater, TNT Area C	
2-16	Statistical Summary and Screening of Chemicals Detected in Overburden Groundwater, Pentolite Road Red Water Pond Area	
2-17	Statistical Summary and Screening of Chemicals Detected in Overburden Direct-Push Groundwater, Pentolite Road Red Water Pond Area	
2-18	Statistical Summary and COPC Selection of Chemicals Detected in Overburden Groundwater, West Area Red Water Ponds Area	

List of Tables *(Continued)*

Table	Title	Follows Tab
2-19	Statistical Summary and Screening of Chemicals Detected in Overburden Direct-Push Groundwater, West Area Red Water Ponds Area	
3-1	Variables Used to Estimate Potential Chemical Intake and Contact Rates from Groundwater	
3-2	Chemical-Specific Physical Property Values Used for Exposure Assessment	
4-1	COPC-Specific Toxicity Values Used for Toxicity Assessment	
6-1	Summary of Groundwater Risk for the On-Site Worker, TNT Area A	
6-2	Summary of Target Organ Noncancer Hazard Evaluation, On-Site Worker Exposure to Groundwater, TNT Area A	
6-3	Summary of Groundwater Noncancer Risk for the Child Resident, TNT Area A	
6-4	Summary of Target Organ Noncancer Hazard Evaluation, Child Resident Exposure to Groundwater, TNT Area A	
6-5	Summary of Groundwater Noncancer Risk for the Adult Resident, TNT Area A	
6-6	Target Organ Noncancer Hazard Evaluation, Adult Resident Exposure to Groundwater, TNT Area A	
6-7	Summary of Groundwater Cancer Risk for the Resident, TNT Area A	
6-8	Summary of Groundwater Risk for the On-Site Worker, TNT Area B	
6-9	Summary of Groundwater Noncancer Risk for the Child Resident, TNT Area B	
6-10	Summary of Target Organ Noncancer Hazard Evaluation, Child Resident Exposure to Groundwater, TNT Area B	
6-11	Summary of Groundwater Noncancer Risk for the Adult Resident, TNT Area B	
6-12	Summary of Target Organ Noncancer Hazard Evaluation, Adult Resident Exposure to Groundwater, TNT Area B	
6-13	Summary of Groundwater Cancer Risk for the Resident, TNT Area B	
6-14	Summary of Groundwater Risk for the On-Site Worker, TNT Area C	
6-15	Summary of Groundwater Noncancer Risk for the Child Resident, TNT Area C	
6-16	Summary of Target Organ Noncancer Hazard Evaluation, Child Resident Exposure to Groundwater, TNT Area C	
6-17	Summary of Groundwater Noncancer Risk for the Adult Resident, TNT Area C	
6-18	Summary of Target Organ Noncancer Hazard Evaluation, Adult Resident Exposure to Groundwater, TNT Area C	
6-19	Summary of Groundwater Cancer Risk for the Resident, TNT Area C	
6-20	Summary of Groundwater Risk for the On-Site Worker, Pentolite Road Red Water Pond Area	

List of Tables *(Continued)*

Table	Title	Follows Tab
6-21	Summary of Target Organ Noncancer Hazard Evaluation, On-Site Worker Exposure to Groundwater, Pentolite Road Red Water Pond Area	
6-22	Summary of Groundwater Noncancer Risk for the Child Resident, Pentolite Road Red Water Pond Area	
6-23	Summary of Target Organ Noncancer Hazard Evaluation, Child Resident Exposure to Groundwater, Pentolite Road Red Water Pond Area	
6-24	Summary of Groundwater Noncancer Risk for the Adult Resident, Pentolite Road Water Pond Area	
6-25	Summary of Target Organ Noncancer Hazard Evaluation, Adult Resident Exposure to Groundwater, Pentolite Road Red Water Pond Area	
6-26	Summary of Groundwater Cancer Risk for the Resident, Pentolite Road Red Water Pond Area	
6-27	Summary of Groundwater Risk for the On-Site Worker, West Area Red Water Ponds Area	
6-28	Summary of Target Organ Noncancer Hazard Evaluation, On-Site Worker Exposure to Groundwater, West Area Red Water Ponds Area	
6-29	Summary of Groundwater Noncancer Risk for the Child Resident, West Area Red Water Ponds Area	
6-30	Summary of Target Organ Noncancer Hazard Evaluation, Child Resident Exposure to Groundwater, West Area Red Water Ponds Area	
6-31	Summary of Groundwater Noncancer Risk for the Adult Resident, West Area Red Water Ponds Area	
6-32	Summary of Target Organ Noncancer Hazard Evaluation, Adult Resident Exposure to Groundwater, West Area Red Water Ponds Area	
6-33	Summary of Groundwater Cancer Risk for the Resident, West Area Red Water Ponds Area	
6-34	Summary of Groundwater Noncancer Risk for the Child Resident, Downgradient Areas at the Facility Boundary	
6-35	Summary of Target Organ Noncancer Hazard Evaluation, Child Resident Exposure to Groundwater, Downgradient Area at the Facility Boundary	
6-36	Summary of Groundwater Noncancer Risk for the Adult Resident, Downgradient Areas at the Facility Boundary	
6-37	Summary of Target Organ Noncancer Hazard Evaluation, Adult Resident Exposure to Groundwater, Downgradient Areas at the Facility Boundary	
6-38	Summary of Groundwater Cancer Risk for the Resident, Downgradient Areas of the Facility Boundary	
6-39	Synopsis of Evaluation for Site Relatedness	

List of Tables *(Continued)*

Table	Title	Follows Tab
6-40	Summary of Groundwater Risk Based on Modeled Groundwater Concentrations, TNT Area A	
6-41	Summary of Groundwater Risk Based on Modeled Groundwater Concentrations, TNT Area B	
6-42	Summary of Groundwater Risk Based on Modeled Groundwater Concentrations, TNT Area C	
6-43	Summary of Groundwater Risk Based on Modeled Groundwater Concentrations, Pentolite Road Red Water Pond Area	
6-44	Summary of Groundwater Risk Based on Modeled Groundwater Concentrations, West Area Red Water Ponds Area	
6-45	Summary of Groundwater Risk Based on Modeled Groundwater Concentrations, Facility Boundary Downgradient of TNT Area A	
6-46	Summary of Groundwater Risk Based on Modeled Groundwater Concentrations, Facility Boundary Downgradient of TNT Area B, TNT Area C, and Pentolite Road Red Water Pond Area	
6-47	Summary of Groundwater Risk Based on Modeled Groundwater Concentrations, Facility Boundary Downgradient of West Area Red Water Ponds Area	
7-1	Comparison of Bedrock Groundwater Inorganics Concentrations to Those of Background	
8-1	Summary of Aggregate Risks by Source Medium, TNT Area A	
8-2	Summary of Aggregate Risks by Source Medium, TNT Area B	
8-3	Summary of Aggregate Risks by Source Medium, TNT Area C	
8-4	Summary of Aggregate Risks by Source Medium, Pentolite Road Red Water Pond Area	
8-5	Summary of Aggregate Risks by Source Medium, West Area Red Water Ponds Area	
9-1	Risk-Based Remediation Criteria for Bedrock Groundwater, TNT Area A	
9-2	Risk-Based Remediation Criteria for Bedrock Groundwater, TNT Area B	
9-3	Risk-Based Remediation Criteria for Bedrock Groundwater, TNT Area C	
9-4	Risk-Based Remediation Criteria for Bedrock Groundwater, Pentolite Road Red Water Pond Area	
9-5	Risk-Based Remediation Criteria for Bedrock Groundwater, West Area Red Water Ponds Area	
9-6	Risk-Based Remediation Criteria for Bedrock Groundwater, Downgradient Areas at the Facility Boundary	

List of Figures

Figure	Title	Follows Tab
1-1	Vicinity Map	
1-2	Locations of Areas of Concern	
2-1	Groundwater Sampling Locations – TNT Area A	
2-2	Groundwater Sampling Locations – TNT Area B	
2-3	Groundwater Sampling Locations – TNT Area C	
2-4	Groundwater Sampling Locations – Pentolite Road Red Water Pond Area	
2-5	Groundwater Sampling Locations – West Area Red Water Ponds Area	
2-6	Role of COPC Screening in the Risk Assessment and Risk Management Process	
3-1	Human Health Conceptual Site Exposure Model – Former TNT Production Areas	
3-2	Human Health Conceptual Site Exposure Model – Red Water Pond Areas	

List of Acronyms

AOC	area of concern
AT	averaging time
atm/m^3	atmospheres per cubic meter
BEHP	bis(2-ethylhexyl)phthalate
BHHRA	baseline human health risk assessment
BSC	background screening concentration
BTEX	benzene, toluene, ethylbenzene, and xylenes
BW	body weight
BW/OW	body weight/organ weight
cm^2	square centimeter
cm/hour	centimeters per hour
COC	chemical of concern
COPC	chemical of potential concern
CSEM	conceptual site exposure model
D&M	Dames & Moore, Inc.
DA	dose absorbed per unit body surface area per event
°F	degrees Fahrenheit
DERP-FUDS	Defense Environmental Restoration Program – Formerly Used Defense Sites
DNT	dinitrotoluene
ED	exposure duration
EF	exposure frequency
EPA	U.S. Environmental Protection Agency
EPC	exposure-point concentration
ET	exposure time
GAF	gastrointestinal absorption factor
gpm	gallons per minute
GSA	General Services Administration
HHEM	human health evaluation manual
HI	hazard index
HQ	hazard quotient
IEUBK	Integrated Exposure Uptake Biokinetic
ILCR	incremental lifetime cancer risk
IRIS	Integrated Risk Information System

List of Acronyms *(Continued)*

IT	IT Corporation
kg	kilogram
K_p	permeability coefficient
L/day	liters per day
LMS	linearized multistage
m^3	cubic meter
m^3/hour	cubic meters per hour
MDC	maximum detected concentration
µg/dL	micrograms per deciliter
µg/L	micrograms per liter
mg/cm^2-event	milligrams per square centimeter per event
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mg/kg-day	milligrams per kilogram per day
mg/m^3	milligrams per cubic meter
NASA	National Aeronautics and Space Administration
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NOE	nasal and olfactory epithelia
NS/CNS	nervous system/central nervous system
OEPA	Ohio Environmental Protection Agency
PAH	polycyclic aromatic hydrocarbon
PBOW	Plum Brook Ordnance Works
PRG	preliminary remediation goal
PRRWP	Pentolite Road Red Water Pond
PVS	peripheral vascular system
RBRC	risk-based remediation criteria
RBSC	risk-based screening concentration
RfC	reference concentration
RfD	reference dose
RME	reasonable maximum exposure
SAIC	Science Applications International Corporation
SF	slope factor
Shaw	Shaw Environmental, Inc.

List of Acronyms *(Continued)*

SMCL	secondary maximum contaminant level
TNT	trinitrotoluene
TNTA	TNT Area A
TNTB	TNT Area B
TNTC	TNT Area C
UCL	95th percent upper confidence limit on the arithmetic mean
UF	uncertainty factor
USACE	U.S. Army Corps of Engineers
VOC	volatile organic compound
WARWP	West Area Red Water Ponds
WRS	Wilcoxon Rank Sum
WTI	WasteTron, Inc.

Executive Summary

A baseline human health risk assessment (BHHRA) was conducted to evaluate risks associated with exposure to groundwater underlying the three former 2,4,6-trinitrotoluene (TNT) production areas, the two former red water pond areas, and downgradient areas at the Plum Brook Ordnance Works (PBOW), Sandusky, Ohio. The approach used in the BHHRA is consistent with methodologies described in the U.S. Environmental Protection Agency's primary risk assessment guidance documents, the site-specific work plan, and ongoing discussions between the Ohio Environmental Protection Agency (OEPA), the U.S. Army Corps of Engineers Nashville and Huntington Districts, and Shaw Environmental, Inc.

Site History/Description. The 9,009-acre PBOW facility was built in early 1941 as a manufacturing plant for 2,4,6-TNT, dinitrotoluene (DNT), and pentolite. Production of explosives at PBOW began in December 1941 and continued until 1945. During PBOW operation, 12 process lines were used in the manufacture of explosives: 4 lines at TNT Area A (TNTA), 3 lines at TNT Area B (TNTB), and 5 lines at TNT Area C (TNTC). Manufacturing wastewater ("red water") from these production lines was stored at the two ponds in the West Area Red Water Ponds (WARWP) Area and the single pond at the Pentolite Road Red Water Pond Area (PRRWP) Area. The three former production areas, together with the WARWP and PRRWP Areas, are the potential source areas of concern (AOC) addressed by this BHHRA.

Some of the areas used by the U.S. Department of Defense were decontaminated in the 1940s by the War Department. After decontamination, the property was initially transferred to the Ordnance Department, then to the War Assets Administration after it was certified by the U.S. Army to be decontaminated. In 1949, PBOW was transferred to the General Services Administration (GSA). In the 1950s and 1960s, GSA completed further decontamination of PBOW sites; other areas had been decommissioned but not decontaminated. The National Aeronautics and Space Administration (NASA) acquired the property on March 15, 1963. NASA currently owns most of the former PBOW property, which is operated as the Plum Brook Station of the John Glenn Research Center, headquartered in Cleveland, Ohio. Most of the aerospace testing facilities built in the 1960s at the site are on standby or inactive status. On April 18, 1978, NASA declared approximately 2,152 acres of PBOW as excess. The Perkins Township Board of Education acquired 46 acres of the excess land and uses this area as a bus transportation area. GSA obtained ownership of the remaining excess acreage and currently has a use agreement with the Ohio National Guard for 604 acres of this land. NASA currently

controls approximately 6,400 acres and is using the site to conduct space research as a satellite operation facility of the John Glenn Research Center.

Approach. The BHHRA evaluated chemicals in bedrock groundwater for overall risks and site-related risks associated with assumed exposure to this groundwater under on-site worker and resident tap water use scenarios. A screening for chemicals of potential concern (COPC) was used to focus the evaluation on those chemicals most likely to present a risk to potentially exposed individuals. Overburden groundwater was not quantitatively evaluated in the BHHRA with respect to direct exposure because of low and undependable yield. However, concentrations of TNT, 2,4-DNT, and 2,6-DNT in both the overburden groundwater and soil were used as inputs for modeled impact to the bedrock aquifer. The model includes both a soil leaching component and a groundwater flow component. Quantitative risk evaluation was performed for all COPCs and for modeled concentrations of TNT, 2,4-DNT, and 2,6-DNT underlying each of the five AOCs and the facility boundary downgradient of these AOCs.

Each COPC was qualitatively evaluated for site relatedness. This evaluation used information such as groundwater production volume at a given well, sampling methods, analytical results of filtered versus unfiltered samples, prevalence of the COPC in site soil samples and/or overburden groundwater samples, the presence of petroleum observed on well cores during installation, and issues associated with potential blank contamination.

Results/Conclusions. Hypothetical residential use of groundwater at each of the five AOCs and the downgradient boundary locations was evaluated. Currently, there are no groundwater users on the site or at the facility boundary. Noncancer hazards were evaluated against a target hazard index (HI) criterion of 1 and the OEPA target cancer risk of 1E-5 (i.e., 1 additional incidence of cancer per 100,000 individuals exposed). Note that the use of a 1E-5 target cancer risk is a departure from Army policy, which uses a cancer risk of 1E-4 to trigger remedial action concerns. This Army trigger value equals the upper end of the cancer risk range of 1E-6 to 1E-4 which the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) identifies as acceptable.

Based on the OEPA cancer criterion, residential and on-site worker use of groundwater at each of these locations was found to result in unacceptable cancer risks and to have the potential to produce adverse noncancer health effects. The BHHRA results also show that long-term worker use of site groundwater would results in levels of exposure that would exceed the OEPA target level. At each area, except the WARWP Area, the non-site-related COPCs dominate both the cancer risk and noncancer hazards; at the WARWP Area, residential and worker incremental

lifetime cancer risk (ILCR) values associated with non-site-related arsenic also exceed the target ILCR.

The following COPCs are dominant with respect to cancer risk and/or noncancer hazard for the five AOCs and the downgradient areas; site-related COPCs are specifically noted as such:

- TNTA – Naturally occurring petroleum-related organic compounds
- TNTB – Inorganics and naturally occurring petroleum-related organic compounds
- TNTC – Naturally occurring petroleum-related organic compounds
- PRRWP – Naturally occurring petroleum-related organic compounds
- WARWP – Site-related nitroaromatics and naturally occurring arsenic
- Downgradient – Naturally occurring petroleum-related organic compounds.

For each of these areas, even if no site-related COPCs were present, noncancer hazards associated with residential groundwater use, cancer risk associated with residential groundwater use, and cancer risks associated with worker use would result in respective HI and ILCR values that would exceed the target HI criterion (1) and OEPA target cancer risk (1E-5). Site-related risks associated with groundwater are discussed for the respective site areas in the following paragraphs.

Site-related risks associated with residential use of TNTA groundwater (ILCR=4E-5; HI=2) were found to exceed the OEPA target cancer risk criterion and target HI criterion, but those associated with on-site worker use (ILCR=1E-5; HI=0.2) were not. The modeled nitroaromatics concentrations for TNTA indicate unacceptable cancer risks for the resident (ILCR=5E-4) and worker (ILCR=1E-4), and the HI (4) for the resident based on modeled TNTA nitroaromatics exceeded the target HI.

No site-related COPCs were identified for TNTB groundwater. The modeled nitroaromatics concentrations for TNTB indicate that cancer risks (ILCR=2E-5) only marginally exceed the OEPA target cancer risk criterion for the resident, but not for the worker (ILCR=6E-6); both of these values are less than the Army's criterion of 1E-4 used to trigger remedial action concerns. It is noted that the groundwater model is likely to be conservative with respect to human health protection. The HI associated with residential use of groundwater at modeled concentrations (HI=0.1) meet the OEPA noncancer hazard criterion. Much of the planned soil remediation, based on risks associated with direct contact, has already been completed at TNTB, and the remainder is planned for completion in 2006. These remedial actions were accounted for in the soil-to-groundwater leaching model. Thus, the model results indicate that soil removal based on direct contact is effective for groundwater protection as well at TNTB.

No site-related COPCs were identified for TNTC groundwater. The modeled nitroaromatics concentrations for TNTC indicate unacceptable cancer risks for the worker (ILCR=4E-4) and resident (ILCR=2E-3). The HI (8) of the resident based on nitroaromatic modeling also exceeds the target criterion of 1.

The site-related noncancer hazard (HI=0.07) and cancer risk (ILCR=4E-6) for the on-site worker associated with PRRWP Area bedrock groundwater use meet the target HI of 1 and the OEPA target cancer risk of 1E-5. The site-related HI (1) for the resident also meets the noncancer criterion. The ILCR associated with residential use of PRRWP Area bedrock groundwater (2E-5) slightly exceeds the OEPA criterion. Additionally, elevated sulfate present appears to be site related. The modeled nitroaromatics concentrations associated with PRRWP Area bedrock groundwater indicate unacceptable cancer risks for the worker (ILCR=4E-5) and resident (ILCR=2E-4). The HI values of the worker (0.1) and resident (0.7), based on the modeled nitroaromatics concentrations, meet the target criterion of 1.

As mentioned, the WARWP Area is the only area evaluated in this BHHRA where the non-site-related groundwater COPCs do not dominate both the overall HI and ILCR values. The site-related cancer risks and noncancer hazards for residential groundwater use (ILCR=2E-4; HI=61) exceed the target criteria, as do those for worker groundwater use (ILCR=6E-5; HI=6). These HI and ILCR values are mostly associated with site-related nitroaromatics. It is noted that the ILCRs for naturally occurring arsenic (2E-4 for the resident; 5E-5 for the worker) are approximately as high as those associated with site-related nitroaromatics. The modeled nitroaromatics concentrations for the WARWP Area indicate that noncancer hazards would meet the target criterion for both the worker (HI=0.09) and resident (HI=0.6). The cancer risks associated with the worker (ILCR=4E-5) and resident (ILCR=2E-4) would both exceed the OEPA criterion of 1E-5.

Because land use outside of the PBOW facility boundary cannot be prescribed, only the resident was evaluated at the facility boundary. Based on current, measured concentrations of COPCs in groundwater, the site-related noncancer HI (0.4) meets the target criterion of 1, but the site-related ILCR (3E-5) exceeds the OEPA criterion of 1E-5. The site-related ILCR is less than the Army criterion of 1E-4. Site-related nitroaromatics were primarily responsible for this exceedance. Thus, under the conditions of the BHHRA, if a hypothetical resident were to drink water from the PBOW downgradient facility boundary at current concentrations, the associated ILCR is estimated to be greater than the OEPA criterion, within the range regarded as acceptable by the NCP, and less than the Army cancer risk trigger level.

Three downgradient areas along the PBOW facility boundary were identified and modeled for future concentrations of nitroaromatics. These modeled concentrations were evaluated for risk. The HI values for the resident (0.002 to 0.08) meet the target HI of 1 for noncancer effect at each of the three modeled downgradient locations. The ILCR values for boundary areas downgradient of TNTA (4E-7) and the WARWP Area (1E-6) meet the OEPA target cancer risk criterion of 1E-5. The ILCR downgradient of TNTB at the PBOW facility boundary (2E-5) slightly exceeds the OEPA criterion for cancer risk, but is less than the Army cancer risk trigger and less than the risk range of 1E-6 to 1E-4 identified in the NCP as acceptable. These results indicate that potential future users of groundwater at the property boundary are unlikely to suffer adverse site-related human health effects or an unacceptable additional risk of cancer, with the possible exception of cancer risk along the northern PBOW boundary that is downgradient of TNTB.

1.0 Introduction

The purpose of this baseline human health risk assessment (BHHRA) is to evaluate potential human health risks associated with exposure to groundwater underlying and associated with the former Plum Brook Ordnance Works (PBOW), Sandusky, Erie County, Ohio. Specifically, the BHHRA evaluates groundwater at the following areas:

- TNT Area A (TNTA)
- TNT Area B (TNTB)
- TNT Area C (TNTC)
- Pentolite Road Red Water Pond (PRRWP) Area
- West Area Red Water Ponds (WARWP) Area
- Downgradient areas at the facility boundary.

Risks associated with exposure to other environmental media from the five site areas listed above (not including the facility boundary) were evaluated in previous BHHRAs (IT Corporation [IT], 2001a; 2000a, b). The approach and methodologies described in Chapters 1.0 through 5.0 of this BHHRA follow the groundwater BHHRA work plan (Shaw Environmental, Inc. [Shaw], 2005a). They are intended to apply directly to the evaluation of groundwater risks but not necessarily to the evaluation of other environmental media. Chapter 6.0 presents the groundwater risk characterization results. In Chapter 8.0, the groundwater risk characterization results are combined with the risks from potential exposure to other media (as reported in the previous risk assessment reports) for the five site areas to estimate overall risks for each respective area. Combining risks associated with groundwater with those of other environmental media evaluated previously is consistent with the groundwater BHHRA work plan and earlier PBOW work plans (IT, 1999a; 1998).

This BHHRA was prepared for the U.S. Army Corps of Engineers (USACE) in partnership with, and supported by, the State of Ohio and is consistent with U.S. Environmental Protection Agency (EPA) guidance. As the lead agency for environmental response actions at PBOW, USACE is responsible for site investigation and evaluation regarding PBOW as well as any remedial activities. The Ohio Environmental Protection Agency (OEPA) provides regulatory review, comment, and oversight. This work is being pursued by USACE under the Defense Environmental Restoration Program—Formerly Used Defense Sites (DERP-FUDS). The environmental restoration of PBOW is a U.S. Army DERP-FUDS project, managed and overseen by the Huntington, West Virginia, and Nashville, Tennessee, USACE district offices.

1.1 Facility Description

Location. PBOW is located in Erie County, Ohio, approximately 4 miles south of Sandusky and 59 miles west of Cleveland (Figure 1-1). Although most of the PBOW facility is within Perkins and Oxford Townships, the eastern edge of the facility extends into Huron and Milan Townships. PBOW is bounded on the north by Bogart Road, on the south by Mason Road, on the west by Patten Tract Road, and on the east by U.S. Highway 250. The area surrounding PBOW is mostly agricultural and residential (IT, 2001b).

1.2 Background

The 9,009-acre PBOW facility was built in early 1941 as a manufacturing plant for 2,4,6-trinitrotoluene (TNT), dinitrotoluene (DNT), and pentolite (International Consultants Incorporated, 1995). Production of explosives at PBOW began in December 1941 and continued until 1945. It is estimated that more than 1 billion pounds of nitroaromatic explosives were manufactured during the 4-year operating period.

Some of the areas used by the U.S. Department of Defense were decontaminated in the 1940s by the War Department. After decontamination, the property was initially transferred to the Ordnance Department, then to the War Assets Administration after it was certified by the Army to be decontaminated. In 1949, PBOW was transferred to the General Services Administration (GSA). In the 1950s and 1960s, GSA completed further decontamination of PBOW sites; other areas had been decommissioned but not decontaminated. The National Aeronautics and Space Administration (NASA) acquired the property on March 15, 1963. NASA currently owns most of the former PBOW property, which is operated as the Plum Brook Station of the John Glenn Research Center, headquartered in Cleveland, Ohio. Most of the aerospace testing facilities built in the 1960s at the site are on standby or inactive status. On April 18, 1978, NASA declared approximately 2,152 acres of PBOW as excess. The Perkins Township Board of Education acquired 46 acres of the excess land and uses this area as a bus transportation area. GSA obtained ownership of the remaining excess acreage and currently has a use agreement with the Ohio National Guard for 604 acres of this land. NASA presently controls approximately 6,400 acres and is using the site to conduct space research as a satellite operation facility of the John Glenn Research Center.

During PBOW operation, 12 process lines were used in the manufacture of explosives: 4 lines at TNTA, 3 lines at TNTB, and 5 lines at TNTC. Manufacturing wastewater (“red water”) from these production lines was stored at the two ponds on the WARWP Area and the single pond at the PRRWP Area. The three former production areas, together with the WARWP and PRRWP

Areas, are the potential source areas of concern (AOC) addressed by this BHHRA. Note that in this work plan, the term "facility" refers to the entire former PBOW property, and the term "site" refers to an AOC or other specified area within PBOW. Each of the AOCs is identified on Figure 1-2 and briefly described below.

TNTA. Located in the northeastern portion of PBOW, TNTA occupies approximately 114 acres. TNT Manufacturing Lines 1 through 4 were located at this area. It is mostly covered with prairie grasses and scrub trees, though it is partly wooded in the extreme southern section. It is slightly hilly, generally decreasing in elevation from southeast to northwest. The Engineering Building, occupied by NASA employees, is currently in the central portion of TNTA.

TNTB. TNTB is located in the south-central portion of PBOW and comprises an area of approximately 55 acres. TNT Manufacturing Lines 5, 6, and 7 were located at TNTB. The area is relatively flat with some low hummocks and marshy areas present. Two active NASA facilities are present: the Hypersonic Tunnel Facility and the Nitrogen Dewar Tanks.

TNTC. Located in the southwestern portion of PBOW, TNTC is densely wooded, with small areas of open grassland. It occupies approximately 119 acres. TNT Manufacturing Lines 8 through 12 were located at this area. TNTC is not used by NASA and one inactive building formerly used by EPA is present.

PRRWP Area. A single, unlined "red water" pond was located in the north-central portion of PBOW and had an area of approximately 2 acres (Figure 1-2). During PBOW operations, "red water" was pumped from manufacturing activities at TNTA and TNTB to the PRRWP. In 1977, "red water" was removed from the former pond and the area was regraded (Science Applications International Corporation [SAIC], 1991). Currently, the PRRWP Area is covered in grasses and is largely marshy. Ponded areas, which resulted from the regrading activities, are present in the PRRWP Area but outside of the original PRRWP Area footprint. Note that the corresponding area on Figure 1-2 is larger than 2 acres, as it depicts the AOC, which includes the areas that had been suspected of receiving potential impact from site activities (in addition to the original pond footprint). The PRRWP Area is not used by NASA, and no buildings are present.

WARWP Area. Two unlined "red water" ponds, an "east pond" and a "west pond," were present in the WARWP Area of the site and covered approximately 8 acres (Figure 1-2) (SAIC, 1991). During PBOW operations, the WARWP received "red water" from TNTC. Currently, only the "west pond" is present and occupies approximately 4 acres. According to information from Dames & Moore, Inc. (D&M) (1997), the east pond existed from the 1940s until the 1970s,

when it was breached in an attempt to drain it. Most of the WARWP Area (i.e., the "west pond") is typically ponded, with the remainder being marshy. This area is not used by NASA, and no buildings are present.

1.3 Site Use and Groundwater Use

The facility is currently surrounded by a chain-link fence, and the perimeter is patrolled regularly. Access by authorized personnel is limited to established checkpoints. Public access is restricted except during the controlled annual deer hunting season.

Two deep or bedrock groundwater aquifer systems are utilized for drinking water in the area: a carbonate aquifer to the west and a shale aquifer to the east (IT, 1997). PBOW is located within the transition of the two systems. A majority of residents in Erie County receive water from public utilities whose sources are surface water. The Erie County Health Department does not allow the use of surface water as private drinking water. However, there are six known private wells within 1 mile downgradient of PBOW. The nearest known downgradient private well is approximately 840 feet northeast of the facility boundary, in the east-middle portion of PBOW (northeast of abandoned well BED-MW27). Owners of five of these wells had agreed to participate in a well survey and sampling event conducted by the USACE in September 2003. None of these five wells was being used as a source of drinking water. Three of the wells were being used for watering lawns and gardens, one was being used for irrigating an herb farm, and the remaining well was not being used for any purpose. Nitroaromatics were not detected in any of the five private wells that were sampled (refer to Appendix A). Two additional wells were identified as present in the survey. However, one of these was later reported to have a tree trunk growing on top of it; no remnant of the well was discernible from the ground surface. The other additional well was found to be more distant and upgradient from PBOW and thus was not sampled in the survey.

Perched groundwater exists within the unconsolidated material atop the bedrock under much of PBOW. The perched water within the five AOCs included in this BHHRA (TNTA, TNTB, TNTC, PRRWP Area, and WARWP Area) is isolated, discontinuous, and seasonally dependent, generally resulting in low and undependable production where it exists. Therefore, perched groundwater is not a suitable drinking water source in these AOCs. Perched zone-to-bedrock modeling is being performed to determine the potential impact that nitroaromatic contaminants in the perched zone may have on the bedrock water-bearing unit.

Both current and potential future land users are pertinent for the purpose of identifying plausible human receptors and exposure pathways for evaluation in the BHHRA. Current use of the

PBOW facility is classified as industrial. It is the desire of NASA to release PBOW for unrestricted use. D&M (1997) describes the following potential future uses of all or portions of the facility:

- Continued industrial use (NASA activities and programs).
- Recreational use of portions of the site by hunters and fishermen.
- Portions of the site may be sold to state or local government or private individuals (unrestricted land use).
- Parts of the facility may be used for residential or agricultural purposes.
- Parts of the facility may be used for training by the National Guard.
- Construction activities may be performed during development of any of the sites.

1.4 Protocol for the Baseline Human Health Risk Assessment

The BHHRA was performed consistent with the groundwater BHHRA work plan (Shaw, 2005a). The groundwater BHHRA work plan was developed consistent with previous PBOW BHHRAs and is based on EPA, USACE, and OEPA guidance, including, but not limited to, the following:

- OEPA, 1993, *Closure Plan Review Guidance for RCRA Facilities*, Interim Final, OEPA Division of Hazardous Waste Management, September 1.
- EPA, 1989a, *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A)*, Interim Final, Office of Emergency and Remedial Response, Washington, D.C., EPA/540/1-89/002.
- EPA, 1991a, *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual Supplemental Guidance, Standard Default Exposure Factors*, Interim Final, Office of Solid Waste and Emergency Response, OSWER Directive: 9285.6-03.
- EPA, 1991b, *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual Part B – Development of Risk-Based Preliminary Remediation Goals*, Interim, Office of Emergency and Remedial Response, Washington, D.C., EPA/540/R-92/003, December.
- EPA, 1992a, *Supplemental Guidance to RAGS: Calculating the Concentration Term*, Office of Solid Waste and Emergency Response, Washington, D.C., Publication 9285.7-081.

- EPA, 1992b, *Dermal Exposure Assessment: Principles and Applications*, Interim Report, Office of Research and Development, Washington, D.C., EPA/600/8-91/011B, including Supplemental Guidance dated August 18, 1992.

- EPA, 1992c, "Guidance on Risk Characterization for Risk Managers and Risk Assessors," Memorandum from F. Henry Habicht II, Deputy Administrator, to Assistant Administrators, Regional Administrators, February 26.

- EPA, 1997a, *Exposure Factors Handbook*, Office of Research and Development, National Center for Environmental Assessment, Washington, D.C., EPA/600/P-95/002F, August.

- USACE, 1999, *Risk Assessment Handbook, Volume I: Human Health Evaluation*, Engineer Manual EM 200-1-4.

- EPA, 2004a, *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part E - Supplemental Guidance for Dermal Risk Assessment)*, Final, Office of Superfund Remediation and Technology Innovation, Washington, D.C., EPA/540/R-99/005, July.

1.5 Organization of the Baseline Human Health Risk Assessment

The BHHRA presents the methods used, results generated, and the interpretation of these results. The report is organized as follows:

- ***Data Evaluation.*** Identifies data sources, evaluates data quality, identifies chemicals of potential concern (COPC), and provides a background screening.

- ***Exposure Assessment.*** Presents a conceptual site exposure model (CSEM), including contaminant sources, contaminant release mechanisms, receptors, and exposure pathways; describes exposure-point concentrations (EPC); and presents methods for calculating chemical intake and contact rates.

- ***Toxicity Assessment.*** Describes the potential for cancer and/or noncancer human health effects, provides an estimate of the quantitative relationship between the magnitude of dose or contact rate and the probability and/or severity of adverse effects, identifies the toxicity values that are used in the BHHRA, and describes the development of dermal toxicity values.

- ***Risk Characterization.*** Combines the output of the exposure assessment and toxicity assessment to quantify the risk to each receptor in each AOC and at the downgradient boundary. Risks associated with exposure to groundwater from each of these areas were evaluated.

- ***Uncertainty Analysis.*** Identifies uncertainties in all phases of the BHHRA and discusses their individual effects on the risk assessment results, focusing on those

issues that are most likely to have the greatest effect on risk estimates and/or risk management decisions.

- ***Aggregate Risk Summary.*** Overall groundwater risks for the on-site resident and on-site worker are combined with those associated with exposure to other environmental media (as estimated in previous BHHRA reports) to estimate overall risks. Combined risks associated with exposure to groundwater and other environmental media for each of the AOCs are summarized.

- ***Risk-Based Remediation Criteria Development for Groundwater.*** Provides risk-based remediation criteria (RBRC) for groundwater, based on the methodology of the BHHRA. RBRCs are intended for consideration as cleanup goals during the feasibility study process.

- ***Summary/Conclusions.*** Provides a brief summary of the entire BHHRA, including quantitative results, uncertainties, and pertinent site information. Summary and discussion are focused on those results and issues that are most likely to directly affect site management decisions.

- ***References.*** Provides a complete bibliography of all references used and cited in the BHHRA.

2.0 Data Evaluation

2.1 Selection of Analytical Data

Analytical data for each AOC were selected based on the representativeness and quality of the data. For inorganics, the sampling method can affect the representativeness of the analytical data; thus, the sampling method is also considered in selection of the analytical data set. The basis for data selection based on sampling method is presented in Section 2.1.1, and the protocol for the evaluation of data quality is presented in Section 2.1.2. Bedrock wells, overburden wells, and overburden direct-push groundwater samples considered for the evaluation of the respective AOCs, as well as downgradient locations, are identified in Table 2-1. Sampling locations for TNTA, TNTB, TNTC, the PRRWP Area, and the WARWP Area are depicted on Figures 2-1 through 2-5, respectively. The downgradient bedrock well locations near the PBOW facility boundary that were used in this BHHRA are shown on Figure 1-2.

2.1.1 Sampling Method Considerations

Although groundwater samples have been collected for laboratory analysis dating back to 1989 (IT, 1997), comprehensive site-wide groundwater monitoring began in November 1997 (IT, 1999b). Consistent with the 2004 groundwater data summary and evaluation report (Shaw, 2005b), the BHHRA includes analytical data from November 1997 through the most recent samples collected. The most recent samples were collected for site wells in April 2002, and the downgradient and background wells were most recently sampled in June 2004.

Low-flow groundwater sampling was begun in 2001 for monitoring wells with sufficient production to result in laminar flow. The PBOW project team has agreed that low-flow data should be used where possible because low-flow sampling results in samples that more closely represent groundwater conditions in the subsurface. Prior to 2001, all groundwater monitoring wells were sampled by bailer. Similarly, samples that could not be collected using low-flow techniques due to insufficient recharge were collected with a bailer during recent (2001 through 2004) sampling events as well. Whether collected by bailer or low-flow methodology, two fractions for inorganics analysis were taken where possible for each sample: 1) one fraction to be analyzed for dissolved inorganics was filtered in the field at the time of sample collection, and 2) a second sample was collected for analysis without filtration. Only the unfiltered fraction was collected in cases where well recharge was insufficient and allowed only limited water volume for analysis.

Because of possible turbidity issues, particularly with respect to the bailer-collected samples, a May 23, 2005 technical memorandum was prepared by Shaw to evaluate which samples for each

well should be included in the BHHRA. The technical memorandum and accompanying data tables were reviewed by OEPA, and the USACE/Shaw responses to OEPA comments on this technical memorandum were accepted by OEPA during the PBOW team meeting on September 15, 2005. The technical memorandum and responses to comments are attached to this BHHRA as Appendix B. The following protocol was used in the BHHRA to select monitoring well samples for evaluation of groundwater at each AOC as well as the property boundary:

- All unfiltered monitoring well analytical data resulting from low-flow samples were evaluated for inclusion unless rejected because of a data quality issue (see Section 2.1.2).

- Natural site conditions are present that may introduce turbidity, such that even samples collected by low-flow methodology may be noticeably turbid. This may be especially true for wells that have naturally occurring hydrogen sulfide (refer to the technical memorandum in Appendix B). A review of the unfiltered low-flow data revealed that all low-flow samples had turbidity readings of 150 nephelometric turbidity units or less.

- For each unfiltered bailer-collected sample having a turbidity reading above 150 nephelometric turbidity units, a sample-by-sample comparison was performed to determine whether these high-turbidity samples yielded inorganics results that were consistent with those of other samples collected from that well.

- Where it was determined that high turbidities did not have an appreciable impact on inorganics concentrations, these high-turbidity unfiltered samples were included as part of the data set evaluated in the BHHRA. For high-turbidity unfiltered samples having inorganics concentrations that were accordingly higher than those of other samples from that well, the inorganics data for that sample were excluded from the BHHRA.

- For all analytes other than inorganics, the results of samples collected by bailer and low-flow methodology were used unless rejected because of data quality issues (Section 2.1.2).

The turbidity evaluation summarized above resulted in the exclusion of inorganics results from five unfiltered bailer-collected samples for the BHHRA. These include the 1997 sample collected from BED-MW14, the 1998 sample collected from TNTC-MW3, the 1998 sample collected from IT-MW10, the 2001 sample collected from TNTA-MW11, and the July 2002 sample collected from BED-MW24. The technical memorandum considered the use of filtered samples to replace the unfiltered aliquots that showed unusually high turbidity, but OEPA commented that the results of filtered samples should not be combined with those of unfiltered samples under any circumstances. Consistent with this OEPA position, no filtered data were

used in the risk assessment (See Response to OEPA Comment No. 1a on the technical memorandum).

In addition to the monitoring well samples, overburden groundwater samples were collected using direct-push technology from TNTA, TNTB, TNTC, and the two former red water pond areas. TNTA and TNTC direct-push samples were collected in September/October 2000 as part of the remedial investigation (IT, 2001b), the PRRWP and WARWP direct-push samples were collected in June 1998 (IT, 2000b), and two samples were collected from each of the three former TNT areas in 2001 (Shaw, 2003a). Additional direct-push sampling locations were planned for the 2001 sampling effort, but further collection was abandoned due to a paucity of groundwater in the overburden. Because the direct-push sampling technique does not include well development or use of a filter pack, the inorganics results from these samples are regarded as unsuitable for risk assessment purposes due to turbidity issues. Based on review of filtered and unfiltered nitroaromatics sampling results at other sites, it has been observed that turbidity does not generally have a notable effect on nitroaromatics concentrations. However, it is noted that differences in sampling technique between collection from monitoring wells and the direct-push technique may result in differences in analytical results, and the effect of turbidity on the results of nitroaromatics and other organics cannot be entirely ruled out. All validated analytical data from these direct-push samples are included in the BHHRA data evaluation summary (Section 2.3) unless rejected because of data quality issues (Section 2.1.2). A complete list of samples and associated analytes evaluated is provided in Table 2-2.

2.1.2 Evaluation of Data Quality

The quality of the analytical data was evaluated to select data for inclusion in the BHHRA. Data quality is expressed by the assignment of qualifier codes during the analytical laboratory quality control process or during data validation that reflect the level of confidence in the data. The following are some of the more common qualifiers and their meanings (EPA, 1989a):

U - Chemical was analyzed for but not detected; the associated value is the sample quantitation limit.

J - Value is estimated, probably below the contract-required quantitation limit.

N - The analysis indicates an analyte for which there is presumptive evidence to make a tentative identification.

NJ - The analysis indicates a “tentatively identified analyte,” and the reported value represents its approximate concentration.

UJ - The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

R - Quality control indicates that the data are unusable (chemical may or may not be present).

B - The concentration in the sample is not sufficiently higher than concentration in the blank, using the 5-times, 10-times (5x, 10x) rule: A chemical is considered a nondetect unless its concentration exceeds five times the blank concentration. For common laboratory contaminants (acetone, 2-butanone [methyl ethyl ketone], methylene chloride, toluene, and the phthalate esters), the sample concentration must exceed 10 times the blank concentration to be considered a detection.

"J"-, "N"-, and "NJ"-qualified data were used in the BHHRA; "R"- and "B"-qualified data were not. The handling of "U"-qualified data (nondetects) in the BHHRA is described in Section 3.2.1. The use of data with other, less common qualifiers is typically evaluated on a case-by-case basis. However, no such qualifiers were associated with any of the groundwater samples considered for use in the BHHRA.

Some chemicals may be analyzed under two different analytical programs. For example, the DNT isomers are analyzed by EPA Method 8330 for nitroaromatics as well as EPA Method 8270C for semivolatile organic compounds. Risks associated with the reported values from both analyses are considered in the risk characterization (Chapter 5.0) and discussed as appropriate in the uncertainty analysis (Chapter 7.0), together with potential issues such as the relative sensitivities (i.e., differences in respective reporting limits) of the methods.

2.2 Identification of Chemicals of Potential Concern

A screening process is used to identify COPCs, which are the detected analytes carried through the full risk assessment process. The objectives of COPC screening are to focus the risk assessment on those chemicals that may contribute significantly to overall risk and to remove from quantification those chemicals whose contribution is clearly inconsequential. COPC screening includes a risk-based screen which also considers status as a human nutrient (Section 2.2.1), a frequency-of-detection evaluation (Section 2.2.2), and a background screen (Section 2.2.3).

2.2.1 Risk-Based Screening

In the risk-based screen, the maximum detected concentration (MDC) is compared to the appropriate risk-based screening concentration (RBSC) for each analyte. The units of the MDC

and RBSC are the same for each chemical in a given medium; with respect to the PBOW groundwater BHHRA, both the MDC and RBSC have units of micrograms per liter (µg/L) in water.

If the MDC of a chemical is less than or equal to its RBSC, then the chemical in this medium is not considered further in the BHHRA, because it is very unlikely that chemical concentrations at or below the RBSC would contribute substantially to risk. An analyte may be identified as a COPC if its MDC exceeds its RBSC. As indicated in Section 2.2, actual status as a COPC also depends on a chemical's frequency of detection (Section 2.2.2), concentration with respect to background (Section 2.2.3), and potential status as a nutrient. RBSCs used in the PBOW groundwater BHHRA were derived from the EPA Region 9 preliminary remediation goals (PRG) table "tap water" values (EPA, 2004b).

PRG values are based on a concentration equal to either an incremental lifetime cancer risk (ILCR) of 1E-6 or a noncancer hazard quotient (HQ) of 1, the threshold at (or below) which adverse noncancer effects are regarded as unlikely to occur. For the PBOW groundwater BHHRA, the noncancer values listed in the PRG tables were multiplied by a factor of 0.1 to provide additional protection for simultaneous exposure to multiple chemicals (EPA, 2004c; 1995). This results in groundwater RBSC values associated with an HQ of 0.1. For cancer risk, the PRG values were used directly as RBSCs in the BHHRA, as they are based on an ILCR of 1E-6. The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) identifies acceptable exposure levels that are generally associated with concentration levels that represent an excess upper bound lifetime cancer risk to an individual of 1E-6 to 1E-4 (EPA, 1990). This range is hereinafter referred to as the "NCP risk management range." Cancer risks associated with PRG values represent the lower end of this range. The RBSC for a chemical that elicits both cancer and noncancer health effects was selected based on either a cancer risk of 1E-6 or an HQ of 0.1, whichever associated water concentration is lower.

There are no PRGs for lead or sulfate, but the EPA (2004d) Office of Water lists a treatment technique action level of 0.015 milligrams per liter (mg/L) for lead and a health-based advisory level of 500 mg/L for sulfate. These values were used as RBSCs. It is noted that a secondary maximum contaminant level (SMCL) of 250 mg/L exists for sulfate. SMCLs are non-promulgated values, based on aesthetic characteristics, which are used as guidelines for public water systems. The sulfate SMCL is associated with taste and odor, rather than human health; therefore, the health advisory rather than the SMCL was used for risk-based human health screening. The exposure assessment, toxicity assessment, and risk characterization associated

with lead in bedrock groundwater are discussed in Sections 3.1.3.3, 4.5, and 6.4, respectively. The evaluation of sulfate in bedrock groundwater is provided in Section 6.5.

Certain elements are essential human nutrients that are generally regarded as innocuous at levels found in environmental media. These include calcium, chloride, iodine, magnesium, phosphorous, potassium, and sodium. There are no EPA Region 9 PRGs listed for these nutrients. Therefore, none of these essential nutrients is typically included as a COPC unless its concentration is judged to be associated with potential adverse human health effects. None of these nutrients were judged to be present at a concentration likely to be associated with adverse human health effects.

2.2.2 Frequency of Detection

When confidence is high that a given chemical is present, the data generally are used in the BHHRA. For most chemicals, their detection is presumptive evidence of their presence. As suggested by EPA (1989a), chemicals that are reported infrequently may be artifacts in the data that do not reflect the actual presence of the chemical in question. For the BHHRA, chemicals that are reported only at low concentrations in less than 5 percent of the samples from a given medium were excluded from further consideration, unless their presence was expected based on historical information about the site. Chemicals detected infrequently at high concentrations may identify the existence of contaminant plumes or limited "hot spots" and are retained as COPCs.

2.2.3 Comparison to Background

A number of the chemicals detected in PBOW groundwater may have MDCs that exceed RBSCs but are part of normal background concentrations associated with groundwater. Such chemicals may include inorganics and polycyclic aromatic hydrocarbons (PAH), a class of organic compounds which form from natural or anthropogenic combustion of organic matter, including fossil fuels, and are generally ubiquitous in the environment. Airborne PAHs associated with non-Department of Defense sources may be deposited on soil and leach to groundwater. Benzene, ethylbenzene, toluene, and xylenes (BTEX) compounds, as well as PAHs, may also be associated with background concentrations due to the presence of natural petroleum-derived compounds present in the vicinity of PBOW (see Section 3.1.1).

Site concentrations of inorganic chemicals in bedrock groundwater were compared to those of PBOW background using a two-step approach: 1) background screening and 2) statistical data set testing. This second step (Section 2.2.3.2) was initiated only in cases where the concentration used for background screening is exceeded (refer to Section 2.2.3.1) and is addressed after the

risk characterization (Chapter 5.0) in the uncertainty analysis (Chapter 7.0). No suitable background data set exists for overburden wells, so no comparisons to background concentrations were made for perched groundwater.

Inorganics and organics were treated similarly from a quantitative perspective. However, all organics not eliminated on the basis of RBSC exceedance (Section 2.2.1) or infrequent detection (Section 2.2.2) were carried through the risk assessment process (exposure assessment, toxicity assessment, and risk characterization). As presented in Section 2.2.3.3, organic compounds were quantitatively eliminated as background related only through the uncertainty analysis (Chapter 7.0).

2.2.3.1 Background Screening of Inorganics

Background screening was applied to each inorganic whose MDC in bedrock groundwater exceeds the RBSC and that cannot be characterized as an infrequently detected analyte. In background screening, the MDC is compared to the PBOW chemical-specific background screening concentration (BSC). The derivation of BSCs is described in the 2004 groundwater report (Shaw, 2005b). Briefly, BSCs were calculated for use at PBOW based on concentrations found in background bedrock monitoring wells installed upgradient of PBOW sources. Each BSC is either the MDC or the calculated 95th percent upper tolerance limit of the background data set (based on unfiltered samples collected using low-flow sampling), whichever value is lower (Shaw, 2005b). The BSCs and a data summary of the bedrock groundwater background data set are included in Table 2-3.

The screening consists of comparing the MDC of the site data set to the BSC. The chemical was regarded as a COPC if its MDC exceeds the BSC for that chemical or if no BSC could be determined due to a lack of detections in the background data set. COPCs were fully evaluated in the exposure assessment, toxicity assessment, and risk characterization. The chemical was not regarded as a COPC if its MDC is equal to or less than the BSC.

2.2.3.2 Statistical Data Set Testing of Inorganics

Statistical testing was performed to compare data sets of site inorganics data against the PBOW background data set (identified in Appendix M of the 2004 groundwater data summary and evaluation report [Shaw, 2005b]) using the nonparametric Wilcoxon Rank Sum (WRS) statistical test (also known as the Mann-Whitney U test). WRS testing was performed for inorganics whose MDCs exceed the respective BSCs and are identified as COPCs based on RBSC comparison (Section 2.2.1) and frequency of detection (Section 2.2.2). All COPCs were carried through the risk characterization process; thus, statistical testing results were not used to screen

out any chemicals. Site data sets were interpreted as being significantly different from PBOW background if the associated p-level is less than 0.05. WRS statistical output and box and whisker plots of the various inorganic COPC data sets are provided in Appendix C, and the WRS results are discussed as part of the uncertainties associated with site relatedness (Section 7.2.3). Analytes shown by the WRS results to exceed background (or for which the WRS testing was not run) are assumed to be site related, unless a qualitative chemical-specific explanation is presented in the uncertainties analysis as to why the analyte should not be regarded as site related. The WRS test was not run in this BHHRA if the COPC was not detected in the PBOW background groundwater data set or, in the case of the WARWP, the data set was too small to run the statistical method. Data sets for which the WRS results do not suggest site relatedness (i.e., site data and background data are not statistically different) were still evaluated for risks and hazards (Section 6.1).

2.2.3.3 Treatment of Organics

As mentioned in Section 2.2.3, certain organic compounds (BTEX and PAHs) in site groundwater may be attributable to background conditions. The MDC of PAH and BTEX data may also be compared to BSCs (Section 2.2.3.1) and may be compared to PBOW background data using the WRS test (Section 2.2.3.2), but no organic compounds were summarily screened out. Instead, all detected organic compounds were carried through the risk assessment process (i.e., exposure assessment, toxicity assessment, risk characterization) unless screened out on the basis of comparison to RBSCs (Section 2.2.1) or characterized as infrequently detected (Section 2.2.2). Background contribution of organics is discussed in the uncertainties analysis (Section 7.2.3).

2.2.4 Role of COPC Screening in the Risk Assessment Process

Figure 2-6 depicts the role of COPC screening as it applies to the risk assessment process. The figure highlights the role of COPC screening, including frequency of detection, risk-based screening, and comparison to background. The figure is not intended as a detailed flowchart of the risk assessment itself, but rather is intended to illustrate how the steps described in Sections 2.1 through 2.3 are integrated into the overall risk assessment and the processes that lead to risk management decisions.

2.3 Data Evaluation Summary

Tables with the following information for each detected chemical were prepared for bedrock groundwater underlying each AOC and downgradient area (Tables 2-4 through 2-9):

- Chemical name

- Frequency of detection
- Range of detected concentrations
- Range of detection limits
- Arithmetic mean of site concentrations
- 95th percent upper confidence limit on the arithmetic mean (UCL)
- Appropriate RBSC
- Appropriate BSC
- Selection/exclusion of chemical as a COPC.

Similar tables are provided for overburden groundwater in each AOC for data summary purposes. Note that summaries of samples from overburden groundwater wells are kept separate from overburden groundwater samples collected using direct-push techniques (Tables 2-10 through 2-19). However, because overburden groundwater is not regarded as a potential source of tap water (Section 1.3), chemicals with MDCs exceeding the RBSCs are indicated on the tables but are not identified as COPCs. Likewise, comparisons to background concentrations are not included on the tables for the overburden wells, because no background data exist for overburden groundwater at PBOW (Section 2.2.3).

3.0 Exposure Assessment

Exposure is the contact by a receptor with a chemical or physical agent. An exposure assessment estimates the type and magnitude of potential exposure of a receptor to COPCs found at or migrating from a site (EPA, 1989a). The following steps are included in an exposure assessment:

- Characterize the physical setting
- Identify the contaminant sources, release mechanisms, and migration pathways
- Identify the potentially exposed receptors
- Identify the potential exposure pathways
- Estimate EPCs
- Estimate chemical intakes or contact rates.

The exposure assessment characterizes exposure to COPCs in groundwater associated with the respective AOCs and at the facility boundary. As mentioned in Chapter 1.0, exposure and risks associated with COPCs in soils, surface water, and sediment, as applicable, were estimated for the AOCs in previous BHHRAs (IT, 2001a; 2000a, b). The Scope of Work (USACE, 2001) requires the summation of groundwater risks with those of the environmental media previously evaluated (see Chapter 8.0). Therefore, the respective CSEMs described in Section 3.1 include all environmental media evaluated for each AOC (i.e., those evaluated previously as well as groundwater). However, discussion of the receptors and exposure pathways (Section 3.1.3), methodologies for quantification of EPCs (Section 3.2), and methodologies for quantification of chemical intake (Section 3.3) presented in the text pertain only to groundwater, because pertinent information and calculations based on this information for other environmental media are presented in the previous BHHRAs.

3.1 Conceptual Site Exposure Model

A CSEM provides the basis for identifying and evaluating the potential risks to human health in the BHHRA. A CSEM is constructed from plausible site-use scenarios and the potential exposure pathways. The elements of a CSEM include the following:

- Source
- Source media (i.e., initially contaminated environmental media)
- Contaminant release mechanisms
- Contaminant transport pathways
- Intermediate or transport media
- Exposure media

- Plausible receptors
- Routes of exposure.

Contaminant release mechanisms and transport pathways are not relevant for direct receptor contact with a contaminated source medium (e.g., ingestion of or dermal contact with groundwater).

Figure 3-1 depicts the CSEM used for each of the three former production areas. The CSEM for each of the two former red water pond areas is depicted on Figure 3-2. The receptors and pathways on Figures 3-1 and 3-2 reflect plausible scenarios developed from information regarding site background and history, topography, climate, and demographics as presented by the site-wide groundwater investigation (IT, 1997). Exposure pathways that are identified as complete (on Figures 3-1 and 3-2) either are addressed in this groundwater BHHRA or have been addressed by previous BHHRAs. Additional potential receptors not listed on the CSEM figures are briefly discussed in Section 3.1.3.2.

Previous BHHRAs were performed to evaluate exposure to environmental media other than groundwater (IT, 2001a; 2000a, b). Note that the CSEM figures include groundwater as well as the media previously evaluated for the five respective on-site areas. For the current and future off-site resident, only groundwater exposure is evaluated (Figures 3-1 and 3-2). Although a majority of the residents are serviced by municipal water (from surface water sources), there are numerous private groundwater wells in the vicinity, including six that are downgradient of the TNT areas and red water pond areas within 1 mile of the facility boundary (refer to Section 1.3). Also, based on monitoring wells and a nearby off-site private well sampled as part of the site groundwater investigation, the bedrock units can produce an adequate quantity of groundwater. Although natural hydrocarbons are known to be present within the bedrock limestone and shale formations, bedrock groundwater underlying the site cannot be summarily excluded for consideration as a tap water source based on natural water quality parameters. Therefore, given the presence of numerous off-site wells and the assumption of unrestricted future land use on site, the development of bedrock groundwater for off-site or on-site residential (or on-site worker) use as tap water is regarded as plausible.

3.1.1 Physical Setting

Climate/Meteorology. The climate in the Sandusky area is continental and strongly affected by Lake Erie. July is generally the warmest month (average high and low temperatures of 82 and 65 degrees Fahrenheit [°F], respectively), and January is generally the coldest (average high and

low temperatures of 32 and 19°F, respectively) (The Weather Channel, 2004). On average, the first freezing day (low of 32°F or less) occurs in late October (average of three per month), and the last freezing day falls in early May (average of one per month) (National Oceanic and Atmospheric Administration, 1990). The average annual precipitation for Sandusky is 34.5 inches per year, with a monthly average of more than 3 inches per month falling in April through September and less than 3 inches in each of the other seven months (The Weather Channel, 2004). Precipitation is fairly evenly distributed throughout the year, with the fewest precipitation days (0.01 inch or greater) per month (10) occurring during July, August, September, and October, and the most (15) occurring in December and January (City-Data.com, 2004). The mean annual wind speed is 10.3 miles per hour (City-Data.com, 2004), with winds predominantly from the southwest (SAIC, 1991). Sandusky area winters are cloudy, with 33 percent sunshine during November through February, as compared with to 65 percent sunshine during the summer months (City-Data.com, 2004).

Geology. Three formations, all of Devonian Age, outcrop across PBOW, each of which was encountered in the upper 100 feet of bedrock at PBOW (Shaw, 2005b). The Delaware Limestone is the lowermost formation screened by site wells. It is characterized as a hard, dense, finely crystalline limestone and dolomite. The unit is typically buff colored and usually is described as fossiliferous. In the vicinity of PBOW, quarries mine limestone from the Delaware. Traces of natural petroleum-derived hydrocarbons and hydrogen sulfide are common in area quarries (Shaw, 2005b). Overlying the Delaware Limestone is the Olentangy Shale. Two members of the Olentangy Shale have been characterized at the site, the Plum Brook Shale and the overlying Prout Limestone. The Plum Brook Shale is interpreted to consist of approximately 35 feet of bluish-gray, soft, fossiliferous shale containing thin layers of dark, hard, fossiliferous limestone. The Prout Limestone has been described as a 15-foot-thick unit which occasionally outcrops in a 1,000-to-2,000-foot-wide, northeast-striking band across the middle portion of PBOW. It is described as a dark-gray to blue, very hard, siliceous, fossiliferous limestone or dolomitic mudstone. The uppermost formation at the site is the Ohio Shale. Only one member of the Ohio Shale is present in the PBOW area, the Huron Shale. This unit has been described as black, thinly bedded, with abundant carbonaceous matter. Some large pyrite/carbonate concretions are also present in the Huron Shale, some as large as 6 feet in diameter (D&M, 1997).

Soils. The bedrock overburden in Erie County is predominantly glacial till, glacial outwash, or glacial lacustrine (lake) deposits. In the vicinity of PBOW, the soil has been interpreted to be lacustrine. In many areas, the overburden also consists of highly weathered bedrock. The thickness of the overburden ranges from 1 foot to greater than 25 feet. Overburden is thickest on

the northern portion of the site in the vicinity of the Reactor Facility Area, where it has filled in a bedrock low (Shaw, 2005b).

The soil in the northwest portion of PBOW is placed within the Kibbie-Elnora-Tuscola-Colwood Association, which is described as nearly level to gently sloping. This soil is described as somewhat poorly drained, moderately well drained, and very poorly drained soils formed in outwash, lacustrine, and deltaic sediments. Along a strip from west to northeast across the site is the Castalia-Millsdale-Milton-Ritchey Association. This association is described as shallow to moderately deep, nearly level to moderately steep, well-drained and very poorly drained soils formed in glacial till, lacustrine sediments, and limestone residuum. Across much of the central portion of the site is the Hornell-Fries-Colwood Association, described as moderately deep to deep, nearly level to gently sloping, somewhat poorly drained to very poorly drained soils formed in glacial till and lacustrine sediments over shale bedrock. At the extreme southeast portion of PBOW is the Pewamo-Bennington Association, described as nearly level to gently sloping, very poorly drained and somewhat poorly drained soils formed from glacial till and lacustrine sediments.

Hydrology. The two main water-bearing zones at PBOW are located in the overburden and the bedrock, and are thus called the overburden and bedrock water-bearing zones. Data collected during the more recent investigations (IT, 2001a,b; 1999b; 1997) indicate that groundwater in the overburden is in discontinuous pockets during dry time periods. In contrast, the bedrock water-bearing zone is saturated year round. During periods of low precipitation, only limited migration of contaminants would occur in the overburden due to less infiltration. During a wet period, the general flow direction in the overburden water-bearing zone is to the north-northeast, largely mirroring surface topography. A hydrogeological study by the U.S. Geological Survey (1992) conducted in the glacial deposits of Sandusky in 1990 reported a horizontal hydraulic conductivity of 0.046 feet per day and a vertical hydraulic conductivity of 1.2 feet per day.

Regional groundwater flow is to the north-northeast towards Lake Erie, although local flow may vary due to local topography. Water in the limestone typically occurs in joints and along bedding planes or in solutionally enlarged openings. The conceptual model interprets that bedrock groundwater flow in the Delaware Limestone water-bearing zone migrates and is influenced by the frequency, orientation, density, and connectivity of the bedrock fractures.

At PBOW, the bedrock groundwater has been subdivided into three zones based on location and yield. Zone 1 occurs in the north and northwestern portion of PBOW. It has been characterized as yielding from 100 to 500 gallons per minute (gpm) from karstic limestone approximately 100

feet below grade. Zone 2 is in the northern portion of PBOW and has yields of 15 gpm or less from limestone approximately 300 feet below grade. Zone 3 is located in the eastern and southern portion of the site in predominantly shale bedrock. In addition to being found in the shale, groundwater is located in thin sand and gravel horizons interbedded with silt and clay deposits. Most Zone 3 wells are poor yielding, many of them providing less than 3 gpm (D&M, 1997).

3.1.2 Contaminant Sources, Release Mechanisms, and Migration Pathways Associated with Groundwater

Contaminant sources, release mechanisms, and migration pathways are discussed below for the production areas (Figure 3-1) and red water pond areas (Figure 3-2), respectively.

Production Areas. Each manufacturing line in the production areas consisted of individual buildings connected by pipelines that carried the reactive materials and the reactions to completion. Contamination involved the inadvertent release of TNT, its precursors, contaminants and residues, and acids or sellite (sodium sulfite made from soda ash and sulfur) from the process lines, drying areas, or packaging areas. Releases occurred to the surface soil as spills and to the subsurface soil from leaking or damaged underground pipes. Releases in the production areas may also have occurred during decontamination and during building and equipment removal processes. Runoff and erosion may have spread contamination over the surrounding surface soil and may have carried contaminants to nearby streams. Infiltration and leaching may have carried contaminants into the subsurface soil and groundwater.

Red Water Ponds. The pond areas received wastewater from TNT production. The PRRWP had received wastewater from TNTA and TNTB that had been treated at Wastewater Disposal Area No. 1. Reportedly, a tile drain carried water from the PRRWP to a ditch which parallels Pentolite Road. The WARWP Area ponds had received wastewater from TNTC that had been treated at Waste Disposal Area No. 2 (D&M, 1997). Underlying subsurface soils may have been impacted by infiltration; underlying overburden groundwater and possibly bedrock groundwater may have been impacted by leaching. Surrounding surface soil may have been impacted if periods of overflow occurred. Sediment within the drainage ditch along Pentolite Road may have been impacted by contaminants present in the PRRWP surface water that drained into the ditch; groundwater infiltration may also have occurred at this ditch. However, sediment samples collected from this ditch showed no contamination (IT, 2000b).

3.1.3 Groundwater Receptors and Exposure Pathways

3.1.3.1 Overburden Groundwater

As mentioned in Section 1.3, perched groundwater in the vicinity of the former TNT manufacturing areas and red water ponds is not regarded as a potential source of potable water because it is isolated, discontinuous, and seasonally dependent; these characteristics result in low (if any) and undependable yield. It is possible that a construction worker may be exposed to perched water via direct contact; however, such exposure would likely be sporadic and of short duration. Therefore, the BHHRA does not quantitatively evaluate exposure to perched groundwater. As mentioned in Section 1.3, the potential impact of nitroaromatics in perched overburden groundwater on the bedrock unit was modeled. Specifically, future groundwater concentrations of 2,4-DNT, 2,6-DNT, and TNT were modeled based on concentrations currently found in the overburden groundwater and soil.

3.1.3.2 Bedrock Groundwater

Groundwater is not currently being used on site, nor may it plausibly be used in the immediate future at any of the five PBOW sites evaluated. It is the desire of NASA to eventually release PBOW for unrestricted use. Thus, it is reasonable to assume that residential, commercial, and/or industrial development may occur on site in the foreseeable future. Currently, the nearest off-site well is approximately 840 feet downgradient of the PBOW facility boundary (refer to Section 1.3). However, it is plausible that an off-site resident could install a bedrock well just outside the PBOW facility boundary in the immediate future (approximating current time). Because of this possibility, current/future residential groundwater use was evaluated at the property boundary, even though no wells are currently or anticipated to be installed at such a location.

The following receptors were evaluated to represent the upper bound on bedrock groundwater exposure for all plausibly exposed groups of people at the respective AOCs and the facility boundary.

- ***Current/future off site.*** Based on measured concentrations at the five boundary wells and well BED-MW30, assuming a just off-site resident. Data for all six wells (Figure 1-2) are combined into a single evaluation. (Note that downgradient well BED-MW30 was added to the evaluation because it exhibited low levels of nitroaromatics.) It is emphasized that groundwater at the facility boundary is not currently used, but such use is plausible in the near or distant future.

- ***Future on site.*** Based on measured concentrations at each of the five PBOW AOCs (five separate evaluations). Future receptors are an on-site worker and on-

site resident. If current exposure to on-site groundwater existed, then this evaluation would be appropriate for such a hypothetical resident or worker.

- ***Modeled future on site.*** Additionally, risks associated with modeled future groundwater concentrations for 2,4-DNT, 2,6-DNT, and TNT are estimated for the future on-site resident and future on-site worker who uses groundwater as a drinking water source. This model is presented in Section 3.2.4 and discussed in the uncertainties analysis (Section 7.2.7).

- ***Modeled future off site.*** Based on modeled concentrations of 2,4-DNT, 2,6-DNT, and TNT at the just off-site location exhibiting the highest concentrations of these analytes, for up to five areas downgradient of the AOCs based on bedrock groundwater flow directions. This model is presented in Section 3.2.4 and discussed in the uncertainties analysis (Section 7.2.7).

If on-site groundwater were to be developed as a tap water source, other potential future groundwater receptors may include short-term (e.g., construction) workers or site visitors. However, the levels of exposure to these would be shorter in duration and/or frequency than those of an on-site worker or resident. Therefore, the long-term, on-site worker and resident receptor represent an upper bound on exposure for all potential receptors.

Quantitative evaluations of exposure to groundwater COPCs are based on a reasonable maximum exposure (RME) approach for each receptor. The intent of the RME approach is to estimate the highest exposure level that could reasonably be expected to occur, but not necessarily the worst possible case (EPA, 1991a; 1989a). It is interpreted as reflecting the 90th to 95th percentile on exposure. In keeping with EPA (1991a) guidance, variable values chosen for a baseline RME scenario for intake rate, exposure frequency (EF) and exposure duration (ED) are generally upper bounds. Other variables, e.g., body weight (BW) and exposed skin surface area, are generally central or average values. In the case of contact rates consisting of multiple components (e.g., dermal contact with water, which consists of a permeability coefficient [K_p] and exposure time [ET]), only one variable, (e.g., K_p) needs to be an upper bound. The conservativeness built into individual variables is designed to result in contact rate estimates that are more than adequately health protective.

The averaging time (AT) for noncancer evaluation is computed as the product of ED (years) times 365 days/year, to estimate an average daily dose over the entire exposure period (EPA, 1989a). For cancer evaluation, AT is the product of 70 years multiplied by 365 days/year (25,550 days, the assumed human lifetime), to estimate an average daily dose prorated over a lifetime, regardless of the frequency or duration of exposure. This methodology assumes that the risk from short-term exposure to a high dose of a given carcinogen is equivalent to long-term

exposure to a correspondingly lower dose, provided that the total lifetime doses are equivalent. This approach is consistent with current EPA (1986) policy of carcinogen evaluation, although it introduces considerable uncertainty into the cancer evaluation component of the BHHRA.

The only receptors evaluated under the exposure scenarios evaluated for PBOW groundwater are the resident (evaluated for current off-site, future on-site, and future off-site conditions) and the future on-site worker. Exposure assumptions and parameter values specific to the resident and worker are described in the paragraphs that follow. The fraction of tap water intake/exposure (refer to "FI" term in the equations in Section 3.2) attributed to groundwater from each PBOW AOC (as well as the off-site locations) is 1.0 for each receptor. Exposure parameters and parameter values are summarized in Table 3-1.

Resident. The resident is assumed to be exposed to groundwater as household tap water and, for volatile compounds, air concentrations that are associated with groundwater use in the residence. Exposure assumptions and parameter values for the current off-site resident, future on-site resident, and future off-site resident are identical. Cancer and noncancer assessments were performed for both an adult and child. The evaluations assume 30 years of exposure: 24 years as a 70-kilogram (kg) adult (EPA, 1991a) and 6 years as a 15-kg child (EPA, 2004c). For cancer effects, the adult and child effects were summed together; for noncancer effects, the child and adult were evaluated separately. An EF of 350 days per year (EPA, 1991a) was used for adult and child residential pathways.

Drinking water ingestion rates for the adult of 2 liters per day (L/day) (EPA, 1991a) and for the child of 1 L/day (EPA, 2004c) are assumed. Both the child and adult resident are assumed to be dermally exposed to COPCs in groundwater during household use (e.g., bathing). Available skin surface areas of 20,000 and 6,600 square centimeters (cm^2) were used for the adult and child, respectively, regarding contact with water while bathing. The child is assumed to bathe for 20 minutes per day (0.333 hour/day) (EPA, 1997a), and the adult is assumed to shower for 12 minutes per day (0.2 hour/day) (EPA, 2003a). Inhalation rates of 0.833 cubic meters per hour (m^3/hour) for the adult (EPA, 1991a) and 0.416 m^3/hour for the child (EPA, 2004c) were used. Because the *Exposure Factors Handbook* (EPA, 1997a) lists a 90th percentile for time spent in a residence as over 23 hours per day, it was conservatively assumed that the resident spends 24 hours per day in the house.

On-Site Worker. In the future land-use scenario, a site worker may be exposed to groundwater, which theoretically could be developed as a source of drinking water. His drinking water ingestion rate is assumed to be 1 L/day (EPA, 1991a). He may also experience dermal

contact with groundwater used to clean equipment and to rinse dust or perspiration from his body. For this evaluation, it is assumed that the head, forearms, and hands, approximately 3,300 cm^2 (EPA, 2004a), would be exposed intermittently for up to 1 hour per day. Because exposure is assumed to be intermittent, rather than continuous, organic chemical uptake across the dermis would not reach steady state, which guides selection of the EPA (2004a) model to be used to quantify this pathway (Section 3.3.3). Although a worker may be exposed to volatile organic compounds (VOC) released from groundwater during use, potential exposure via this pathway is regarded as minimal and is thus not evaluated in the BHHRA.

3.1.3.3 Exposure to Lead

Exposure to lead in PBOW groundwater is evaluated separately from other COPCs using the Integrated Exposure Uptake Biokinetic (IEUBK) model (EPA, 2005). This model assumes residential exposure to soil, household dust assumed to originate from soil, and drinking water (as well as other sources such as dietary, maternal levels, and ambient air) by a young child and estimates the resulting blood-lead concentration. Exposure and associated risks are characterized based on the resulting modeled blood-lead concentration. For the PBOW sites at which lead was identified as a COPC (i.e., TNTA and TNTB), the respective average soil (IT, 2001a; 2000a, b) and groundwater concentrations (Section 2.3) were used as inputs as prescribed by the IEUBK model. Output for the IEUBK model is included in Appendix D, and results of the modeling are discussed in Section 6.4.

3.2 Quantification of Exposure-Point Concentrations

The EPC is an estimate of the concentration of a COPC in a given medium to which a receptor may be exposed over the duration of the exposure. An EPC may be based on media concentrations that have been directly measured, or it may be derived based on environmental medium-to-medium transport modeling. The EPCs of COPCs in groundwater were statistically derived values, based on measured analytical data. Concentrations of COPCs in air were not measured (and in the case of groundwater volatilization or future exposure scenarios, cannot reasonably be measured) but were based on models, which use the EPCs of COPCs in groundwater as input values.

3.2.1 Groundwater Concentrations

Generally, the UCL or the MDC of the measured concentrations, whichever is lower, is selected as the groundwater EPC and is understood to represent a conservative estimate of average concentration for use in the exposure assessment for RME evaluation. Unusually high detected values are included in the calculation of the UCL concentration. Inclusion of these high values increases the statistical variability and the overall conservativeness of the risk estimate.

Exposure to an environmental medium is generally assumed to be random, and the EPC should be the arithmetic average encountered over the ED (EPA, 1989a). Therefore, the population mean concentration, if known, would be the ideal value selected as the EPC. The sample mean is an obvious estimate of the population mean. However, uncertainties exist as to how well the sample mean represents the population mean. Therefore, EPA (1989a) has recommended the inclusion of an upper confidence limit of 95 percent on the sample mean for RME evaluation. The following paragraphs describe the statistical approaches and the models used to derive EPCs for groundwater. This is basically the same statistical approach used in the previous BHHRAs for soils and other environmental media (IT, 2001a; 2000a, b).

The nature of the statistical distribution (normal, lognormal, nonparametric) is determined for COPC data sets having five or more samples with the Shapiro-Wilks test (EPA, 1992d). Either a normal or lognormal UCL is calculated, whichever provides the better fit in the Shapiro-Wilks test. Where either distribution provides virtually the same level of fit (at $p<0.05$) based on the Shapiro-Wilks test results, a normal distribution is selected because the UCL calculation for the normal distribution has greater mathematical stability (EPA, 1997b; Hardin and Gilbert, 1993). A nonparametric confidence limit was calculated when the data fit neither a normal or lognormal distribution. For data sets with less than five samples, the MDC was used as the EPC. Also, because most of the downgradient boundary wells are spatially unrelated, the MDC of the combined set of boundary wells was used as the EPC in the BHHRA.

The UCL is calculated for a normal distribution as follows (EPA, 1992a):

$$UCL = \bar{x} + t_{1-\alpha,n-1}\ (s/\sqrt{n}\,) \qquad \text{Eq. 3.1}$$

where:

UCL = upper 95th confidence limit on the arithmetic mean concentration (calculated)
= sample arithmetic mean
t_1 = critical value for Student's *t*-test
α = 0.05 (95 percent confidence limit for a one-tailed test)
n = number of samples in the data set
s = sample standard deviation.

The UCL is calculated for a lognormal distribution as follows (Gilbert, 1987):

$$UCL = e^{\left(\bar{y} + (0.5 \bullet s_y^2) + \left[H_{0.95} \bullet \frac{Sy}{(n-1)^{0.5}}\right]\right)} \qquad \text{Eq. 3.2}$$

where:

UCL = upper 95th confidence limit on the arithmetic mean concentration (calculated)
$\bar{y}$ = 3y/n = sample arithmetic mean of the log-transformed data, y = ln x
s_y = sample standard deviation of the log-transformed data
n = number of samples in the data set
$H_{0.95}$ = value for computing the one-sided upper 95 percent confidence limit on a lognormal mean from standard statistical tables (Land, 1975).

A nonparametric confidence limit was calculated when the data fit neither a normal or lognormal distribution. The nonparametric UCL is the 95th percent upper confidence limit on the median, rather than the mean, because the median is a better estimate of central tendency for a nonparametric distribution. The rank order of the data point selected as the UCL is estimated from the following equation (Gilbert, 1987):

$$u = p\,(n+1) + Z_{1-\alpha}\sqrt{n\,p\,(1-p)} \qquad \text{Eq. 3.3}$$

where:

u = rank order of value selected as UCL, calculated
p = percentile corresponding to the arithmetic mean
n = number of samples in the data set
α = confidence limit (95 percent)
$Z_{1-\alpha}$ = normal deviate variable.

The concentration corresponding to the calculated rank order UCL was used as the EPC for nonparametric data in the BHHRA. It is theoretically possible using the lognormal and nonparametric methods that the UCL for a given COPC may be less than the arithmetic mean concentration; however, all of the UCLs that were used as EPCs were observed to be greater than the respective mean concentrations for all BHHRA data sets.

Analytical results are presented as "nondetects" ("U" qualifier) whenever chemical concentrations in samples do not exceed the reporting limits. To apply the previously mentioned statistical procedures to a data set with nondetects, a concentration value must be assigned to nondetects. Nondetects are assumed to be present at one-half the reporting limit, although judgment is used in those cases where matrix interference or other phenomena drive the reporting limits unusually high (EPA, 1989a). No samples were eliminated from any of the BHHRA groundwater data sets due to high reporting limits.

3.2.2 Concentrations in Household Air from Groundwater Use

Inhalation of VOCs released from groundwater, which is assumed to be used as tap water, were evaluated for the on-site and off-site resident scenarios. Chemicals that have a Henry's Law value exceeding 1E-5 atmospheres per cubic meter (atm/m^3) per mole and a molecular weight less than 200 grams per mole are considered to be VOCs and are subject to evaluation via this pathway; Henry's Law values and molecular weights are shown in Table 3-2. Other groundwater contaminants were considered case by case for their potential contribution to risk via the inhalation pathway based on the degree of departure from the Henry's Law and molecular weight criteria, groundwater concentration, and toxicity. As a result of this evaluation, no COPCs having a Henry's Law value of greater than 1E-5 atm/m^3 or a molecular weight greater than 200 grams per mole were added as VOCs.

The simple whole-house tap water-to-air model described in Part B of the human health evaluation manual (HHEM) (EPA, 1991b) was used to evaluate the tap water-to-air pathway. This model was selected based on correspondence between OEPA (2004) and USACE. Part B of the HHEM recommends a volatilization constant of 0.0005 for the total concentrations of all VOCs detected in groundwater; the conversion is characterized by the following equation:

$$C_a = C_{gw} \bullet K_{wa} \bullet 1{,}000 \, L/m^3 \qquad \text{Eq. 3-4}$$

where:

C_a = modeled concentration in air (milligrams per cubic meter [mg/m^3])
C_{gw} = groundwater EPC (mg/L)
K_{wa} = tap water-to-air volatilization constant (0.0005 [unitless]: [EPA, 1991b])

Implicit in the HHEM Part B application of this model are the following: 1) a family of four uses the groundwater as the sole source of household tap water; 2) the volume of the house is 150 cubic meters (m^3); 3) the daily groundwater use is 720 L/day; 4) 50 percent of VOCs in tap water volatilize to household air; and 5) the air exchange rate of the house is 0.25 volumes per hour (EPA, 1991b). The EPA (1997a) *Exposure Factors Handbook* lists values different from some of those assumed by HHEM Part B.

3.2.3 Concentrations of VOCs in Groundwater: Resident Dermal Uptake

Volatilization of VOCs from household water reduces the remaining concentration available for dermal contact. As mentioned in Section 3.2.2, the HHEM Part B whole-house tap water-to-air model assumes that 50 percent of the VOC concentrations are released to household air. Thus,

the concentrations of VOCs remaining in the water after volatilization occurs are calculated by difference as follows:

$$C_d = C_{gw} \bullet (1 - F_v) \qquad \text{Eq. 3-5}$$

where:

C_d = concentration of VOC in household water available for dermal exposure (mg/L, calculated)
C_{gw} = concentration of VOC in groundwater (mg/L)
F_v = fraction of VOCs volatilized to air, (0.5, unitless).

Only the concentration remaining in tap water after volatilization (C_d), as applicable, is assumed to be available for contact with the skin during bathing/showering.

3.2.4 Modeled Future Groundwater Concentrations

Estimated potential future groundwater concentrations of 2,4-DNT, 2,6-DNT, and TNT were modeled for each of the AOCs and the downgradient property boundary. This model is based on soil-to-groundwater leaching and overburden groundwater-to-bedrock groundwater migration. Each model run for these three compounds simulated migration from the soil to groundwater over a 150-year period. The results from the year at which the maximum concentrations were predicted for each area were used as the EPCs. A description of the site groundwater model and complete modeling results are provided in Appendix E.

Soil remedial actions, based on direct soil contact, are planned for each of the TNT areas and the PRRWP Area; additionally, limited sediment remediation is planned for a drainage ditch at TNTC. It was previously determined that no soil remediation was required for the WARWP Area. The commencement of remediation at TNTA and TNTC has not yet been scheduled. At TNTB, most of the remediation has already been completed and the extent of additional remediation for direct soil contact has been identified (subject to post-remediation confirmation sampling) and is scheduled for completion during 2006. A relatively small amount of remediation has already occurred at the PRRWP Area, and the extent of additional remediation has largely been identified. However, additional remediation of the PRRWP Area has not yet been scheduled.

Based on the remedial activities completed and scheduled thus far, TNTB was modeled assuming that remediation had already occurred. Post-remediation confirmation samples and samples previously collected outside of the excavations were incorporated into the soil-to-groundwater model for TNTB.

The PRRWP Area was modeled based on the limited remediation performed to date and incorporation of the confirmation samples as well as the samples collected previously outside of the excavated areas. However, no further remediation was assumed, as it is uncertain when additional excavation may occur. Similarly, no remediation was assumed for TNTA or TNTC.

3.3 Quantification of Chemical Intakes

This section describes the models used to quantify doses or intakes of the COPC by the exposure pathways identified in Section 3.1.2, incorporating the exposure parameter values described in Section 3.1.3. Models were taken or modified from EPA (1989a) unless otherwise indicated. Intakes were calculated for both cancer and noncancer evaluations. The AT variable shown in the following equations is replaced with AT_n for noncancer calculations (365 × ED), and with AT_c (25,550 days) for the cancer calculations. Intake values are based on the EPCs (Section 3.2) and the equations discussed below for the respective exposure pathways.

3.3.1 Ingestion of COPCs in Groundwater

The ingested dose of COPCs in groundwater is estimated from the following equation:

$$I_w = \frac{(C_w)(IR_w)(FI_w)(EF)(ED)}{(BW)(AT)} \qquad \text{Eq. 3.6}$$

where:

I_w	=	ingested dose of COPCs in groundwater (milligrams per kilogram per day [mg/kg-day], calculated)
C_w	=	concentration of COPCs in groundwater (mg/L)
IR_w	=	drinking water ingestion rate (L/day)
FI_w	=	fraction of exposure attributed to site groundwater (unitless)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time (days).

3.3.2 Inhalation of COPCs from Air

The following equation is used to estimate the inhaled dose of COPCs in air as a result of volatilization from tap water. Air concentrations used in this equation are modeled (Section 3.2.2).

$$I_{sa} = \frac{(C_a)(IR_a)(ET_a)(EF)(ED)}{(BW)(AT)} \qquad \text{Eq. 3.7}$$

where:

I_a = inhaled dose of COPC (mg/kg-day, calculated)
C_a = concentration of COPC in air from dust and volatilization (mg/m^3)
IR_a = inhalation rate (m^3/hour)
ET_a = exposure time to VOCs in air (hours/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (days).

3.3.3 Dermal Contact with COPCs in Water

Unlike the methodologies for estimating inhaled or ingested doses of a COPC, which quantify the dose presented to the barrier membrane (the pulmonary or gastrointestinal mucosa, respectively), the dermal dose is estimated as the dose that crosses the skin and is systematically absorbed. For this reason, dermal toxicity values are also based on absorbed dose. The absorbed dose of COPCs from groundwater are estimated using the following equation (EPA, 2004a):

$$DAD = \frac{(DA)(SA)(EF)(ED)}{(BW)(AT)} \qquad \text{Eq. 3.8}$$

where:

DAD = average dermally absorbed dose of COPC (mg/kg-day, calculated)
DA = dose absorbed per unit body surface area per event (milligrams per square centimeter per event [mg/cm^2-event])

SA = surface area of the skin available for contact with environmental medium (soil, groundwater, sediment, or surface water) (cm^2)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (days).

Quantification of dermal uptake of constituents from water depends on a K_p, which describes the rate of movement of a constituent from water across the dermal barrier to the systemic circulation (EPA, 1992b). Separate calculation methods are applied to estimate the DA term (defined above) for inorganic and organic chemicals in water. For inorganic chemicals, DA is calculated from the following equation:

$$DA = (C_w)(K_p)(ET_w)(CF) \qquad \text{Eq. 3.9}$$

where:

DA = dose absorbed per unit body surface area per event (mg/cm^2-event, calculated)
C_w = concentration of COPC in water (mg/L)
K_p = permeability coefficient (centimeters per hour [cm/hour])
ET_w = time of exposure (hours/day)
CF = conversion factor (0.001 liters per cubic centimeter).

K_p values are available for some inorganics (EPA, 2004a). A default K_p value of 0.001 cm/hour (EPA, 2004a) was used for those inorganics for which no chemical-specific values were available.

K_p values for organic chemicals vary by several orders of magnitude, largely dependent on lipophilicity, expressed as a function of the octanol/water partition coefficient (K_{ow}). Because the stratum corneum (the outer skin layer) is rich in lipid content, it may act as a sink, initially reducing the transport of chemical to the systemic circulation. With continued exposure and the attainment of steady-state conditions, the rate of transfer to the systemic circulation increases. Therefore, different equations are used to estimate DA, depending on whether the ET is less or greater than the estimated time to reach steady state. Dermal exposure to groundwater is expected to generally be of relatively short duration (e.g., limited to bathing/showering time and/or intermittent hand and face washing). Therefore, it is assumed that steady state is not reached, which is the usual case for such relatively short ETs. The ET value is accordingly expressed as hours/day. Under these conditions, DA is calculated from the following equation (EPA, 2004a):

$$DA = 2(FA)(K_p)(C_w)(CF)\sqrt{\left(\frac{6\tau(ET_w)}{\pi}\right)} \qquad \text{Eq. 3.10}$$

where:

DA = dose absorbed per unit body surface area per day (milligrams per square centimeter per day, calculated)
FA = fraction available post exposure for absorption in the stratum corneum
K_p = permeability coefficient (cm/hour)
C_w = concentration of constituent in water (µg/L) (note that for volatiles in shower water the C_w should be the concentration remaining after volatilization from the water droplet [i.e., C_d from Equation 3-5])
CF = conversion factor (0.001 liters per cubic centimeter)

J = time for concentration of contaminant in stratum corneum to reach steady state (hours)
ET_w = exposure time to groundwater (hours/day).

When available, values for K_p and **J** were taken from EPA (2004a). For organics that have no K_p values listed, the values were calculated using Equation 3.11 (EPA, 2004a):

$$\text{Log}(K_p) = -2.80 + 0.66(\log K_{ow}) - 0.0056(MW) \qquad \text{Eq. 3.11}$$

where:

K_p = permeability coefficient (cm/hour, calculated)
$\log K_{ow}$ = log of the octanol/water partition coefficient (unitless)
MW = molecular weight.

Where values for **J** were not available, they were calculated using Equation 3.12 (EPA, 2004a). Values of K_p and **J** to be used in the BHHRA are provided in Table 3-2 and are documented in Appendix F.

$$\tau = 0.105 \times 10^{(0.0056 \times MW)} \qquad \text{Eq. 3.12}$$

where:

J = time for concentration of contaminant in stratum corneum to reach steady state (hours, calculated)
MW = molecular weight.

3.3.4 Inhalation of Air Containing VOCs from Groundwater

Equation 3.13 is used to estimate the inhaled dose of VOCs in air that results from household use of groundwater. The inhaled dose is estimated using the following equation:

$$I_{wa} = \frac{(C_{wa})(IR_a)(FI_{wa})(ET_{wa})(EF)(ED)}{(BW)(AT_n)} \qquad \text{Eq. 3.13}$$

where:

I_{wa} = inhaled dose of COPC (mg/kg-day, calculated)
C_{wa} = concentration of VOCs in air from volatilization (mg/m^3)
IR_a = inhalation rate (m^3/hour)
FI_{wa} = fraction of exposure attributed to contaminated medium (unitless)
ET_{wa} = exposure time to VOCs in air (hours/day)
EF = exposure frequency (days/year)

ED = exposure duration (years)
BW = body weight (kg)
AT_n = averaging time for noncancer (days).

4.0 Toxicity Assessment

Toxicity is defined as the ability of a chemical to induce adverse effects in biological systems. The purpose of the toxicity assessment is two-fold:

- Identify the cancer and noncancer effects that may arise from exposure of humans to the COPC (hazard assessment)
- Provide an estimate of the quantitative relationship between the magnitude and duration of exposure and the probability or severity of adverse effects (dose-response assessment).

The latter is accomplished by the derivation of cancer and noncancer toxicity values, as described in the following section.

4.1 Evaluation of Carcinogenicity

A few chemicals are known, and many more are suspected, to be human carcinogens. The evaluation of the potential carcinogenicity of a chemical includes both a qualitative and a quantitative aspect (EPA, 1986). The qualitative aspect is a weight-of-evidence evaluation of the likelihood that a chemical might induce cancer in humans. EPA (1986) recognizes six weight-of-evidence group classifications for carcinogenicity:

- ***Group A - Human Carcinogen***: Human data are sufficient to identify the chemical as a human carcinogen.
- ***Group B1 - Probable Human Carcinogen***: Human data indicate that a causal association is credible, but alternative explanations cannot be dismissed.
- ***Group B2 - Probable Human Carcinogen***: Human data are insufficient to support a causal association, but testing data in animals support a causal association.
- ***Group C - Possible Human Carcinogen***: Human data are inadequate or lacking, but animal data suggest a causal association, although the studies have deficiencies that limit interpretation.
- ***Group D - Not Classifiable as to Human Carcinogenicity***: Human and animal data are lacking or inadequate.
- ***Group E - Evidence of Noncarcinogenicity to Humans***: Human data are negative or lacking, and adequate animal data indicate no association with cancer.

The toxicity value for carcinogenicity, called a cancer slope factor (SF), is an estimate of potency. SFs are developed only for chemicals in Groups A, B1, B2, and C, and only if the data are sufficient. The SFs are statistically derived from the dose-response curve from the best human or animal study or studies of the chemical. Although human data are often considered to be more reliable than animal data because there is no need to extrapolate the results obtained in one species to another, most human studies have one or more of the following limitations:

- The duration of exposure is usually considerably less than lifetime.
- The concentration or dose of chemical to which the humans were exposed can be approximated only crudely, usually from historical data.
- Concurrent exposure to other chemicals frequently confounds interpretation.
- Data regarding other factors (tobacco, alcohol, illicit or medicinal drug use, nutritional factors and dietary habits, heredity) are usually insufficient to eliminate confounding or quantify confounding effects on the results.
- Most epidemiologic studies are occupational investigations of workers, which may not accurately reflect the range of sensitivities of the general population.
- Most epidemiologic studies lack the statistical power (i.e., sample size) to detect a low, but chemical-related increased incidence of tumors.

Most potency estimates are derived from animal data, which present different limitations:

- It is necessary to extrapolate from results in animals to predict results in humans, usually by estimating an equivalent human dose from the animal dose.
- The range of sensitivities arising from genotypic and phenotypic diversity in the human population is not reflected in the animal models ordinarily used in cancer studies.
- Usually very high doses of chemical are used, which may alter normal biology, creating a physiologically artificial state and introducing substantial uncertainty regarding the extrapolation to the low-dose range expected with environmental exposure.
- Individual studies vary in quality (e.g., duration of exposure, group size, scope of evaluation, adequacy of control groups, appropriateness of dose range, absence of concurrent disease, sufficient long-term survival to detect tumors with long induction or latency periods).

The SF is usually expressed as "extra risk" per unit dose, that is, the additional risk above background in a population corrected for background incidence. It is calculated using the following equation:

$$(p_{(d)} - p_{(0)}) / (1 - p_{(0)}) \qquad \text{Eq. 4.1}$$

where:

$p_{(d)}$ = the probability of cancer associated with dose = 1 mg/kg-day
$p_{(0)}$ = the background probability of developing cancer at dose = 0 mg/kg-day.

The SF is expressed as risk per mg/kg-day, shown mathematically as mg/kg-day^{-1}. In order to be appropriately conservative, the SF is usually the 95 percent upper bound on the slope of the dose-response curve extrapolated from high (experimental) doses to the low-dose range expected in environmental exposure scenarios. EPA (1986) assumes that there are no thresholds for carcinogenic expression; therefore, any exposure represents some quantifiable risk.

The oral SF is usually derived directly from the experimental dose data, because oral dose is usually expressed as mg/kg-day. When the test chemical was administered in the diet or drinking water, oral dose first must be estimated from data for the concentration of the test chemical in the food or water, food or water intake data, and BW data.

The Integrated Risk Information System (IRIS) (EPA, 2006) expresses inhalation cancer potency as a unit risk based on concentration, or risk per milligram of chemical per m^3 of ambient air, shown mathematically as $(mg/m^3)^{-1}$. Because cancer risk characterization requires an SF expressed as risk per mg/kg-day, the unit risk must be converted to the mathematical equivalent of an inhalation cancer SF, or risk per unit dose as mg/kg-day^{-1}. Since the inhalation unit risk is based on continuous lifetime exposure of an adult human (assumed to inhale 20 m^3 of air per day and to weigh 70 kg) the mathematical conversion consists of multiplying the unit risk (per mg/m^3) by 70 kg and by 1,000 micrograms per milligram, and dividing the result by 20 m^3 per day.

Cancer toxicity values and sources are provided in Table 4-1.

4.2 Evaluation of Noncarcinogenic Effects

Many chemicals, whether or not associated with carcinogenicity, are associated with adverse noncarcinogenic effects. The evaluation of noncancer effects (EPA, 1989b) involves the following:

- Qualitative identification of the adverse effect(s) associated with the chemical; these may differ depending on the duration (acute or chronic) or route (oral or inhalation) of exposure.
- Identification of the critical effect for each duration of exposure (i.e., the first adverse effect that occurs as dose is increased).
- Estimation of the threshold dose for the critical effect for each duration of exposure.
- Development of an uncertainty factor (UF); i.e., quantification of the uncertainty associated with interspecies extrapolation, intraspecies variation in sensitivity, severity of the critical effect, slope of the dose-response curve, and deficiencies in the database, in regard to developing a reference dose (RfD) for human exposure.
- Identification of the target organ(s) for the critical effect for each route of exposure.

These information points are used to derive an exposure route- and duration-specific toxicity value called an RfD, expressed as mg/kg-day, which is considered to be the dose for humans, with uncertainty of an order of magnitude or greater, at which adverse effects are not expected to occur. Mathematically, it is estimated as the ratio of the threshold dose to the UF. Although a limited number of subchronic RfDs have been identified, only chronic RfDs have been used in this BHHRA. For purposes of risk assessment, chronic exposure is typically defined as equal to or greater than 7 years, i.e., at least 10 percent of expected life span; subchronic exposure is typically defined as 2 weeks to 7 years. However, professional judgment may be used where exposure durations approach 10 percent of the expected life span. Also, exposure during a critical stage of development, such as a portion of early childhood, may be treated as chronic even if the anticipated exposure duration were to be considerably less than 10 percent of the expected life span.

IRIS (EPA, 2006) expresses the inhalation noncancer reference value as a reference concentration (RfC) in units of mg/m^3. Because noncancer risk characterization requires a reference value expressed as mg/kg-day, the RfC must be converted to an inhalation RfD. Since the inhalation RfC is based on continuous exposure of an adult human (assumed to inhale 20 m^3

of air per day and to weigh 70 kg), the mathematical conversion consists of multiplying the RfC (mg/m^3) by 20 m^3/day and dividing the result by 70 kg.

RfD and RfC values are derived for both chronic and subchronic exposure. Under the assumption of monotonicity (incidence, intensity, or severity of effects can increase, but cannot decrease, with increasing magnitude or duration of exposure), a chronic RfD may be considered sufficiently protective for subchronic exposure, but a subchronic RfD may not be protective for chronic exposure. Currently, subchronic RfD values exist for few chemicals. Subchronic RfD values can be derived from chronic RfD values as follows:

- If the UF applied in the derivation of the chronic RfD does not provide for expansion from subchronic to chronic exposure (e.g., if the chronic RfD was derived from a chronic study), the chronic RfD is adopted as being sufficiently protective for subchronic exposure.

- If the UF applied in the derivation of the chronic RfD contains a component to expand from subchronic to chronic exposure, the subchronic RfD is derived by multiplying the chronic RfD by the factor used to expand from subchronic to chronic exposure (e.g., if a factor of 10 was used to expand from subchronic to chronic exposure, the subchronic RfD would be 10 times larger than the chronic RfD).

Oral and dermal (discussed in Section 4.3) RfDs, as well as RfCs and inhalation RfDs, are provided in Table 4-1.

4.3 Dermal Toxicity Values

Dermal RfDs and SFs are derived from the corresponding oral values, provided there is no evidence to suggest that dermal exposure induces exposure route-specific effects that are not appropriately modeled by oral exposure data. In the derivation of a dermal RfD, the oral RfD is multiplied by the gastrointestinal absorption factor (GAF), expressed as a decimal fraction. The resulting dermal RfD, therefore, is based on absorbed dose. The RfD based on absorbed dose is the appropriate value with which to compare a dermal dose, because dermal doses are expressed as absorbed rather than exposure doses. The dermal SF is derived by dividing the oral SF by the GAF. The oral SF is divided, rather than multiplied, by the GAF because the SF is expressed as a reciprocal dose.

4.4 Target Organ Toxicity

As a matter of science policy, EPA assumes dose and effect to be additive for noncarcinogenic effects (EPA, 1989a). This assumption provides the justification for adding the HQs or hazard

indices (HI) in the risk characterization for noncancer effects (Section 5.2) resulting from exposure to multiple chemicals, pathways, or media. However, EPA (1989a) acknowledges that adding all HQ or HI values may overestimate hazard, because the assumption of additivity is probably appropriate only for those chemicals that exert their toxicity by the same mechanism.

Mechanisms of toxicity data sufficient for predicting additivity with a high level of confidence are available for very few chemicals. In the absence of such data, EPA (1989a) assumes that chemicals that act on the same target organ may do so by the same mechanism of toxicity; that is, the target organ serves as a surrogate for mechanism of toxicity. When total HI for all media for a receptor exceeds 1 due to the contributions of several chemicals, it is appropriate to segregate the chemicals by route of exposure and mechanism of toxicity (i.e., target organ) and estimate separate HI values for each target organ.

As a practical matter, since human environmental exposures are likely to involve near- or sub-threshold doses, the target organ chosen for a given chemical is the one associated with the critical effect. If more than one organ is affected by a given chemical at the threshold, then the affected target organs are selected for this chemical. The target organ is also selected on the basis of duration of exposure (i.e., the target organ for chronic or subchronic exposure to low or moderate doses is selected rather than the target organ for acute exposure to high doses) and route of exposure. Because dermal RfD values are derived from oral RfD values, the oral target organ is adopted as the dermal target organ. For some chemicals, no target organ is identified. This occurs when no adverse effects are observed or when adverse effects such as reduced longevity or growth rate are not accompanied by recognized organ- or system-specific functional or morphologic alteration. Target organs for the COPCs via oral and inhalation pathway are provided in Table 4-1.

4.5 Lead Toxicity

The primary toxic effects of lead are neurological and hematological. Subtle neurological changes in children and the effects in the levels of certain blood enzymes appear to occur at levels so low as to be considered nonthreshold effects. Therefore, EPA (2006) considered the derivation of an RfD inappropriate. Although lead is classified as a B2 carcinogen, EPA declined to derive an SF for carcinogenicity because of high uncertainties associated with a number of factors (refer to the toxicological profile for lead in Appendix F). The IEUBK model was used to evaluate lead toxicity and exposure (Section 3.1.3.3). This model generates an estimated blood-lead concentration based on a variety of potential lead sources. The results of this model are presented in Appendix D and discussed in Section 6.4.

4.6 Sources of Toxicity Information Used in the Risk Assessment

Toxicity values were selected for use in the BHHRA based on the EPA Office of Solid Waste and Emergency Response Directive 9285.7-53 (EPA, 2003b), which prescribes the following hierarchy:

- **Tier 1** values: IRIS (EPA, 2006) database.
- **Tier 2** values: These are EPA's provisional peer-reviewed toxicity values. The provisional peer-reviewed toxicity values are developed by the Office of Research and Development, the National Center for Environmental Assessment, and the Superfund Health Risk Technical Support Center on a chemical-specific basis when requested by the Superfund program.
- **Tier 3** values: These are other toxicity values from additional EPA and non-EPA sources of toxicity information. As stated in the EPA Office of Solid Waste and Emergency Response directive, "priority should be given to those sources of information that are the most current, the basis for which is transparent and publicly available, and which have been peer reviewed." Two common examples of Tier 3 values are the EPA's Health Effects Assessment Summary Tables (EPA, 1997c) and the California Environmental Protection Agency (2005) Office of Environmental Health Hazard Assessment Toxicity Criteria Database.

GAFs, used to derive dermal RfD values and SFs from the corresponding oral toxicity values, are obtained from the following sources:

- Oral absorption efficiency data compiled by the National Center for Environmental Assessment for the Superfund Health Risk Technical Support Center of EPA
- Federal agency reviews of the empirical data, such as Agency for Toxic Substances and Disease Registry toxicological profiles and various EPA criteria documents
- Other published reviews of the empirical data
- The primary literature.

GAFs obtained from reviews are compared to empirical (especially more recent) data, when possible, and are evaluated for suitability for use in deriving dermal toxicity values from oral toxicity values. The suitability of the GAF increases when the following similarities are present in the oral pharmacokinetic study from which the GAF is derived and in the key toxicity study from which the oral toxicity value is derived:

- The same strain, sex, age, and species of test animal were used.
- The same chemical form (e.g., the same salt or complex of an inorganic element or organic compound) was used.
- The same mode of administration (e.g., diet, drinking water, or gavage vehicle) was used.
- Similar dose rates were used.

The most defensible GAF values, used in the BHHRA, are provided in Table 4-1. Individual toxicity profiles of the COPCs, including all pertinent toxicity information, are provided in Appendix F.

5.0 Risk Characterization Methodology

Risk characterization is the process of applying numerical methods and professional judgment to determine the potential for adverse human health effects to result from the presence of site-specific contaminants. This is done by combining the intake rates estimated during the exposure assessment with the appropriate toxicity information identified during the toxicity assessment. Noncancer hazards and cancer risks are characterized separately, including COPCs that induce both types of effects.

Quantitative expressions are calculated during risk characterization that describe the probability of developing cancer (ILCRs), or the nonprobabilistic comparison of estimated dose with an RfD for noncancer effects (HQs and HIs). Quantitative estimates are developed for individual chemicals, exposure pathways, and exposure media for each receptor. These quantitative risk characterization expressions, in combination with qualitative information, are used to guide risk management decisions. Risk characterization, as described in this section, is applied only to COPCs.

Generally, the risk characterization follows the methodology prescribed by EPA (1989a), as modified by more recent information and guidance. EPA methods are, appropriately, designed to be health protective and tend to overestimate rather than underestimate risk. The risk results, however, may be overly conservative, because risk characterization involves multiplication of the conservative assumptions built into the estimation of the EPCs, exposure (intake) estimates, and toxicity dose-response assessments.

5.1 Carcinogenic Effects of Chemicals

The risk from exposure to potential chemical carcinogens is estimated as the probability of an individual developing cancer over a lifetime and is expressed as the ILCR. In the low-dose range, which would be expected for most environmental exposures, cancer risk is estimated from the following linear equation (EPA, 1989a):

$$ILCR = (CDI)(SF) \qquad \text{Eq. 5.1}$$

where:

ILCR	=	incremental lifetime cancer risk, a unitless expression of the probability of developing cancer, adjusted for background incidence, calculated
CDI	=	chronic daily intake, averaged over 70 years (mg/kg-day)
SF	=	cancer slope factor (per mg/kg-day)$^{-1}$.

The CDI term in Equation 5.1 is equivalent to the "I" or "DAD" terms (intake or dose) in Equations 3.6, 3.7, 3.8, and 3.13, when these equations are evaluated for cancer intakes.

The use of Equation 5.1 assumes that chemical carcinogenesis does not exhibit a threshold and that the dose-response relationship is linear in the low-dose range. Because this equation could generate theoretical cancer risks greater than 1 for high dose levels, it is considered to be inaccurate at cancer risks greater than 1E-2. In these cases, cancer risk is estimated by the one-hit model:

$$ILCR = 1 - e^{[-(CDI)(SF)]} \qquad \text{Eq. 5.2}$$

where:

ILCR = incremental lifetime cancer risk, a unitless expression of the probability of developing cancer, adjusted for background incidence, calculated
$e^{(-CDI)(SF)}$ = the exponential of the negative of the risk calculated using Equation 5.1.

As a matter of policy, EPA (1986) considers the carcinogenic potency of simultaneous exposure to low doses of carcinogenic chemicals to be additive, regardless of the chemical's mechanisms of toxicity or sites (organs of the body) of action. Cancer risk arising from simultaneous exposure by a given pathway to multiple chemicals is estimated from the following equation:

$$ILCR_p = ILCR_{(chem\ 1)} + ILCR_{(chem\ 2)} + \cdots ILCR_{(chem\ i)} \qquad \text{Eq. 5.3}$$

where:

$ILCR_p$ = total pathway incremental lifetime cancer risk, calculated
$ILCR(chem_i)$ = individual chemical cancer risk.

Cancer risk for a given receptor across pathways and across media is summed in the same manner. The sum of the ILCRs summed across pathways is the total ILCR as shown in the equation below:

$$Total\ ILCR = ILCR_{(p\ 1)} + ILCR_{(p\ 2)} + \cdots ILCR_{(p\ i)} \qquad \text{Eq. 5.4}$$

where:

Total ILCR = total incremental lifetime cancer risk across all pathways
$ILCR_{pi}$ = incremental lifetime cancer risks associate with pathway "*i.*"

The total ILCR represents all additional cancer risks posed to a given receptor by contact with contaminants in site environmental media.

Total ILCRs in the range of 1E-6 to 1E-4 are regarded as acceptable (EPA, 1990); as mentioned in Section 2.2.1, this range referred to as the "NCP risk management range." Risks less than this range are regarded as negligible. A target cancer risk criterion of 1E-5 is used by OEPA and is used in this BHHRA. Use of this 1E-5 criterion represents a departure from Army policy, which prescribes a cancer risk value of 1E-4 (the upper end of the NCP risk management range) to trigger remedial action concerns.

5.2 Noncancer Effects of Chemicals

The hazards associated with noncancer effects of chemicals are evaluated by comparing an exposure level or intake with an RfD. The HQ, defined as the ratio of intake to RfD, is estimated as follows (EPA, 1989a):

$$HQ = I \ / \ RfD \qquad \text{Eq. 5.5}$$

where:

HQ = hazard quotient (unitless, calculated)
I = intake of chemical averaged over subchronic or chronic exposure period (mg/kg-day)
RfD = reference dose (mg/kg-day).

The I term in Equation 5.5 is equivalent to the "I" or "DAD" terms (intake or dose) in Equations 3.6, 3.7, 3.8, and 3.13, when these equations are evaluated for noncancer intakes.

As shown above, both the "I" and the RfD are in units of mg/kg-day. The RfD has been developed to represent a dose rate unlikely to result in any adverse noncancer health effects, even to the most susceptible members of the population. Therefore, if the "I" is equal to or less than the RfD (i.e., $HQ \leq 1$), adverse noncancer health effects are unlikely. HQ values exceeding 1 do not indicate that noncancer hazard is likely to occur, but rather that the occurrence of an adverse noncancer health effect cannot be termed "unlikely." The HQ does not define a particular risk level, nor can it be used to infer information regarding a dose-response curve. That is, an HQ of 0.01 does not imply a 1 in 100 chance of an adverse effect but indicates that the estimated intake is 100 times lower than the RfD. This approach is different from the probabilistic approach described in Section 5.1 to evaluate cancer risks.

In the case of simultaneous exposure of a receptor to several chemicals, an HI is calculated as the sum of the HQs as follows:

$$HI = I_1 / RfD_1 + I_2 / RfD_2 + ... I_i / RfD_i \qquad \text{Eq. 5.6}$$

where:

HI = hazard index (unitless, calculated)
I_i = intake for the ith toxicant
RfD_i = reference dose for the ith toxicant.

A total HI is calculated as the sum of all HI values for a given receptor. If the total HI for that receptor exceeds 1, individual HI values may be calculated for each target organ. A total target organ HI is calculated by summing the HI values (associated by target organ[s]), across exposure pathways as follows:

$$Total\ Target\ Organ\ HI_a = HI_{p1-a} + HI_{p2-a} + ...HI_{pi-a} \qquad \text{Eq. 5.7}$$

where:

Total target organ HI_a = total hazard index for target organ "*a*" (unitless, calculated)
HI_{pi-a} = hazard index for target organ "*a*" via pathway "*i.*"

HI values of 1 or less indicate that adverse noncancer health effects associated with that target organ of any individual under the exposure assumptions for that receptor are unlikely. If the total target organ HI exceeds a value of 1, then adverse noncancer health effects concerning that target organ and receptor cannot be regarded as unlikely.

6.0 Risk Characterization Results

The results of the risk characterization process described in Chapter 5.0 were applied to the COPCs identified in Section 2.2 for bedrock groundwater underlying each of the AOCs evaluated in this BHHRA, assuming both worker and residential use of groundwater as described in Chapter 3.0. Only the residential scenario is evaluated for downgradient bedrock groundwater. This is because future land use cannot be restricted off site, and the residential scenario is generally the most protective. These noncancer hazard and cancer risks results are discussed in the following sections and presented in the accompanying tables. Detailed spreadsheet calculations are provided in Appendix G. Note that the tables referenced in the text include 1) overall groundwater risks and 2) site-related groundwater risks that exclude COPCs which, based on the evaluation of site relatedness, are regarded as unlikely to be related to former site activities.

Overall groundwater risks for each AOC and the downgradient bedrock groundwater, including the noncancer and cancer risks associated with all COPCs, are discussed in detail in the subsections of Section 6.1. The risks associated with COPCs identified as site related are presented in the subsections of Section 6.2. Section 6.2 also identifies the bases for the inclusion of COPCs as site related and the exclusion of the other COPCs with respect to site relatedness. The detailed evaluation of site relatedness for each COPC is attached as Appendix H. Uncertainties associated with the determination of site relatedness are presented in Section 7.2.3. The site-related risk results presented in Section 6.2 should be evaluated only in light of the associated uncertainties of the site-relatedness selection process as described in the uncertainties analysis.

The target organ-specific tables included in the following discussions include only those target organs with an overall HI that exceeds the HI criterion of 1, as values of 1 or less are regarded as unlikely to result in adverse noncancer health effects (Section 5.2). Complete evaluations of all target organs and corresponding HI values are presented in Appendix G.

6.1 Overall Groundwater Risk Results

6.1.1 Overall TNTA Groundwater Risk Results

Site Worker. The total HI for worker exposure to TNTA bedrock groundwater is 10 (Table 6-1). HI values associated with two target organs exceed the target HI of 1 (Table 6-2), indicating that noncancer health effects cannot be regarded as unlikely to occur. These are the

nervous system/central nervous system (HI=5, or 4.9 prior to rounding) and blood/blood cells (HI=2, or 1.8 prior to rounding). With respect to the former, virtually all of the HI is associated with manganese (HQ=4.8), and benzene in groundwater is responsible for the entire blood/blood cell HI. Each of the other target organs have associated HQ values less than or equal to the target organ value of 1. Thus, manganese and benzene are the only two COPCs that may result in adverse noncancer health effects under the worker groundwater use scenario.

The total ILCR for worker exposure to TNTA groundwater is 3E-4 (2.6E-4 prior to rounding) (Table 6-1). This value exceeds the NCP risk management range of 1E-6 to 1E-4 and exceeds the OEPA target ILCR of 1E-5. Over half of the ILCR is associated with exposure to benzene (1.4E-4), and the ILCR associated solely with arsenic (9.1E-5) also exceeds the OEPA target criterion. Four other COPCs have individual ILCRs of 1E-6 or greater: methylene chloride (8.8E-6), 2,6-DNT (8.7E-6), chrysene (2.7E-6), and 2,4-DNT (1.2E-6).

On-Site Resident Child. The total HI for exposure of a hypothetical child resident to TNTA bedrock groundwater, based on current concentrations, is 347 (Table 6-3). HI values associated with 13 target organs (nervous system/central nervous system [NS/CNS], skin, peripheral vascular system [PVS], gastrointestinal system, respiratory tract, iron overload, kidney, erythrocyte, eye, body weight/organ weight [BW/OW], nasal and olfactory epithelia [NOE], blood/blood cells [other than the erythrocyte], and liver) exceed the target HI criterion of 1 (Table 6-4). These target organ HI exceedances of 1 indicate that adverse noncancer health effects cannot be regarded as unlikely to occur. Nearly 70 percent of the total HI is associated with 2-methylnaphthalene (HQ=176) and naphthalene (HQ=64), almost entirely via inhalation. Other COPCs with prominent HQ values exceeding a value of 1 include benzene (HQ=38), manganese (HQ=31), and xylenes (HQ=16). Several other COPCs (arsenic, iron, vanadium, and toluene) have HQ values exceeding the HI target value of 1, as shown in Table 6-3.

On-Site Resident Adult. The total HI for exposure of a hypothetical adult resident to TNTA bedrock groundwater, based on current concentrations, is 149 (Table 6-5). HI values associated with nine target organs (NS/CNS, skin, PVS, NOE, iron overload, kidney, erythrocyte, BW/OW, and blood/blood cells) exceed the target HI of 1 (Table 6-6). These target organ-specific HI values indicate that adverse noncancer health effects cannot be regarded as unlikely to occur. Nearly 70 percent of the total HI is associated with 2-methylnaphthalene (HQ=76) and naphthalene (HQ=27), almost entirely via inhalation. Other COPCs with prominent HQ values include benzene (HQ=16), manganese (HQ=13), and xylenes (HQ=7). Other COPCs having HQ values exceeding the HI target value of 1 are arsenic (HQ=2) and iron (HQ=3) (Table 6-5).

On-Site Child/Adult Resident. The total ILCR for child/adult exposure to TNTA bedrock groundwater is 3E-3 (2.5E-3 prior to rounding) (Table 6-7). This value exceeds the NCP risk management range of 1E-6 to 1E-4 and the OEPA target ILCR of 1E-5. Approximately 80 percent of the ILCR is associated with exposure to benzene (2.0E-3), and 70 percent of the benzene ILCR is associated with the inhalation pathway. The individual ILCRs of methylene chloride (7.7E-5) and 2,6-DNT (3.7E-5) exceed the OEPA target ILCR, and the ILCR values of four other COPCs (chrysene [1.4E-5], 2,4-DNT [5.2E-6], bis[2-ethylhexyl]phthalate [BEHP] [3.3E-6], and 2-nitrotoluene [1.1E-6]) have individual ILCRs of 1E-6 or greater.

6.1.2 Overall TNTB Groundwater Risk Results

Site Worker. The total HI for worker exposure to TNTB bedrock groundwater is 2 (Table 6-8). However, none of the HI values associated with the target organs exceed 1, indicating that adverse noncancer health effects are unlikely to occur under the worker groundwater use scenario.

The total ILCR for worker exposure to TNTB bedrock groundwater is 7E-5 (7.1E-5 prior to rounding) (Table 6-8). This value is within the NCP risk management range of 1E-6 to 1E-4 but exceeds the OEPA target ILCR of 1E-5. Approximately 95 percent of the ILCR is associated with exposure to arsenic (6.8E-5). The only other TNTB carcinogenic COPC is benzene, with an ILCR (3.5E-6) that is within the NCP risk management range and less than the OEPA target value.

On-Site Resident Child. The total HI for exposure of a hypothetical child resident to TNTB bedrock groundwater, based on current concentrations, is 18 (Table 6-9). HI values associated with six target organs (NS/CNS, skin, PVS, iron overload, kidney, and NOE) exceed the target HI of 1 (Table 6-10). These target organ HI exceedances of 1 indicate that adverse noncancer health effects cannot be regarded as unlikely to occur. Five COPCs have HQ values exceeding the target HI value of 1: arsenic (HQ=2.8), iron (HQ=5.5), manganese (HQ=2.1), vanadium (1.7), and 2-methylnaphthalene (HQ=1.8).

On-Site Resident Adult. The total HI for exposure of a hypothetical adult resident to TNTB bedrock groundwater, based on current concentrations, is 8 (7.5, prior to rounding) (Table 6-11). However, the only target organ exceeding the target HI value of 1 is iron overload (HI = 2 [2.3 prior to rounding]) (Table 6-12). This target organ-specific HI value indicates that noncancer

health effects cannot be regarded as unlikely to occur. It is noted, however, that the exceedance of the target HI value is marginal. This exceedance is associated entirely with the presence of iron.

On-Site Child/Adult Resident. The total ILCR for child/adult exposure to TNTB bedrock groundwater is 3E-4 (3.4E-4 prior to rounding) (Table 6-13). This value exceeds the NCP risk management range of 1E-6 to 1E-4 and exceeds the OEPA target ILCR of 1E-5. Over 85 percent of this ILCR is associated with exposure to arsenic (2.9E-4). The only other TNTB carcinogenic COPC is benzene (4.9E-5).

6.1.3 Overall TNTC Groundwater Risk Results

Site Worker. The total HI for worker exposure to TNTC groundwater is 1 (1.4. prior to rounding (Table 6-14), most of which is associated with benzene (HQ=1.1). Because this value does not exceed the OEPA target HI, it is unlikely that exposure under the worker scenario would result in adverse noncancer health effects.

The total ILCR for worker exposure to TNTC bedrock groundwater is 9E-5 (9.4E-5 prior to rounding) (Table 6-14). This value is within the NCP risk management range of 1E-6 to 1E-4 but exceeds the OEPA target ILCR of 1E-5. Approximately 90 percent of the ILCR is associated with exposure to benzene (8.5E-5). The only other TNTC carcinogenic COPCs are the common laboratory contaminants BEHP (4.7E-6) and methylene chloride (4.3E-6), both with ILCR values that are within the NCP risk management range and less than the OEPA target value.

On-Site Resident Child. The total HI for exposure of a hypothetical child resident to TNTC bedrock groundwater, based on current concentrations, is 65 (Table 6-15). HI values associated with three target organs (NS/CNS, NOE, and blood/blood cells) exceed the target HI of 1 (Table 6-16). These target organ HI exceedances indicate that adverse noncancer health effects cannot be regarded as unlikely to occur. Five COPCs have HQ values exceeding the target HI value of 1: benzene (22), xylenes (HQ=15), naphthalene (HQ=13), 2-methylnaphthalene (HQ=10), and bromomethane (HQ=3.6). Over 85 percent of the total HI is associated with the inhalation pathway.

On-Site Resident Adult. The total HI for exposure of a hypothetical adult resident to TNTC bedrock groundwater, based on current concentrations, is 28 (Table 6-17). HI values associated with three target organs (NS/CNS, NOE, and blood/blood cells) exceed the target HI of 1 (Table

6-18). These target organ HI exceedances of 1 indicate that adverse noncancer health effects cannot be regarded as unlikely to occur. Five COPCs have HQ values exceeding the target HI value of 1: benzene (HQ=9.5), xylenes (HQ=6.4), naphthalene (HQ=5.5), 2-methylnaphthalene (HQ=4.3), and bromomethane (HQ=1.5). Over 85 percent of the total HI is associated with the inhalation pathway.

On-Site Child/Adult Resident. The total ILCR for child/adult exposure to TNTC bedrock groundwater is 1E-3 (1.2E-3 prior to rounding) (Table 6-19). This value exceeds the NCP risk management range of 1E-6 to 1E-4 and exceeds the OEPA target ILCR of 1E-5. Approximately 95 percent of the ILCR is associated with exposure to benzene (1.2E-3). The only other TNTC carcinogenic COPCs are the common laboratory contaminants methylene chloride (3.7E-5) and BEHP (2.2E-5), both of which have ILCRs exceeding the OEPA target ILCR.

6.1.4 Overall PRRWP Area Groundwater Risk Results

Site Worker. The total HI for worker exposure to PRRWP Area bedrock groundwater is 15 (Table 6-20). HI values associated with three target organs (skin, blood/blood cells, and liver) exceed the target HI of 1 (Table 6-21). These target organ HI exceedances indicate that noncancer health effects cannot be regarded as unlikely to occur. Two COPCs (thallium [HQ=7.7] and benzene [HQ=6.6]) have HQ values exceeding the target HI value of 1.

The total ILCR for worker exposure to PRRWP Area bedrock groundwater is 5E-4 (5.3E-4, prior to rounding) (Table 6-20). This value exceeds both the NCP risk management range of 1E-6 to 1E-4 and the OEPA target ILCR of 1E-5. Approximately 98 percent of the ILCR is associated with exposure to benzene (5.2E-4). The other PRRWP Area carcinogenic COPCs with ILCR values within the NCP risk management range are 2,4-DNT (2.2E-6), 2,6-DNT (2.2E-6), 1,1,2-trichloroethane (1.0E-6) and the common laboratory contaminants methylene chloride (4.3E-6) and BEHP (3.2E-6); each of these values is less than the OEPA target ILCR range.

On-Site Resident Child. The total HI for exposure of a hypothetical child resident to PRRWP Area bedrock groundwater, based on current concentrations, is 235 (Table 6-22). HI values associated with eight target organs (NS/CNS, skin, gastrointestinal system, respiratory tract, iron overload, NOE, blood/blood cells, and liver) exceed the target HI of 1 (Table 6-23). These target organ HI exceedances of 1 indicate that noncancer health effects cannot be regarded as unlikely to occur. Eight COPCs have HQ values exceeding the target HI value of 1: benzene

(HQ=134), thallium (HQ=50), xylenes (HQ=16), 2-methylnaphthalene (HQ=13), naphthalene (HQ=11), manganese (HQ=3.1), toluene (3.1), and iron (1.6).

On-Site Resident Adult. The total HI for exposure of a hypothetical adult resident to PRRWP Area bedrock groundwater, based on current concentrations, is 101 (Table 6-24). HI values associated with five target organs (NS/CNS, skin, NOE, blood/blood cells, and liver) exceed the target HI of 1 (Table 6-25). These target organ HI exceedances of 1 indicate that noncancer health effects cannot be regarded as unlikely to occur. Five COPCs have HQ values exceeding the target HI value of 1: benzene (HQ=58), thallium (HQ=21), xylenes (HQ=6.8), 2-methylnaphthalene (HQ=5.6), and naphthalene (HQ=4.8).

On-Site Child/Adult Resident. The total ILCR for child/adult exposure to PRRWP Area bedrock groundwater is 7E-3 (7.3E-3 prior to rounding) (Table 6-26). This value exceeds the NCP risk management range of 1E-6 to 1E-4 and exceeds the OEPA target ILCR of 1E-5. Approximately 99 percent of the ILCR is associated with exposure to benzene (7.2E-3). The other PRRWP Area carcinogenic COPCs are 1,1,2-trichloroethane (2.5E-5), 2,4-DNT (9.3E-6), 2,6-DNT (9.2E-6), and the common laboratory contaminants methylene chloride (3.7E-5) and BEHP (1.5E-5), both of which have ILCRs exceeding the OEPA target ILCR.

6.1.5 Overall WARWP Area Groundwater Risk Results

Site Worker. The total HI for worker exposure to WARWP Area bedrock groundwater is 9 (Table 6-27). HI values associated with two target organs (erythrocytes and cellular respiration) exceed the target HI of 1 (Table 6-28). These target organ HI exceedances of 1 indicate that adverse noncancer health effects cannot be regarded as unlikely to occur. Two COPCs (3-nitroaniline [HQ=5.0] and 4,6-dinitro-2-methylphenol [HQ=2.8]), have HQ values exceeding the target HI criterion of 1.

The total ILCR for worker exposure to WARWP Area bedrock groundwater is 1E-4 (1.1E-4, prior to rounding) (Table 6-27). This value equals the upper end of the NCP risk management range and exceeds the OEPA target ILCR of 1E-5. Virtually all of this ILCR is associate with the three COPC having ILCRs within the NCP risk management range: arsenic (5E-5), 2,4-DNT (4.7E-5), and 3-nitroaniline (1.1E-5).

On-Site Resident Child. The total HI for exposure of a hypothetical child resident to WARWP Area bedrock groundwater, based on current concentrations, is 63 (Table 6-29). HI

values associated with six target organs (skin, PVS, kidney, erythrocyte, cellular respiration, and liver) exceed the target HI of 1 (Table 6-30). These target organ HI exceedances indicate that adverse noncancer health effects cannot be regarded as unlikely to occur. Five COPCs have HQ values exceeding the target HI value of 1: 3-nitroaniline (HQ=33), 4,6-dinitro-2-methylphenol (HQ=18), nitrobenzene (HQ=4.0), nitrate (HQ=3.2), and arsenic (HQ=2.0).

On-Site Resident Adult. The total HI for exposure of a hypothetical adult resident to WARWP Area bedrock groundwater, based on current concentrations, is 27 (Table 6-31). HI values associated with four target organs (kidney, erythrocyte, cellular respiration, and liver) exceed the target HI of 1 (Table 6-32). These target organ HI exceedances indicate that adverse noncancer health effects cannot be regarded as unlikely to occur. Three COPCs have HQ values exceeding the target HI value of 1: 3-nitroaniline (HQ=14), 4,6-dinitro-2-methylphenol (HQ=7.8), and nitrobenzene (HQ=1.7).

On-Site Child/Adult Resident. The total ILCR for child/adult exposure to WARWP Area bedrock groundwater is 5E-4 (4.6E-4 prior to rounding) (Table 6-33). This value exceeds the NCP risk management range of 1E-6 to 1E-4 and the OEPA target ILCR of 1E-5. Over 99 percent of the ILCR is attributed to arsenic (2.1E-4), 2,4-DNT (2.0E-4), and 3-nitroaniline (4.8E-5); benzene contributes a relatively minor ILCR (3.1E-6).

6.1.6 Overall Downgradient Areas Groundwater Risk Results

Because restrictions against residential land use cannot be considered outside the PBOW facility, only the residential scenario, which is more conservative, is evaluated for risk at downgradient locations.

Resident Child. The total HI for exposure of a hypothetical child resident to downgradient bedrock groundwater, based on current concentrations, is 100 (Table 6-34). HI values associated with four target organs (NS/CNS, iron overload, NOE, and blood/blood cells) exceed the target HI of 1 (Table 6-35). These target organ HI exceedances indicate that adverse noncancer health effects cannot be regarded as unlikely to occur. Six COPCs have HQ values exceeding the target HI value of 1: iron (HQ=55), manganese (HQ=12), 2-methylnaphthalene (HQ=9.0), benzene (HQ=7.0), naphthalene (6.7), and xylenes (HQ=6.4).

Resident Adult. The total HI for exposure of a hypothetical adult resident to downgradient bedrock groundwater, based on current concentrations, is 43 (Table 6-36). HI values associated with four target organs (NS/CNS, iron overload, NOE, and blood/blood cells) exceed the target

HI of 1 (Table 6-37). These target organ HI exceedances indicate that adverse noncancer health effects cannot be regarded as unlikely to occur. Six COPCs have HQ values exceeding the target HI value of 1: iron (HQ=24), manganese (HQ=5.3), 2-methylnaphthalene (HQ=3.9), benzene (HQ=3.0), naphthalene (HQ=2.9), and xylenes (HQ=2.7).

Child/Adult Resident. The total ILCR for child/adult exposure to downgradient bedrock groundwater is 4E-4 (4.3E-4 prior to rounding) (Table 6-38). This value exceeds the NCP risk management range of 1E-6 to 1E-4 and the OEPA target ILCR of 1E-5. Over 85 percent of the ILCR is associated with exposure to benzene (3.7E-4). Other carcinogenic COPCs that contribute to the overall ILCR are 2,4-DNT (1.6E-5), 2,6-DNT (1.5E-5), 2-nitroaniline (2.0E-6), and the two common laboratory contaminants methylene chloride (2.3E-5) and BEHP (3.9E-6).

6.2 Site-Related Groundwater Risk Results

The following subsections describe the risk characterization results for the COPCs that were identified as site related based on the evaluation performed in Appendix H. A synopsis of this evaluation is provided in Table 6-39. As described in Appendix H, a variety of lines of evidence, combined with best professional judgment, was used in the inclusion and exclusion of COPCs as site related. These lines of evidence for determination of site relatedness and non-site relatedness include the following:

- Sampling method artifacts (e.g., high total metals concentrations among certain samples, associated with high turbidity, that had to be collected using a bailer)
- Statistical evaluation with background data set
- Association with naturally occurring petroleum
- Infrequent, low detections among combined site groundwater samples that were not found in other media
- Evidence of laboratory artifact
- Site history indicating absence/presence.

In many cases, multiple lines of evidence were used in the determination of whether or not a given COPC was identified as site related. For instance, no COPC was identified as non-site related simply because site history did not indicate that it was used or produced at the site. Instead, the other lines of evidence also were used to determine whether such a COPC should truly be regarded as site related. Although the goal was to reach a reasonable determination as to

whether a given COPC should be regarded as site related, effort was made to err on the side of inclusion rather than exclusion. Because of the uncertainties involved, the results described below should be viewed with reference to the uncertainties discussed in Section 7.2.3 and the specific determinations made in Appendix H.

6.2.1 Site-Related TNTA Groundwater Risk Results

Site Worker. The total site-related HI for worker exposure to TNTA bedrock groundwater is 0.2 (Table 6-1), which is less than the target value of 1. This indicates that adverse noncancer health effects are unlikely to result from worker exposure to site-related COPCs in TNTA bedrock groundwater.

The total site-related ILCR for worker exposure to TNTA bedrock groundwater is 1E-5 (Table 6-1). This value is within the NCP risk management range of 1E-6 to 1E-4 and equals the OEPA target ILCR of 1E-5. Virtually all of this ILCR is associated with 2,6-DNT (8.7E-6) and 2,4-DNT (1.2E-6).

On-Site Resident Child. The total site-related HI for exposure of a hypothetical child resident to TNTA bedrock groundwater, based on current concentrations, is 2 (Table 6-3). HI values associated with three target organs (kidney, erythrocyte, and liver) exceed the target HI of 1 (Table 6-4). For each target organ, nitrobenzene (HQ=1.4) is the primary contributor.

On-Site Resident Adult. The total site-related HI for exposure of a hypothetical adult resident to TNTA bedrock groundwater, based on current concentrations, is equal to the target HI criterion of 1 (Table 6-5). This indicates that exposure by an adult resident to site-related COPCs in groundwater used as drinking water is unlikely to result in adverse noncancer health effects.

On-Site Child/Adult Resident. The total site-related ILCR for child/adult exposure to TNTA bedrock groundwater is 4E-5 (4.4E-5, prior to rounding) (Table 6-7). This value is within the NCP risk management range of 1E-6 to 1E-4 but exceeds the OEPA target ILCR of 1E-5. This ILCR is associated with 2,6-DNT (3.7E-5), 2,4-DNT (5.1E-6), and 2-nitrotoluene (1.1E-6).

6.2.2 Site-Related TNTB Groundwater Risk Results

None of the TNTB bedrock groundwater COPCs were identified as site related.

6.2.3 Site-Related TNTC Groundwater Risk Results

None of the TNTC bedrock groundwater COPCs were identified as site related.

6.2.4 Site-Related PRRWP Area Groundwater Risk Results

Site Worker. The total site-related HI for worker exposure to PRRWP Area bedrock groundwater is 0.07 (Table 6-20). Because this value is less than the target HI criterion of 1, adverse noncancer health effects associated with exposure to site-related COPCs are unlikely.

The total site-related ILCR for worker exposure to PRRWP Area bedrock groundwater is 4E-6 (4.3E-6 prior to rounding) (Table 6-20). This value is within the NCP risk management range of 1E-6 to 1E-4 and is less than the OEPA target ILCR of 1E-5. This site-related ILCR is associated exclusively with the DNT isomers.

On-Site Resident Child. The total site-related HI for exposure of a hypothetical child resident to PRRWP Area bedrock groundwater, based on current concentrations, is 0.6 (Table 6-22). Because this value is less than the target HI criterion of 1, adverse noncancer health effects associated with exposure to site-related COPCs are unlikely.

On-Site Resident Adult. The total site-related HI for exposure of a hypothetical adult resident to PRRWP Area bedrock groundwater, based on current concentrations, is 0.3 (Table 6-24). This value is less than the target HI criterion, which indicates that adverse noncancer health effects are regarded as unlikely to occur as the result of adult residential exposure to site-related COPCs in PRRWP Area bedrock groundwater.

On-Site Child/Adult Resident. The total site-related ILCR for child/adult exposure to PRRWP Area bedrock groundwater is 2E-5 (1.9E-5 prior to rounding) (Table 6-26). This value is near the midpoint of the NCP risk management range of 1E-6 to 1E-4 but exceeds the OEPA target ILCR of 1E-5. This site-related ILCR is associated entirely with 2,4-DNT (9.3E-5) and 2,6-DNT (9.2E-5).

6.2.5 Site-Related WARWP Area Groundwater Risk Results

Site Worker. The total site-related HI for worker exposure to WARWP Area bedrock groundwater is 9 (Table 6-27). HI values associated with two target organs (erythrocytes and cellular respiration) exceed the target HI of 1 (Table 6-28). These target organ HI exceedances

of 1 indicate that adverse noncancer health effects cannot be regarded as unlikely to occur. Two site-related COPCs have HQ values exceeding the target HI value of 1: 3-nitroaniline (HQ=5.0) and 4,6-dinitro-2-methylphenol (HQ=2.8).

The total site-related ILCR for worker exposure to WARWP Area bedrock groundwater is 6E-5 (5.8E-5 prior to rounding) (Table 6-27). This is within the NCP risk management range but exceeds the OEPA target ILCR of 1E-5. Virtually all of this ILCR is associated with 2,4-DNT (4.7E-5) and 3-nitroaniline (1.1E-5).

On-Site Resident Child. The total site-related HI for exposure of a hypothetical child resident to WARWP Area bedrock groundwater, based on current concentrations, is 61 (Table 6-29). HI values associated with four target organs (kidney, erythrocyte, cellular respiration, and liver) exceed the target HI of 1 (Table 6-30). These target organ HI exceedances indicate that adverse noncancer health effects associated with site-related COPCs cannot be regarded as unlikely to occur under the residential child exposure scenario. Four site-related COPCs have HQ values exceeding the target HI value of 1: 3-nitroaniline (HQ=33), 4,6-dinitro-2-methylphenol (HQ=18), nitrobenzene (HQ=4.0), and nitrate (HQ=3.2).

On-Site Resident Adult. The total site-related HI for exposure of a hypothetical adult resident to WARWP Area bedrock groundwater, based on current concentrations, is 26 (Table 6-31). HI values associated with four target organs (kidney, erythrocyte, cellular respiration, and liver) exceed the target HI of 1 (Table 6-32). These target organ HI exceedances of 1 indicate that adverse noncancer health effects cannot be regarded as unlikely to occur as the result of exposure to site-related COPCs under the residential adult exposure scenario. Three site-related COPCs have HQ values exceeding the target HI value of 1: 3-nitroaniline (HQ=14), 4,6-dinitro-2-methylphenol (HQ=7.8), and nitrobenzene (HQ=1.7).

On-Site Child/Adult Resident. The total site-related ILCR for child/adult exposure to WARWP Area bedrock groundwater is 2E-4 (Table 6-33). This value exceeds the NCP risk management range of 1E-6 to 1E-4 and exceeds the OEPA target ILCR of 1E-5. All of this ILCR is attributed to 2,4-DNT (2E-4) and 3-nitroaniline (4.8E-5).

6.2.6 Site-Related Downgradient Areas Groundwater Risk Results

Because restrictions against residential land use cannot be considered outside the PBOW facility, only the resident is evaluated for risk at downgradient locations.

Resident Child. The total site-related HI for exposure of a hypothetical child resident to off-site boundary bedrock groundwater, based on current concentrations, is 0.4 (Table 6-34). Because this value is less than the target HI criterion of 1, adverse noncancer health effects associated with residential child exposure to site-related COPCs are unlikely.

Resident Adult. The total site-related HI for exposure of a hypothetical adult resident to off-site boundary bedrock groundwater, based on current concentrations, is 0.2 (Table 6-36). Because this value is less than the target HI criterion of 1, adverse noncancer health effects associated with residential adult exposure to site-related COPCs are unlikely.

Child/Adult Resident. The total site-related ILCR for child/adult exposure to off-site boundary downgradient bedrock groundwater is 3E-5 (3.2E-5, prior to rounding) (Table 6-38). This value is within the NCP risk management range of 1E-6 to 1E-4 but exceeds the OEPA target ILCR of 1E-5. Approximately 95 percent of the site-related ILCR is associated with exposure to the DNT isomers (3.0E-5 combined), with 2-nitrotoluene (2.0E-6) also contributing to risk.

6.3 Modeled Future Groundwater Risk Results

Potential future concentrations of 2,4-DNT, 2,6-DNT, and TNT were modeled, based on soil and overburden groundwater concentrations, as discussed in Section 3.2.4 and presented in Appendix E. Each model run for 2,4-DNT, 2,6-DNT, and TNT simulated contaminant migration from the soil into groundwater over a 150-year period. The risks associated with the maximum modeled concentrations were estimated for each of the five AOCs and each of three downgradient locations. These downgradient locations were selected based on groundwater flow and apparent impact from the five AOCs. It was determined that the downgradient flow from TNTB, TNTC, and the PRRWP Area would meet at approximately the same area along the northern facility boundary. Separate areas of potential areas of downgradient effect were identified along the downgradient boundary for TNTA and the WARWP.

Because the relationship of cancer risk and noncancer hazard of a given chemical is linear with concentration, ILCRs and HIs were estimated for the modeled concentrations using the following respective equations:

$$ILCR_{m\text{-}a} = ILCR_{c\text{-}a} \times C_{m\text{-}a}/C_{c\text{-}a} \qquad \text{Eq. 6.1}$$

where:

$ILCR_{m-a}$ = incremental lifetime cancer risk of the modeled concentration for chemical "a"
$ILCR_{c-a}$ = incremental lifetime cancer risk of the EPC for chemical "a" (presented in Sections 6.1 and 6.2)
C_{m-a} = modeled concentration of chemical "a" (mg/L)
$C_{c=a}$ = EPC of chemical "a" (mg/L) (presented in Section 2.3).

$$HI_{m-a} = ILCR_{c-a} \times C_{m-a}/C_{c-a} \qquad \text{Eq. 6.2}$$

where:

HI_{m-a} = hazard index of the modeled concentration for chemical "a"
HI_{c-a} = hazard index of the EPC for chemical "a" (presented in Sections 6.1 and 6.2)
C_{m-a} = modeled concentration of chemical "a" (mg/L)
$C_{c=a}$ = EPC of chemical "a" (mg/L) (presented in Section 2.3).

The relationship between the $ILCR_{m-a}$ (or HI_{m-a}) with the C_{m-a} is consistent throughout the five AOCs. Thus, the $ILCR_{c-a}$ and C_{c-a} for the TNTA site worker, for example, may be used with the C_{m-a} for the PRRWP in Equation 6.1 to derive the $ILCR_{m-a}$ for the site worker at the PRRWP. TNT was not identified as a COPC for any of the five AOCs or downgradient locations, but it is modeled based on its identification as a chemical of concern (COC) in soil for the TNT areas and the PRRWP Area (IT, 2001c, 2002; Shaw, 2003b). However, the TNT ILCR and HI values for the PRRWP receptors were derived in Appendix G for the UCL value. These values were used in Equations 6.1 and 6.2, along with the model output for each of the site areas and downgradient locations, to estimate future cancer risks and noncancer hazards, respectively.

The resulting cancer risks and noncancer hazards associated with the modeled concentrations are described for each receptor in the following subsections. The modeled risks for each of the five AOCs and the three downgradient boundary areas are based on the year in which the combined modeled concentration of these three nitroaromatics is expected to be at a maximum in that AOC or at that downgradient location. The year selected for each location is identified below.

6.3.1 Modeled TNTA Groundwater Risk Results

The model for TNTA assumes that no soil remediation has occurred, even though remediation for direct contact is planned for TNTA (USACE, 2004a). Concentrations used in the evaluation of future risk are based on year 130 of the model run; after year 130, the combined concentrations of these three nitroaromatics begin to decrease. Based on the model results, the

nitroaromatic contaminants in overburden groundwater would contribute much more heavily to future bedrock groundwater concentrations than would those in soil via leaching.

Site Worker. The total HI for worker exposure to modeled TNTA bedrock groundwater is 0.5 (Table 6-40), which is less than the target value of 1. This indicates that adverse noncancer health effects are unlikely to result from worker exposure to modeled nitroaromatic concentrations in TNTA bedrock groundwater.

The total ILCR for worker exposure to modeled TNTA bedrock groundwater is 1E-4 (Table 6-40). This value equals the upper bound of the NCP risk management range of 1E-6 to 1E-4 and exceeds the OEPA target ILCR of 1E-5. Virtually all of this ILCR is associated with 2,6-DNT (9.8E-5) and 2,4-DNT (2.3E-5).

On-Site Resident Child. The total HI for exposure of a hypothetical child resident to modeled TNTA bedrock groundwater, based on current concentrations, is 4 (Table 6-40). This value indicates the potential for adverse noncancer health effects in the TNTA resident child.

On-Site Resident Adult. The total HI for exposure of a hypothetical adult resident to modeled TNTA bedrock groundwater, based on current concentrations, is 2 (1.5. prior to rounding) (Table 6-40). This marginally exceeds the HI criterion of 1. Because these concentrations would not last through a duration of greater than about 5 years, it is considered unlikely that adverse noncancer health effects would be associated with the modeled concentrations, based only on adult exposure.

On-Site Child/Adult Resident. The total site-related ILCR for child/adult exposure to modeled TNTA bedrock groundwater is 5E-4 (Table 6-40). This exceeds the NCP risk management range of 1E-6 to 1E-4 as well as the OEPA target ILCR of 1E-5. This ILCR is associated primarily with 2,6-DNT (4.2E-4) and 2,4-DNT (9.8E-5).

6.3.2 Modeled TNTB Groundwater Risk Results

The model for TNTB assumes that soil remediation has occurred, as described in the TNTB soil remediation report (WasteTron, Inc. [WTI], 2005a). Concentrations used in the evaluation of future risk are based on year 130 of the model run; after year 130, the combined concentrations of these three nitroaromatics begin to decrease. Based on the model results, the nitroaromatic contaminants in overburden groundwater would contribute much more heavily to future bedrock groundwater concentrations than would those in soil via leaching.

Site Worker. The total HI for worker exposure to modeled TNTB bedrock groundwater is 0.02 (Table 6-41), which is less than the target value of 1. This indicates that adverse noncancer health effects are unlikely to result from worker exposure to modeled nitroaromatic concentrations in TNTB bedrock groundwater.

The total ILCR for worker exposure to modeled TNTB bedrock groundwater is 6E-6 (Table 6-41). This value is within the NCP risk management range of 1E-6 to 1E-4 and is less than OEPA target ILCR of 1E-5.

On-Site Resident Child. The total HI for exposure of a hypothetical child resident to modeled TNTB bedrock groundwater, based on current concentrations, is 0.l (Table 6-41). This indicates that adverse noncancer health effects are unlikely to result from childhood exposure to modeled nitroaromatic concentrations in TNTB bedrock groundwater.

On-Site Resident Adult. The total HI for exposure of a hypothetical adult resident to modeled TNTB bedrock groundwater, based on current concentrations, is 0.05 (Table 6-41). This indicates that adverse noncancer health effects are unlikely to result from adult resident exposure to modeled nitroaromatic concentrations in TNTB bedrock groundwater.

On-Site Child/Adult Resident. The total site-related ILCR for child/adult exposure to modeled TNTB bedrock groundwater is 2E-5 (2.5E-5 prior to rounding) (Table 6-41). This is within the NCP risk management range of 1E-6 to 1E-4 but exceeds the OEPA target ILCR of 1E-5. This ILCR is associated primarily with 2,4-DNT (1.4E-5) and 2,6-DNT (1.1E-5).

6.3.3 Modeled TNTC Groundwater Risk Results

The model for TNTC assumes that no soil remediation has occurred, even though remediation for direct contact is planned for TNTC (USACE, 2004b). Concentrations used in the evaluation of future risk are based on year 145 of the model run; after year 145, the combined concentrations of these three nitroaromatics begin to decrease. Based on the model results, the nitroaromatic contaminants in overburden groundwater would contribute much more heavily to future bedrock groundwater concentrations than would those in soil via leaching.

Site Worker. The total HI for worker exposure to modeled TNTC bedrock groundwater is 1 (1.3 prior to rounding) (Table 6-42), which equals the target value of 1. This indicates that

adverse noncancer health effects are unlikely to result from worker exposure to modeled nitroaromatic concentrations in TNTC bedrock groundwater.

The total ILCR for worker exposure to modeled TNTC bedrock groundwater is 4E-4 (Table 6-42). This value exceeds the NCP risk management range of 1E-6 to 1E-4 and the OEPA target ILCR of 1E-5. Virtually all of this ILCR is associated with 2,4-DNT (2.1E-4) and 2,6-DNT (1.5E-4).

On-Site Resident Child. The total HI for exposure of a hypothetical child resident to modeled TNTC bedrock groundwater, based on current concentrations, is 8 (Table 6-42). This value indicates the potential for adverse noncancer health effects in the TNTA resident child.

On-Site Resident Adult. The total HI for exposure of a hypothetical adult resident to modeled TNTC bedrock groundwater, based on current concentrations, is 4 (Table 6-42). This marginally exceeds the HI criterion of 1, indicating that the potential for adverse noncancer health effects in the TNTC resident child cannot be regarded as unlikely.

On-Site Child/Adult Resident. The total site-related ILCR for child/adult exposure to modeled TNTC bedrock groundwater is 2E-3 (Table 6-42). This exceeds the NCP risk management range of 1E-6 to 1E-4 as well as the OEPA target ILCR of 1E-5. This ILCR is associated primarily with 2,4-DNT (9.1E-4) and 2,6-DNT (6.3E-4).

6.3.4 Modeled PRRWP Area Groundwater Risk Results

The model for the PRRWP Area assumes that initial remediation for direct contact to soil has occurred, as described in the PRRWP Area soil remediation report (WTI, 2005b). Concentrations used in the risk evaluation of future risk are based on year 150 of the model run.

Site Worker. The total HI for worker exposure to modeled PRRWP Area bedrock groundwater is 0.1 (Table 6-43), which is less than the target value of 1. This indicates that adverse noncancer health effects are unlikely to result from worker exposure to modeled nitroaromatic concentrations in PRRWP Area bedrock groundwater.

The total ILCR for worker exposure to modeled PRRWP Area bedrock groundwater is 4E-5 (Table 6-43). This value is within the NCP risk management range of 1E-6 to 1E-4 but exceeds the OEPA target ILCR of 1E-5.

On-Site Resident Child. The total HI for exposure of a hypothetical child resident to modeled PRRWP Area bedrock groundwater, based on current concentrations, is 0.7 (Table 6-43). This indicates that adverse noncancer health effects are unlikely to result from childhood exposure to modeled nitroaromatic concentrations in PRRWP Area bedrock groundwater.

On-Site Resident Adult. The total HI for exposure of a hypothetical adult resident to modeled PRRWP bedrock groundwater, based on current concentrations, is 0.3 (Table 6-43). This indicates that adverse noncancer health effects are unlikely to result from adult resident exposure to modeled nitroaromatic concentrations in PRRWP Area bedrock groundwater.

On-Site Child/Adult Resident. The total site-related ILCR for child/adult exposure to modeled PRRWP bedrock groundwater is 2E-4 (1.5E-4 prior to rounding) (Table 6-43). This marginally exceeds the NCP risk management range of 1E-6 to 1E-4 but exceeds the OEPA target ILCR of 1E-5. This ILCR is associated primarily with 2,4-DNT (7.6E-5) and 2,6-DNT (7.5E-5).

6.3.5 Modeled WARWP Area Groundwater Risk Results

Nitroaromatics concentrations used in the risk evaluation of future risk are based on year 105 of the WARWP Area model run; after year 105, the combined concentrations of these three nitroaromatics begin to decrease. Based on the model results, the nitroaromatic contaminants in overburden groundwater would contribute much more heavily to future bedrock groundwater concentrations than would those in soil via leaching.

Site Worker. The total HI for worker exposure to modeled WARWP Area bedrock groundwater is 0.09 (Table 6-44), which is less than the target value of 1. This indicates that adverse noncancer health effects are unlikely to result from worker exposure to modeled nitroaromatic concentrations in WARWP Area bedrock groundwater.

The total ILCR for worker exposure to modeled WARWP Area bedrock groundwater is 4E-5 (Table 6-44). This value is within the NCP risk management range of 1E-6 to 1E-4 but exceeds the OEPA target ILCR of 1E-5. Virtually all of this ILCR is associated with 2,4-DNT (3.9E-5) and 2,6-DNT (1.1E-6).

On-Site Resident Child. The total HI for exposure of a hypothetical child resident to modeled WARWP Area bedrock groundwater, based on current concentrations, is 0.6 (Table 6-44), which is less than the target HI value of 1. This value indicates that adverse noncancer

health effects would be unlikely to result from residential use of the groundwater by a child receptor.

On-Site Resident Adult. The total HI for exposure of a hypothetical adult resident to modeled WARWP bedrock groundwater, based on current concentrations, is 0.2 (Table 6-44). This value is less than the target HI criterion of 1, indicating that the potential for adverse noncancer health effects in the WARWP resident child is regarded as unlikely.

On-Site Child/Adult Resident. The total site-related ILCR for child/adult exposure to modeled WARWP bedrock groundwater is 2E-4 (1.7E-4 prior to rounding) (Table 6-44). This marginally exceeds the NCP risk management range of 1E-6 to 1E-4 and exceeds the OEPA target ILCR of 1E-5. This ILCR is associated primarily with 2,4-DNT (1.7E-4) and 2,6-DNT (4.9E-6).

6.3.6 Modeled Groundwater Risk Results – Area Downgradient from TNTA

The location of the maximum modeled groundwater nitroaromatics concentrations downgradient of TNTA was identified from the PBOW groundwater model (Appendix E). Model results from year 150 were used, as these provided the maximum modeled concentrations of TNT, 2,4-DNT, and 2,6-DNT. Cancer risks and noncancer hazards were determined using these maximum concentrations as input for Equations 6.1 and 6.2. Because restrictions against residential land use cannot be considered outside the PBOW facility, only the resident is evaluated for risk at downgradient locations. The risks are characterized for the residential receptor just downgradient of TNTA at the facility boundary in the paragraphs that follow.

On-Site Resident Child. The total HI for exposure of a child resident to groundwater just outside of the PBOW facility boundary, downgradient of TNTA, is modeled as 0.002 (Table 6-45). Because this value is less than the target HI criterion of 1, adverse noncancer health effects associated with residential child exposure to site-related COPCs are unlikely.

On-Site Resident Adult. The total HI for exposure of an adult resident to groundwater just outside of the PBOW facility boundary and downgradient of TNTA is modeled as 0.0009 (Table 6-46). Because this value is less than the target HI criterion of 1, adverse noncancer health effects associated with residential adult exposure to site-related COPCs are unlikely.

On-Site Child/Adult Resident. The total ILCR for child/adult resident to groundwater just outside of the PBOW facility boundary and downgradient of TNTA is modeled as 4E-7 (Table 6-

47). This value is less than the NCP risk management range of 1E-6 to 1E-4 and the OEPA target ILCR of 1E-5.

6.3.7 Modeled Groundwater Risk Results – Area Downgradient from TNTB, TNTC, and the PRRWP Area

The location of the maximum modeled groundwater nitroaromatics concentrations downgradient of TNTB, TNTC, and the PRRWP was identified from the PBOW groundwater model. As mentioned in Section 6.3, the locations at which the maximum potential impact from TNTB, TNTC and the PRRWP were modeled co-occur. Thus, the remainder of this text refers to groundwater downgradient of TNTB, but this is understood to mean downgradient of these other two locations as well. Model results from year 150 were used, as these provided the maximum modeled concentrations of TNT, 2,4-DNT, and 2,6-DNT. Cancer risks and noncancer hazards were determined using these maximum concentrations as input for Equations 6.1 and 6.2. Because restrictions against residential land use cannot be considered outside the PBOW facility, only the resident is evaluated for risk at downgradient locations. The risks are characterized for the residential receptor just downgradient of TNTB at the facility boundary in the paragraphs that follow.

On-Site Resident Child. The total HI for exposure of a child resident to groundwater just outside of the PBOW facility boundary and downgradient of TNTB is modeled as 0.08 (Table 6-46). Because this value is less than the target HI criterion of 1, adverse noncancer health effects associated with residential child exposure to site-related COPCs are unlikely.

On-Site Resident Adult. The total HI for exposure of an adult resident to groundwater just outside of the PBOW facility boundary and downgradient of TNTB is modeled as 0.04 (Table 6-46). Because this value is less than the target HI criterion of 1, adverse noncancer health effects associated with residential adult exposure to site-related COPCs are unlikely.

On-Site Child/Adult Resident. The total ILCR for child/adult resident to groundwater just outside of the PBOW facility boundary and downgradient of TNTB is modeled as 2E-5 (Table 6-46). This value is within the NCP risk management range of 1E-6 to 1E-4 but slightly exceeds the OEPA target ILCR of 1E-5.

6.3.8 Modeled Groundwater Risk Results – Area Downgradient from the WARWP Area

The location of the maximum modeled groundwater nitroaromatics concentrations downgradient of the WARWP Area was identified from the PBOW groundwater model (Appendix E). Model results from year 150 were used, as these provided the maximum modeled concentrations of TNT, 2,4-DNT, and 2,6-DNT. Cancer risks and noncancer hazards were determined using these maximum concentrations as input for Equations 6.1 and 6.2. Because restrictions against residential land use cannot be considered outside the PBOW facility, only the resident is evaluated for risk at downgradient locations. The risks are characterized for the residential receptor just downgradient of the WARWP at the facility boundary in the paragraphs that follow.

On-Site Resident Child. The total HI for exposure of a child resident to groundwater just outside of the PBOW facility boundary and downgradient of the WARWP Area is modeled as 0.006 (Table 6-47). Because this value is less than the target HI criterion of 1, adverse noncancer health effects associated with residential child exposure to site-related COPCs are unlikely.

On-Site Resident Adult. The total HI for exposure of an adult resident to groundwater just outside of the PBOW facility boundary and downgradient of the WARWP Area is modeled as 0.002 (Table 6-47). Because this value is less than the target HI criterion of 1, adverse noncancer health effects associated with residential adult exposure to site-related COPCs are unlikely.

On-Site Child/Adult Resident. The total ILCR for child/adult resident to groundwater just outside of the PBOW facility boundary and downgradient of the WARWP Area is modeled as 1E-6 (Table 6-47). This value equals the lower end of the NCP risk management range of 1E-6 to 1E-4 and is less than the OEPA target ILCR of 1E-5.

6.4 Evaluation of Lead

The IEUBK blood-lead model (Section 3.1.3.3) is a multimedia model that incorporates the mean concentrations of each environmental medium being evaluated (EPA, 2005). Lead was identified as a COPC for TNTA and TNTB groundwater. Thus, the IEUBK model was run using the recommended default settings and the respective TNTA and TNTB arithmetic mean lead concentrations in groundwater and total soil. The IEUBK model output for each of these areas is provided in Appendix D.

TNTA. The IEUBK model was first run for TNTA using the arithmetic mean lead concentrations in groundwater (12.3 µg/L) and total soil (377 milligrams per kilogram [mg/kg]), the latter as presented in the TNTA remedial investigation. The resulting geometric mean blood-lead concentration for an exposed child was estimated as 5.47 micrograms per deciliter (µg/dL). Under the modeled parameters, 9.99 percent of children would be expected to have a blood-lead concentration of 10 µg/dL or greater. This does not meet the health protection goal of 5 percent (or less) of children exceeding a blood-lead concentration of 10 µg/dL (EPA, 2004e), indicating that unacceptable human health risks may occur. It is noted that according to the model behavior, much of blood-lead concentration is associated with the relatively high soil lead concentrations.

Lead was identified as a COC in TNTA soil (Shaw, 2003b). An action memorandum (USACE, 2004a) has been signed to remediate TNTA soil for lead as well as other chemicals. As mentioned in Section 3.2.4, the commencement of the remediation activities is not yet scheduled, but they are anticipated to proceed in the near future (e.g., within the next few years). This property will not be released for residential use until remediation is completed and the goals of the action memorandum are met; thus, a rerunning of the model based on a post-remediation concentration is appropriate. The post-remediation lead concentration was estimated as 69.5 mg/kg (Shaw, 2003b). Therefore, a separate IEUBK model was run based on the current mean groundwater concentration (12.3 µg/L) and this estimated post-remediation lead concentration for TNTA. The resulting geometric mean blood-lead concentration for an exposed child was estimated as 2.86 µg/dL. Under the modeled parameters, only 0.39 percent of children would be expected to have a blood-lead concentration of 10 µg/dL or greater. This easily meets the health protection goal of 5 percent (or less) of children exceeding a blood-lead concentration of 10 µg/dL (EPA, 2004e).

TNTB. The IEUBK model was first run for TNTB using the arithmetic mean lead concentrations in groundwater (4.85 µg/L) and total soil (46.8 mg/kg), the latter as presented in the TNTB remedial investigation. The resulting geometric mean blood-lead concentration for an exposed child was estimated as 2.08 µg/dL. Under the modeled parameters, only 0.042 percent of children would be expected to have a blood-lead concentration of 10 µg/dL or greater. This easily meets the health protection goal of 5 percent (or less) of children exceeding a blood-lead concentration of 10 µg/dL (EPA, 2004e). Therefore, the IEUBK model concludes that residential exposure to groundwater would not result in unacceptable human health risks.

6.5 Evaluation of Sulfate

No RfDs or similar toxicity values exist for sulfate. The EPA (2004d) Office of Water health advisory level of 500 mg/L was used for COPC screening. Bedrock groundwater underlying TNTC, the PRRWP Area, and the downgradient wells have sulfate MDCs that exceed the health advisory level. Specifically, the following wells had one or more samples with a sulfate concentration exceeding the health advisory level: TNTC-BEDGW-001 (located within TNTC), BEDMW-14 (located within the WARWP Area), and BEDMW-27 (downgradient boundary well). Sulfate concentrations among these wells range from 269 to 2,660 mg/L, with most samples exceeding 500 mg/L.

Numerous potential natural and anthropogenic sources of sulfate in groundwater are possible at PBOW. As concluded in the groundwater summary report (Shaw, 2005b), naturally occurring sulfate is interpreted to be present in the overburden groundwater due to the oxidation of sulfide minerals. However, this is complicated by the use and disposal of sulfate-bearing compounds in the TNT manufacturing process. These sources include sulfur, sulfuric acid, and sellite (sodium sulfate) used in the production and purification of TNT, particularly at the Wash Houses. Wastewater from the purification process was discharged to the PRRWP and WARWP.

Naturally occurring sources of sulfate are present at two of the three wells exhibiting elevated sulfate. These two wells are TNTC-BEDGW-001 (TNTC) and BEDMW-27 (downgradient). During monitoring well installation and groundwater sampling, these two wells exhibited hydrogen sulfide gas as well as petroleum. Oxidation of the hydrogen sulfide could produce the sulfate detected in these groundwater samples. In addition, the general low concentrations of nitroaromatics in these three wells suggest that this sulfate likely is from hydrogen sulfide. This cannot be definitively stated because there is also the potential of leaks and disposal of waste sulfate in the form of sulfuric acid. Sellite likely is not the source of the sulfate, because the concentration of sodium is relatively low in these three wells (10.9 to 109 mg/L). The presence of hydrogen sulfide was not observed during the installation and monitoring of BEDMW-14, located in the WARWP Area. BEDMW-14 also had notably higher concentrations of nitroaromatics (up to 150 µg/L) and sodium (269 to 1,020 mg/L), which is a component of sellite, than TNTC-BEDGW-001 and BEDMW-27.

In summary, the detection of sulfate in well BEDMW-14 is likely resultant from the disposal of waste products (sellite) associated with the production of TNT based on the following:

- The presence of relatively high concentrations of nitroaromatics in this well, which indicate site-related contamination
- The lack of hydrogen sulfide
- Concentrations of sodium that are high enough to be consistent with the disposal of sellite
- Historically, wastewater containing sellite would have been disposed of at the WARWP.

It is doubtful that sulfate associated with the other wells (TNTC-BEDGW-001 and BEDMW-27) is related to former site operations. This statement is based on low concentrations or nondetects of nitroaromatics, the presence of hydrogen sulfide, low concentrations of sodium that are regarded as uncharacteristic of sellite contamination, and the unlikely use of sellite at TNTC and the site boundary locations.

7.0 Uncertainty Analysis

The primary objective of the BHHRA is to characterize and quantify potential human health risks. However, these risks are estimated using incomplete and imperfect information that introduces uncertainties at various stages of the risk assessment process. Uncertainties associated with earlier stages of the risk assessment become magnified when they are concatenated with other uncertainties in the latter stages. Reliance on a simplified numerical presentation of dose rate and risk without consideration of uncertainties, limitations, and assumptions inherent in their derivation can be misleading. For example, the calculated ILCR for a given scenario "A" may be 8E-6 (within the risk management range) and that of scenario "B" given as 2E-4 (exceeding the risk management range). However, if the uncertainties associated with scenario "B" span, for instance, orders of magnitude and the ILCR is regarded as biased high, it is not unlikely that scenario "A" actually presents a higher risk of developing cancer.

The chief goal of this analysis is to evaluate uncertainties and present them in context of their potential impact on the interpretation of the risk assessment results and the types of environmental management decisions that may be based on these results. The uncertainty analysis does not exhaustively describe all potential uncertainties but presents those that have the largest implications for the interpretation of the risk assessment results. This analysis also overviews the types and, as applicable, the magnitude of the uncertainties at each stage of the risk assessment. Although the following discussion also includes generic uncertainties that are common to the state of human health risk assessment practice (e.g., additivity of health effects in the risk characterization), overall, the uncertainty analysis focuses on a set of uncertainties that is peculiar to the specific PBOW sites.

7.1 Types of Uncertainty

Uncertainties in risk assessment are categorized into two general types: 1) variability inherent in the (true) heterogeneity of the data set, measurement precision, and measurement accuracy and 2) uncertainty that arises from data gaps. Estimates of the degree of variability tend to decrease as the sample size increases. This is because larger data sets are less impacted by individual samples/measurements and typically allow for greater accuracy. Uncertainty that arises from data gaps is addressed by applying models and assumptions. Models are applied because they represent a level of understanding to address certain exposure parameters that are impractical or impossible to measure (e.g., COPC concentrations in air that would result from groundwater use

that has not yet occurred —or may never occur—at the site). Assumptions represent an educated estimate to address information that is not available (e.g., additivity of carcinogens).

7.2 Sources of Uncertainty

The following discussion provides an overview of uncertainty, with a focus on those sources that are most likely to affect interpretation of the risk assessment results.

7.2.1 Sample Selection

Well locations and direct-push locations were selected primarily from potential nitroaromatics source areas. The use of these samples assumes that they are representative of a given site in general. Therefore, the use of these sampling locations is more likely to introduce a high bias than a low bias. However, if a private well were to be installed on site at some future time, that well could potentially be located in the part of a plume exhibiting the highest groundwater concentrations. There are potential sources at the TNT areas; at a given location, one COPC may be present at a concentration greater than the EPC, but another COPC may be present at a very low concentration. Also, contaminant concentrations might vary greatly throughout the course of groundwater use by a resident or business, and groundwater concentrations may either decrease or increase. As a result, the degree to which the placement of PBOW wells and direct-push samples may overestimate (or underestimate) actual exposure would depend upon the well's location with respect to source areas.

7.2.2 Exposure-Point Concentration Estimates

Uncertainty is introduced in the statistical approach used to calculate the EPCs. As stated in the *Human Health Evaluation Manual (Part A)* (EPA, 1989a), the average concentration of the site should be used as the concentration term, generally with a 95 percent upper confidence limit used to account for the uncertainty of using a sample data set to estimate the true population mean concentration for the site. As described in Section 3.2.1, either the UCL or the MDC was generally used as the EPC. It is unclear whether the use of the UCL or MDC value of a specific EPC would result in an underestimate or overestimate of the true population mean. However, the general use of the UCL or MDC on all the data sets would result in general overestimation of the population mean and associated risks. Therefore, as intended by the guidance (EPA, 1989a), this practice of using the UCL or MDC as the EPC introduces bias that tends to overestimate the EPC and the resultant risk values. However, as indicated in Section 7.2.1, the EPC or MDC may underestimate the risks of certain COPCs at specific locations, especially with respect to groundwater plumes.

For off-site groundwater, the MDC was used exclusively as the EPC. This assumption should particularly add a conservative bias. This is because there were several sampling rounds performed at each well and because, in reality, no individual at any single location would be exposed to the MDC of each COPC.

7.2.3 Site Relatedness of Risks

Site relatedness with respect to background comparisons was mentioned in Section 2.2.3, which discusses background screening of inorganics (Section 2.2.3.1), statistical testing of inorganics as part of the uncertainties analysis (Section 2.2.3.2), and the treatment of organics with respect to background as part of the uncertainties analysis (Section 2.2.3.3). The background screening compares the MDC of the site data set to the BSC of the background data set; those chemicals with MDCs less than the BSC are excluded from identification as COPCs. It is possible that an inorganic chemical that is truly site related may be screened out using this method because it emphasizes the MDC of the site data more than the central tendency. However, a review of the inorganics that were screened out reveals that the mean concentrations of the site data were generally less than those of the PBOW background data set; the few site mean concentrations that exceeded the corresponding PBOW background means of these screened-out chemicals were found to be only slightly greater. Therefore, it does not appear that any inorganics were inappropriately eliminated using this method. It is noted that use of the BSC screening was intended to conservatively eliminate those compounds which were clearly associated with background. This screening was not intended as a tool to identify all inorganics that may be associated with background. Chemicals that were not screened out are not conclusively defined as site related. Thus, the background screening method accomplished its intended purpose without any apparent bias.

The WRS statistical comparison of site to background data was performed for all inorganic TNTA, TNTB, PRRWP Area, and downgradient well COPCs detected in PBOW background. The data set for the WARWP Area was judged to be too small for quantitative statistical analysis, and no inorganic COPCs were identified for TNTC. The data sets for TNTA, TNTB, and the PRRWP Area are rather small as well, so the WRS comparisons must be viewed cautiously due to the uncertainties associated with small sample sizes. Thus, WRS results should not be judged as ultimately determining whether or not an inorganic analyte is truly site related. WRS results are summarized in Table 7-1. The WRS statistical test output tables and plots are provided in Appendix C.

Many of the site samples could only be collected using a bailer because of poor well production, whereas the PBOW background samples were all collected using low-flow methodology. Also, petroleum had to be bailed out of some of the on-site and downgradient wells prior to sampling, and some of the wells were bailed dry. This bailing action, especially in wells with limited water column, agitates sediment in the well. This agitation increases turbidity and may also effectively increase the solubility of inorganics in the substrate. Both of these effects might substantially elevate inorganics concentrations in site groundwater. Therefore, a qualitative evaluation was performed on inorganic COPCs that focuses on issues such as groundwater production at a given well, analytical results of filtered versus unfiltered samples, prevalence of the COPC in site soil samples, and issues associated with potential blank contamination. This qualitative analysis of site-relatedness is provided for inorganic and organic (see discussion below) COPCs in Appendix H.

Organic COPCs were evaluated for site relatedness based on a number of lines of evidence. Naturally occurring petroleum occurs regionally. This qualitative evaluation evaluates the depths at which petroleum is encountered based on boring logs, the concentrations (or lack thereof) of COPCs found in site soil and overburden groundwater, the potential for contributions to COPC concentrations associated with artifacts of laboratory analysis, and site history. This qualitative analysis is provided in Appendix H. A synopsis of this analysis is provided in Table 6-39.

Based on information provided in the qualitative analysis provided in Appendix H, it is apparent that the concentrations reported for certain COPCs are unlikely to be associated with past site operations. Of particular note is the presence of petroleum-related compounds (e.g., BTEX and PAHs) in wells where petroleum was found at depth during boring but not at shallower locations, and where petroleum-related compounds were not detected in soils or overburden groundwater at appreciable concentrations. Also of note were elevated inorganic COPC concentrations reported in unfiltered fractions but not in filtered groundwater fractions, especially where the well was bailed (nearly) dry and was a poor water producer.

With respect to the petroleum-related compounds, all but one of the wells completed in the Delaware Limestone exhibited evidence of petroleum during well installation and sampling. This evidence included petroleum stains on rock cores, visible petroleum on drilling bits, free product detected during groundwater sampling, and detectable levels of hydrogen sulfide in boreholes and monitoring wells. The exception to this was BED-MW18 at TNT Area A. This well was completed across the contact of the Olentangy Shale and Delaware Limestone.

Groundwater from all of the wells completed in the Delaware Limestone (including BED-MW18) had reportable concentrations of petroleum-related compounds. The concentrations for benzene and total xylenes exceeded 1,000 µg/L in some site wells.

The only bedrock wells not completed in the Delaware Limestone are the three TNTB wells. These three wells (TNTB-BEDGW-001, TNTB-BEDGW-003, and TNTB-BEDGW-004) were all completed in the Olentangy Shale. No staining or product was observed in rock cores or drilling equipment during completion of these wells, though hydrogen sulfide was observed at isolated intervals during drilling. The detection of hydrogen sulfide without observable staining suggests the possibility that petroleum may be present but at much lower concentrations than were found in the Delaware Limestone; this expectation was corroborated by a comparison of the TNTB analytical data to that of the other site areas. Petroleum-related compounds (benzene, ethylbenzene, toluene, and xylene) were also detected in the background wells at concentrations similar to those observed in TNT Area B. Just as the TNTB wells, the background wells were all completed in the Olentangy Shale. The following table compares the MDCs of the BTEX compounds among the site areas, downgradient locations, and upgradient background.

Comparison of Maximum Detected BTEX Compound Concentrations Among the Site Areas and Hydrological Units

Area	Hydrological Unit	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Xylene (µg/L)
Background	SH	2.4	0.87	1.7	5.5
TNTA	LS	700	240	730	1400
TNTB	SH	17	0.52	5.2	2.3
TNTC	LS	410	130	300	1300
PRRWP	LS	2500	230	1000	1600
WARWP	LS	1.1	ND	0.59	3.9
Downgradient	LS	130	120	180	560

The list of COPCs identified as site related is the product of data review and best professional judgment. It was recognized that a level of uncertainty would be associated with any selection of site-related chemicals, so care was taken not to remove a COPC as non-site related without logical cause. Thus, an effort was made to err on the side of inclusion rather than exclusion. This was the basis under which the inorganics such as cobalt and nickel, which have no known site-related source based on knowledge of the TNT manufacturing process, were included as site related (refer to Appendix H).

In summary, it is difficult to hold this list or any other as the definitive set of site-related COPCs. It is possible that this list may include COPCs that are not truly site related or, despite the emphasis on inclusion, it may exclude COPCs that are truly site related. Thus, the list of site-related chemicals provided (Table 6-39) is intended as a suggestion for site management decisions. It is expected that further consideration of site relatedness during the feasibility study will result in an amended, final list of site-related COCs.

7.2.4 Land-Use Assumptions/Receptor Selection

The off-site current and future residential receptor at the facility boundary is reasonable, because residential land use is generally the most conservative assumption; land use outside of the facility cannot reasonably be restricted. Future residential and long-term, on-site worker use of groundwater are not unreasonable given that NASA intends to release the property for unrestricted use.

7.2.5 Exposure Assumption Values

The exposure assumption values used in the exposure assessment (Table 3-1) are selected to represent either an upper bound (e.g., 95th percentile) or mid-range value, depending on the particular parameter. Mathematically combining these terms in exposure equations is generally thought to result in decidedly conservative exposure estimations (Cogliano, 1997; Burmaster and Harris, 1993). However, this conservativeness is associated with the state of risk assessment practice, which attempts to focus on the upper end of exposure possibilities rather than the more likely levels of exposure, rather than on assumptions made specifically for the PBOW sites.

The BHHRA assumes a bathing duration for the resident child of 20 minutes per day and a showering duration for the resident child of 12 minutes per day, as described and referenced in the final work plan (Shaw, 2005a) and presented in Section 3.1.3.2. The BHHRA assumes that a resident bathes once per day. The 12-minute bathing and 20-minute showering durations would yield slightly higher risk estimates than would the 15-minute durations identified in the previous PBOW work plans (IT, 1999a; 1998) for the child and child/adult resident used to evaluate long-term residential cancer risks. Although the current *Exposure Factors Handbook* (EPA, 1997a) references survey data that describes 12 minutes for showering and 20 minutes for bathing as median values, a previous version of the *Exposure Factors Handbook* (EPA, 1989c) references a paper (James and Knimann, 1987) that identifies a 7-minute showering/bathing duration as the median and 12 minutes as an upper-end estimate. The 1997 *Exposure Factors Handbook* (EPA, 1997a) revisited the James and Knuimann study and found that only 50 of 2,550 respondents reported taking showers of greater than 20 minutes duration. This reevaluation identified a mean

shower duration of 8 minutes and a 95th percentile of 16 minutes, as well as a median of 7 minutes.

Alternative values that might have been selected for the BHHRA include those found in the EPA (2004a) *Risk Assessment for Superfund, Volume 1: Human Health Evaluation Manual, Part E* (RAGS E), which recommends a daily bathing duration of 60 minutes for a child and a showering duration of 35 minutes per day for the adult. These values are based on a 95th percentile of the study referenced by RAGS E and reported in the *Exposure Factors Handbook*. However, as suggested by the following statements, a 60-minute bathing duration for a young child may be a considerable overestimate of even an upper bound:

- The survey on which the *Exposure Factors Handbook* (EPA, 1997a) is based does not include children. Instead, this 35 minutes-per-day shower value is based only on adult activities (age 18 and older).

- A young child would need constant attention because of safety concerns; for a young child to remain in the bathtub for an hour would mean that the parent does essentially nothing but bathe and stay with the child for an hour every day. It is doubtful that in one could find a parent in 20 (equating to the 95th percentile) who could reasonably afford this level of time to bathe a child each day.

- Multiple children in the family would multiply this time accordingly.

- Long bathing durations, especially for young children, can lead to skin problems such as eczema.

- Apparent exaggerations were found in the Tsang and Klepeis (1996) study referenced in the *Exposure Factors Handbook*, which forms the basis for the RAGS E recommendation of the 60-minute bath (e.g., the average number of showers per day reported by some respondents in the study was 10; the average number of baths reported by some individuals was 15 per day.) Such apparent exaggerations would artificially skew high-end estimates such as the 95th percentile.

Moreover, even if an average duration of 60 minutes per bathing event were assumed for a child, it is noted that EPA has identified that children in the age group of 1 through 6 years bathe only, on average, approximately every other day (EPA, 2001). Thus, if an average bathing duration for an exposed individual were assumed to be 60 minutes per bathing event, the average daily duration would be only about 30 minutes.

In summary, the bathing duration values used in the BHHRA may be technically more defensible than the values recommended by the RAGS E guidance, even for application to conservative estimates of exposure. If the RAGS E showering and bathing duration values had been used, the effect on the risk and hazard estimates would be negligible because the ingestion pathway dominates over the ingestion pathway. For example, the dermal HQ for associated with 2,4-DNT in TNTA bedrock groundwater assumed to be used by the resident child is 0.00054 and the oral HQ is 0.0157; these combine for a 2,4-DNT HQ of 0.0162 (refer to Table 6-3). Use of the RAGS E 60-minute shower duration would result in a dermal HQ for 2,4-DNT that is approximately 2 percent higher; both of these values would be rounded to 0.02. Given the level of uncertainties associated with the discipline of risk assessment, the difference in results between use of the sets of bathing/showering durations in this BHHRA and those recommended by RAGS E would be within rounding error and would have no impact on the BHHRA conclusions or related site management decisions.

7.2.6 Groundwater-to-Air Household Model

The groundwater-to-air household model (EPA, 1991b) has considerable uncertainties. Some parameters that can change the model include the air exchange rate of the house, which can vary with the season; level of groundwater usage; and size of the house. EPA (1991b) states that the model assumes a four-member household that uses 720 liters of water per day, the home has a volume of 150 cubic meters, and 0.25 household air exchanges per hour. The *Exposure Factors Handbook* (EPA, 1997a) lists the following information for the average four-person home: household use of 892 L/day (4 × 223 L/day), volume of 431 m^3, and an air exchange rate of 0.63 volumes per hour. If the values from the *Exposure Factors Handbook* were used instead of the default values from EPA (1991b), the resultant estimated household air concentrations would be less than those estimated in the BHHRA by a factor of nearly 5. This would affect total HI and total ILCR values, but because no volatile compounds were identified as site related, it would not affect the site-related HI and ILCR values.

7.2.7 Site Groundwater Model

Groundwater flow and fate and transport modeling is subject to uncertainties due to the limited information typically available, even for well-characterized sites. Hydraulic properties of the aquifer are derived from soil borings and from well slug tests and pumping tests that, in reality, affect only a limited area around the well. These data are then extrapolated to areas between the soil borings and wells. This can introduce errors if there are large variations in the actual hydrogeological properties across the site. In addition, other input data, such as groundwater recharge from precipitation, are also estimated values. Proper model calibration reduces the

impact of this variability by producing a best-fit condition of all the model input parameters. These input parameters are only varied within the range of values considered to be representative of the site being modeled. While calibration produces a model that may accurately simulate flow direction and groundwater gradients, the potential exists that actual groundwater flow velocities may be higher or lower than the groundwater flow velocity predicted by the model.

Fate and transport modeling of chemical contaminants is subject to the same scalar effects as flow modeling. Typically, the required input parameters (e.g., fraction of organic carbon, bulk density) are available for a limited number of locations that must be extrapolated across the site being modeled. The selection of these parameter values is biased on the conservative side, resulting in a simulation that likely produces higher concentrations in groundwater than may actually occur. Other input parameters to the fate and transport modeling include the leaching of contamination from source material (unsaturated soils) to groundwater and the degradation of contaminants over time. Simulation of contaminant leaching was modeled through the soil column with conservative input parameter values. For example, degradation likely occurs at PBOW but accurately estimating the rate is difficult; therefore, no degradation was assumed in the model, which likely will contribute a high (i.e., conservative with respect to health protectiveness) bias toward modeled future concentrations. Also, preferential flowpaths of water percolating downward through the water column were not included in the model; this lack of preferred pathways through the soil column reflected by the model likely contributes a high bias. The considerable seasonal fluctuation in the overburden groundwater cannot be specifically portrayed by the model. To assume a relatively constant water level in the overburden as reflected by the model is likely to introduce a high bias to modeled groundwater concentrations. In addition, the actual concentration mass in the unsaturated soil must be estimated based on soil samples collected in previous investigations. It is common in models that numerous soil sample results are available for areas to be modeled. Determining the concentration of contaminants to be simulated can be difficult, given the wide variability in analytical results due to soil heterogeneity. For the PBOW model, the highest soil concentrations detected in a given modeled area were used. This approach contributes a high bias, although if the data do not adequately reflect the full range of soil concentrations, it is still possible that a low bias may result for a given area.

Overall, the groundwater modeling results are expected to be conservative, resulting in higher concentrations than are actually likely to occur in the future, due to the selection of conservative parameters critical for input in the model. Still, while the selection of most input parameters was biased toward conservative values, the range of input values was still limited to what was

deemed possible for this site. Therefore, although the modeling results may be biased toward overestimation of future concentrations, they are still likely within the realm of realistic possibilities for a site of this complexity.

7.2.8 Toxicity Assessment

Uncertainties associated with the toxicity assessment include those regarding development of the health effects criteria values, the classification of potential carcinogenicity, the extrapolation of exposure route-specific toxicity values to other routes of exposure, and the extrapolation of toxic effects observed in animal studies to potential adverse effects in humans. A general summary of these uncertainties is provided in the following paragraphs.

The development of health effects criteria for noncancer effects involves considerable professional judgment. An uncertainty factor of up to 10 may be applied to a toxicologically identified benchmark dose or concentration to address the unknown regarding each of the following (EPA, 1989b): lowest-observed-adverse-effects level to no-observed-adverse-effects level, subchronic-to-chronic extrapolation, route-to-route extrapolation, and species-to-species extrapolation. A "modifying factor" of 10 or less is likewise applied in the development of RfDs and RfCs, using professional judgment. This modifying factor is intended to address gaps in the database and steepness of the dose-response curve. In practice, the overall UF, derived by multiplying the individual uncertainty factors by the modifying factor, associated with RfD and RfC values may span up to four orders of magnitude.

The EPA weight-of-classification system for carcinogens is used to examine and classify chemical agents with respect to their carcinogenic potential. Most EPA potential carcinogens are classified based on animal data, without sufficient human data to support a causal association (i.e., Group B2; refer to Section 4.1). Also, the linearized multistage (LMS) mathematical model was used to extrapolate values from relatively high-dose rodent studies to relatively low-dose human exposures in the development of SFs for these compounds; the LMS model is the subject of much controversy. Thus, the LMS approach used to develop SFs, combined with other assumptions, tends to overestimate potential risks.

Overall, the toxicity values, assuming similar effects between humans and test species, tend to result in overestimates of noncancer hazards or cancer risks. However, it is possible that a given chemical can elicit a toxic response in humans that is not observed in the laboratory species studied or that humans may be more sensitive to a given chemical. In this instance, it is possible

for the use of the toxicity values to result in underestimates of risks/hazards. Specific toxicity values that may affect some of the PBOW sites are discussed below.

Iron. Iron was identified as a risk driver (refer to Chapter 9.0) in bedrock groundwater underlying TNTA, TNTB, the PRRWP Area, and in downgradient areas, but in each case was determined as unrelated to former PBOW activities. Although iron is identified as a risk driver, it is doubtful that receptors exposed to iron in PBOW groundwater would suffer adverse human health effects for several reasons.

The RfD for iron (i.e., the acceptable daily dose that is not expected to cause adverse effects) that is used to calculate the HQ is a provisional value based on dietary intakes estimated from nutritional surveys rather than toxicological endpoints as is preferable. This RfD is a daily dose of 0.3 mg/kg of BW per day. This value is dependent on the estimation of a dose rate that is protective against iron deficiency but unlikely to cause iron overload. A symptom of iron overload has been observed in one individual who ingested iron supplements at a dose rate of approximately 19 mg/kg-day for 27 years (i.e., 60 times the RfD) (EPA, 1996). Iron supplements are salts intended for gastrointestinal absorption. It is expected that gastrointestinal absorption of the chemical forms of iron found in groundwater, particularly those associated with suspended particulates, would not exceed that found in the iron supplements. Also, the dietary iron ingestion rate among Ethiopians ranges from 1.4 to 20 mg/kg-day, with an average of 6.7 mg/kg-day; Ethiopians exhibit no signs of toxicity associated with dietary iron.

The table below shows child and worker iron intakes from the tables in Appendix G for each of the four areas at which iron was identified as a risk driver.

Iron Intake Rates			
Site	**Worker Intake (mg/kg-day)**	**Child Resident Intake (mg/kg-day)**	**Identified as Site Related?**
TNTA	0.32	2.4	No
TNTB	0.25	1.6	No
PRRWP Area	0.072	0.47	No
Downgradient	NA	16	No

NA – Not applicable.

The intake rate for the on-site worker at each of the three applicable sites is much less than the average Ethiopian dietary range and is less than the chronic dose observed to result in iron overload by a factor of 59 to 260. The iron intake rate for the on-site TNTB child resident

approximates the lower end of the average Ethiopian diet. The TNTA resident child has a slightly higher iron intake rate than the TNTB resident child, and the downgradient resident has an associated iron intake approaching that which was shown, in highly absorbable supplement form, to result in adverse effects. However, the elevated iron concentrations in TNTA and downgradient groundwater was shown to be virtually entirely associated with suspended particulates that are an artifact of the sampling technique (Section 7.2.3). It is also noted that, with respect to TNTB and the PRRWP Area, it appears that the presence of elevated iron is mostly associated with natural reducing conditions (Appendix H).

Manganese. Manganese was identified as a risk driver (refer to Chapter 9.0) in bedrock groundwater underlying TNTA, TNTB, the PRRWP Area, and in downgradient areas, but was not identified as site related (Section 6.2). Its presence was attributed either to sampling technique (turbidity associated with collection by bailer) or reducing conditions (Appendix H). Manganese is nutritionally required by humans for normal growth and health. An RfD of 0.14 mg/kg-day was verified, but this value is based on total intake, including dietary. This RfD equals an adult intake of approximately 10 milligrams/day. However, EPA (2006) notes that a normal dietary intake may well exceed 10 milligrams/day. EPA apportions 0.024 mg/kg-day of the RfD for nondietary sources including groundwater. Thus, there is considerable uncertainty in the RfD.

Humans exposed to 0.8 mg/kg-day in drinking water exhibited adverse effects such as lethargy, tremors, and mental disturbances. This approximates 28 mg/L in drinking water. The manganese EPC for each of the site areas was less than this value. Of particular note, the manganese EPC for TNTA (11.7 mg/L), which by far had the highest MDC among the five sites and downgradient locations, was less than one-half the concentration in groundwater found to result in adverse health effects. The other PBOW sites had manganese MDCs of 1.2 mg/L or less.

7.2.9 Risk Characterization

It is assumed that the effects of simultaneous exposures to multiple carcinogens at a site are additive. Likewise, it is assumed that noncancer effects of contaminants are additive if they have a similar mechanism of toxicity. In risk assessment practice, it is assumed that the effects of chemicals that affect the same target organ are additive unless chemical-specific information would dictate otherwise. However, chemicals in combination may act additively, synergistically, or antagonistically or may not influence one another at all. Therefore, depending on the

interactive effects (if any), the risk characterization approach to multiple contaminants may lead to either underestimates or overestimates of potential risk/hazard.

As mentioned in Section 6.5, no RfD was identified for sulfate. The EPA health advisory level of 500 mg/L is based on mild laxative effects observed at 800 to 1,200 mg/L. It also appears that over a prolonged exposure period (e.g., 2 to 3 weeks), humans may become acclimated to elevated sulfur such that this laxative effect subsides (EPA, 2003c). As discussed in Section 6.5, sulfate was detected in three wells at concentrations exceeding 500 mg/L. However, sulfate was identified as likely to be site related only in well BEDMW-14, located in the WARWP Area, in which it was detected at concentrations ranging from 630 to 2,660 mg/L. The fact that no RfD has been identified for sulfate makes it impossible to characterize risks using standard risk assessment protocol. Although the short-term mild laxative effects in humans appear to be well documented and these effects would be expected at the WARWP Area groundwater concentrations, it is unclear whether these effects would continue (or any others arise) during chronic exposure as evaluated in this BHHRA. A further issue, certainly outside of the realm of risk assessment, is that sulfate in tap water at concentrations in the range of 250 to 1,000 mg/L (or greater) is judged by many individual to have an unacceptable taste and/or odor.

8.0 Aggregate Risk Summary

Human health risk assessments were performed previously for the three TNT areas and the two red water pond areas based on risks associated with other environmental media. The following sections provide aggregate risk estimates for a future resident and future site workers. The risks associated with groundwater from each of the AOCs as determined in this BHHRA was summed with the risks associated with other environmental media from these sites, as determined based on the previous risk assessments (IT, 2001a, b; 2000), to derive estimates of aggregate risks. The previous risk assessment reports included a long-term groundskeeper (duration of 25 years) and a short-term construction worker (duration of 1 year). This groundwater BHHRA includes only a generic long-term worker (duration of 25 years), which is the same as the groundskeeper from previous risk assessments. Construction worker cancer risks associated with groundwater were determined by dividing the worker groundwater risks (of this BHHRA) by a factor of 25 (i.e., ratio of the duration of long-term worker exposure to duration of the construction worker exposure); all other aggregate risks were determined using direct addition. The aggregate risks for each of the receptors are discussed in the paragraphs that follow. For noncancer residential hazards, the aggregate risks of only the child are evaluated because in the previous risk evaluations, only the child resident was evaluated for noncancer risks, as the child resident is the more conservative receptor to consider for potential future land use and site management decisions.

Soil remediation, based on potential risks associated with direct contact, has commenced or is planned for each of the AOCs. These aggregate risk estimates do not consider these remedial actions. Most of the soil in TNTB has been remediated (WTI, 2005a), with the remainder scheduled for remediation in 2006. Soil at the PRRWP Area has been partly remediated as well, with the remainder planned for remediation (WTI, 2005b). Soil remediation at TNTA (USACE, 2004a) and TNTC (USACE, 2004b) has not yet commenced but is anticipated to occur in the near future (e.g., within the next few years).

8.1 TNTA Aggregate Risk Estimates

Noncancer. The aggregate overall HI for each of the three site receptors is greater than 1 (Table 8-1), indicating that adverse noncancer health effects cannot be regarded as unlikely to occur. The aggregate site-related construction worker and resident HI values are greater than 1, but the aggregate site-related HI for the groundskeeper is not. Groundwater comprises

approximately 90 percent of the groundskeeper aggregate overall HI, 15 percent of the construction worker aggregate overall HI, and 60 percent of the on-site resident aggregate overall HI. However, the site-related groundwater HI comprised only 20 percent of the aggregate site-related groundskeeper HI, approximately 0.3 percent of the aggregate site-related construction worker HI, and approximately 0.9 percent of the aggregate site-related resident HI. In summary, the aggregate results indicate that the groundskeeper is unlikely to suffer adverse health effects associated with exposure to site-related chemicals, and the contributions of site-related groundwater to the aggregate site-related HIs are relatively minimal for the construction worker and resident. The contributions of the overall groundwater HIs to the aggregate overall HIs are more substantial.

Cancer. The aggregate overall ILCR for each of the three site receptors is greater than the NCP risk management range of 1E-6 to 1E-4 and the OEPA target cancer risk of 1E-5, as are the aggregate site-related ILCRs for the construction worker and the resident. The aggregate site-related ILCR from the groundskeeper is within the NCP range but exceeds the OEPA criterion (Table 8-1). Groundwater comprises approximately 94 percent of the groundskeeper overall ILCR, 2 percent of the construction worker overall HI, and 8 percent of the on-site resident overall ILCR. However, the site-related groundwater ILCR comprised only 60 percent of the aggregate site-related groundskeeper ILCR, approximately 0.1 percent of the aggregate site-related construction worker ILCR, and approximately 0.1 percent of the aggregate site-related resident ILCR. In summary, the contributions of groundwater to the aggregate ILCRs are relatively minimal in comparison to total soil for the construction worker and resident, especially with respect to the aggregate site-related ILCR. The contribution of groundwater to the aggregate site-related ILCR, and especially to the aggregate overall ILCR, is substantial in comparison to the contribution of surface soil to groundskeeper ILCR values.

8.2 TNTB Aggregate Risk Estimates

Noncancer. The aggregate overall HI and aggregate site-related HI for each of the three site receptors are greater than 1 (Table 8-2), indicating that adverse noncancer health effects cannot be regarded as unlikely to occur. Groundwater comprises approximately 12 percent of the groundskeeper aggregate overall HI, 3 percent of the construction worker overall HI, and 7 percent of the on-site resident aggregate overall HI. The site-related groundwater HI comprised only 7 percent of the aggregate site-related groundskeeper HI, approximately 2 percent of the aggregate site-related construction worker HI, and approximately 3 percent of the aggregate site-related resident HI. In summary, the relative contributions of site-related groundwater to the

aggregate site-related HI values are relatively minimal. The contributions of the overall groundwater HIs to the aggregate overall HIs are slightly greater, but are considerably less than the contributions associated with exposure to soil.

Cancer. The aggregate overall ILCR for the groundskeeper and on-site resident are greater than the NCP risk management range of 1E-6 to 1E-4 and the OEPA target cancer risk of 1E-5 (Table 8-2). The aggregate overall and aggregate site-related ILCRs for the construction worker (2E-5) are within the NCP range but slightly exceed the OEPA target risk criterion of 1E-5. Groundwater comprises approximately 40 percent of the groundskeeper aggregate overall ILCR, 15 percent of the construction worker aggregate overall HI, and 23 percent of the on-site resident aggregate overall ILCR. Site-related groundwater components do not contribute significantly to aggregate site-related ILCR, as no carcinogenic site-related chemicals were identified for TNTB groundwater (Section 6.2.2). In summary, the contribution of groundwater to the aggregate overall ILCR is substantial for the groundskeeper. The contribution of groundwater to the aggregate overall ILCR for the construction worker and resident are also substantial but are less than the contributions from total soil. Site-related components of groundwater do not contribute appreciably, as no carcinogenic site-related chemicals were identified in TNTB groundwater.

8.3 TNTC Aggregate Risk Estimates

Noncancer. The aggregate overall HI for each of the three site receptors is far greater than 1 (Table 8-3), indicating that adverse noncancer health effects cannot be regarded as unlikely to occur. Groundwater comprises approximately 1 percent of the groundskeeper aggregate overall HI, 0.4 percent of the construction worker aggregate overall HI, and 5 percent of the on-site resident aggregate overall HI. No site-related COPCs were identified for TNTC groundwater; thus, TNTC groundwater has virtually no contribution to the aggregate site-related HI. In summary, the contributions of the overall groundwater HIs to the aggregate overall HIs are very minimal. The contribution of groundwater to the aggregate site-related HIs is virtually nil.

Cancer. The aggregate overall ILCR for the groundskeeper and on-site resident are greater than the NCP risk management range of 1E-6 to 1E-4 and the OEPA target cancer risk of 1E-5 (Table 8-3). The aggregate overall ILCR for the construction worker (6E-5) is within the NCP range, but exceeds the OEPA target risk criterion of 1E-5. Groundwater comprises approximately 15 percent of the groundskeeper overall ILCR, 7 percent of the construction worker overall HI, and 25 percent of the on-site resident overall ILCR. No site-related COPCs were identified for TNTC groundwater; therefore, TNTC groundwater has essentially no

contribution to the aggregate site-related ILCR. In summary, the contributions of the overall groundwater ILCRs to the aggregate overall ILCRs are appreciable but smaller than the contributions from soil. TNTC groundwater makes virtually no contribution to the aggregate site-related ILCRs.

8.4 PRRWP Aggregate Risk Estimates

Noncancer. The aggregate overall HI for each of the three site receptors is greater than 1 (Table 8-4), indicating that adverse noncancer health effects cannot be regarded as unlikely to occur. The aggregate site-related HI is greater than 1 for the construction worker and resident but not for the groundskeeper. This indicates that adverse noncancer health effects would be unlikely to result from exposure by the groundskeeper to site-related chemicals. Groundwater comprises approximately 98 percent of the groundskeeper aggregate overall HI, 13 percent of the construction worker aggregate overall HI, and 40 percent of the on-site resident aggregate overall HI. The site-related groundwater HI comprised 83 percent of the aggregate site-related groundskeeper HI, approximately 0.3 percent of the aggregate site-related construction worker HI, and approximately 0.6 percent of the aggregate site-related resident HI. In summary, the contribution of site-related groundwater to the aggregate site-related HI is very minimal for the construction worker and resident in comparison to the contribution of total soil. Groundwater contributes a greater portion to the aggregate site-related HI of the groundskeeper, but this is because of the relatively low HI associated with surface soil. The contributions of groundwater to the aggregate overall HI values are more substantial than the contributions of groundwater to the aggregate site-related HI.

Cancer. The aggregate overall groundskeeper ILCR, aggregate overall on-site resident ILCR, and aggregate site-related resident ILCR are greater than the NCP risk management range of 1E-6 to 1E-4 and the OEPA target cancer risk of 1E-5 (Table 8-4). The aggregate overall ILCR for the construction worker (3E-5) is within the NCP range but exceeds the OEPA target risk criterion of 1E-5. The aggregate site-related ILCRS for the groundskeeper (5E-6) and construction worker (1E-5) are within the NCP cancer risk range and are less than or equal to the OEPA target cancer risk. Groundwater comprises 99.8 percent of the groundskeeper overall ILCR, approximately 65 percent of the construction worker overall HI, and 45 percent of the on-site resident overall ILCR. The site-related groundwater ILCR comprises 88 percent of the aggregate site-related groundskeeper ILCR, approximately 1 percent of the aggregate site-related construction worker ILCR, and approximately 0.2 percent of the aggregate site-related resident ILCR. In summary, the contribution of groundwater to the aggregate site-related ILCR is

relatively minimal in comparison to total soil for the construction worker and resident. Groundwater contributes most of the ILCR with respect to the aggregate site-related groundskeeper and most of the aggregate overall ILCR with respect to the groundskeeper and construction worker. Groundwater contributes nearly half of the aggregate overall ILCR to the resident.

8.5 WARWP Aggregate Risk Estimates

Noncancer. The aggregate overall and site-related HI for each of the three site receptors is greater than 1 (Table 8-5), indicating that adverse noncancer health effects cannot be regarded as unlikely to occur. Groundwater comprises 99.9 percent of the groundskeeper overall HI, 96 percent of the construction worker overall HI, and 99 percent of the on-site resident overall HI; the site-related groundwater HIs contribute nearly identical percentages to the aggregate site-related HIs. In summary, groundwater dominates the aggregate site-related and overall HI values. This is not unexpected because no appreciable noncancer hazards were previously found associated with WARWP Area soil, sediment, or surface water.

Cancer. The aggregate overall and aggregate site-related ILCRs for the on-site resident are greater than the NCP risk management range of 1E-6 to 1E-4 and the OEPA target cancer risk of 1E-5 (Table 8-5). The aggregate overall ILCR for the groundskeeper equals the upper limit of the NCP range (1E-4) but exceeds the OEPA target cancer risk. The aggregate ILCR for the construction worker (5E-6) is within the NCP cancer risk range and is less than the OEPA target cancer risk. Aggregate site-related ILCRs for the construction worker and groundskeeper are both within the NCP range and less than the OEPA target cancer risk criterion. Groundwater comprises approximately 94 percent of the groundskeeper aggregate overall ILCR, 84 percent of the construction worker overall HI, and 97 percent of the on-site resident overall ILCR. The site-related groundwater ILCR comprises 89 percent of the aggregate site-related groundskeeper ILCR, approximately 74 percent of the aggregate site-related construction worker ILCR, and approximately 94 percent of the aggregate site-related resident ILCR. In summary, groundwater dominates the aggregate site-related and overall ILCR values. This is not unexpected, because no unacceptable cancer risks were previously found associated with WARWP Area soil, sediment, or surface water.

9.0 Development of Risk-Based Remediation Criteria for Groundwater

RBRCs are derived to provide support for risk management decisions. Thus, they are developed only for the COPCs in media that are associated with unacceptable risk and that may potentially warrant corrective action. This "association with unacceptable risk" is defined as either contributing a groundwater ILCR to the on-site resident of equal to or greater than 1E-6 or contributing an HQ of 0.1 or greater to a target organ-specific HI for the child resident that exceeds a value of 1. Such chemicals are referred to as "risk drivers." RBRCs are site-specific concentrations that reflect the exposure and toxicity assumptions applied in the BHHRA(s).

Separate sets of groundwater RBRC values were derived for the risk drivers at each of the five AOCs and the site boundary; these are presented in Tables 9-1 through 9-6. Site relatedness was identified as described in Section 6.2 and Appendix H. RBRCs were derived for all risk-driving COPCs, although these site-related chemicals are duly identified on the tables.

10.0 Summary, Conclusions, and Recommendations

10.1 Summary

Risks associated with groundwater underlying the three former TNT areas, the former red water pond areas, and downgradient boundary areas were evaluated. A qualitative screening was performed on bedrock and overburden groundwater in each of these three areas. Overburden groundwater was not further evaluated for risks associated with direct contact because this groundwater zone greatly fluctuates seasonally and would not yield adequate quantities for tap water uses. Chemicals in bedrock groundwater which failed the screen were identified as COPCs and were evaluated quantitatively for risks. This quantitative risk assessment of the COPCs included an exposure assessment, toxicity assessment, risk characterization, and uncertainties analysis. The risk characterization included overall risks, site-related risks, and modeled future risks associated with 2,4-DNT, 2,6-DNT, and TNT. Site relatedness of each of the COPCs is evaluated in Appendix H and presented in Section 6.2. Uncertainties associated with the determination of site relatedness are discussed in Section 7.2.3.

The groundwater risks associated with each of the AOCs are summarized in the paragraphs that follow. The HI values presented below are for the target organ with the highest corresponding HI, unless the total HI is equal to or less than 1; in the latter case, the total HI or summed site-related HI is presented. Currently, there are no groundwater users either on site or at the facility boundary. Thus, the risks and hazards presented below are for potential or hypothetical human receptors, not for any currently exposed individuals.

TNTA. The site-related noncancer hazard for the on-site worker (HI=0.2) and cancer risk (ILCR=1E-5) associated with TNTA bedrock groundwater meet the target HI of 1 and the OEPA target cancer risk of 1E-5. The site-related HI (2) and ILCR (4E-5) associated with TNTA bedrock groundwater exceed these targets for the long-term resident, who is assumed to spend early childhood on this site and use this water as tap water. Overall risks, which include those identified as not related to the site as well as those which are site related (Section 7.2.3), exceeded these target levels for both the worker (HI=5; ILCR=3E-4) and resident (HI=237; ILCR=3E-3). Site-related risks are associated with nitroaromatics, and overall risks are mostly associated with naturally occurring petroleum-related compounds.

The modeled nitroaromatics concentrations for TNTA indicate unacceptable cancer risks for the worker (ILCR=1E-4) and resident (ILCR=5E-4). The HI (4) of the resident also exceeds the target criterion of 1.

The IEUBK model predicted unacceptable blood-lead concentrations associated with residential use of TNTA, as 9.99 percent of children were predicted to exceed a blood-lead concentration of 10 µg/dL. However, soil contributed far more to the elevated model results than did groundwater. When the model was run assuming that the planned soil remediation (to protect for direct soil contact) was complete, the results showed that only 0.39 percent of children would have a blood-lead concentration exceeding 10 µg/dL, which easily meets the criterion of no more than 5 percent exceedance (Section 6.4).

TNTB. No site-related COPCs were identified for TNTB bedrock groundwater. Therefore, aside from the discussion about modeled concentrations of nitroaromatics below, site-related risks would be very minor and are not discussed. The overall (HI=0.8) noncancer hazard values associated with worker use of TNTB bedrock groundwater meet the target HI of 1. The overall HI (5) for the resident is associated with iron. As discussed in Section 7.2.8, the iron RfD is based on dietary assumptions, and it is likely that iron at these intake levels would not result in adverse health effects. The target organ HI values associated with five other target organs exceed the target HI of 1; the chemicals responsible for these exceedances are inorganics and petroleum-related compounds. As described in Section 7.2.8, the RfD for manganese was based partly on dietary assumptions, and it is likely as described therein that concentrations of manganese present in TNTB groundwater would not result in adverse human health effects. The overall cancer risk for the resident (ILCR=3E-4) exceeds the OEPA target level. This value is associated with arsenic and (petroleum-related) benzene.

The modeled nitroaromatics concentrations for TNTB indicate that noncancer hazards would meet the target criterion for both the worker (HI=0.02) and resident (HI=0.1). The cancer risks associated with the worker would meet the OEPA criterion of 1E-5, but the resident cancer risk (ILCR=2E-5) is predicted to slightly exceed the OEPA criterion but would still be well within the NCP risk management range of 1E-6 to 1E-4. It is noted that the modeled concentrations likely overestimate the future concentrations, thus biasing the risk estimates high.

TNTC. No site-related COPCs were identified for TNTC bedrock groundwater. Therefore, aside from the discussion about modeled concentrations of nitroaromatics below, site-related risks would be very minor and are not discussed. The overall noncancer hazards (HI=1)

associated with the on-site worker meet the noncancer target criterion; however, the noncancer hazards for the resident (HI=25) do not. The cancer risks for the worker (ILCR=9E-5) and resident (ILCR=1E-3) exceed the OEPA target criterion of 1E-5. The noncancer hazards and cancer risks are mostly associated with naturally occurring petroleum-related chemicals.

The modeled nitroaromatics concentrations for TNTC indicate unacceptable cancer risks for the worker (ILCR=4E-4) and resident (2E-3). The HI (8) of the resident also exceeds the target criterion of 1.

PRRWP Area. The site-related noncancer hazard for the on-site worker (HI=0.07) and cancer risk (ILCR=4E-6) associated with PRRWP Area bedrock groundwater meet the target HI of 1 and the OEPA target cancer risk of 1E-5. The site-related HI (0.6) for the resident is less than the noncancer criterion. The site-related ILCR (2E-5) associated with residential use of PRRWP Area bedrock groundwater slightly exceeds the OEPA criterion. Overall risks, which includes those identified as not related to the site as well as those which are site related (Section 7.2.3), exceeded these target levels for both the worker (HI=8; ILCR=5E-4) and resident (HI=134; ILCR=2E-5). Site-related risks are associated with nitroaromatics, and overall risks are mostly associated with naturally occurring petroleum-related compounds.

The modeled nitroaromatics concentrations for the PRRWP Area indicate unacceptable cancer risks for the worker (ILCR=4E-5) and resident (ILCR=2E-4), though the former is within the NCP risk management range. The HI values of the worker (0.1) and resident (0.7) meet the target criterion of 1.

WARWP Area. Each WARWP Area site-related and overall noncancer HI exceeds the criterion of 1 for the worker (site-related and overall HI=6) and resident (site-related and overall HI=41). These HI values are mostly associated with site-related nitroaromatics.

Each site-related and overall ILCR exceeds the OEPA criterion of 1E-5 for the worker (site-related ILCR=6E-5; overall ILCR=1E-4) and resident (site-related ILCR=2E-4; overall ILCR=5E-4). These ILCR values are mostly associated with site-related nitroaromatics and naturally occurring arsenic. Additionally, elevated sulfate present at the WARWP Area appears to be site related.

The modeled nitroaromatics concentrations for the WARWP Area indicate that noncancer hazards would meet the target criterion for both the worker (HI=0.09) and resident (HI=0.6).

The cancer risks associated with the worker (4E-5) and resident (2E-4) would both exceed the OEPA criterion of 1E-5.

Downgradient Areas. Only the resident was evaluated at the facility boundary. The site-related noncancer HI (0.4) meets the target criterion of 1. However, the site-related ILCR (3E-5) exceeds the OEPA criterion of 1E-5. Site-related nitroaromatics were primarily responsible for this exceedance. The overall HI (55) and the overall ILCR (4E-4) exceed the respective noncancer and cancer criteria. Noncancer COPCs which exceeded the HI criterion include iron, manganese, and naturally occurring petroleum-related compounds. Benzene, a naturally occurring petroleum-related compound, was responsible for most of the ILCR.

Three downgradient areas along the PBOW facility boundary were identified (Section 6.3) and modeled for future concentrations of 2,4-DNT, 2,6-DNT, and TNT. These modeled concentrations were evaluated for risk. The HI values (0.0009 to 0.08) meet the target HI target of 1 for each boundary area. The ILCR values for boundary areas downgradient of TNTA (4E-7) and the WARWP Area (4E-7) meet OEPA target cancer risk of 1E-5. The ILCR downgradient of boundary area of TNTB (2E-5) slightly exceeds the OEPA 1E-5 target level but is within the NCP risk management range of 1E-6 to 1E-4.

10.2 Conclusions

Conclusions of the groundwater risk assessment results, considering risks associated with both site-related and naturally occurring COPCs, are briefly summarized below in context of the site conditions.

- Based on current site bedrock concentrations, overall HI and ILCR values for each of the five AOCs and the downgradient boundary exceed the respective risk management criteria for residential use.

- With the exception of the WARWP Area, both noncancer hazards and cancer risks associated with bedrock groundwater use in each of these areas is dominated by chemicals that were identified as naturally occurring. (Site-related nitroaromatics were mostly responsible for the HI and ILCR exceedances in WARWP Area groundwater.) For the WARWP Area, cancer risks associated with naturally occurring arsenic exceed the OEPA criterion (1E-5) for the resident (ILCR=2E-4) and worker (ILCR=5E-5).

- Even if no site-related contamination were present, hazards and risks associated with natural constituents of the groundwater for each of the five AOCs and downgradient areas would result in unacceptable human health risks.

- The risk results of modeled concentrations in the five AOCs show that four of these would eventually reach an ILCR for the worker that would exceed the OEPA criterion of 1E-5. The modeled concentrations of TNTB indicate that the worker ILCR (6E-6) would be less than the target criteria. The PBOW groundwater model includes the soil remediation (based on direct contact) that has been completed to date and the remaining soil remediation, which is planned for 2006. The model results indicate that the TNTB soil remediation conducted for direct contact has also been effective to protect future groundwater against unacceptable levels of nitroaromatic contamination. The modeled concentration resulted in an ILCR of 2E-5 for the TNTB resident. However, it should be understood that the groundwater model is likely to be conservative, overestimating concentrations and risks based on those concentrations.

- Based on the PBOW groundwater model, off-site groundwater will stay within concentrations that are protective of human health with respect to noncancer effects. The estimated model-based cancer risks at the PBOW boundary downgradient of TNTB (ILCR=2E-5) slightly exceeded the OEPA criterion of 1E-5, but was well within the NCP risk management range and the Army policy trigger level for remedial concerns (1E-4). Estimated model-based cancer risks along other areas of the PBOW boundary met the OEPA target criterion.

- Site-related COPCs were not identified in TNTC bedrock groundwater.

- With respect to the PBOW groundwater model, overburden groundwater contributed a majority of the nitroaromatics modeled in bedrock groundwater, with respect to each of the COCs.

- Iron and manganese were identified as the only site-related COPCs in TNTB bedrock groundwater. Their site relatedness is questionable, as these chemicals are not known to have been used in quantity during former site operations. Also, based on toxicological information, it is very possible that the concentrations present in TNTB groundwater would not result in adverse human health effects (Section 7.2.8).

- Once the planned soil remediation (based on direct contact) is complete for TNTA, lead should not adversely affect a hypothetical resident child at TNTA who would use the groundwater as tap water (Section 6.4).

- Site-related impact from sulfate appears to be present in WARWP Area groundwater.

10.3 Recommendations

The performance of a feasibility study is recommended for groundwater underlying TNTA, TNTB, TNTC, the PRRWP Area, and the WARWP Area. This recommendation is made based

on the results of the BHHRA, which indicates the potential for site-related human health risks and hazards associated with use of the on-site bedrock groundwater as a drinking water source. This potential for human health risks and hazards is based on either the risks associated with analytical concentrations collected from groundwater samples to date, or modeled future concentrations based on leaching of contaminants from the soil and/or the seasonal overburden groundwater.

A soil removal action was completed at TNTB in September 2006 primarily to reduce exposure via direct contact with soil. Similar soil removal actions are likewise planned for TNTA, TNTC, and the PRRWP Area. The removal action at the PRRWP Area was begun in 2005 and only partially completed. Therefore, the site groundwater model was run for the BHHRA under the following assumptions:

1. All remediation at TNTB is complete.
2. Partial remediation of the PRRWP Area has been performed.
3. Remediation planned for TNTA and TNTC has not begun.

The modeling results assumed for TNTB indicate that soil removal may be successful in reducing risks and hazards from bedrock groundwater exposure to acceptable criteria. The modeled on-site cancer risks for TNTB groundwater (2E-5), assuming resident use, marginally exceed the OEPA criterion, but are well within the NCP risk management range (1E-6 to 1E-4) and less than the Army policy criterion (1E-4). Because of the conservative nature of the model, it is possible that actual future concentrations will be less than predicted and will result in cancer risks that do not exceed the OEPA criterion. The noncancer HI (0.1), based on the model's assumption that remediation is complete, is less than the acceptable criterion of 1.

As part of the groundwater feasibility study, it is recommended that the site groundwater model be run under the assumption that the planned removal actions for TNTA, TNTC, and the PRRWP Area likewise have been completed. Additional remedial actions may likewise be considered in the groundwater feasibility study. These include actions which may be taken directly with respect to groundwater and those which would apply to additional soil remediation beyond those actions which have already taken place (i.e., at TNTB) or are planned.

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TABLES

Table 2-1

Sampling Locations Used in the Baseline Human Health Risk Assessment of Groundwater Former Plum Brook Ordnance Works Sandusky, Ohio

Site Area	Overburden Sampling Location	Bedrock Sampling Location
TNT Area A	TNTA-MW10 TNTA-MW11 MK-MW22 MK-MW23 MK-MW24 TNTA-GW01 through TNTA-GW08[a] TNTA-GW10[a] TNTA-DP14[a] TNTA-DP21[a]	PB-BED-MW18 (SH/LS) TNTA-BEDGW-001 (LS)
TNT Area B	MK-MW17 TNTB-DP02[a] TNTB-DP03[a]	TNT-BEDGW-001 (SH) TNT-BEDGW-003 (SH) TNT-BEDGW-004 (SH)
TNT Area C	TNTC-MW03 TNTC-MW04 TNTC-MW05 TNTC-MW06 IT-MW09 TNTC-GW02 through TNTC-GW10[a] TNTC-DP13[a] TNTC-DP19[a]	TNTC-BEDGW-001 (LS) BED-MW13 (LS)
Pentolite Road Red Water Pond Area	IT-MW05 PR-MW07 PR-MW08 PR-MW09 PRRP-DP01 through PRRP-DP20[a]	BED-MW15 (LS) BED-MW23 (LS)
West Area Red Water Ponds Area	WA-MW01 WA-MW02 IT-MW02 IT-MW10 WARP-DP01 WARP-DP02 WARP-DP04 WARP-DP06 through WARP-DP09[a] WARP-DP11 through WARP-DP13[a] WARP-DP15 through WARP-DP17[a] WARP-DP19	BED-MW14 (LS)

Table 2-1

Sampling Locations Used in the Baseline Human Health Risk Assessment of Groundwater Former Plum Brook Ordnance Works Sandusky, Ohio

Site Area	Overburden Sampling Location	Bedrock Sampling Location
Downgradient Boundary Wells	NA[b]	BED-MW17 (LS) BED-MW19 (LS) BED-MW22 (LS) BED-MW24 (LS) BED-MW27 (LS) BED-MW30 (LS)

(LS) – Well screened in limestone.
(SH) – Well screened in shale.
(SH/LS) – Well screened in the limestone/shale interface.
[a] Sample collected using direct-push method.
[b] "NA" indicates "not applicable." Some overburden groundwater samples were collected near the facility boundary, but these are not regarded as representing conditions downgradient because groundwater within the overburden is highly discontinuous.

Table 2-2

Groundwater Samples Evaluated
Former Plum Brook Ordnance Works, Sandusky, Ohio

Location	Sample Number	Sample Date	Analyses
TNT Area A			
Bedrock Wells			
PB-BED-MW18	5940	11/19/1997	ALKALINITY, Chloride, Cyanide, Exp, Hardness, Metals*, Nitrate, Pests, PCBs, SVOC, Sulfate, TDS, TOC, TSS, VOC
PB-BED-MW18	5945	05/19/1998	ALKALINITY, Chloride, Cyanide, Exp, Hardness, Metals*, Nitrate, PCBs, SVOC, Sulfate, TDS, TOC, TSS, VOC
PB-BED-MW18	BD3024	10/02/2001	ALKALINITY, Chloride, Cyanide, Exp, Hardness, Metals*, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turbidity, VOC
TNTA-BEDGW-001	BD3037	10/09/2001	Exp, Metals*, SVOC, TOC, VOC
PB-BED-MW18	CB3015	04/05/2002	ALKALINITY, Chloride, Cyanide, Exp, Hardness, Metals*, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turbidity, VOC
TNTA-BEDGW-001	CB3044	04/15/2002	ALKALINITY, Chloride, Cyanide, Exp, Hardness, Metals*, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turbidity, VOC
Overburden Wells			
MK-MW24	5840	11/13/1997	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, Pests, PCBs, SVOCs, Sulfate, TDS, TOC, TSS, VOCs
MK-MW22	5820	11/14/1997	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, Pests, PCBs, SVOCs, Sulfate, TDS, TOC, TSS, VOCs
MK-MW23	5830	11/16/1997	Exp, Metals, SVOC, VOC
PB-TNTA-MW10	5610	11/18/1997	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, Pests, PCBs, SVOCs, Sulfate, TDS, TOC, TSS, VOCs
PB-TNTA-MW10	5611 (FD)	11/18/1997	Exp, Metals, PCBs, SVOC, TOC, VOC
PB-TNTA-MW11	5620	11/18/1997	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, Pests, PCBs, SVOCs, Sulfate, TDS, TOC, TSS, VOCs
MK-MW22	5825	05/18/1998	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, Pests, PCBs, SVOCs, Sulfate, TDS, TOC, TSS, VOCs
MK-MW24	5845	05/20/1998	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, PCBs, SVOCs, Sulfate, TDS, TOC, TSS, VOCs
MK-MW23	5835	05/29/1998	Exp, Metals, PCBs, SVOC, TOC, VOC
PB-TNTA-MW10	5615	05/29/1998	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, PCBs, SVOCs, Sulfate, TDS, TOC, TSS, VOCs
PB-TNTA-MW10	5616 (FD)	05/29/1998	Exp, Metals, PCBs, SVOC, VOC
PB-TNTA-MW11	5625	05/29/1998	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, PCBs, SVOCs, Sulfate, TDS, TOC, TSS, VOCs
PB-TNTA-MW11	BD3034	10/03/2001	Exp, SVOC, TOC, VOC
PB-TNTA-MW10	CB3042	04/15/2002	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
PB-TNTA-MW11	CB3043	04/15/2002	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
Overburden Direct-Push Samples			
TNTA-GW10	AA3010	09/26/2000	Exp, Metals, PCBs, SVOC, VOC
TNTA-GW10	AA3011 (FD)	09/26/2000	Exp, Metals, PCBs, SVOC, VOC
TNTA-GW06	AA3006	09/27/2000	Exp, Metals, PCBs, SVOC, VOC
TNTA-GW01	AA3001	10/11/2000	Exp, Metals, PCBs, SVOC, VOC
TNTA-GW02	AA3002	10/11/2000	Exp, Metals, PCBs, SVOC, VOC
TNTA-GW05	AA3005	10/11/2000	Exp, Metals, PCBs, SVOC, VOC
TNTA-GW07	AA3007	10/11/2000	Exp, Metals, PCBs, SVOC, VOC
TNTA-GW03	AA3003	10/12/2000	Exp, Metals, PCBs, SVOC, VOC
TNTA-GW04	AA3004	10/12/2000	Exp, Metals, PCBs, SVOC, VOC
TNTA-GW08	AA3008	10/12/2000	Exp, Metals, PCBs, SVOC, VOC
TNTA-DP21	BA3021	08/01/2001	Exp, VOCs
TNTA-DP14	BA3014	08/02/2001	Exp, VOCs
TNT Area B			
Bedrock Wells			
IT-TNTB-BEDGW-001	5420	11/17/1997	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, Pests, PCBs, SVOC, Sulfate, TDS, TOC, TSS, VOC
IT-TNTB-BEDGW-001	5425	05/18/1998	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, PCBs, SVOC, Sulfate, TDS, TOC, TSS, VOC

Table 2-2

Groundwater Samples Evaluated
Former Plum Brook Ordnance Works, Sandusky, Ohio

Location	Sample Number	Sample Date	Analyses
TNT Area B (continued)			
Bedrock Wells (continued)			
IT-TNTB-BEDGW-001	BD3009	09/28/2001	Alkalinity, Chloride, Cyanide, Exp, Hardness, SVOC, Sulfate, TDS, TOC, TSS
IT-TNTB-BEDGW-001	BD3009R	10/05/2001	Metals, Nitrate, Turb, VOC
TNTB-BEDGW-004	BD3041	10/05/2001	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
TNTB-BEDGW-004	BD3050 (FD)	10/05/2001	Exp, Metals, SVOC, VOC
TNTB-BEDGW-003	BD3038	10/08/2001	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
IT-TNTB-BEDGW-001	CB3019	04/05/2002	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
IT-TNTB-BEDGW-001	CB3020 (FD)	04/05/2002	Exp, Metals, SVOC, VOC
TNTB-BEDGW-004	CB3023	04/08/2002	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
TNTB-BEDGW-003	CB3024	04/10/2002	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
Overburden Wells			
MK-MW17	5790	11/21/1997	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, Pests, PCB, SVOC, Sulfate, TDS, TOC, TSS, VOC
MK-MW17	5795	05/27/1998	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, Pests, PCB, SVOC, Sulfate, TDS, TOC, TSS, VOC
MK-MW17	BD3012	10/01/2001	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, Pests, PCB, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
MK-MW17	CB3038	04/12/2002	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, Pests, PCB, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
Overburden Direct-Push Samples			
TNTB-DP03	BB3003	08/01/2001	Exp, Metals
TNTB-DP02	BB3002	08/06/2001	Exp, Metals
TNT Area C			
Bedrock Wells			
PB-BED-MW13	5890	11/13/1997	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, Pests, PCBs, SVOC, Sulfate, TDS, TOC, TSS, VOC
PB-BED-MW13	5895	05/29/1998	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, Pests, PCBs, SVOC, Sulfate, TDS, TOC, TSS, VOC
PB-BED-MW13	BD3017	10/03/2001	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
TNTC-BEDGW-001	BD3042	10/04/2001	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
TNTC-BEDGW-001	BD3048 (FD)	10/04/2001	Exp, Metals, Nitrate, SVOC, VOC
TNTC-BEDGW-001	CB3026	04/09/2002	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
PB-BED-MW13	CB3025	04/10/2002	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
Overburden Wells			
PB-TNTC-MW6	5660	11/20/1997	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, Pest, PCB, SVOC, Sulfate, TDS, TOC, TSS, VOC
PB-TNTC-MW3	5630	11/21/1997	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, Pest, PCB, SVOC, Sulfate, TDS, TOC, TSS, VOC
PB-TNTC-MW5	5650	11/21/1997	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, Pest, PCB, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
IT-MW09	5590	11/23/1997	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, Pest, PCB, SVOC, Sulfate, TDS, TOC, TSS, VOC
PB-TNTC-MW4	5640	11/24/1997	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, Pest, PCB, SVOC, Sulfate, TDS, TOC, TSS, VOC
PB-TNTC-MW6	5665	05/16/1998	Alkalinity, Chloride, Cyanide, Hardness, Metals, Nitrate, Sulfate, TDS, TOC, TSS
PB-TNTC-MW3	5635	05/18/1998	Alkalinity, Chloride, Cyanide, Exp, Hardness, Nitrate, PCB, SVOC, Sulfate, TDS, TOC, TSS, VOC
PB-TNTC-MW4	5645	05/18/1998	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, PCB, SVOC, Sulfate, TDS, TOC, TSS, VOC
PB-TNTC-MW5	5655	05/18/1998	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, PCB, SVOC, Sulfate, TDS, TOC, TSS, VOC
PB-TNTC-MW6	5665R	05/18/1998	Exp, PCB, SVOC, VOC
IT-MW09	5595	05/19/1998	Alkalinity, Cyanide, Exp, Hardness, Metals, Nitrate, PCB, SVOC, Sulfate, TDS, TOC, TSS, VOC

Table 2-2

Groundwater Samples Evaluated
Former Plum Brook Ordnance Works, Sandusky, Ohio

Location	Sample Number	Sample Date	Analyses
TNT Area C (continued)			
Overburden Direct-Push Samples (continued)			
PB-TNTC-MW5	BD3035	10/03/2001	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
PB-TNTC-MW4	BD3043	10/04/2001	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
PB-TNTC-MW5	CB3029	04/08/2002	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
PB-TNTC-MW3	CB3027	04/10/2002	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
PB-TNTC-MW4	CB3028	04/10/2002	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
Overburden Direct-Push Samples			
TNTC-GW10	AB3010	09/27/2000	Exp, Metals, PCB, SVOC, VOC
TNTC-GW10	AB3011 (FD)	09/27/2000	Exp, Metals, PCB, SVOC, VOC
TNTC-GW03	AB3003	09/28/2000	Exp, Metals, PCB, SVOC, VOC
TNTC-GW04	AB3004	09/28/2000	Exp, Metals, PCB, SVOC, VOC
TNTC-GW06	AB3006	09/28/2000	Exp, Metals, PCB, SVOC, VOC
TNTC-GW07	AB3007	09/28/2000	Exp, Metals, PCB, SVOC, VOC
TNTC-GW09	AB3009	09/29/2000	Exp, Metals, PCB, SVOC, VOC
TNTC-GW02	AB3002	10/10/2000	Exp, Metals, PCB, SVOC, VOC
TNTC-GW05	AB3005	10/10/2000	Exp, Metals, PCB, SVOC, VOC
TNTC-GW08	AB3008	10/10/2000	Exp, Metals, PCB, SVOC, VOC
TNTC-DP13	BC3013	08/01/2001	Exp, VOC
TNTC-DP19	BC3019	08/06/2001	Exp, VOC
Pentolite Road Red Water Ponds Area			
Bedrock Wells			
PB-BED-MW15	5910	11/18/1997	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, Pest, PCB, SVOC, Sulfate, TDS, TOC, TSS, VOC
PB-BED-MW15	5915	05/28/1998	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, PCB, SVOC, Sulfate, TDS, TOC, TSS, VOC
PB-BED-MW15	BD3019	10/09/2001	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
PB-BED-MW23	BD3028	10/09/2001	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
PB-BED-MW23	CB3040	04/11/2002	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
PB-BED-MW15	CB3041	04/15/2002	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
Overburden Wells			
PB-PR-MW7	5690	11/17/1997	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, Pest, PCB, SVOC, Sulfate, TDS, TOC, TSS, VOC
PB-PR-MW8	5700	11/17/1997	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, Pest, PCB, SVOC, Sulfate, TDS, TOC, TSS, VOC
PB-PR-MW8	5701 (FD)	11/17/1997	Exp, Metals, PCBs, SVOC, VOC
PB-PR-MW9	5710	11/17/1997	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, Pest, PCB, SVOC, Sulfate, TDS, TOC, TSS, VOC
IT-MW05	5550	11/19/1997	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, Pest, PCB, SVOC, Sulfate, TDS, TOC, TSS, VOC
PB-PR-MW7	5695	05/20/1998	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, PCB, SVOC, Sulfate, TDS, TOC, TSS, VOC
PB-PR-MW7	5696 (FD)	05/20/1998	Exp, Metals, PCBs, SVOC, VOC
PB-PR-MW8	5705	05/20/1998	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, PCB, SVOC, Sulfate, TDS, TOC, TSS, VOC
PB-PR-MW9	5715	05/20/1998	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, Pest, PCB, SVOC, Sulfate, TDS, TOC, TSS, VOC
IT-MW05	5555	05/28/1998	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, Pest, PCB, SVOC, Sulfate, TDS, TOC, TSS, VOC
IT-MW05	5556 (FD)	05/28/1998	Exp, Metals, PCBs, SVOC, VOC

Table 2-2

Groundwater Samples Evaluated
Former Plum Brook Ordnance Works, Sandusky, Ohio

Location	Sample Number	Sample Date	Analyses
Pentolite Road Red Water Ponds Area (continued)			
Overburden Direct-Push Samples			
PRRP-DP03	7310	06/08/1998	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, PCBs, SVOC, Sufate, TDS, TOC, TSS, VOC
PRRP-DP04	7350	06/09/1998	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, PCBs, SVOC, Sufate, TDS, TOC, TSS, VOC
PRRP-DP06	7430	06/09/1998	Exp
PRRP-DP07	7470	06/10/1998	Metal, SVOC, VOC
PRRP-DP08	7510	06/10/1998	Exp, Metals, SVOC, VOC
PRRP-DP10	7590	06/10/1998	Exp, Metals, PCBs, SVOC, VOC
PRRP-DP12	7670	06/11/1998	Exp, Metal, PCBs, SVOC, VOC
PRRP-DP17	7870	06/11/1998	Exp, Metals, PCBs, SVOC, VOC
PRRP-DP17	7871 (FD)	06/11/1998	Exp, Metals, PCBs, SVOC, VOC
PRRP-DP01	7230	06/12/1998	Exp, Metals, PCBs, SVOC, VOC
PRRP-DP13	7710	06/12/1998	Exp, Metals, PCBs, SVOC, VOC
PRRP-DP14	7750	06/12/1998	Exp, Metals, PCBs, SVOC, VOC
PRRP-DP15	7790	06/12/1998	Exp, Metals, PCBs, SVOC, VOC
PRRP-DP18	7910	06/12/1998	Exp, Metals, PCBs, SVOC, VOC
PRRP-DP16	7830	06/13/1998	Exp, Metals, SVOC, VOC
PRRP-DP19	7950	06/13/1998	Exp, Metals, SVOC, VOC
PRRP-DP02	7270	06/14/1998	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, PCBs, SVOC, Sufate, TDS, TOC, TSS, VOC
PRRP-DP05	7390	06/14/1998	Exp, Metals, PCBs, SVOC, VOC
PRRP-DP09	7550	06/14/1998	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, PCBs, SVOC, Sufate, TDS, TOC, TSS, VOC
PRRP-DP11	7630	06/14/1998	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sufate, TDS, TOC, TSS, VOC
PRRP-DP20	7990	06/14/1998	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, PCBs, SVOC, Sufate, TDS, TOC, TSS, VOC
PRRP-DP11	7630R	06/25/1998	Exp, PCB
West Area Red Water Pond Area			
Bedrock Wells			
PB-BED-MW14	5900	11/18/1997	Alkalinity, Chloride, Cyanide, Exp, Hardness, Nitrate, Pest, PCB, SVOC, Sulfate, TDS, TOC, TSS, VOC
PB-BED-MW14	5905	05/16/1998	Alkalinity, Chloride, Cyanide, Hardness, Metals, Nitrate, Sulfate, TDS, TOC, TSS
PB-BED-MW14	5905R	05/18/1998	Exp, PCB, SVOC, VOC
PB-BED-MW14	BD3018	09/28/2001	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, SVOC, Sulfate, TDS, TOC, TSS
PB-BED-MW14	BD3018R	10/05/2001	Nitrate, Turb, VOC
PB-BED-MW14	CB3022	04/08/2002	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
Overburden Wells			
IT-MW10	5600	11/14/1997	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, Pest, PCBs, SVOCs, Sulfate, TDS, TOC, TSS, VOCs
IT-MW02	5540	11/21/1997	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, Pest, PCBs, SVOCs, Sulfate, TDS, TOC, TSS, VOCs
PB-WA-MW1	5670	11/21/1997	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, Pest, PCBs, SVOCs, Sulfate, TDS, TOC, TSS, VOCs
PB-WA-MW2	5680	11/23/1997	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, Pest, PCBs, SVOCs, Sulfate, TDS, TOC, TSS, VOCs
IT-MW10	5605	05/14/1998	Alkalinity, Chloride, Cyanide, Exp, Hardness, Nitrate, PCBs, SVOCs, Sulfate, TDS, TOC, TSS, VOCs
IT-MW02	5545	05/15/1998	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, PCBs, SVOCs, Sulfate, TDS, TOC, TSS, VOCs
PB-WA-MW2	5685	05/15/1998	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, PCBs, SVOCs, Sulfate, TDS, TOC, TSS, VOCs
PB-WA-MW1	5675	05/18/1998	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, PCBs, SVOCs, Sulfate, TDS, TOC, TSS, VOCs

Table 2-2

Groundwater Samples Evaluated
Former Plum Brook Ordnance Works, Sandusky, Ohio

Location	Sample Number	Sample Date	Analyses
West Area Red Water Pond Area (continued)			
Overburden Direct-Push Samples			
WARP-DP01	8130	06/25/1998	Exp, VOC
WARP-DP02	8170	06/24/1998	Exp, Metals, VOC
WARP-DP04	8250	06/24/1998	Exp, VOC
WARP-DP04	8251 (FD)	06/24/1998	Exp, VOC
WARP-DP04	8250B	06/25/1998	Metals, SVOC
WARP-DP06	8330	06/23/1998	Exp, VOC
WARP-DP07	8370	06/26/1998	Exp, Metals, SVOC, VOC
WARP-DP08	8410	06/16/1998	Exp, VOC
WARP-DP09	8450	06/16/1998	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, PCB, SVOC, Sulfate, TDS, TOC, TSS, VOC
WARP-DP11	8530	06/26/1998	Exp, Metals, SVOC, VOC
WARP-DP12	8570	06/15/1998	Exp, VOC
WARP-DP13	8610	06/15/1998	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, PCB, SVOC, Sulfate, TDS, TOC, TSS, VOC
WARP-DP15	8690	06/26/1998	Exp, VOC
WARP-DP16	8730	06/25/1998	Exp, Metals, PCB, SVOC, VOC
WARP-DP17	8770	06/25/1998	Exp, Metals, PCB, SVOC, VOC
WARP-DP19	8850	06/26/1998	Exp, VOC
Downgradient Boundary Area			
Bedrock Wells			
PB-BED-MW19	5950	11/14/1997	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, Pest, PCB, SVOC, Sulfate, TDS, TOC, TSS, VOC
PB-BED-MW17	5930	11/20/1997	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, Pest, PCB, SVOC, Sulfate, TDS, TOC, TSS, VOC
PB-BED-MW19	5955	05/16/1998	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, PCB, SVOC, Sulfate, TDS, TOC, TSS, VOC
PB-BED-MW17	5935	05/29/1998	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, Pest, PCB, SVOC, Sulfate, TDS, TOC, TSS, VOC
PB-BED-MW17	BD3021	10/03/2001	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
PB-BED-MW19	BD3025	10/04/2001	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
PB-BED-MW19	BD3046 (FD)	10/04/2001	Exp, Metals, SVOC, VOC
PB-BED-MW22	BD3027	10/08/2001	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
PB-BED-MW24	BD3029	10/09/2001	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
PB-BED-MW27	BD3032	10/09/2001	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
PB-BED-MW24	CA3001	01/17/2002	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
PB-BED-MW24	CB3008	04/03/2002	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
PB-BED-MW19	CB3013	04/04/2002	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
PB-BED-MW22	CB3009	04/04/2002	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
PB-BED-MW22	CB3010 (FD)	04/04/2002	Exp, Metals, SVOC, VOC
PB-BED-MW27	CB3012	04/09/2002	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
PB-BED-MW17	CB3014	04/11/2002	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
PB-BED-MW24	CC3004	07/12/2002	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
PB-BED-MW27	CD3009	10/18/2002	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
PB-BED-MW24	CD3004	10/19/2002	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
PB-BED-MW24	DA3004	04/09/2003	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC

Table 2-2

Groundwater Samples Evaluated
Former Plum Brook Ordnance Works, Sandusky, Ohio

Location	Sample Number	Sample Date	Analyses
PB-BED-MW24	DC3002	09/17/2003	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
Downgradient Boundary Area (continued)			
Bedrock Wells (continued)			
PB-BED-MW24	DD3003	12/11/2003	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
PB-BED-MW24	DE3002	03/10/2004	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
PB-BED-MW19	DF3001	05/05/2004	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
PB-BED-MW22	DF3002	05/05/2004	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
PB-BED-MW22	DF3005 (FD)	05/05/2004	Exp, Metals, SVOC, VOC
PB-BED-MW17	DF3000	05/06/2004	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
PB-BED-MW30	DF3003	05/07/2004	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
PB-BED-MW19	DH3001	08/25/2004	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
PB-BED-MW30	DH3003	08/25/2004	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
PB-BED-MW17	DH3000	08/26/2004	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
PB-BED-MW22	DH3002	08/26/2004	Alkalinity, Chloride, Cyanide, Exp, Hardness, Metals, Nitrate, SVOC, Sulfate, TDS, TOC, TSS, Turb, VOC
PB-BED-MW22	DH3005 (FD)	08/26/2004	Exp, Metals, SVOC, VOC

FD - Field duplicate.
PCB - Polychlorinated biphenyl.
SVOC - Semivolatile organic compound.
TDS - Total dissolved solid.
TOC - Total organic carbon.
TPH - Total petroleum hydrocarbon.
TSS - Total suspended solid.
Turb - Turbidity.
VOC - Volatile organic compound.
EXP - Nitroaromatic explosive.

Table 2-3

Background Screening Concentrations for Inorganics and BTEX Compounds in Groundwater Former Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of Values, µg/L: Detected Concentrations Minimum	Detected Concentrations Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Mean µg/L	Standard Deviation	UTL [a] µg/L	BSC [b] µg/L
Metals - Unfiltered										
Aluminum	11 / 13	85	3.15E+01	3.09E+02	2.00E+02	2.00E+02	1.05E+02	6.98E+01	4.17E+02	309
Arsenic	4 / 26	15	3.30E+00	7.40E+00	1.00E+01	1.00E+01	4.99E+00	6.56E-01	7.92E+00	7.4
Barium	28 / 28	100	2.58E+01	1.18E+04	2.00E+02	2.00E+03	1.73E+03	3.77E+03	1.86E+04	11800
Calcium	28 / 28	100	1.74E+04	3.16E+05	5.00E+03	5.00E+03	1.38E+05	8.31E+04	5.09E+05	316000
Cobalt	6 / 27	22	1.00E+00	1.21E+01	5.00E+01	5.00E+01	2.05E+01	8.75E+00	5.96E+01	12.1
Copper	2 / 28	7	3.30E+00	1.98E+01	2.50E+01	2.50E+01	1.24E+01	2.26E+00	2.25E+01	19.8
Iron	24 / 27	89	3.82E+01	1.55E+03	1.00E+02	1.00E+02	4.15E+02	4.87E+02	2.59E+03	1550
Magnesium	28 / 28	100	7.28E+03	2.17E+05	5.00E+03	5.00E+03	7.17E+04	5.85E+04	3.33E+05	217000
Manganese	28 / 28	100	3.60E+00	6.88E+02	1.50E+01	1.50E+01	8.12E+01	1.24E+02	6.36E+02	636
Nickel	4 / 27	15	4.80E+00	8.60E+00	4.00E+01	4.00E+01	1.81E+01	4.67E+00	3.90E+01	8.6
Potassium	28 / 28	100	2.53E+03	1.16E+05	5.00E+03	5.00E+04	2.70E+04	3.06E+04	1.64E+05	116000
Sodium	28 / 28	100	1.33E+04	1.39E+06	5.00E+03	5.00E+04	3.55E+05	4.36E+05	2.30E+06	1390000
Zinc	14 / 19	74	8.30E-01	5.07E+02	2.00E+01	2.00E+01	5.55E+01	1.23E+02	6.06E+02	507
Volatile Organic Compounds										
Benzene	9 / 28	32	1.45E-01	2.40E+00	1.00E+00	5.00E+00	6.73E-01	5.43E-01	3.10E+00	2.4
Ethylbenzene	6 / 28	21	1.30E-01	8.70E-01	1.00E+00	5.00E+00	5.82E-01	4.00E-01	2.37E+00	0.87
Toluene	8 / 28	29	1.20E-01	1.70E+00	1.00E+00	5.00E+00	4.99E-01	2.83E-01	1.76E+00	1.7
Xylenes, total	8 / 28	29	3.60E-01	5.50E+00	1.00E+00	5.00E+00	1.22E+00	1.53E+00	8.07E+00	5.5

[a] The UTL (upper tolerance limit) is calculated using the Chebychev equation (mean + 4.47 * standard deviation).

[b] The BSC (background screening criterion) is the calculated UTL or the maximum detected concentration, whichever is less.

µg/L - Micrograms per liter.

mg/L - Milligrams per liter.

BTEX - Benzene, toluene, ethylbenzene, and xylenes.

Source: Shaw Environmental, Inc., 2005, 2004 Data Summary and Evaluation Report, Final, Plum Brook Ordnance Works, Sandusky, Ohio, April.

Table 2-4

Statistical Summary and COPC Selection of Chemicals Detected in Bedrock Groundwater
TNT Area A, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of Values, µg/L: Detected Concentrations Minimum	Detected Concentrations Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Statistical Distribution [a]	Mean µg/L	95% UCL µg/L b	BSC [c] µg/L	RBSC [d] µg/L	COPC? [e,f]	Exposure Point Concentration [g] µg/L
Inorganics													
Aluminum	3 / 5	60	79.2	8300	200	200	NP	1.77E+03	8.30E+03	3.09E+02	3.65E+03	Y	8.30E+03
Arsenic	2 / 6	33	10.8	17.3	10	200	L	3.14E+01	5.31E+02	7.40E+00	4.48E-02	Y	1.73E+01
Barium	6 / 6	100	471	1290	200	200	N	9.19E+02	1.14E+03	1.18E+04	2.55E+02	N (b)	---
Beryllium	1 / 5	20	1.1	1.1	5	5	NP	2.22E+00	2.50E+00		7.30E+00	N (a)	---
Cadmium	1 / 6	17	1.2	1.2	5	5	NP	2.28E+00	2.50E+00		1.82E+00	N (a)	---
Calcium	6 / 6	100	724000	12000000	50000	500000	L	3.01E+06	1.93E+07	3.16E+05	Nutrient	N (c)	---
Chromium	1 / 6	17	37.2	37.2	10	10	NP	1.04E+01	3.72E+01		1.09E+01 h	Y	3.72E+01
Cobalt	2 / 6	33	6.4	12.7	50	50	NP	1.99E+01	2.50E+01	1.21E+01	7.30E+01	N (a)	---
Copper	2 / 6	33	3.2	53.1	25	25	L	1.77E+01	8.43E+01	1.98E+01	1.46E+02	N (a)	---
Iron	4 / 5	80	40	33400	100	100	NP	6.76E+03	3.34E+04	1.55E+03	1.09E+03	Y	3.34E+04
Lead	1 / 6	17	18.4	18.4	3	60	N	1.23E+01	2.14E+01		1.50E+01 i	Y	1.84E+01
Magnesium	6 / 6	100	384000	943000	5000	50000	L	6.53E+05	1.02E+06	2.17E+05	Nutrient	N (c)	---
Manganese	6 / 6	100	36.8	11700	15	15	L	2.30E+03	5.15E+07	6.36E+02	8.76E+01	Y	1.17E+04
Mercury	2 / 6	33	0.067	1	0.2	0.2	NP	2.45E-01	1.00E+00		1.09E+00	N (a)	---
Nickel	2 / 6	33	48.8	75.7	40	40	NP	3.41E+01	7.57E+01	8.60E+00	7.30E+01	Y	7.57E+01
Potassium	6 / 6	100	94200	334000	5000	50000	L	1.78E+05	2.84E+05	1.16E+05	Nutrient	N (c)	---
Sodium	6 / 6	100	442000	4050000	5000	200000	N	2.40E+06	3.48E+06	1.39E+06	Nutrient	N (c)	---
Vanadium	1 / 6	17	36.9	36.9	50	50	NP	2.70E+01	3.69E+01		3.65E+00	Y	3.69E+01
Zinc	4 / 6	67	31	425	20	20	L	1.37E+02	1.90E+04	5.07E+02	1.09E+03	N (a)	---
Explosives													
1,3,5-Trinitrobenzene	1 / 6	17	1.5	1.5	0.2	0.2	NP	3.33E-01	1.50E+00		1.09E+02	N (a)	---
1,3-Dinitrobenzene	1 / 6	17	1	1	0.2	0.36	NP	2.74E-01	1.00E+00		3.65E-01	Y	1.00E+00
2,4-Dinitrotoluene	1 / 6	17	0.49	0.49	0.2	1.8	N	3.56E-01	6.21E-01		9.89E-02 j	Y	4.90E-01
2,6-Dinitrotoluene	1 / 6	17	3.6	3.6	0.2	1.1	NP	7.64E-01	3.60E+00		9.89E-02 j	Y	3.60E+00
2-Amino-4,6-dinitrotoluene	2 / 4	50	0.33	0.55	0.2	0.2	NA	2.70E-01	NA		7.30E-01 k	N (a)	---
2-Nitrotoluene	1 / 6	17	0.31	0.31	0.2	8.1	NP	8.13E-01	4.05E+00		4.87E-02	Y	3.10E-01
3-Nitrotoluene	1 / 6	17	0.3	0.3	0.2	0.27	NP	1.40E-01	3.00E-01		1.22E+01	N (a)	---
4-Amino-2,6-dinitrotoluene	2 / 6	33	1.3	1.3	0.2	1.8	NP	6.33E-01	1.30E+00		7.30E-01 k	Y	1.30E+00
Nitrobenzene	1 / 6	17	2	2	0.2	1.9	NP	5.62E-01	2.00E+00		3.40E-01	Y	2.00E+00
Semivolatile Organic Compounds													
2,4-Dimethylphenol	6 / 6	100	5.1	18	10	100	N	1.11E+01	1.48E+01		7.30E+01	N (a)	---
2-Methylnaphthalene	6 / 6	100	1.6	470	10	100	L	8.85E+01	4.07E+05		6.20E-01 l	Y	4.70E+02
2-Methylphenol	5 / 6	83	2.6	12	10	100	L	1.25E+01	1.44E+02		1.82E+02	N (a)	---
4-Methylphenol	6 / 6	100	1.2	15	10	100	L	6.20E+00	3.14E+01		1.82E+01	N (a)	---
Bis(2-ethylhexyl)phthalate	2 / 5	40	3.5	8.6	10	100	L	5.42E+00	8.15E+00		4.80E+00	Y	8.15E+00
Chrysene	2 / 6	33	0.62	15	10	100	NP	5.94E+00	1.50E+01		9.21E+00	Y	1.50E+01
Dibenzofuran	1 / 6	17	12	12	10	100	NP	6.17E+00	1.20E+01		1.22E+00	Y	1.20E+01
Fluorene	2 / 6	33	1.9	28	10	100	NP	8.32E+00	2.80E+01		2.43E+01	Y	2.80E+01
Naphthalene	6 / 6	100	3.1	170	10	100	L	3.93E+01	2.50E+03		6.20E-01	Y	1.70E+02
Phenanthrene	2 / 6	33	3.4	74	10	100	NP	1.62E+01	7.40E+01		1.83E+01 m	Y	7.40E+01
Phenol	5 / 6	83	1.4	27	10	100	L	1.18E+01	1.57E+02		1.09E+03	N (a)	---
Volatile Organic Compounds													
Acetone	3 / 3	100	34	290	50	1000	NA	1.37E+02	NA		5.48E+02	N (a)	---
Benzene	5 / 6	83	5.7	700	5	200	L	2.12E+02	5.12E+05		3.54E-01	Y	7.00E+02
Carbon disulfide	3 / 6	50	4.8	32	5	200	N	4.08E+01	6.96E+01		1.04E+02	N (a)	---

Table 2-4

Statistical Summary and COPC Selection of Chemicals Detected in Bedrock Groundwater
TNT Area A, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of Values, µg/L: Detected Concentrations Minimum	Detected Concentrations Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Statistical Distribution [a]	Mean µg/L	95% UCL µg/L [b]	BSC [c] µg/L	RBSC [d] µg/L	COPC? [e,f]	Exposure Point Concentration [g] µg/L
Chloromethane	1 / 6	17	35	35	10	400	L	5.83E+01	1.10E+04		1.58E+01	Y	3.50E+01
Ethylbenzene	6 / 6	100	32	240	5	200	L	1.17E+02	5.53E+02		1.34E+02	Y	2.40E+02
Methylene chloride	3 / 5	60	47	330	5	400	L	1.11E+02	1.45E+07		4.28E+00	Y	3.30E+02
Toluene	5 / 6	83	21	730	5	200	L	2.60E+02	1.40E+04		7.23E+01	Y	7.30E+02
Xylenes, total	6 / 6	100	150	1400	5	200	L	6.27E+02	3.60E+03		2.06E+01	Y	1.40E+03
Miscellaneous													
Chloride	5 / 5	100	1200	12900	0.1	200	N	7.05E+03	1.13E+04		Nutrient	N (d)	1.13E+04
Sulfate	4 / 4	100	16	388	0.01	100	NA	1.20E+02	NA		5.00E+05 [n]	N (a)	---

COPC - Chemical of potential concern; UCL - Upper confidence limit; BSC - Background screening criterion; RBSC - Risk-based screening concentration
ND - No data; µg/L - Micrograms per liter.

[a] Statistical Distribution: N = Normal distribution; L = Lognormal distribution; NP = Nonparametric distribution; NA = Not applicable, distribution not determined for sample sets less than 5.
[b] Method of estimation based on statistical distribution (please see Section 3.2.1).
[c] Background screening criteria are presented in the ***2004 Data Summary and Evaluation Report*** (Shaw, 2005).
[d] Risk-Based Screening Concentrations based on EPA Region 9 Preliminary Remediation Goals (PRGs [EPA, 2004]) for tap water.
PRGs were adjusted to provide an Hazard Index of 0.1 and an Incremental Lifetime Cancer Range of 1E-6.
[e] N - Chemical is not chosen as a COPC:
(a) - maximum detected concentration is less than the RBSC.
(b) - maximum detected concentration is less than the BSC.
(c) - essential nutrient.
(d) - essential nutrient with no toxicity value available.
[f] Y - Chemical is chosen as COPC.
[g] Exposure point concentration is chosen based on criteria described in section 3.2.1.
[h] Based on PRG for chromium VI.
[i] Screening criteria for lead based on the action level of 15 µg/L (EPA, 1996, *Drinking Water Regulations and Health Advisories* , Office of Water, Washington, DC, October).
[j] Based on PRG for dinitrotoluene mixture.
[k] Based on PRG for aminodinitrotoluene.
[l] Based on PRG for naphthalene.
[m] Based on PRG for pyrene.
[n] Screening criteria for sulfate based on the *Drinking Water Advisory* .

Table 2-5

Statistical Summary and COPC Selection of Chemicals Detected in Bedrock Groundwater
TNT Area B, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of values, µg/L: Detected Conc Minimum	Detected Conc Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Statistical Distribution [a]	Arithmetic Mean µg/L	95% UCL [b] µg/L	BSC [c] µg/L	RBSC [d] µg/L	COPC? [e,f]	Exposure Point Concentration [g] µg/L
Metals													
Aluminum	7 / 7	100	53.1	16900	200	200	L	3.77E+03	1.54E+06	3.09E+02	3.65E+03	Y	1.69E+04
Arsenic	3 / 8	38	12.5	22.7	10	10	NP	9.14E+00	1.29E+01	7.40E+00	4.48E-02	Y	1.29E+01
Barium	7 / 8	88	39.9	1780	200	200	N	8.80E+02	1.36E+03	1.18E+04	2.55E+02	N (b)	---
Calcium	8 / 8	100	76500	217000	5000	5000	L	1.20E+05	1.64E+05	3.16E+05	Nutrient	N (c)	---
Chromium	3 / 8	38	1.3	32.3	10	10	L	9.18E+00	3.03E+01		1.09E+01 h	Y	3.03E+01
Cobalt	2 / 8	25	10.1	18.7	50	50	NP	2.24E+01	2.50E+01	1.21E+01	7.30E+01	N (a)	---
Copper	5 / 7	71	10.9	99.2	25	25	L	4.28E+01	1.79E+02	1.98E+01	1.46E+02	N (a)	---
Iron	7 / 8	88	132	41700	100	100	N	1.52E+04	2.56E+04	1.55E+03	1.09E+03	Y	2.56E+04
Lead	4 / 8	50	3.9	15.7	3	3	L	4.85E+00	1.54E+01		1.50E+01 i	Y	1.54E+01
Magnesium	8 / 8	100	22800	72500	5000	5000	N	4.80E+04	6.22E+04	2.17E+05	Nutrient	N (c)	---
Manganese	8 / 8	100	32.65	1140	15	15	N	5.18E+02	7.91E+02	6.36E+02	8.76E+01	Y	7.91E+02
Mercury	1 / 8	13	0.079	0.079	0.2	0.2	NP	9.74E-02	1.00E-01		1.09E+00	N (a)	---
Nickel	4 / 8	50	5.1	71.2	40	40	L	2.95E+01	7.48E+01	8.60E+00	7.30E+01	N (a)	---
Potassium	8 / 8	100	851	136000	5000	50000	L	4.95E+04	5.15E+06	1.16E+05	Nutrient	N (c)	---
Selenium	2 / 8	25	5.6	14.4	5	5	NP	4.38E+00	5.60E+00		1.82E+01	N (a)	---
Sodium	8 / 8	100	6660	849000	5000	50000	N	3.60E+05	5.71E+05	1.39E+06	Nutrient	N (c)	---
Vanadium	3 / 8	38	2.3	48.6	50	50	NP	2.49E+01	2.50E+01		3.65E+00	Y	2.50E+01
Zinc	8 / 8	100	3.8	184	20	20	L	7.27E+01	9.41E+02	5.07E+02	1.09E+03	N (a)	---
Semivolatile Organic Compounds													
2-Methylnaphthalene	1 / 8	13	4.8	4.8	10	14.5	NP	5.26E+00	5.00E+00		6.20E-01 j	Y	4.80E+00
Bis(2-ethylhexyl)phthalate	2 / 7	29	2	3.6	10	14.5	N	4.69E+00	5.87E+00		4.80E+00	N (a)	---
Naphthalene	1 / 8	13	2.8	2.8	10	14.5	NP	5.01E+00	5.00E+00		6.20E-01	Y	2.80E+00
Phenanthrene	1 / 8	13	0.73	0.73	10	14.5	NP	4.75E+00	5.00E+00		1.83E+01 k	N (a)	---
Phenol	2 / 8	25	1.6	2.2	10	14.5	N	4.51E+00	5.71E+00		1.09E+03	N (a)	---
Volatile Organic Compounds													
1,1-Dichloroethane	2 / 8	25	0.19	0.4	1	5	L	7.93E-01	1.80E+00		8.11E+01	N (a)	---
2-Butanone	2 / 4	50	69	75	5	25	N	3.73E+01	8.46E+01		6.97E+02	N (a)	---
2-Hexanone	1 / 6	17	0.56	0.56	5	25	L	4.47E+00	3.54E+01		1.99E+02 l	N (a)	---
4-Methyl-2-pentanone	1 / 8	13	0.7	0.7	5	25	L	3.99E+00	1.04E+01		1.99E+02	N (a)	---
Acetone	3 / 3	100	38	110	10	50	N	7.77E+01	NA		5.48E+02	N (a)	---
Benzene	5 / 8	63	0.14	17	1	5	L	4.38E+00	1.53E+02		3.54E-01	Y	1.70E+01
Carbon disulfide	4 / 8	50	0.37	8	1	5	NP	2.39E+00	7.20E+00		1.04E+02	N (a)	---
Ethylbenzene	1 / 8	13	0.52	0.52	1	5	NP	8.46E-01	1.00E+00		1.34E+02	N (a)	---
Toluene	3 / 7	43	1.25	5.2	1	5	L	1.95E+00	1.01E+01		7.23E+01	N (a)	---
Xylenes, total	2 / 7	29	0.945	2.3	1	5	L	1.18E+00	2.79E+00		2.06E+01	N (a)	---
Miscellaneous													
Chloride	8 / 8	100	2800	3720000	1000	1000	L	9.18E+05	1.21E+10		Nutrient	N (d)	---
Nitrate	1 / 7	14	48	48	1000	1000	NP	4.35E+02	5.00E+01		1.00E+02 m	N (a)	---
Sulfate	8 / 8	100	31100	160000	1000	1000	N	9.64E+04	1.29E+05		5.00E+05 n	N (a)	---

Table 2-5

Statistical Summary and COPC Selection of Chemicals Detected in Bedrock Groundwater
TNT Area B, Former Plum Brook Ordnance Works
Sandusky, Ohio

COPC - Chemical of potential concern; UCL - Upper confidence limit; BSC - Background screening criterion; RBSC - Risk-based screening concentration;
ND - No data; µg/L - Micrograms per liter; NA - Not applicable.

[a] Statistical Distribution: N - Normal distribution; L - Lognormal distribution; NP - Nonparametric distribution; NA - Not applicable, distribution 1not determined for sample sets less than 5.
[b] Method of estimation based on statistical distribution (please see Section 3.2.1).
[c] Background screening criteria are presented in the ***2004 Data Summary and Evaluation Report*** (Shaw, 2005).
[d] Risk-Based Screening Concentrations based on EPA Region 9 Preliminary Remediation Goals (PRGs [EPA, 2004]) for tap water.
PRGs were adjusted to provide an Hazard Index of 0.1 and an Incremental Lifetime Cancer Range of 1E-6.
[e] N - Chemical is not chosen as a COPC:
(a) - maximum detected concentration is less than the RBSC.
(b) - maximum detected concentration is less than the BSC.
(c) - essential nutrient.
(d) - essential nutrient with no toxicity value available.
[f] Y - Chemical is chosen as COPC.
[g] Exposure point concentration is chosen based on criteria described in section 3.2.1.
[h] Based on PRG for chromium VI.
[i] Screening criteria for lead based on the action level of 15 µg/L (EPA, 1996, *Drinking Water Regulations and Health Advisories* , Office of Water, Washington, DC, October).
[j] Based on PRG as for naphthalene.
[k] Based on PRG as for pyrene.
[l] Based on PRG as for 4-methyl-2-pentanone.
[m] Based on PRG for nitrite.
[n] Screening criteria for sulfate based on the *Drinking Water Advisory* .

Table 2-6

Statistical Distribution and COPC Selection of Chemicals Detected in Bedrock Groundwater
TNT Area C, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Detection Frequency	Percent Hits	Range of Values, µg/L: Detected Concentrations Minimum	Detected Concentrations Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Statistical Distribution [a]	Mean µg/L	95% UCL [b] µg/L	BSC [c] µg/L	RBSC [d] µg/L	COPC? [e,f]	Exposure Point Concentration [g] µg/L
Metals													
Aluminum	1 / 3	33	96.8	96.8	200	200	NA	9.89E+01	NA	3.09E+02	3.65E+03	N (a)	---
Arsenic	1 / 6	17	4.1	4.1	10	10	NP	4.74E+00	5.00E+00	7.40E+00	4.48E-02	N (b)	---
Barium	5 / 6	83	16.5	2680	200	200	L	9.28E+02	5.49E+06	1.18E+04	2.55E+02	N (b)	---
Calcium	6 / 6	100	125000	439000	5000	5000	NP	3.48E+05	4.34E+05	3.16E+05	Nutrient	N (c)	---
Copper	1 / 6	17	6.1	6.1	25	25	NP	1.16E+01	1.25E+01	1.98E+01	1.46E+02	N (a)	---
Iron	4 / 6	67	55.1	335	100	100	L	1.37E+02	4.59E+02	1.55E+03	1.09E+03	N (a)	---
Magnesium	6 / 6	100	9250	334000	5000	5000	N	1.67E+05	2.43E+05	2.17E+05	Nutrient	N (c)	---
Manganese	6 / 6	100	5.1	271	15	15	L	9.17E+01	2.84E+03	6.36E+02	8.76E+01	N (b)	---
Nickel	1 / 6	17	2.3	2.3	40	40	NP	1.75E+01	2.00E+01	8.60E+00	7.30E+01	N (a)	---
Potassium	5 / 6	83	9610	101000	5000	5000	L	4.89E+04	1.46E+06	1.16E+05	Nutrient	N (c)	---
Sodium	6 / 6	100	29500	1330000	5000	50000	NP	5.52E+05	1.19E+06	1.39E+06	Nutrient	N (c)	---
Zinc	3 / 6	50	5.6	47.2	20	20	NP	1.43E+01	1.00E+01	5.07E+02	1.09E+03	N (a)	---
Semivolatile Organic Compounds													
2,4-Dimethylphenol	4 / 6	67	13	22	10	10	N	1.24E+01	1.84E+01		7.30E+01	N (a)	---
2-Methylnaphthalene	6 / 6	100	3.2	34	10	10	N	1.67E+01	2.66E+01		6.20E-01 h	Y	2.66E+01
2-Methylphenol	4 / 6	67	3.3	6.6	10	10	N	5.00E+00	5.87E+00		1.82E+02	N (a)	---
4-Methylphenol	4 / 6	67	3.3	6.9	10	10	N	5.10E+00	5.97E+00		1.82E+01	N (a)	---
Bis(2-ethylhexyl)phthalate	4 / 6	67	5.2	55	10	10	NP	1.95E+01	5.50E+01		4.80E+00	Y	5.50E+01
Fluorene	2 / 6	33	1	1.4	10	10	NP	3.91E+00	5.00E+00		2.43E+01	N (a)	---
Isophorone	1 / 6	17	2.7	2.7	10	10	NP	4.67E+00	5.00E+00		7.08E+01	N (a)	---
Naphthalene	6 / 6	100	2.5	34	10	10	L	1.38E+01	8.66E+01		6.20E-01	Y	3.40E+01
Phenanthrene	2 / 6	33	1.3	1.9	10	10	NP	4.03E+00	5.00E+00		1.83E+01 i	N (a)	---
Phenol	4 / 6	67	11	69	10	10	NP	2.41E+01	6.20E+01		1.09E+03	N (a)	---
Volatile Organic Compounds													
Acetone	1 / 6	17	53	53	200	200	NA	5.30E+01	NA		5.48E+02	N (a)	---
Benzene	6 / 6	100	8.4	410	20	100	L	1.34E+02	3.55E+03		3.54E-01	Y	4.10E+02
Bromomethane	1 / 6	17	13	13	2	200	L	4.41E+01	3.88E+03		8.66E-01	Y	1.30E+01
Carbon disulfide	1 / 6	17	5.8	5.8	1	100	L	2.55E+01	8.87E+01		1.04E+02	N (a)	---
Ethylbenzene	6 / 6	100	12	130	20	100	L	6.26E+01	2.87E+02		1.34E+02	N (a)	---
Methylene chloride	4 / 5	80	19	160	1	200	L	5.03E+01	2.73E+05		4.28E+00	Y	1.60E+02
Toluene	6 / 6	100	8.8	300	20	100	L	1.34E+02	3.46E+03		7.23E+01	Y	3.00E+02
Xylenes, total	6 / 6	100	90	1300	20	100	L	5.76E+02	3.48E+03		2.06E+01	Y	1.30E+03
Miscellaneous													
Chloride	5 / 6	83	242000	4290000	50	1000000	L	2.00E+06	6.96E+07		Nutrient	N (d)	---
Sulfate	6 / 6	100	5000	1340000	10	250000	L	4.22E+05	6.91E+09		5.00E+05 j	Y	1.34E+06

Table 2-6

Statistical Distribution and COPC Selection of Chemicals Detected in Bedrock Groundwater
TNT Area C, Former Plum Brook Ordnance Works
Sandusky, Ohio

COPC - Chemical of potential concern; UCL - Upper confidence limit; BSC - Background screening criterion; RBSC - Risk-based screening concentration;
ND - No data; µg/L - Micrograms per liter.

[a] Statistical Distribution: N - Normal distribution; L - Lognormal distribution; NP - Nonparametric distribution; NA - Not applicable, distribution not determined for sample sets less than 5.
[b] Method of estimation based on statistical distribution (please see Section 3.2.1).
[c] Background screening criteria are presented in the ***2004 Data Summary and Evaluation Report*** (Shaw, 2005).
[d] Risk-Based Screening Concentrations based on EPA Region 9 Preliminary Remediation Goals (PRGs [EPA, 2004]) for tap water.
PRGs were adjusted to provide an Hazard Index of 0.1 and an Incremental Lifetime Cancer Range of 1E-6.
[e] N - Chemical is not chosen as a COPC:
(a) - maximum detected concentration is less than the RBSC.
(b) - maximum detected concentration is less than the BSC.
(c) - essential nutrient.
(d) - essential nutrient with no toxicity value available.
[f] Y - Chemical is chosen as COPC.
[g] Exposure point concentration is chosen based on criteria described in section 3.2.1.
[h] Based on PRG for naphthalene.
[i] Based on PRG as for pyrene.
[j] Screening criteria for sulfate based on the *Drinking Water Advisory*.

Table 2-7

Statistical Summary and COPC Selection of Chemicals Detected in Bedrock Groundwater
Pentolite Road Red Water Pond Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of Values, µg/L: Detected Concentrations Minimum	Detected Concentrations Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Statistical Distribution [a]	Mean µg/L	95% UCL [b] µg/L	BSC [c] µg/L	RBSC [d] µg/L	COPC? [e,f]	Exposure Point Concentration [g] µg/L
Metals													
Aluminum	2 / 3	67	350	513	200	200	N	3.21E+02	6.72E+02	3.09E+02	3.65E+03	N (a)	---
Barium	6 / 6	100	64.2	1710	200	200	L	6.37E+02	1.46E+04	1.18E+04	2.55E+02	N (b)	---
Calcium	6 / 6	100	199000	859000	5000	50000	L	4.43E+05	9.13E+05	3.16E+05	Nutrient	N (c)	---
Chromium	3 / 6	50	6.1	20.6	10	10	NP	9.45E+00	2.06E+01		1.09E+01 h	Y	2.06E+01
Cobalt	1 / 6	17	5.9	5.9	50	50	NP	2.18E+01	2.50E+01	1.21E+01	7.30E+01	N (a)	---
Copper	2 / 6	33	4.8	39.5	25	25	L	1.57E+01	4.08E+01	1.98E+01	1.46E+02	N (a)	---
Iron	5 / 6	83	142	7280	100	100	L	3.14E+03	1.97E+07	1.55E+03	1.09E+03	Y	7.28E+03
Magnesium	6 / 6	100	169000	591000	5000	50000	L	2.73E+05	4.63E+05	2.17E+05	Nutrient	N (c)	---
Manganese	6 / 6	100	5.6	1170	15	15	L	2.61E+02	1.06E+06	6.36E+02	8.76E+01	Y	1.17E+03
Nickel	3 / 6	50	3.8	13.6	40	40	N	1.41E+01	2.00E+01	8.60E+00	7.30E+01	N (a)	---
Potassium	6 / 6	100	58800	96000	5000	50000	L	7.20E+04	8.56E+04	1.16E+05	Nutrient	N (c)	---
Sodium	6 / 6	100	559000	1810000	5000	50000	NP	8.40E+05	1.81E+06	1.39E+06	Nutrient	N (c)	---
Thallium	1 / 6	17	50.8	50.8	10	50	NP	1.26E+01	5.08E+01		2.41E-01	Y	5.08E+01
Zinc	3 / 5	60	3	30.6	20	20	L	1.43E+01	1.05E+02	5.07E+02	1.09E+03	N (a)	---
Explosives													
2,4,6-Trinitrotoluene	2 / 6	33	1.3	1.6	0.2	2	N	8.63E-01	1.30E+00		1.82E+00	N (a)	---
2,4-Dinitrotoluene	1 / 6	17	0.89	0.89	0.2	2	N	5.97E-01	9.33E-01		9.89E-02 i	Y	8.90E-01
2,6-Dinitrotoluene	1 / 6	17	0.89	0.89	0.4	6	L	1.49E+00	2.55E+00		9.89E-02 i	Y	8.90E-01
4-Amino-2,6-dinitrotoluene	1 / 6	17	0.97	0.97	0.2	2.6	N	7.63E-01	1.11E+00		7.30E-01 j	Y	9.70E-01
Nitrobenzene	1 / 6	17	0.35	0.35	0.2	2	L	3.76E-01	1.92E+00		3.40E-01	Y	3.50E-01
RDX	1 / 6	17	0.51	0.51	0.5	5	L	8.77E-01	4.42E+00		6.11E-01	N (a)	---
Semivolatile Organic Compounds													
2,4-Dimethylphenol	6 / 6	100	5.6	51	10	10	L	2.04E+01	1.32E+02		7.30E+01	N (a)	---
2-Methylnaphthalene	6 / 6	100	22	37	10	10	L	2.90E+01	3.45E+01		6.20E-01 k	Y	3.45E+01
2-Methylphenol	6 / 6	100	3	37	10	10	L	1.32E+01	1.24E+02		1.82E+02	N (a)	---
4-Methylphenol	6 / 6	100	3.9	43	10	10	L	1.42E+01	8.51E+01		1.82E+01	Y	4.30E+01
Bis(2-ethylhexyl)phthalate	5 / 5	100	1.8	37	10	10	L	1.03E+01	4.06E+02		4.80E+00	Y	3.70E+01
Butyl benzyl phthalate	1 / 6	17	1.5	1.5	10	10	NP	4.42E+00	5.00E+00		7.30E+02	N (a)	---
Diethyl phthalate	2 / 6	33	0.68	1.2	10	10	NP	3.65E+00	5.00E+00		2.92E+03	N (a)	---
Di-n-butyl phthalate	1 / 6	17	1.1	1.1	10	10	NP	4.35E+00	5.00E+00		3.65E+02	N (a)	---
Fluorene	2 / 6	33	1.4	1.7	10	10	NP	3.85E+00	5.00E+00		2.43E+01	N (a)	---
Isophorone	2 / 6	33	3.8	4.2	10	10	NP	4.67E+00	5.00E+00		7.08E+01	N (a)	---
Naphthalene	6 / 6	100	21	31	10	10	L	2.57E+01	2.99E+01		6.20E-01	Y	2.99E+01
n-Nitrosodiphenylamine	1 / 6	17	0.64	0.64	10	10	NP	4.27E+00	5.00E+00		1.37E+01	N (a)	---
Phenanthrene	6 / 6	100	0.98	2.4	10	10	L	1.70E+00	2.51E+00		1.83E+01 l	N (a)	---
Phenol	6 / 6	100	12	150	10	10	L	5.12E+01	3.57E+02		1.09E+03	N (a)	---
Volatile Organic Compounds													
1,1,2-Trichloroethane	1 / 6	17	4.9	4.9	20	200	L	4.83E+01	9.88E+02		2.00E-01	Y	4.90E+00
Acetone	4 / 4	100	87	1600	200	2000	L	8.14E+02	5.03E+06		5.48E+02	Y	1.60E+03
Benzene	6 / 6	100	570	2500	20	200	L	1.20E+03	3.07E+03		3.54E-01	Y	2.50E+03
Carbon disulfide	1 / 6	17	3.1	3.1	20	200	L	4.97E+01	1.47E+03		1.04E+02	N (a)	---

Table 2-7

Statistical Summary and COPC Selection of Chemicals Detected in Bedrock Groundwater
Pentolite Road Red Water Pond Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of Values, μg/L: Detected Concentrations Minimum	Detected Concentrations Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Statistical Distribution [a]	Mean μg/L	95% UCL [b] μg/L	BSC [c] μg/L	RBSC [d] μg/L	COPC? [e,f]	Exposure Point Concentration [g] μg/L
Chlorobenzene	1 / 6	17	5.5	5.5	20	200	L	4.84E+01	8.45E+02		1.06E+01	N (a)	---
Ethylbenzene	6 / 6	100	130	230	20	200	L	1.62E+02	2.02E+02		1.34E+02	Y	2.02E+02
Methylene chloride	4 / 4	100	31	160	40	400	N	1.03E+02	1.66E+02		4.28E+00	Y	1.60E+02
Toluene	6 / 6	100	460	1000	20	200	L	6.73E+02	9.46E+02		7.23E+01	Y	9.46E+02
Xylenes, total	6 / 6	100	880	1600	20	200	L	1.10E+03	1.40E+03		2.06E+01	Y	1.40E+03
Miscellaneous													
Chloride	6 / 6	100	1400000	6400000	50	100000	L	2.75E+06	5.13E+06		Nutrient	N (d)	---
Sulfate	5 / 6	83	82000	218000	5	50000	N	9.63E+04	1.54E+05		5.00E+05 [m]	N (a)	---

COPC - Chemical of potential concern; UCL - Upper confidence limit; BSC - Background screening criterion; RBSC - Risk-based screening concentration;
ND - No data; μg/L - Micrograms per liter.

[a] Statistical Distribution: N - Normal distribution; L - Lognormal distribution; NP - Nonparametric distribution; NA - Not applicable, 1distribution not determined for sample sets less than 5.

[b] Method of estimation based on statistical distribution (please see Section 3.2.1).

[c] Background screening criteria are presented in the ***2004 Data Summary and Evaluation Report*** (Shaw, 2005).

[d] Risk-Based Screening Concentrations based on EPA Region 9 Preliminary Remediation Goals (PRGs [EPA, 2004]) for tap water.
PRGs were adjusted to provide an Hazard Index of 0.1 and an Incremental Lifetime Cancer Range of 1E-6.

[e] N - Chemical is not chosen as a COPC:
(a) - maximum detected concentration is less than the RBSC.
(b) - maximum detected concentration is less than the BSC.
(c) - essential nutrient.
(d) - essential nutrient with no toxicity value available.

[f] Y - Chemical is chosen as COPC.

[g] Exposure point concentration is chosen based on criteria described in section 3.2.1.

[h] Based on PRG for chromium VI.

[i] Based on PRG for dinitrotoluene mixture.

[j] Based on PRG for aminodinitrotoluene.

[k] Based on PRG for naphthalene.

[l] Based on PRG for pyrene.

[m] Screening criteria for sulfate based on the *Drinking Water Advisory* .

Table 2-8

Statistical Summary and COPC Selection of Chemicals Detected in Bedrock Groundwater
West Area Red Water Ponds Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of Values, µg/L: Detected Concentrations Minimum	Detected Concentrations Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Statistical Distribution [a]	Mean µg/L	BSC [b] µg/L	RBSC [c] µg/L	COPC? [d,e]	Exposure Point Concentration [f] µg/L
Metals												
Arsenic	2 / 3	67	6.1	9.5	10	100	NA	2.19E+01	7.40E+00	4.48E-02	Y	9.50E+00
Barium	2 / 3	67	49.5	51.4	200	200	NA	6.70E+01	1.18E+04	2.55E+02	N (a)	--
Calcium	3 / 3	100	99000	325000	5000	5000	NA	2.13E+05	3.16E+05	Nutrient	N (c)	--
Chromium	2 / 3	67	1.6	3.4	10	10	NA	3.33E+00		1.09E+01 g	N (a)	--
Cobalt	2 / 3	67	102	267	50	50	NA	1.31E+02	1.21E+01	7.30E+01	Y	2.67E+02
Copper	2 / 3	67	30.7	94.8	25	25	NA	4.60E+01	1.98E+01	1.46E+02	N (a)	--
Iron	3 / 3	100	164	438	100	100	NA	3.43E+02	1.55E+03	1.09E+03	N (a)	--
Lead	1 / 3	33	3.6	3.6	3	30	NA	6.70E+00		1.50E+01 h	N (a)	--
Magnesium	3 / 3	100	59700	230000	5000	5000	NA	1.45E+05	2.17E+05	Nutrient	N (c)	--
Manganese	3 / 3	100	32	136	15	15	NA	7.77E+01	6.36E+02	8.76E+01	N (b)	--
Nickel	3 / 3	100	45.5	278	40	40	NA	1.45E+02	8.60E+00	7.30E+01	Y	2.78E+02
Potassium	3 / 3	100	42100	56800	5000	5000	NA	4.93E+04	1.16E+05	Nutrient	N (c)	--
Selenium	2 / 3	67	5.5	7.8	5	50	NA	1.28E+01		1.82E+01	N (a)	--
Sodium	3 / 3	100	269000	1020000	5000	50000	NA	6.39E+05	1.39E+06	Nutrient	N (c)	--
Vanadium	1 / 2	50	5.5	5.5	50	50	NA	1.53E+01		3.65E+00	Y	5.50E+00
Zinc	2 / 2	100	10.8	64.8	20	20	NA	3.78E+01	5.07E+02	1.09E+03	N (a)	--
Semivolatile Organic Compounds												
2,4-Dinitrotoluene	2 / 4	50	16	19	10	1000	NA	1.65E+02		9.89E-02 i	Y	1.90E+01
4,6-Dinitro-2-methylphenol	1 / 4	25	28	28	50	5000	NA	7.88E+02		3.65E-01	Y	2.80E+01
2,4-Dinitrophenol	1 / 4	25	14	14	50	5000	NA	7.85E+02		7.30E+00	Y	1.40E+01
3-Nitroaniline	1 / 4	25	150	150	50	5000	NA	8.19E+02		1.09E+00	Y	1.50E+02
Nitrobenzene	1 / 4	25	5.8	5.8	10	1000	NA	1.59E+02		3.40E-01	Y	5.80E+00
Volatile Organic Compounds												
Benzene	1 / 4	25	1.1	1.1	1	5	NA	1.65E+00		3.54E-01	Y	1.10E+00
Carbon disulfide	2 / 4	50	0.25	1.3	1	5	NA	1.64E+00		1.04E+02	N (a)	--
Ethylbenzene	1 / 4	25	0.59	0.59	1	5	NA	1.52E+00		1.34E+02	N (a)	--
Xylenes, total	1 / 4	25	3.9	3.9	1	5	NA	2.35E+00		2.06E+01	N (a)	--
Miscellaneous												
Chloride	4 / 4	100	3000	79000	50	20000	NA	5.75E+04		Nutrient	N (d)	--
Cyanide, total	3 / 4	75	16	44	10	10	NA	2.58E+01		7.30E+01	N (a)	--
Nitrate	3 / 3	100	22000	79300	2000	10000	NA	4.18E+04		1.00E+03	Y	7.93E+04
Nitrate-Nitrite	1 / 1	100	300	300	0.1	0.1	NA	3.00E+02		1.00E+02 j	Y	3.00E+02
Sulfate	4 / 4	100	610000	2660000	500	1000000	NA	1.34E+06		5.00E+05 k	Y	2.66E+06

Table 2-8

Statistical Summary and COPC Selection of Chemicals Detected in Bedrock Groundwater
West Area Red Water Ponds Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

COPC - Chemical of potential concern; BSC - Background screening criterion; RBSC - Risk-based screening concentration;
ND - No data; µg/L - Micrograms per liter.

[a] Statistical Distribution: NA - Not applicable, distribution not determined for sample sets less than 5.

[b] Background screening criteria are presented in the ***2004 Data Summary and Evaluation Report*** (Shaw, 2005).

[c] Risk-Based Screening Concentrations based on EPA Region 9 Preliminary Remediation Goals (PRGs [EPA, 2004]) for tap water. PRGs were adjusted to provide an Hazard Index of 0.1 and an Incremental Lifetime Cancer Range of 1E-6.

[d] N - Chemical is not chosen as a COPC:
- (a) - maximum detected concentration is less than the RBSC.
- (b) - maximum detected concentration is less than the BSC.
- (c) - essential nutrient.
- (d) - essential nutrient with no toxicity value available.

[e] Y - Chemical is chosen as COPC.

[f] Exposure point concentration is equal to the maximum detected.

[g] Based on PRG for chromium VI.

[h] Screening criteria for lead based on the action level of 15 µg/L (EPA, 1996, *Drinking Water Regulations and Health Advisories* , Office of Water, Washington, DC, October).

[i] Based on PRG for dinitrotoluene mixture.

[j] Based on PRG for nitrite.

[k] Screening criteria for sulfate based on the *Drinking Water Advisory* .

Table 2-9

Statistical Summary and COPC Selection of Chemicals Detected in Bedrock Groundwater Downgradient Areas at the Facility Boundary, Former Plum Brook Ordnance Works Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of Values, µg/L: Detected Concentrations Minimum	Detected Concentrations Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Statistical Distribution [a]	Mean µg/L	95% UCL [b] µg/L	BSC [c] µg/L	RBSC [d] µg/L	COPC? [e,f]	Exposure Point Concentration [g] µg/L
Metals													
Aluminum	16 / 19	84	35.7	1171	200	200	L	2.44E+02	4.30E+02	3.09E+02	3.65E+03	N (a)	---
Arsenic	3 / 25	12	4.5	6.1	10	20	NP	5.24E+00	5.00E+00	7.40E+00	4.48E-02	N (b)	---
Barium	28 / 28	100	86.2	1860	200	200	N	8.72E+02	1.03E+03	1.18E+04	2.55E+02	N (b)	---
Cadmium	2 / 28	7	0.25	1.1	5	10	NP	2.46E+00	2.50E+00		1.82E+00	N (a)	---
Calcium	28 / 28	100	117500	462000	5000	5000	NP	2.12E+05	2.55E+05	3.16E+05	Nutrient	N (c)	---
Chromium	5 / 28	18	1.6	24.4	10	10	NP	5.76E+00	5.00E+00		1.09E+01 h	Y	2.44E+01
Cobalt	5 / 28	18	1.2	10.9	50	50	NP	2.14E+01	2.50E+01	1.21E+01	7.30E+01	N (a)	---
Copper	7 / 27	26	13.3	94.45	25	25	NP	1.99E+01	1.25E+01	1.98E+01	1.46E+02	N (a)	---
Iron	16 / 27	59	48.3	257000	100	100	NP	1.25E+04	2.51E+02	1.55E+03	1.09E+03	Y	2.57E+05
Lead	1 / 28	4	6.8	6.8	3	14	NP	2.26E+00	1.50E+00		1.50E+01 i	N (a)	---
Magnesium	28 / 28	100	34600	279000	5000	5000	NP	1.10E+05	8.45E+04	2.17E+05	Nutrient	N (c)	---
Manganese	25 / 27	93	2	4660	15	15	NP	2.69E+02	3.04E+01	6.36E+02	8.76E+01	Y	4.66E+03
Mercury	1 / 28	4	0.035	0.035	0.2	0.2	NP	9.77E-02	1.00E-01		1.09E+00	N (a)	---
Nickel	7 / 27	26	3.5	17.7	40	40	NP	1.76E+01	2.00E+01	8.60E+00	7.30E+01	N (a)	---
Potassium	28 / 28	100	2365	67200	5000	5000	N	3.28E+04	3.89E+04	1.16E+05	Nutrient	N (c)	---
Sodium	28 / 28	100	18550	685000	5000	5000	NP	1.76E+05	1.06E+05	1.39E+06	Nutrient	N (c)	---
Thallium	1 / 22	5	3.7	3.7	10	20	NP	5.17E+00	5.00E+00		2.41E-01	N (d)	---
Vanadium	1 / 28	4	7.8	7.8	50	50	NP	2.44E+01	2.50E+01		3.65E+00	N (d)	---
Zinc	20 / 25	80	3.9	139.5	20	20	L	2.97E+01	4.81E+01	5.07E+02	1.09E+03	N (a)	---
Explosives													
1,3-Dinitrobenzene	1 / 29	3	0.22	0.22	0.2	0.41	NP	1.08E-01	1.00E-01		3.65E-01	N (a)	---
2,4,6-Trinitrotoluene	2 / 29	7	0.081	0.27	0.2	0.53	NP	1.17E-01	1.00E-01		1.82E+00	N (a)	---
2,4-Dinitrotoluene	3 / 29	10	0.58	1.5	0.2	0.41	NP	1.99E-01	1.00E-01		9.89E-02 j	Y	1.50E+00
2,6-Dinitrotoluene	5 / 29	17	0.3	1.4	0.2	0.44	NP	2.26E-01	1.00E-01		9.89E-02 j	Y	1.40E+00
2-Amino-4,6-dinitrotoluene	1 / 25	4	0.19	0.19	0.2	0.2	NP	1.04E-01	1.00E-01		7.30E-01 k	N (a)	---
2-Nitrotoluene	2 / 29	7	0.16	0.55	0.2	6.3	NP	2.81E-01	1.00E-01		4.87E-02	Y	5.50E-01
3-Nitrotoluene	1 / 29	3	0.62	0.62	0.2	2.2	NP	1.58E-01	1.00E-01		1.22E+01	N (a)	---
4-Nitrotoluene	1 / 25	4	0.23	0.23	0.2	4	NP	1.91E-01	1.00E-01		6.59E-01	N (a)	---
Nitrobenzene	3 / 29	10	0.32	0.34	0.2	2.8	NP	1.94E-01	1.00E-01		3.40E-01	Y	3.40E-01
RDX	2 / 29	7	0.17	0.22	0.5	6.5	NP	4.45E-01	2.50E-01		6.11E-01	N (a)	---
Semivolatile Organic Compounds													
2,4-Dimethylphenol	8 / 30	27	0.76	5.1	5	100	NP	5.88E+00	5.00E+00		7.30E+01	N (a)	---
2-Methylnaphthalene	25 / 30	83	1.4	24	5	100	L	9.27E+00	1.31E+01		6.20E-01 l	Y	2.40E+01
2-Methylphenol	2 / 30	7	0.89	1.1	5	100	NP	6.15E+00	5.00E+00		1.82E+02	N (a)	---
4-Methylphenol	3 / 30	10	1.1	2	5	100	NP	6.07E+00	5.00E+00		1.82E+01	N (a)	---
Bis(2-ethylhexyl)phthalate	6 / 27	22	2.3	9.7	5	100	NP	6.46E+00	5.00E+00		4.80E+00	Y	9.70E+00
Chrysene	1 / 30	3	1	1	5	100	NP	6.28E+00	5.00E+00		9.21E+00	N (a)	---
Naphthalene	21 / 30	70	2.1	18	5	100	L	8.54E+00	1.06E+01		6.20E-01	Y	1.80E+01
Phenanthrene	8 / 30	27	0.74	1.4	5	100	NP	5.34E+00	5.00E+00		1.83E+01 m	N (a)	---
Phenol	10 / 30	33	1.2	55	5	100	NP	7.14E+00	5.00E+00		1.09E+03	N (a)	---

Table 2-9

Statistical Summary and COPC Selection of Chemicals Detected in Bedrock Groundwater Downgradient Areas at the Facility Boundary, Former Plum Brook Ordnance Works Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of Values, µg/L: Detected Concentrations Minimum	Detected Concentrations Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Statistical Distribution [a]	Mean µg/L	95% UCL [b] µg/L	BSC [c] µg/L	RBSC [d] µg/L	COPC? [e,f]	Exposure Point Concentration [g] µg/L
Volatile Organic Compounds													
2-Butanone	3 / 5	60	8.1	130	5	500	L	4.60E+01	7.95E+02		6.97E+02	N (a)	---
Acetone	8 / 14	57	19	230	5	1800	L	1.20E+02	7.77E+02		5.48E+02	N (a)	---
Benzene	26 / 30	87	0.195	130	1	180	NP	3.22E+01	3.60E+01		3.54E-01	Y	1.30E+02
Bromomethane	1 / 28	4	13.95	13.95	2	360	L	3.35E+01	1.17E+02		8.66E-01	N (d)	---
Carbon disulfide	15 / 29	52	0.59	40	1	180	L	1.57E+01	3.95E+01		1.04E+02	N (a)	---
Chlorobenzene	2 / 30	7	2.2	11	1	180	L	1.45E+01	4.17E+01		1.06E+01	Y	1.10E+01
Chloromethane	1 / 30	3	1.3	1.3	2	360	L	3.22E+01	9.70E+01		1.58E+01	N (a)	---
Ethylbenzene	27 / 30	90	1	120	1	180	L	3.20E+01	8.71E+01		1.34E+02	N (a)	---
Methylene chloride	12 / 26	46	5.95	98	1	360	L	2.01E+01	5.95E+01		4.28E+00	Y	9.80E+01
Toluene	25 / 28	89	1.2	180	1	180	NP	5.25E+01	7.30E+01		7.23E+01	Y	1.80E+02
Xylenes, total	27 / 30	90	6.4	560	1	180	NP	1.66E+02	1.80E+02		2.06E+01	Y	5.60E+02
Miscellaneous													
Chloride	30 / 30	100	33400	2790000	1000	1000	NP	5.76E+05	2.60E+05		Nutrient	N (e)	---
Cyanide, total	2 / 28	7	16	320	1000	1000	NP	4.76E+02	5.00E+00		7.30E+01	Y	3.20E+02
Sulfate	25 / 30	83	11300	1280000	1000	1000	NP	1.38E+05	4.27E+04		5.00E+05 [n]	Y	1.28E+06

COPC - Chemical of potential concern; UCL - Upper confidence limit; BSC - Background screening criterion; RBSC - Risk-based screening concentration; ND - No data; µg/L - Micrograms per liter.

[a] Statistical Distribution: N - Normal distribution; L - Lognormal distribution; NP - Nonparametric distribution.

[b] Method of estimation based on statistical distribution (please see Section 3.2.1).

[c] Background screening criteria are presented in the ***2004 Data Summary and Evaluation Report*** (Shaw, 2005).

[d] Risk-Based Screening Concentrations based on EPA Region 9 Preliminary Remediation Goals (PRGs [EPA, 2004]) for tap water. PRGs were adjusted to provide an Hazard Index of 0.1 and an Incremental Lifetime Cancer Range of 1E-6.

[e] N - Chemical is not chosen as a COPC:
- (a) - maximum detected concentration is less than the RBSC.
- (b) - maximum detected concentration is less than the BSC.
- (c) - essential nutrient.
- (d) - frequency of detection is less than 5 percent.
- (e) - essential nutrient with no toxicity value available.

[f] Y - Chemical is chosen as COPC.

[g] Because the downgradient wells are in various areas, the maximum detected concentration was selected as the exposure point concentration.

[h] Based on PRG for chromium VI.

[i] Screening criteria for lead based on the action level of 15 µg/L (EPA, 1996, *Drinking Water Regulations and Health Advisories*, Office of Water, Washington, DC, October).

[j] Based on PRG for dinitrotoluene mixture.

[k] Based on PRG for aminodinitrotoluene.

[l] Based on PRG for naphthalene.

[m] Based on PRG for pyrene.

[n] Screening criteria for sulfate based on the *Drinking Water Advisory*.

Table 2-10

Statistical Summary and COPC Selection of Chemicals Detected in Overburden Groundwater
TNT Area A, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of Values, µg/L: Detected Concentrations Minimum	Detected Concentrations Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Statistical Distribution [a]	Arithmetic Mean µg/L	95% UCL [b] µg/L	BSC [c] µg/L	RBSC [d] µg/L	MDC Exceeds RBSC? [e,f]
Metals												
Aluminum	13 / 13	100	242	143000	200	200	L	1.68E+04	1.38E+05	3.09E+02	3.65E+03	Y
Antimony	1 / 14	7	82	82	60	60	NP	3.37E+01	3.00E+01		1.46E+00	Y
Arsenic	7 / 14	50	10.5	113	10	100	NP	2.39E+01	3.19E+01	7.40E+00	4.48E-02	Y
Barium	5 / 14	36	24	373	200	200	NP	1.38E+02	1.00E+02	1.18E+04	2.55E+02	Y (a)
Beryllium	1 / 14	7	6.9	6.9	5	5	NP	2.81E+00	2.50E+00		7.30E+00	N
Calcium	14 / 14	100	112000	1010000	5000	50000	NP	3.01E+05	2.52E+05	3.16E+05	Nutrient	N
Chromium	9 / 14	64	2	258	10	10	L	3.36E+01	9.60E+01		1.09E+01 g	Y
Cobalt	2 / 14	14	50.8	222	50	50	NP	4.09E+01	2.50E+01	1.21E+01	7.30E+01	Y
Copper	3 / 14	21	40.4	225	25	25	NP	3.22E+01	1.25E+01	1.98E+01	1.46E+02	Y
Iron	14 / 14	100	1700	304000	100	100	L	3.88E+04	1.33E+05	1.55E+03	1.09E+03	Y
Lead	10 / 14	71	3	108	3	30	L	1.65E+01	5.24E+01		1.50E+01 h	Y
Magnesium	14 / 14	100	16200	172000	5000	5000	L	5.42E+04	7.76E+04	2.17E+05	Nutrient	N
Manganese	14 / 14	100	86.5	7550	15	15	L	1.31E+03	3.78E+03	6.36E+02	8.76E+01	Y
Mercury	2 / 14	14	0.24	0.25	0.2	0.2	NP	1.21E-01	1.00E-01		1.09E+00	N
Nickel	5 / 14	36	2.1	628	40	40	NP	7.14E+01	2.00E+01	8.60E+00	7.30E+01	Y
Potassium	8 / 14	57	1420	35700	5000	5000	L	9.04E+03	2.06E+04	1.16E+05	Nutrient	N
Sodium	14 / 14	100	5530	91400	5000	5000	N	4.01E+04	5.49E+04	1.39E+06	Nutrient	N
Vanadium	5 / 13	38	1.9	244	50	50	NP	4.90E+01	5.51E+01		3.65E+00	Y
Zinc	9 / 9	100	5.9	735	20	20	L	1.34E+02	1.05E+03	5.07E+02	1.09E+03	N
Explosives												
1,3,5-Trinitrobenzene	2 / 15	13	0.24	0.43	0.2	5	NP	3.21E-01	1.45E-01		1.09E+02	N
2,4,6-Trinitrotoluene	4 / 15	27	0.29	110	0.2	5	NP	7.62E+00	2.90E-01		1.82E+00	Y
2,4-Dinitrotoluene	2 / 15	13	0.2	0.35	0.2	5	NP	3.13E-01	1.45E-01		9.89E-02 i	Y
2,6-Dinitrotoluene	2 / 15	13	0.53	1.2	0.2	5	NP	3.92E-01	1.45E-01		9.89E-02 i	Y
2-Amino-4,6-dinitrotoluene	2 / 3	67	2.1	46	0.2	5	L	1.61E+01	1.29E+40		7.30E-01 j	Y
4-Amino-2,6-dinitrotoluene	4 / 15	27	0.62	16	0.2	5	NP	1.37E+00	5.00E-01		7.30E-01 j	Y
Nitrobenzene	1 / 15	7	0.26	0.26	0.2	5	NP	3.00E-01	1.00E-01		3.40E-01	N
Semivolatile Organic Compounds												
Bis(2-ethylhexyl)phthalate	1 / 15	7	890	890	10	200	NP	6.40E+01	5.00E+00		4.80E+00	Y
Di-n-octyl phthalate	1 / 15	7	9.3	9.3	10	20	NP	5.62E+00	5.00E+00		1.46E+02	N
Volatile Organic Compounds												
Acetone	7 / 7	100	1.7	68	10	10	L	2.24E+01	3.12E+02		5.48E+02	N
Benzene	1 / 15	7	0.17	0.17	1	1	NP	4.78E-01	5.00E-01		3.54E-01	N
Carbon disulfide	1 / 15	7	0.37	0.37	1	1	NP	4.91E-01	5.00E-01		1.04E+02	N
Toluene	2 / 12	17	7.8	10	1	1	NP	1.90E+00	5.00E-01		7.23E+01	N
Miscellaneous												
Chloride	10 / 10	100	3000	180000	1	2000	L	5.41E+04	5.57E+05		Nutrient	N
Sulfate	10 / 10	100	30000	1200000	10	500000	L	3.44E+05	1.71E+06		5.00E+05 k	Y

Table 2-10

Statistical Summary and COPC Selection of Chemicals Detected in Overburden Groundwater
TNT Area A, Former Plum Brook Ordnance Works
Sandusky, Ohio

UCL - Upper confidence Limit; BSC - Background screening criterion; RBSC - Risk-based screening concentration;
ND - No data; µg/L - Micrograms per liter.

[a] Statistical Distribution: N - Normal distribution; L - Lognormal distribution; NP - Nonparametric distribution; NA - Not applicable, distribution not determined for sample sets less than 5.
[b] Method of estimation based on statistical distribution (please see Section 3.2.1).
[c] Background screening criteria are presented in the ***2004 Data Summary and Evaluation Report*** (Shaw, 2005).
[d] Risk-Based Screening Concentrations based on EPA Region 9 Preliminary Remediation Goals (PRGs [EPA, 2004]) for tap water.
PRGs were adjusted to provide an Hazard Index of 0.1 and an Incremental Lifetime Cancer Range of 1E-6.
[e] N - No; the MDC is less than the RBSC or it is an essential nutrient.
[f] Y - Yes; the MDC exceeds the RBSC; Y (a) - the MDC exceeds the RBSC, but the MDC is less than the BSC.
[g] Based on PRG for chromium VI.
[h] Screening criteria for lead based on the action level of 15 µg/L (EPA, 1996, *Drinking Water Regulations and Health Advisories*, Office of Water, Washington, DC, October).
[i] Based on PRG for dinitrotoluene mixture.
[j] Based on PRG for aminodinitrotoluene.
[k] Screening criteria for sulfate based on the *Drinking Water Advisory*.

Table 2-11

Statistical Summary and Screening of Chemicals Detected in Overburden Direct-Push Groundwater
TNT Area A, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Detection Frequency	Percent Hits	Range of Values, µg/L: Detected Concentrations Minimum	Detected Concentrations Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Statistical Distribution [a]	Mean µg/L	95% UCL [b] µg/L	BSC [c] µg/L	RBSC [d] µg/L	MDC Exceeds RBSC? [e,f]
Metals												
Aluminum	10 / 10	100	144	48600	200	200	N	1.82E+04	2.73E+04	3.09E+02	3.65E+03	Y
Antimony	2 / 10	20	6.25	12.5	6	6	NP	4.28E+00	3.00E+00		1.46E+00	Y
Arsenic	8 / 10	80	5.43	52.7	5	5	L	1.67E+01	5.40E+01	7.40E+00	4.48E-02	Y
Barium	10 / 10	100	23.4	669	5	5	L	2.02E+02	6.48E+02	1.18E+04	2.55E+02	Y (a)
Beryllium	9 / 10	90	0.175	4.23	1	1	L	1.57E+00	6.21E+00		7.30E+00	N
Cadmium	8 / 10	80	0.708	6.39	3	3	L	2.44E+00	5.17E+00		1.82E+00	Y
Calcium	10 / 10	100	144000	557000	500	500	L	2.90E+05	3.88E+05	3.16E+05	Nutrient	N
Chromium	10 / 10	100	1.11	66.3	5	5	N	2.96E+01	4.48E+01		1.09E+01 g	Y
Cobalt	10 / 10	100	5.73	49	5	5	L	2.41E+01	4.80E+01	1.21E+01	7.30E+01	N
Copper	8 / 8	100	9.54	253	5	5	L	7.25E+01	2.93E+02	1.98E+01	1.46E+02	Y
Iron	10 / 10	100	906	78700	100	100	N	3.40E+04	4.94E+04	1.55E+03	1.09E+03	Y
Lead	8 / 8	100	2.13	1010	3	3	N	3.95E+02	6.33E+02		1.50E+01 h	Y
Magnesium	10 / 10	100	20300	130000	250	250	L	4.92E+04	8.46E+04	2.17E+05	Nutrient	N
Manganese	10 / 10	100	1430	7050	5	5	NP	2.37E+03	2.24E+03	6.36E+02	8.76E+01	Y
Mercury	5 / 10	50	0.126	1.86	0.2	0.2	NP	4.68E-01	2.30E-01		1.09E+00	Y
Nickel	10 / 10	100	11	103	5	5	L	5.27E+01	1.10E+02	8.60E+00	7.30E+01	Y
Potassium	10 / 10	100	2210	15500	250	250	L	7.86E+03	1.46E+04	1.16E+05	Nutrient	N
Silver	1 / 9	11	0.987	0.987	3	3	NP	1.44E+00	1.50E+00		1.82E+01	N
Sodium	10 / 10	100	6300	113000	1000	1000	NP	3.43E+04	6.78E+04	1.39E+06	Nutrient	N
Vanadium	9 / 10	90	1.59	106	5	5	L	4.33E+01	5.08E+02		3.65E+00	Y
Zinc	10 / 10	100	37.2	1830	15	15	L	4.49E+02	2.36E+03	5.07E+02	1.09E+03	Y
Explosives												
1,3,5-Trinitrobenzene	3 / 12	25	0.279	19	0.2	0.6	NP	2.38E+00	2.79E-01		1.09E+02	N
1,3-Dinitrobenzene	3 / 12	25	0.529	0.654	0.2	0.6	NP	2.55E-01	3.00E-01		3.65E-01	Y
2,4,6-Trinitrotoluene	8 / 12	67	0.451	32400	0.2	51.9	L	3.69E+03	5.73E+11		1.82E+00	Y
2,6-Dinitrotoluene	6 / 12	50	4.9	6400	0.2	1080	NP	1.04E+03	5.08E+01		9.89E-02 i	Y
2-Amino-4,6-dinitrotoluene	6 / 12	50	0.937	1890	0.2	51.9	NP	1.89E+02	1.61E+01		7.30E-01 j	Y
2-Nitrotoluene	6 / 12	50	0.599	2510	0.519	51.9	NP	2.34E+02	2.66E+01		4.87E-02	Y
3-Nitrotoluene	6 / 12	50	1.3	190	0.2	51.9	L	2.22E+01	4.04E+03		1.22E+01	Y
4-Amino-2,6-dinitrotoluene	6 / 12	50	0.629	931	0.2	51.9	NP	1.16E+02	2.89E+01		7.30E-01 j	Y
4-Nitrotoluene	6 / 12	50	3.1	1880	0.2	51.9	L	1.68E+02	2.20E+05		6.59E-01	Y
Dinitrotoluene, total	7 / 10	70	0.526	13800	0.26	260	L	2.33E+03	1.52E+13		9.89E-02	Y
Nitrobenzene	1 / 12	8	5.37	5.37	0.2	0.6	NP	5.78E-01	1.30E-01		3.40E-01	Y
PCBs												
Aroclor 1260	1 / 10	10	0.239	0.239	2.04	2.63	NP	1.03E+00	1.10E+00		3.36E-02	Y
Semivolatile Organic Compounds												
2,4-Dinitrotoluene	9 / 12	75	3.29	6760	0.2	1080	L	1.14E+03	2.93E+07		9.89E-02	Y

Table 2-11

Statistical Summary and Screening of Chemicals Detected in Overburden Direct-Push Groundwater
TNT Area A, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Detection Frequency	Percent Hits	Range of Values, µg/L: Detected Concentrations Minimum	Detected Concentrations Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Statistical Distribution [a]	Mean µg/L	95% UCL [b] µg/L	BSC [c] µg/L	RBSC [d] µg/L	MDC Exceeds RBSC? [e,f]
Volatile Organic Compounds												
Acetone	2 / 4	50	6.59	8.8	5	20	NA	6.97E+00	NA		5.48E+02	N
Benzene	1 / 12	8	4.81	4.81	1	5	NP	1.19E+00	5.00E-01		3.54E-01	Y
Carbon disulfide	3 / 12	25	0.79	1.16	1	5	NP	9.43E-01	8.60E-01		1.04E+02	N
Chloroform	1 / 12	8	1	1	1	5	NP	7.08E-01	5.00E-01		7.98E+00	N
Chloromethane	1 / 12	8	0.53	0.53	1	10	NP	1.25E+00	5.00E-01		1.58E+01	N
cis-1,2-Dichloroethene	1 / 10	10	2.11	2.11	1	1	NP	6.61E-01	5.00E-01		6.08E+00	N
Ethylbenzene	1 / 12	8	2.33	2.33	1	5	NP	9.86E-01	5.00E-01		1.34E+02	N
Toluene	3 / 12	25	1.11	1350	1	50	NP	1.14E+02	2.50E+00		7.23E+01	Y
Xylene, o-	1 / 10	10	5.29	5.29	1	1	NP	9.79E-01	5.00E-01		2.06E+01 k	N
Xylenes, m,p-	1 / 10	10	6.9	6.9	1	1	NP	1.14E+00	5.00E-01		2.06E+01 k	N

UCL - Upper confidence limit; BSC - Background screening criterion; RBSC - Risk-based screening concentration;
ND - No data; µg/L - Micrograms per liter.

[a] Statistical Distribution: N - Normal distribution; L - Lognormal distribution; NP - Nonparametric distribution; NA - Not applicable, distribution not determined for sample sets less than 5.

[b] Method of estimation based on statistical distribution (please see Section 3.2.1).

[c] Background screening criteria are presented in the ***2004 Data Summary and Evaluation Report*** (Shaw, 2005).

[d] Risk-Based Screening Concentrations based on EPA Region 9 Preliminary Remediation Goals (PRGs [EPA, 2004]) for tap water. PRGs were adjusted to provide an Hazard Index of 0.1 and an Incremental Lifetime Cancer Range of 1E-6.

[e] N - No; the MDC is less than the RBSC or chemical is an essential nutrient.

[f] Y - Yes; the MDC exceeds the RBSC; Y (a) - the MDC exceeds the RBSC, but the MDC is less than the BSC.

[g] Based on PRG for chromium VI.

[h] Screening criteria for lead based on the action level of 15 µg/L (EPA, 1996, *Drinking Water Regulations and Health Advisories* , Office of Water, Washington, DC, October).

[i] Based on PRG for dinitrotoluene mixture.

[j] Based on PRG for aminodinitrotoluene.

[k] Based on PRG for total xylenes.

Table 2-12

Statistical Summary and Screening of Chemicals Detected in Overburden Groundwater
TNT Area B, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of values, µg/L: Detected Conc Minimum	Detected Conc Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Statistical Distribution [a]	Arithmetic Mean µg/L	95% UCL [b] µg/L	BSC [c] µg/L	RBSC [d] µg/L		MDC Exceeds RBSC? [e,f]
Metals													
Aluminum	5 / 5	100	1830	6920	200	200	N	4.23E+03	6.02E+03	3.09E+02	3.65E+03		Y
Arsenic	3 / 5	60	6.6	18.7	10	10	L	9.58E+00	2.61E+01	7.40E+00	4.48E-02		Y
Barium	3 / 5	60	14.4	23.1	200	200	L	5.04E+01	6.32E+02	1.18E+04	2.55E+02		Y (a)
Beryllium	1 / 3	33	2	2	5	5	NA	2.33E+00	NA		7.30E+00		N
Calcium	5 / 5	100	77500	127000	5000	5000	N	1.01E+05	1.21E+05	3.16E+05	Nutrient		N
Cobalt	5 / 5	100	54.9	101	50	50	N	8.49E+01	1.03E+02	1.21E+01	7.30E+01		Y
Copper	2 / 5	40	6.7	32.9	25	25	L	1.54E+01	3.94E+01	1.98E+01	1.46E+02		N
Iron	5 / 5	100	11600	44300	100	100	L	2.48E+04	8.91E+04	1.55E+03	1.09E+03		Y
Lead	1 / 4	25	16.4	16.4	3	3	NA	5.23E+00	NA		1.50E+01	g	Y
Magnesium	5 / 5	100	22600	32100	5000	5000	L	2.64E+04	3.13E+04	2.17E+05	Nutrient		N
Manganese	5 / 5	100	1120	1770	15	15	L	1.39E+03	1.66E+03	6.36E+02	8.76E+01		Y
Nickel	5 / 5	100	130	240	40	40	N	1.89E+02	2.31E+02	8.60E+00	7.30E+01		Y
Potassium	4 / 5	80	1430	5040	5000	5000	N	2.90E+03	4.43E+03	1.16E+05	Nutrient		N
Selenium	1 / 5	20	5.1	5.1	5	5	NP	3.02E+00	5.10E+00		1.82E+01		N
Sodium	5 / 5	100	3240	6090	5000	5000	NP	4.99E+03	6.09E+03	1.39E+06	Nutrient		N
Zinc	5 / 5	100	137	214	20	20	N	1.78E+02	2.08E+02	5.07E+02	1.09E+03		Y (a)
Explosives													
2,4-Dinitrotoluene	4 / 5	80	1.7	5.8	0.4	3	N	3.82E+00	6.00E+00		9.89E-02	h	Y
2,6-Dinitrotoluene	2 / 5	40	2.7	4	0.4	10	N	2.58E+00	4.49E+00		9.89E-02	h	Y
4-Amino-2,6-dinitrotoluene	5 / 5	100	3.6	22	0.4	3	L	1.45E+01	1.03E+02		7.30E-01	i	Y
2-Amino-4,6-dinitrotoluene	3 / 3	100	23	26	1	3	L	2.43E+01	NA		7.30E-01	i	Y
2,4,6-Trinitrotoluene	4 / 5	80	0.68	68	0.4	3	N	3.05E+01	6.10E+01		1.82E+00		Y
Semivolatile Organic Compounds													
2,4-Dinitrotoluene	4 / 5	80	1.8	4	10	10	N	3.30E+00	4.60E+00		9.89E-02	h	Y
2,6-Dinitrotoluene	2 / 5	40	1.4	8.7	10	10	N	5.02E+00	7.48E+00		9.89E-02	h	Y
Bis(2-ethylhexyl)phthalate	1 / 5	20	2	2	10	10	NP	4.40E+00	5.00E+00		4.80E+00		N
Indeno(1,2,3-cd)pyrene	1 / 5	20	1	1	10	10	NP	4.20E+00	5.00E+00		9.21E-02		Y
Benzo(ghi)perylene	1 / 5	20	0.97	0.97	10	10	NP	4.19E+00	5.00E+00		1.83E+01	j	N
Volatile Organic Compounds													
Acetone	2 / 2	100	2.4	2.4	10	10	NA	2.40E+00	NA		5.48E+02		N
Miscellaneous													
Chloride	3 / 3	100	2.1	6	1	1	NA	4.30E+00	NA		Nutrient		N
Sulfate	4 / 4	100	286	504	0.1	100	NA	3.55E+02	NA		5.00E+05	k	N

UCL - Upper confidence limit; BSC - Background screening criterion; RBSC - Risk-based screening concentration;
ND - No data; µg/L - Micrograms per liter.

Table 2-12

Statistical Summary and Screening of Chemicals Detected in Overburden Groundwater
TNT Area B, Former Plum Brook Ordnance Works
Sandusky, Ohio

[a] Statistical Distribution: N - Normal distribution; L - Lognormal distribution; NP - Nonparametric distribution; NA - Not applicable, distribution not determined for sample sets less than 5.
[b] Method of estimation based on statistical distribution (please see Section 3.2.1).
[c] Background screening criteria are presented in the ***2004 Data Summary and Evaluation Report*** (Shaw, 2005).
[d] Risk-Based Screening Concentrations based on EPA Region 9 Preliminary Remediation Goals (PRGs [EPA, 2004]) for tap water.
PRGs were adjusted to provide an Hazard Index of 0.1 and an Incremental Lifetime Cancer Range of 1E-6.
[e] N - No; the MDC is less than the RBSC or it is an essential nutrient.
[f] Y - Yes; the MDC exceeds the RBSC; Y (a) - the MDC exceeds the RBSC, but the MDC is less than the BSC.
[g] Screening criteria for lead based on the action level of 15 µg/L (EPA, 1996, *Drinking Water Regulations and Health Advisories* , Office of Water, Washington, DC, October).
[h] Based on PRG for dinitrotoluene mixture.
[i] Based on PRG as for aminodinitrotoluene.
[j] Based on PRG as for pyrene.
[k] Screening criteria for sulfate based on the *Drinking Water Advisory* .

Table 2-13

Statistical Summary and Screening of Chemicals Detected in Overburden Direct-Push Groundwater
TNT Area B, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of values, μg/L: Detected Conc Minimum	Detected Conc Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Statistical Distribution [a]	Arithmetic Mean μg/L	95% UCL [b] μg/L	RBSC [c] μg/L	MDC Exceeds RBSC? [d,e]
Explosives											
2,4,6-Trinitrotoluene	1 / 2	50	0.14	0.14	0.2	0.2	NA	1.20E-01	NA	1.82E+00	N
Volatile Organic Compounds											
Acetone	2 / 2	100	10	17	20	20	NA	1.35E+01	NA	5.48E+02	N

UCL - Upper confidence limit; BSC - Background screening criterion; RBSC - Risk-based screening concentration;
ND - No data; μg/L - Micrograms per liter.

[a] Statistical Distribution: NA - Not applicable, distribution not determined for sample sets less than 5.

[b] Method of estimation based on statistical distribution (please see Section 3.2.1).

[c] Risk-Based Screening Concentrations based on EPA Region 9 Preliminary Remediation Goals (PRGs [EPA, 2004]) for tap water. PRGs were adjusted to provide an Hazard Index of 0.1 and an Incremental Lifetime Cancer Range of 1E-6.

[d] N - No; the MDC is less than the RBSC.

[e] Y - Yes; the MDC exceeds the RBSC; Y (a) - the MDC exceeds the RBSC, but the MDC is less than the BSC.

Table 2-14

Statistical Summary and Screening of Chemicals Detected in Overburden Groundwater
TNT Area C, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Detection Frequency	Percent Hits	Range of values, µg/L: Detected Concentrations Minimum	Detected Concentrations Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Statistical Distribution [a]	Arithmetic Mean µg/L	95% UCL [b] µg/L	BSC [c] µg/L	RBSC [d] µg/L	MDC Exceeds RBSC? [e,f]
Inorganics												
Aluminum	10 / 13	77	164	6160	200	200	NP	2.19E+03	3.82E+03	3.09E+02	3.65E+03	Y
Arsenic	4 / 14	29	8.8	21.5	10	10	NP	7.98E+00	8.80E+00	7.40E+00	4.48E-02	Y
Barium	5 / 14	36	24	203	200	200	NP	8.66E+01	1.00E+02	1.18E+04	2.55E+02	Y (a)
Calcium	14 / 14	100	86600	566000	5000	5000	L	2.38E+05	3.23E+05	3.16E+05	Nutrient	N
Chromium	8 / 14	57	2.4	28	10	10	L	1.02E+01	1.72E+01		1.09E+01 g	Y
Cobalt	4 / 14	29	7.2	67.5	50	50	NP	2.51E+01	2.50E+01	1.21E+01	7.30E+01	N
Copper	2 / 13	15	19.5	31	25	25	NP	1.45E+01	1.25E+01	1.98E+01	1.46E+02	N
Iron	14 / 14	100	61.3	22700	100	100	L	6.48E+03	1.39E+05	1.55E+03	1.09E+03	Y
Lead	6 / 13	46	2	20.1	3	3	NP	5.74E+00	1.05E+01		1.50E+01 h	Y
Magnesium	14 / 14	100	12700	253000	5000	5000	L	9.64E+04	2.31E+05	2.17E+05	Nutrient	N
Manganese	14 / 14	100	8.1	3830	15	15	L	1.18E+03	2.19E+04	6.36E+02	8.76E+01	Y
Nickel	6 / 14	43	2.2	120	40	40	NP	2.65E+01	2.00E+01	8.60E+00	7.30E+01	Y
Potassium	14 / 14	100	406	28200	5000	5000	N	1.49E+04	1.90E+04	1.16E+05	Nutrient	N
Selenium	1 / 14	7	7.2	7.2	5	5	NP	2.84E+00	2.50E+00		1.82E+01	N
Sodium	14 / 14	100	9450	161000	5000	5000	N	7.52E+04	9.86E+04	1.39E+06	Nutrient	N
Vanadium	3 / 14	21	2.1	14.4	50	50	NP	2.10E+01	2.50E+01		3.65E+00	Y
Zinc	9 / 11	82	2.8	58.7	20	20	L	2.46E+01	6.99E+01	5.07E+02	1.09E+03	Y (a)
Explosives												
2,4,6-Trinitrotoluene	1 / 15	7	0.61	0.61	0.2	0.2	NP	1.34E-01	1.00E-01		1.82E+00	N
Semivolatile Organic Compounds												
Bis(2-ethylhexyl)phthalate	1 / 14	7	7.3	7.3	10	10	NP	5.16E+00	5.00E+00		4.80E+00	Y
Volatile Organic Compounds												
2-Butanone	1 / 2	50	4.9	4.9	5	5	NA	3.70E+00	NA		6.97E+02	N
Acetone	1 / 1	100	13	13	10	10	NA	1.30E+01	NA		5.48E+02	N
Benzene	1 / 15	7	0.16	0.16	1	5	NP	6.11E-01	5.00E-01		3.54E-01	N
Chlorobenzene	1 / 15	7	0.17	0.17	1	5	NP	6.11E-01	5.00E-01		1.06E+01	N
Toluene	2 / 15	13	17	22	1	5	NP	3.17E+00	5.00E-01		7.23E+01	N
Xylenes, total	1 / 15	7	3.3	3.3	1	5	NP	6.87E-01	5.00E-01		2.06E+01	N
Miscellaneous												
Chloride	14 / 14	100	3000	180000	1	100000	L	3.31E+04	8.10E+04		Nutrient	N
Nitrate	4 / 10	40	100	400	100	2000	L	2.07E+02	6.06E+02		1.00E+02 i	Y
Nitrate-Nitrite	2 / 5	40	17000	91000	5	5	NP	2.16E+04	9.10E+04		1.00E+02 i	Y
Sulfate	13 / 15	87	163000	2000000	5	250000	N	7.18E+05	9.84E+05		5.00E+05 j	Y

Table 2-14

Statistical Summary and Screening of Chemicals Detected in Overburden Groundwater
TNT Area C, Former Plum Brook Ordnance Works
Sandusky, Ohio

UCL - Upper confidence limit; BSC - Background screening criterion; RBSC - Risk-based screening concentration;
ND - No data; μg/L - Micrograms per liter.

[a] Statistical Distribution: N - Normal distribution; L - Lognormal distribution; NP - Nonparametric distribution; NA - Not applicable, distribution not determined for sample sets less than 5.
[b] Method of estimation based on statistical distribution (please see Section 3.2.1).
[c] Background screening criteria are presented in the ***2004 Data Summary and Evaluation Report*** (Shaw, 2005).
[d] Risk-Based Screening Concentrations based on EPA Region 9 Preliminary Remediation Goals (PRGs [EPA, 2004]) for tap water.
PRGs were adjusted to provide an Hazard Index of 0.1 and an Incremental Lifetime Cancer Range of 1E-6.
[e] N - No; the MDC is less than the RBSC or it is an essential nutrient.
[f] Y - Yes; the MDC exceeds the RBSC; Y (a) - the MDC exceeds the RBSC, but the MDC is less than the BSC.
[g] Based on PRG for chromium VI.
[h] Screening criteria for lead based on the action level of 15 µg/L (EPA, 1996, *Drinking Water Regulations and Health Advisories* , Office of Water, Washington, DC, October).
[i] Based on PRG for nitrite.
[j] Screening criteria for sulfate based on the *Drinking Water Advisory* .

Table 2-15

Statistical Summary and Screening of Chemicals Detected in Overburden Direct-Push Groundwater
TNT Area C, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Detection Frequency	Percent Hits	Range of values, µg/L: Detected Concentrations Minimum	Detected Concentrations Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Statistical Distribution [a]	Arithmetic Mean µg/L	95% UCL [b] µg/L	BSC [c] µg/L	RBSC [d] µg/L	MDC Exceeds RBSC? [e,f]
Metals												
Aluminum	10 / 10	100	426	221000	200	200	L	3.17E+04	6.08E+05	3.09E+02	3.65E+03	Y
Antimony	2 / 10	20	3.98	4.02	6	6	NP	3.20E+00	3.00E+00		1.46E+00	Y
Arsenic	8 / 10	80	5.15	432	5	5	L	5.41E+01	3.28E+02	7.40E+00	4.48E-02	Y
Barium	10 / 10	100	21.5	3540	5	5	L	5.25E+02	3.77E+03	1.18E+04	2.55E+02	Y (a)
Beryllium	7 / 9	78	0.608	17.2	1	1	NP	2.86E+00	1.60E+00		7.30E+00	Y
Cadmium	1 / 10	10	0.962	0.962	3	3	NP	1.45E+00	1.50E+00		1.82E+00	N
Calcium	10 / 10	100	147000	2664000	500	500	NP	4.84E+05	3.38E+05	3.16E+05	Nutrient	N
Chromium	8 / 9	89	10	450	5	5	L	7.76E+01	6.94E+02		1.09E+01 g	Y
Cobalt	9 / 10	90	1.62	471	5	5	L	5.83E+01	4.25E+02	1.21E+01	7.30E+01	Y
Copper	9 / 9	100	4.13	1110	5	5	L	2.00E+02	5.18E+03	1.98E+01	1.46E+02	Y
Iron	10 / 10	100	810	979000	100	100	L	1.26E+05	6.02E+06	1.55E+03	1.09E+03	Y
Lead	9 / 10	90	4.37	2050	3	3	L	3.92E+02	9.00E+04		1.50E+01 h	Y
Magnesium	10 / 10	100	12500	726000	250	250	L	1.08E+05	3.29E+05	2.17E+05	Nutrient	N
Manganese	10 / 10	100	109	38100	5	5	L	4.61E+03	4.15E+04	6.36E+02	8.76E+01	Y
Mercury	5 / 10	50	0.1	9.3	0.2	0.2	NP	1.03E+00	1.46E-01		1.09E+00	Y
Nickel	10 / 10	100	2.5	1540	5	5	L	1.86E+02	2.61E+03	8.60E+00	7.30E+01	Y
Potassium	10 / 10	100	1650	32500	250	250	L	8.39E+03	1.79E+04	1.16E+05	Nutrient	N
Selenium	2 / 9	22	2.31	202	5	5	NP	2.46E+01	2.50E+00		1.82E+01	Y
Silver	2 / 10	20	0.703	0.955	3	3	NP	1.37E+00	1.50E+00		1.82E+01	N
Sodium	10 / 10	100	1810	28100	1000	1000	NP	7.93E+03	7.36E+03	1.39E+06	Nutrient	N
Vanadium	10 / 10	100	1.02	647	5	5	L	1.05E+02	3.35E+03		3.65E+00	Y
Zinc	10 / 10	100	24.9	3960	15	15	L	5.68E+02	5.06E+03	5.07E+02	1.09E+03	Y
Explosives												
1,3,5-Trinitrobenzene	1 / 12	8	10.3	10.3	0.2	0.26	NP	9.73E-01	1.30E-01		1.09E+02	N
1,3-Dinitrobenzene	1 / 12	8	0.802	0.802	0.2	0.26	NP	1.81E-01	1.30E-01		3.65E-01	Y
2,4,6-Trinitrotoluene	11 / 12	92	0.208	20100	0.2	130	L	2.70E+03	3.60E+10		1.82E+00	Y
2-Amino-4,6-dinitrotoluene	8 / 12	67	0.181	147	0.2	13	L	2.15E+01	1.03E+04		7.30E-01 i	Y
2-Nitrotoluene	7 / 12	58	0.791	2310	0.2	51.9	L	2.35E+02	3.58E+06		4.87E-02	Y
3-Nitrotoluene	6 / 12	50	0.367	182	0.2	51.9	NP	1.83E+01	8.80E-01		1.22E+01	Y
4-Amino-2,6-dinitrotoluene	10 / 12	83	0.715	436	0.2	13	L	8.55E+01	3.91E+04		7.30E-01 i	Y
4-Nitrotoluene	5 / 12	42	0.396	1290	0.2	51.9	NP	1.31E+02	4.29E-01		6.59E-01	Y
Dinitrotoluene, total	9 / 10	90	0.754	21100	0.26	130	L	2.32E+03	6.67E+09		9.89E-02 j	Y
Nitrobenzene	1 / 12	8	0.488	0.488	0.2	0.26	NP	1.55E-01	1.30E-01		3.40E-01	Y
Semivolatile Organic Compounds												
2,4-Dinitrotoluene	8 / 10	80	3.64	37600	10.5	5810	NP	4.29E+03	4.42E+02		9.89E-02 j	Y
2,6-Dinitrotoluene	6 / 10	60	2.1	1330	10.5	1160	NP	2.59E+02	1.22E+02		9.89E-02 j	Y
Di-n-butyl phthalate	1 / 10	10	4.92	4.92	10.5	1160	NP	7.53E+01	2.50E+01		3.65E+02	N

Table 2-15

Statistical Summary and Screening of Chemicals Detected in Overburden Direct-Push Groundwater
TNT Area C, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Detection Frequency	Percent Hits	Range of values, µg/L: Detected Concentrations Minimum	Detected Concentrations Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Statistical Distribution [a]	Arithmetic Mean µg/L	95% UCL [b] µg/L	BSC [c] µg/L	RBSC [d] µg/L	MDC Exceeds RBSC? [e,f]
Volatile Organic Compounds												
Acetone	2 / 3	67	8.8	13.4	5	20	NA	1.07E+01	NA		5.48E+02	N
Benzene	2 / 12	17	0.51	0.59	1	5	NP	8.42E-01	5.10E-01		3.54E-01	Y
Carbon disulfide	2 / 12	17	0.75	0.76	1	5	NP	7.09E-01	5.00E-01		1.04E+02	N
Toluene	3 / 12	25	0.83	7.88	1	5	NP	1.52E+00	1.00E+00		7.23E+01	N

UCL - Upper confidence limit; BSC - Background screening criterion; RBSC - Risk-based screening concentration;
ND - No data; µg/L - Micrograms per liter.

[a] Statistical Distribution: N - Normal distribution; L - Lognormal distribution; NP - Nonparametric distribution; NA - Not applicable, distribution not determined for sample sets less than 5.

[b] Method of estimation based on statistical distribution (please see Section 3.2.1).

[c] Background screening criteria are presented in the ***2004 Data Summary and Evaluation Report*** (Shaw, 2005).

[d] Risk-Based Screening Concentrations based on EPA Region 9 Preliminary Remediation Goals (PRGs [EPA, 2004]) for tap water.
PRGs were adjusted to provide an Hazard Index of 0.1 and an Incremental Lifetime Cancer Range of 1E-6.

[e] N - No; the MDC is less than the RBSC or it is an essential nutrient.

[f] Y - Yes; the MDC exceeds the RBSC; Y (a) - the MDC exceeds the RBSC, but the MDC is less than the BSC.

[g] Based on PRG for chromium VI.

[h] Screening criteria for lead based on the action level of 15 µg/L (EPA, 1996, *Drinking Water Regulations and Health Advisories* , Office of Water, Washington, DC, October).

[i] Based on PRG for aminodinitrotoluene.

[j] Based on PRG for dinitrotoluene mixture.

Table 2-16

Statistical Summary and Screening of Chemicals Detected in Overburden Groundwater
Pentolite Road Red Water Pond Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of values, µg/L: Detected Concentrations Minimum	Detected Concentrations Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Statistical Distribution [a]	Arithmetic Mean µg/L	95% UCL [b] µg/L	BSC [c] µg/L	RBSC [d] µg/L		MDC Exceeds RBSC? [e,f]
Metals													
Aluminum	6 / 11	55	3970	27500	200	20000	N	1.01E+04	1.41E+04	3.09E+02	3.65E+03		Y
Arsenic	3 / 11	27	11.5	25.2	10	1000	L	1.66E+02	2.12E+03	7.40E+00	4.48E-02		Y
Barium	2 / 11	18	312	361	200	20000	L	3.30E+03	3.18E+04	1.18E+04	2.55E+02		Y (a)
Calcium	10 / 11	91	116000	998000	5000	500000	N	4.65E+05	6.31E+05	3.16E+05	Nutrient		N
Chromium	3 / 11	27	10.6	42.6	10	1000	L	1.68E+02	9.05E+02		1.09E+01	g	Y
Cobalt	7 / 11	64	480	7270	50	5000	NP	2.88E+03	6.75E+03	1.21E+01	7.30E+01		Y
Copper	9 / 11	82	43.7	3790	25	2500	L	1.44E+03	8.72E+04	1.98E+01	1.46E+02		Y
Iron	10 / 11	91	2070	49100	100	10000	N	2.12E+04	2.86E+04	1.55E+03	1.09E+03		Y
Lead	3 / 11	27	6.6	18.1	3	300	L	5.16E+01	4.47E+02		1.50E+01	h	Y
Magnesium	9 / 11	82	38400	574000	5000	500000	L	2.18E+05	5.71E+05	2.17E+05	Nutrient		N
Manganese	11 / 11	100	302	43900	15	1500	L	1.47E+04	3.89E+05	6.36E+02	8.76E+01		Y
Mercury	1 / 11	9	0.3	0.3	0.2	2	NP	2.73E-01	5.00E-01		1.09E+00		N
Nickel	8 / 11	73	59.6	7600	40	4000	NP	2.71E+03	6.95E+03	8.60E+00	7.30E+01		Y
Potassium	2 / 11	18	7710	10000	5000	500000	L	8.25E+04	7.79E+05	1.16E+05	Nutrient		N
Sodium	11 / 11	100	18100	11900000	5000	500000	NP	4.20E+06	9.46E+06	1.39E+06	Nutrient		N
Vanadium	1 / 11	9	66.1	66.1	50	5000	L	8.17E+02	1.34E+04		3.65E+00		Y
Zinc	2 / 10	20	47.6	157	20	2000	NP	3.75E+02	1.00E+03	5.07E+02	1.09E+03		Y (a)
Explosives													
1,3,5-Trinitrobenzene	7 / 11	64	71	6900	0.2	800	NP	1.58E+03	2.40E+03		1.09E+02		Y
1,3-Dinitrobenzene	8 / 11	73	35	5200	0.2	800	NP	1.28E+03	2.00E+03		3.65E-01		Y
2,4-Dinitrotoluene	8 / 11	73	28	4100	0.2	800	NP	1.12E+03	1.60E+03		9.89E-02	i	Y
2,6-Dinitrotoluene	1 / 11	9	210	210	0.2	800	NP	1.21E+02	2.10E+02		9.89E-02	i	Y
Semivolatile Organic Compounds													
2,4-Dinitrophenol	4 / 10	40	48	6000	50	5000	NP	1.67E+03	3.80E+03		7.30E+00		Y
2,4-Dinitrotoluene	8 / 11	73	110	1800	10	1000	NP	9.04E+02	1.80E+03		9.89E-02	i	Y
2,6-Dinitrotoluene	3 / 10	30	140	190	10	1000	NP	5.50E+01	1.40E+02		9.89E-02	i	Y
2-Nitrophenol	3 / 11	27	5.9	15	10	1000	NP	1.45E+02	5.00E+02		ND		Y
3-Nitroaniline	2 / 10	20	160	450	50	5000	NP	5.76E+02	4.50E+02		1.09E+00		Y
4,6-Dinitro-2-methylphenol	7 / 11	64	280	20000	50	5000	L	4.39E+03	2.69E+06		3.65E-01		Y
4-Nitrophenol	2 / 10	20	11	42	50	5000	NP	7.90E+02	2.50E+03		4.90E+00		Y
Dibenzofuran	2 / 10	20	6.5	620	10	1000	NP	2.20E+02	5.00E+02		1.22E+00		Y
Fluorene	2 / 10	20	28	44	10	1000	NP	1.64E+02	5.00E+02		2.43E+01		Y
Nitrobenzene	3 / 11	27	12	14	10	1000	NP	1.46E+02	5.00E+02		3.40E-01		Y
Volatile Organic Compounds													
2-Butanone	1 / 4	25	14	14	5	25	NA	7.88E+00	NA		6.97E+02		N
2-Hexanone	1 / 4	25	2	2	5	25	NA	4.88E+00	NA		1.99E+02	j	N
Acetone	4 / 5	80	22	70	10	50	N	3.28E+01	5.68E+01		5.48E+02		N

Table 2-16

Statistical Summary and Screening of Chemicals Detected in Overburden Groundwater
Pentolite Road Red Water Pond Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of values, µg/L: Detected Concentrations Minimum	Detected Concentrations Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Statistical Distribution [a]	Arithmetic Mean µg/L	95% UCL [b] µg/L	BSC [c] µg/L	RBSC [d] µg/L		MDC Exceeds RBSC? [e,f]
Benzene	3 / 11	27	0.21	0.48	1	5	NP	1.06E+00	2.50E+00		3.54E-01		Y
Bromodichloromethane	1 / 11	9	0.23	0.23	1	5	NP	1.07E+00	2.50E+00		1.81E-01		Y
Carbon disulfide	1 / 11	9	0.21	0.21	1	5	NP	1.06E+00	2.50E+00		1.04E+02		N
Ethylbenzene	2 / 11	18	0.17	1.5	1	5	L	1.15E+00	2.68E+00		1.34E+02		N
Toluene	1 / 6	17	1.5	1.5	1	5	N	1.75E+00	2.47E+00		7.23E+01		N
Xylenes, total	3 / 10	30	0.44	8	1	5	NP	1.73E+00	2.50E+00		2.06E+01		N
Miscellaneous													
Chloride	7 / 8	88	3	9500	0.001	1000	N	3.94E+03	6.41E+03		Nutrient		N
Cyanide, total	6 / 8	75	0.036	1.7	0.01	0.1	L	2.97E-01	4.82E+01		7.30E+01		N
Nitrate	3 / 4	75	110	1500	0.1	20	NA	4.50E+02	NA		1.00E+03		Y
Nitrate-Nitrite	3 / 4	75	0.2	1600	0.0001	0.2	NA	4.00E+02	NA		1.00E+02	k	Y
Sulfate	8 / 8	100	48	12000	0.01	2000	N	5.26E+03	8.58E+03		5.00E+05	l	N

UCL - Upper confidence limit; BSC - Background screening criterion; RBSC - Risk-based screening concentration;
ND - No data; µg/L - Micrograms per liter.

[a] Statistical Distribution: N - Normal distribution; L - Lognormal distribution; NP - Nonparametric distribution; NA - Not applicable, distribution not determined for sample sets less than 5.

[b] Method of estimation based on statistical distribution (please see Section 3.2.1).

[c] Background screening criteria are presented in the ***2004 Data Summary and Evaluation Report*** (Shaw, 2005).

[d] Risk-Based Screening Concentrations based on EPA Region 9 Preliminary Remediation Goals (PRGs [EPA, 2004]) for tap water. PRGs were adjusted to provide an Hazard Index of 0.1 and an Incremental Lifetime Cancer Range of 1E-6.

[e] N - No; the MDC is less than the RBSC or it is an essential nutrient.

[f] Y - Yes; the MDC exceeds the RBSC; Y (a) - the MDC exceeds the RBSC, but the MDC is less than the BSC.

[g] Based on PRG for chromium VI.

[h] Screening criteria for lead based on the action level of 15 µg/L (EPA, 1996, *Drinking Water Regulations and Health Advisories* , Office of Water, Washington, DC, October).

[i] Based on PRG for dinitrotoluene mixture.

[j] Based on PRG for 4-methyl-2-pentanone.

[k] Based on PRG for nitrite.

[l] Screening criteria for sulfate based on the *Drinking Water Advisory* .

Table 2-17

Statistical Summary and Screening of Chemicals Detected in Overburden Direct-Push Groundwater
Pentolite Road Red Water Pond Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of values, µg/L: Detected Concentrations Minimum	Detected Concentrations Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Statistical Distribution [a]	Arithmetic Mean µg/L	95% UCL [b] µg/L	BSC [c] µg/L	RBSC [d] µg/L	MDC Exceeds RBSC? [e,f]
Metals												
Aluminum	18 / 20	90	1930	280000	200	2000	L	6.33E+04	1.07E+06	3.09E+02	3.65E+03	Y
Antimony	3 / 20	15	77.8	118	60	600	NP	1.67E+02	3.00E+02		1.46E+00	Y
Arsenic	9 / 20	45	11.1	584	10	200	L	1.14E+02	2.35E+02	7.40E+00	4.48E-02	Y
Barium	6 / 20	30	218	1680	200	2000	NP	7.49E+02	1.00E+03	1.18E+04	2.55E+02	Y (a)
Beryllium	3 / 20	15	5.5	8.8	5	50	NP	1.38E+01	2.50E+01		7.30E+00	Y
Cadmium	1 / 20	5	6.5	6.5	5	50	NP	1.32E+01	2.50E+01		1.82E+00	Y
Calcium	18 / 20	90	86100	1530000	5000	100000	N	5.79E+05	7.38E+05	3.16E+05	Nutrient	N
Chromium	15 / 20	75	16	561	10	100	L	1.33E+02	3.97E+02		1.09E+01 g	Y
Cobalt	8 / 20	40	77.6	5610	50	500	NP	7.17E+02	2.50E+02	1.21E+01	7.30E+01	Y
Copper	14 / 20	70	27.7	2800	25	250	L	4.86E+02	2.14E+03	1.98E+01	1.46E+02	Y
Iron	18 / 20	90	4250	679000	100	1000	NP	1.55E+05	1.76E+05	1.55E+03	1.09E+03	Y
Lead	15 / 20	75	9.5	323	3	60	L	9.36E+01	2.93E+02		1.50E+01 h	Y
Magnesium	18 / 20	90	21200	616000	5000	50000	NP	1.80E+05	2.40E+05	2.17E+05	Nutrient	N
Manganese	18 / 20	90	141	55100	15	150	L	9.58E+03	2.45E+05	6.36E+02	8.76E+01	Y
Mercury	6 / 20	30	0.2	0.55	0.2	2	NP	2.32E-01	2.00E-01		1.09E+00	N
Nickel	11 / 20	55	113	5040	40	400	L	6.76E+02	2.91E+03	8.60E+00	7.30E+01	Y
Potassium	6 / 20	30	6430	31500	5000	50000	NP	1.75E+04	2.50E+04	1.16E+05	Nutrient	N
Sodium	15 / 20	75	5960	9410000	5000	100000	NP	1.11E+06	2.66E+05	1.39E+06	Nutrient	N
Vanadium	11 / 20	55	52.3	1000	50	500	L	3.10E+02	5.56E+02		3.65E+00	Y
Zinc	15 / 20	75	44.7	2010	20	200	L	4.99E+02	1.57E+03	5.07E+02	1.09E+03	Y
Explosives												
1,3,5-Trinitrobenzene	1 / 21	5	600	600	0.2	1000	NP	6.01E+01	7.00E+00		1.09E+02	Y
1,3-Dinitrobenzene	12 / 21	57	0.28	4800	0.2	1000	NP	3.72E+02	1.00E+01		3.65E-01	Y
2,4-Dinitrotoluene	13 / 21	62	0.47	6800	0.2	1000	NP	4.41E+02	1.00E+01		9.89E-02 i	Y
2,6-Dinitrotoluene	8 / 21	38	0.28	400	0.2	1000	L	4.70E+01	9.09E+02		9.89E-02 i	Y
Tetryl	1 / 21	5	0.2	0.2	0.2	1000	NP	3.24E+01	5.00E+00		3.65E+01	N
Semivolatile Organic Compounds												
2,4-Dinitrophenol	4 / 20	20	8.3	5900	50	5000	NP	7.54E+02	3.20E+01		7.30E+00	Y
2,4-Dinitrotoluene	11 / 20	55	1.5	9200	10	1000	NP	7.06E+02	2.00E+01		9.89E-02 i	Y
2,6-Dinitrotoluene	4 / 20	20	3.3	550	10	500	NP	8.10E+01	6.50E+00		9.89E-02 i	Y
2-Nitroaniline	2 / 20	10	1.3	3.2	50	2500	NP	2.18E+02	3.20E+01		1.09E+01	N
2-Nitrophenol	1 / 20	5	2.1	2.1	10	500	NP	4.38E+01	6.50E+00		ND	Y
3-Nitroaniline	1 / 20	5	88	88	50	2500	NP	2.23E+02	3.20E+01		1.09E+00	Y
4,6-Dinitro-2-methylphenol	3 / 20	15	830	2300	50	2500	NP	3.86E+02	3.20E+01		3.65E-01	Y
4-Nitrophenol	3 / 20	15	5	290	50	2500	NP	1.94E+02	3.20E+01		4.90E+00	Y
Bis(2-ethylhexyl)phthalate	2 / 20	10	3.2	10	10	500	NP	4.41E+01	6.50E+00		4.80E+00	Y
Naphthalene	1 / 20	5	1.9	1.9	10	500	NP	4.37E+01	6.50E+00		6.20E-01	Y

Table 2-17

Statistical Summary and Screening of Chemicals Detected in Overburden Direct-Push Groundwater
Pentolite Road Red Water Pond Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of values, µg/L: Detected Concentrations Minimum	Detected Concentrations Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Statistical Distribution [a]	Arithmetic Mean µg/L	95% UCL [b] µg/L	BSC [c] µg/L	RBSC [d] µg/L	MDC Exceeds RBSC? [e,f]
Volatile Organic Compounds												
2-Butanone	1 / 1	100	24	24	5	5	NA	2.40E+01	NA		6.97E+02	N
2-Hexanone	1 / 19	5	1.8	1.8	5	50	NP	4.70E+00	5.00E+00		1.99E+02 j	N
Acetone	1 / 1	100	20	20	10	10	NA	2.00E+01	NA		5.48E+02	N
Benzene	1 / 20	5	0.14	0.14	1	10	NP	9.07E-01	5.00E-01		3.54E-01	N
Carbon disulfide	3 / 20	15	0.16	0.26	1	10	NP	8.79E-01	5.00E-01		1.04E+02	N
Ethylbenzene	1 / 20	5	0.19	0.19	1	10	NP	9.10E-01	5.00E-01		1.34E+02	N
Tetrachloroethene	5 / 20	25	0.13	0.26	1	10	L	8.46E-01	1.34E+00		1.04E-01	Y
Toluene	1 / 7	14	1.9	1.9	1	10	NP	1.91E+00	2.50E+00		7.23E+01	N
Trichloroethene	2 / 20	10	0.16	0.43	1	10	NP	9.05E-01	5.00E-01		2.80E-02	Y
Xylenes, total	1 / 20	5	0.88	0.88	1	10	NP	9.44E-01	8.80E-01		2.06E+01	N
Miscellaneous												
Chloride	3 / 6	50	2300	9800	1000	1000000	L	1.77E+05	2.14E+10		Nutrient	N
Cyanide, total	3 / 6	50	23	780	10	100	NP	2.03E+02	7.80E+02		7.30E+01	Y
Nitrate	3 / 6	50	16900	465000	500	50000	NP	1.39E+05	4.65E+05		1.00E+03	Y
Sulfate	6 / 6	100	22700	10000000	5000	2000000	L	2.58E+06	7.77E+11		5.00E+05 k	Y

UCL - Upper confidence limit; BSC - Background screening criterion; RBSC - Risk-based screening concentration;
ND - No data; µg/L - Micrograms per liter.

[a] Statistical Distribution: N - Normal distribution; L - Lognormal distribution; NP - Nonparametric distribution; NA - Not applicable, distribution not determined for sample sets less than 5.

[b] Method of estimation based on statistical distribution (please see Section 3.2.1).

[c] Background screening criteria are presented in the ***2004 Data Summary and Evaluation Report*** (Shaw, 2005).

[d] Risk-Based Screening Concentrations based on EPA Region 9 Preliminary Remediation Goals (PRGs [EPA, 2004]) for tap water. PRGs were adjusted to provide an Hazard Index of 0.1 and an Incremental Lifetime Cancer Range of 1E-6.

[e] N - No; the MDC is less than the RBSC or it is an essential nutrient.

[f] Y - Yes; the MDC exceeds the RBSC; Y (a) - the MDC exceeds the RBSC, but the MDC is less than the BSC.

[g] Based on PRG for chromium VI.

[h] Screening criteria for lead based on the action level of 15 µg/L (EPA, 1996, *Drinking Water Regulations and Health Advisories* , Office of Water, Washington, DC, October).

[i] Based on PRG for dinitrotoluene mixture.

[j] Based on PRG for 4-methyl-2-pentanone.

[k] Screening criteria for sulfate based on the *Drinking Water Advisory* .

Table 2-18

Statistical Summary and COPC Selection of Chemicals Detected in Overburden Groundwater
West Area Red Water Ponds Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of Values, µg/L: Detected Concentrations Minimum	Detected Concentrations Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Statistical Distribution [a]	Mean µg/L	95% UCL µg/L b	BSC [c] µg/L	RBSC [d] µg/L	MDC Exceeds RBSC? [e,f]
Metals												
Aluminum	4 / 7	57	1040	4220	200	200	N	1.71E+03	3.04E+03	3.09E+02	3.65E+03	Y
Calcium	7 / 7	100	109000	497000	5000	5000	L	2.32E+05	4.16E+05	3.16E+05	Nutrient	N
Chromium	2 / 7	29	11.4	12.8	10	10	NP	7.03E+00	1.14E+01		1.09E+01 g	Y
Cobalt	2 / 7	29	118	142	50	50	NP	5.50E+01	1.18E+02	1.21E+01	7.30E+01	Y
Copper	4 / 7	57	30.7	70.2	25	25	NP	3.76E+01	6.26E+01	1.98E+01	1.46E+02	N
Iron	6 / 7	86	319	9390	100	100	L	3.85E+03	2.04E+06	1.55E+03	1.09E+03	Y
Lead	1 / 5	20	4.5	4.5	3	30	L	4.80E+00	6.52E+01		1.50E+01 h	N
Magnesium	7 / 7	100	52500	181000	5000	5000	L	9.10E+04	1.50E+05	2.17E+05	Nutrient	N
Manganese	7 / 7	100	235	1670	15	15	N	1.00E+03	1.46E+03	6.36E+02	8.76E+01	Y
Nickel	2 / 7	29	190	228	40	40	NP	7.40E+01	1.90E+02	8.60E+00	7.30E+01	Y
Potassium	2 / 7	29	20900	28000	5000	5000	NP	8.77E+03	2.09E+04	1.16E+05	Nutrient	N
Selenium	1 / 7	14	16.7	16.7	5	50	NP	7.74E+00	1.67E+01		1.82E+01	N
Sodium	7 / 7	100	12100	1010000	5000	50000	L	3.46E+05	6.35E+07	1.39E+06	Nutrient	N
Zinc	1 / 3	33	36.7	36.7	20	20	NP	1.89E+01	3.67E+01	5.07E+02	1.09E+03	Y (a)
Explosives												
1,3,5-Trinitrobenzene	3 / 8	38	14	23	0.2	6.8	NP	6.98E+00	1.50E+01		1.09E+02	N
1,3-Dinitrobenzene	3 / 8	38	17	23	0.2	7.4	NP	7.89E+00	1.90E+01		3.65E-01	Y
2,4-Dinitrotoluene	3 / 8	38	21	47	0.2	5.5	NP	1.48E+01	4.70E+01		9.89E-02 i	Y
2,6-Dinitrotoluene	3 / 8	38	4.1	8.9	0.2	4	NP	2.78E+00	7.80E+00		9.89E-02 i	Y
3-Nitrotoluene	1 / 8	13	36	36	0.2	4	NP	5.18E+00	2.00E+00		1.22E+01	Y
Nitrobenzene	1 / 8	13	2.5	2.5	0.2	4	NP	9.88E-01	2.00E+00		3.40E-01	Y
RDX	1 / 8	13	6.2	6.2	0.5	10	NP	2.46E+00	5.00E+00		6.11E-01	Y
Semivolatile Organic Compounds												
2,4-Dinitrophenol	1 / 8	13	7.6	7.6	50	5000	NP	3.32E+02	2.50E+01		7.30E+00	Y
2,4-Dinitrotoluene	3 / 8	38	43	55	10	1000	NP	8.26E+01	5.50E+01		9.89E-02 i	Y
2,6-Dinitrotoluene	3 / 8	38	1.8	7.1	10	1000	NP	6.70E+01	7.10E+00		9.89E-02 i	Y
2-Nitroaniline	2 / 8	25	1.3	1.5	50	5000	NP	3.28E+02	2.50E+01		1.09E+02	N
3-Nitroaniline	2 / 8	25	3.3	330	50	5000	NP	3.70E+02	3.30E+02		1.09E+00	Y
4,6-Dinitro-2-methylphenol	1 / 8	13	12	12	50	5000	NP	3.33E+02	2.50E+01		3.65E-01	Y
4-Nitrophenol	1 / 8	13	1.6	1.6	50	5000	NP	3.31E+02	2.50E+01		4.90E+01	N
Bis(2-ethylhexyl)phthalate	1 / 6	17	5.1	5.1	10	1000	NP	8.75E+01	5.00E+02		4.80E+00	Y
Di-n-octyl phthalate	1 / 7	14	2.7	2.7	10	1000	NP	7.54E+01	5.00E+00		1.46E+02	N
Nitrobenzene	1 / 8	13	3.7	3.7	10	1000	NP	6.67E+01	5.00E+00		3.40E-01	Y
Volatile Organic Compounds												
Carbon disulfide	1 / 7	14	0.17	0.17	1	2	NP	5.24E-01	5.00E-01		1.04E+02	N

Table 2-18

Statistical Summary and COPC Selection of Chemicals Detected in Overburden Groundwater
West Area Red Water Ponds Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of Values, µg/L: Detected Concentrations Minimum	Detected Concentrations Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Statistical Distribution [a]	Mean µg/L	95% UCL µg/L [b]	BSC [c] µg/L	RBSC [d] µg/L	MDC Exceeds RBSC? [e,f]
Miscellaneous												
Chloride	7 / 8	88	2000	97000	1	100000	L	2.70E+04	1.97E+05		Nutrient	N
Cyanide, total	3 / 8	38	16	89	10	10	NP	2.61E+01	7.90E+01		7.30E+01	Y
Nitrate	2 / 4	50	200	62000	100	10000	NP	1.68E+04	1.00E+02		1.00E+03	Y
Nitrate-Nitrite	2 / 4	50	100	80000	0.1	5	L	2.00E+04	1.83E+46		1.00E+02 [j]	Y
Sulfate	8 / 8	100	170000	2300000	25	500000	NP	7.21E+05	2.00E+06		5.00E+05 [k]	Y

UCL - Upper confidence limit; BSC - Background screening criterion; RBSC - Risk-based screening concentration;
ND - No data; µg/L - Micrograms per liter.

[a] Statistical Distribution: N - Normal distribution; L - Lognormal distribution; NP - Nonparametric distribution; NA - Not applicable, distribution not determined for sample sets less than 5.

[b] Method of estimation based on statistical distribution (please see Section 3.2.1).

[c] Background screening criteria are presented in the ***2004 Data Summary and Evaluation Report*** (Shaw, 2005).

[d] Risk-Based Screening Concentrations based on EPA Region 9 Preliminary Remediation Goals (PRGs [EPA, 2004]) for tap water. PRGs were adjusted to provide an Hazard Index of 0.1 and an Incremental Lifetime Cancer Range of 1E-6.

[e] N - No; the MDC is less than the RBSC or it is an essential nutrient.

[f] Y - Yes; the MDC exceeds the RBSC; Y (a) - the MDC exceeds the RBSC, but the MDC is less than the BSC.

[g] Based on PRG for chromium VI.

[h] Screening criteria for lead based on the action level of 15 µg/L (EPA, 1996, *Drinking Water Regulations and Health Advisories* , Office of Water, Washington, DC, October).

[i] Based on PRG for dinitrotoluene mixture.

[j] Based on PRG for nitrite.

[k] Screening criteria for sulfate based on the *Drinking Water Advisory* .

Table 2-19

Statistical Summary and Screening of Chemicals Detected in Overburden Direct-Push Groundwater
West Area Red Water Ponds Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of Values, µg/L: Detected Concentrations Minimum	Detected Concentrations Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Statistical Distribution [a]	Mean µg/L	95% UCL ug/L [b]	BSC [c] µg/L	RBSC [d] µg/L	MDC Exceeds RBSC? [e,f]
Metals												
Aluminum	8 / 8	100	1240	206000	200	2000	L	5.72E+04	1.76E+06	3.09E+02	3.65E+03	Y
Antimony	1 / 8	13	106	106	60	600	NP	8.83E+01	1.50E+02		1.46E+00	Y
Arsenic	5 / 8	63	15.2	1780	10	100	L	2.58E+02	4.76E+03	7.40E+00	4.48E-02	Y
Barium	4 / 8	50	217	773	200	2000	L	4.16E+02	1.23E+03	1.18E+04	2.55E+02	Y (a)
Beryllium	1 / 8	13	9.5	9.5	5	50	NP	7.44E+00	1.25E+01		7.30E+00	Y
Calcium	8 / 8	100	230000	2680000	5000	50000	L	7.89E+05	1.82E+06	3.16E+05	Nutrient	N
Chromium	6 / 8	75	28.8	296	10	100	L	9.11E+01	8.06E+02		1.09E+01 g	Y
Cobalt	4 / 8	50	68.4	264	50	500	N	1.27E+02	1.90E+02	1.21E+01	7.30E+01	Y
Copper	5 / 8	63	90.2	654	25	250	L	1.80E+02	1.04E+03	1.98E+01	1.46E+02	Y
Iron	8 / 8	100	2650	339000	100	1000	L	1.12E+05	2.68E+06	1.55E+03	1.09E+03	Y
Lead	6 / 8	75	11.8	459	3	30	L	9.47E+01	2.46E+03		1.50E+01 h	Y
Magnesium	8 / 8	100	86200	651000	5000	50000	L	2.26E+05	4.46E+05	2.17E+05	Nutrient	N
Manganese	8 / 8	100	750	12600	15	150	L	5.41E+03	2.18E+04	6.36E+02	8.76E+01	Y
Mercury	4 / 8	50	0.24	0.65	0.2	0.2	NP	2.51E-01	4.70E-01		1.09E+00	N
Nickel	5 / 8	63	61.5	515	40	400	L	1.87E+02	7.84E+02	8.60E+00	7.30E+01	Y
Potassium	6 / 8	75	6880	33100	5000	50000	N	1.75E+04	2.34E+04	1.16E+05	Nutrient	N
Selenium	1 / 8	13	1790	1790	5	50	NP	2.33E+02	2.50E+01		1.82E+01	Y
Sodium	8 / 8	100	44300	1060000	5000	50000	L	4.22E+05	2.48E+06	1.39E+06	Nutrient	N
Thallium	1 / 8	13	1770	1770	10	100	NP	2.41E+02	5.00E+01		2.41E-01	Y
Vanadium	5 / 8	63	62	381	50	500	L	1.55E+02	4.41E+02		3.65E+00	Y
Zinc	7 / 8	88	22.1	1260	20	200	L	3.74E+02	4.16E+03	5.07E+02	1.09E+03	Y
Explosives												
1,3,5-Trinitrobenzene	5 / 15	33	7.2	680	0.2	40	L	5.18E+01	3.73E+03		1.09E+02	Y
1,3-Dinitrobenzene	6 / 15	40	0.2	270	0.2	40	NP	2.06E+01	5.00E+00		3.65E-01	Y
2,4,6-Trinitrotoluene	1 / 15	7	7.1	7.1	0.2	46	L	3.97E+00	5.15E+01		1.82E+00	Y
2,4-Dinitrotoluene	6 / 15	40	1.1	950	0.2	40	L	6.83E+01	1.11E+03		9.89E-02 i	Y
2,6-Dinitrotoluene	3 / 15	20	0.25	2.7	0.2	40	L	3.50E+00	2.41E+01		9.89E-02 i	Y
Semivolatile Organic Compounds												
2,4-Dinitrotoluene	5 / 7	71	1.8	660	10	100	L	1.21E+02	5.92E+04		9.89E-02 i	Y
2,6-Dinitrotoluene	4 / 7	57	6.3	56	10	100	L	1.58E+01	5.88E+01		9.89E-02 i	Y
3-Nitroaniline	6 / 7	86	2.1	49	50	500	L	2.03E+01	2.68E+02		1.09E+00	Y
4,6-Dinitro-2-methylphenol	1 / 7	14	24	24	50	500	NP	1.21E+02	2.50E+02		3.65E-01	Y
4-Nitrophenol	1 / 7	14	2.4	2.4	50	500	L	1.18E+02	1.60E+04		4.90E+00	N

Table 2-19

Statistical Summary and Screening of Chemicals Detected in Overburden Direct-Push Groundwater
West Area Red Water Ponds Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Detection Frequency	Percent hits	Range of Values, µg/L: Detected Concentrations Minimum	Detected Concentrations Maximum	Reporting Limits Minimum	Reporting Limits Maximum	Statistical Distribution [a]	Mean µg/L	95% UCL ug/L [b]	BSC [c] µg/L	RBSC [d] µg/L	MDC Exceeds RBSC? [e,f]
Volatile Organic Compounds												
2-Butanone	2 / 2	100	1.2	1.8	5	5	N	1.50E+00	3.39E+00		6.97E+02	N
Benzene	2 / 15	13	0.13	0.15	1	1	NP	4.52E-01	5.00E-01		3.54E-01	N
Carbon disulfide	2 / 15	13	0.15	0.18	1	1	NP	4.55E-01	5.00E-01		1.04E+02	N
Ethylbenzene	1 / 15	7	0.19	0.19	1	1	NP	4.79E-01	5.00E-01		1.34E+02	N
Tetrachloroethene	2 / 15	13	0.15	0.2	1	1	NP	4.57E-01	5.00E-01		1.04E-01	Y
Miscellaneous												
Nitrate	1 / 2	50	1600	1600	500	1000	NA	1.05E+03	NA		1.00E+03	Y
Sulfate	2 / 2	100	278000	305000	50000	100000	NA	2.92E+05	NA		5.00E+05 j	N

UCL - Upper confidence limit; BSC - Background screening criterion; RBSC - Risk-based screening concentration;
ND - No data; µg/L - Micrograms per liter.

[a] Statistical Distribution: N - Normal distribution; L - Lognormal distribution; NP - Nonparametric distribution; NA - Not applicable, distribution not determined for sample sets less than 5.

[b] Method of estimation based on statistical distribution (please see Section 3.2.1).

[c] Background screening criteria are presented in the ***2004 Data Summary and Evaluation Report*** (Shaw, 2005).

[d] Risk-Based Screening Concentrations based on EPA Region 9 Preliminary Remediation Goals (PRGs [EPA, 2004]) for tap water. PRGs were adjusted to provide an Hazard Index of 0.1 and an Incremental Lifetime Cancer Range of 1E-6.

[e] N - No; the MDC is less than the RBSC or it is an essential nutrient.

[f] Y - Yes; the MDC exceeds the RBSC; Y (a) - the MDC exceeds the RBSC, but the MDC is less than the BSC.

[g] Based on PRG for chromium VI.

[h] Screening criteria for lead based on the action level of 15 µg/L (EPA, 1996, *Drinking Water Regulations and Health Advisories* , Office of Water, Washington, DC, October).

[i] Based on PRG for dinitrotoluene mixture.

[j] Screening criteria for sulfate based on the *Drinking Water Advisory* .

Table 3-1

Variables Used to Estimate Potential Chemical Intake and Contact Rates from Groundwater Plum Brook Ordnance Works, Sandusky, Ohio

Pathway Variable	On-site Worker	Resident
General Variables		
Exposure duration (ED), years	25[a]	Child: 6[b] Adult: 24[b]
Body weight (BW), kg	70[a]	Child: 15[b] Adult: 70[a]
Averaging time, noncancer (AT), days[c]	9125	Child: 2190 Adult: 8760
Averaging time, cancer (AT), days[c]	25550	25550
Inhalation of VOCs from Groundwater		
Exposure time (ET), hours/day	NA	24[d]
Inhalation rate (IR_a), m^3/hour	NA	Adult: 0.833[b] Child: 0.416[b]
Exposure frequency (EF), days/year	250[a]	350[a]
Drinking Water Ingestion of Groundwater		
Fraction exposed to contaminated medium (F_{gw}), unitless	1[f]	1[f]
Drinking water ingestion rate (IRgw), L/day	1[a]	Child: 1[b] Adult: 2[a]
Exposure frequency (EF), days/year	250[a]	350[a]
Dermal Contact with Groundwater		
Fraction exposed to contaminated medium (F_{gw}), unitless	1[e]	1[e]
Body surface area exposed to water (Sa_{gw}), cm^2	3300[g]	Child: 6600[f] Adult: 20000[f]
Permeability coefficient (PC), cm/hour	csv	csv
Exposure time (ET_{gw}), hours/day	1[f]	Child: 0.333[g] Adult: 0.2[d]
Exposure frequency (EF), days/year	250[a]	350[a]

cm - Centimeter.
cm^2 - Square centimeter.
csv - Chemical-specific value.
kg - Kilogram.
L - Liters.
m^3 - Cubic meters.
NA - Not applicable to this receptor.
VOC - Volatile organic compound.

[a]U.S. Environmental Protection Agency (EPA), 1991, *Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual Supplemental Guidance, Standard Default Exposure Factors*, Interim Final, Office of Solid Waste and Emergency Response, OSWER Directive: 9285.603.

[b]U.S. Environmental Protection Agency (EPA), 2004, *User's Guide and Background Technical Document for EPA Region 9 Preliminary Remediation Goals (PRG) Table*, Region 9, San Francisco, California, October.

[c]Calculated as the product of ED (years) x 365 days/year.

[d]The *Exposure Factors Handbook* (see reference g) indicates that the 90th percentile for the amount of time spent at a residence is more than 23 hours per day.

[e]Assumed; see text.

[f]U.S. Environmental Protection Agency (EPA), 2004, *Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual (Part E - Supplemental Guidance for Dermal Risk Assessment)*, Final, Office of Superfund Remediation and Technology Innovation, Washington, D.C., July, EPA/540/R-99/005.

[g]U.S. Environmental Protection Agency, (EPA), 1997, *Exposure Factors Handbook*, Final, National Center for Environmental Assessment, Washington, D.C., EPA/600/P-95/002Fa, August.

Table 3-2

Chemical-Specific Physical Property Values Used for Exposure Assessment[a]
Former Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	FA (unitless)	Kp (cm/hour)		tau (hours)	Henry's Law Constant (atm-m^3/mole)	Molecular Weight (g/mole)
Metals						
Aluminum	NA	1.00E-03	b	NA	NA	NA
Arsenic	NA	1.00E-03		NA	NA	NA
Chromium	NA	1.00E-03		NA	NA	NA
Cobalt	NA	1.00E-03		NA	NA	NA
Iron	NA	1.00E-03		NA	NA	NA
Lead	NA	1.00E-04	b	NA	NA	NA
Manganese	NA	1.00E-03	b	NA	NA	NA
Nickel	NA	2.00E-04	b	NA	NA	NA
Thallium	NA	1.00E-03		NA	NA	NA
Vanadium	NA	1.00E-03		NA	NA	NA
Explosives						
2,4,6-Trinitrotoluene	1	9.64E-04		1.96	4.57E-07	227.13
1,3-Dichlorobenzene	1	5.80E-02		0.71	2.80E-03	147
2,4-Dinitrotoluene	1	3.10E-03		1.12	9.27E-08	182.1
2,6-Dinitrotoluene	1	2.10E-03		1.12	9.26E-08	182.1
2-Nitrotoluene	1	8.91E-03		0.62	5.60E-05	137.13
4-Amino-2,6-dinitrotoluene	1	2.04E-03		1.33	1.61E-10	197.15
Nitrobenzene	1	5.39E-03		0.514	2.40E-05	123.11
Semivolatile Organic Compounds						
2-Methylnaphthalene	1	8.94E-02		0.657	5.18E-04	142.2
4,6-Dinitro-2-methylphenol	1	3.14E-03		1.35	NA	198.13
2,4-Dinitrophenol	1	1.50E-03		1.15	4.44E-07	184.1
3-Nitroaniline	1	2.14E-03		0.623	7.20E-09	138.12
4-Methylphenol	1	7.70E-03		0.43	1.00E-06	108.1
Bis(2-ethylhexyl)phthalate	0.8	2.50E-02		16.64	1.02E-07	391
Chrysene	1	4.70E-01		2.03	9.46E-05	228.3
Dibenzofuran	0.6	9.49E-02		0.918	2.10E-04	168.19
Fluorene	1	1.07E-01		0.895	6.37E-05	166.21
Naphthalene	1	4.70E-02		0.56	4.83E-04	128.2
Phenanthrene	1	1.40E-01		1.06	1.24E-04	178.2
Volatile Organic Compounds						
1,1,2-Trichloroethane	1	6.40E-03		0.6	0.000912	133.4
Acetone	1	5.20E-04		0.22	3.88E-05	58.08
Benzene	1	1.50E-02		0.29	5.56E-03	78.1
Bromomethane	1	2.80E-03		0.36	6.24E-03	95
Chlorobenzene	1	2.80E-02		0.46	3.71E-03	112.6
Chloromethane	1	3.30E-03		0.2	8.82E-03	50.5
Ethylbenzene	1	4.90E-02		0.42	7.88E-03	106.2
Methylene chloride	1	3.50E-03		0.32	2.19E-03	84.9
Toluene	1	3.10E-02		0.35	6.63E-03	92.1
Xylenes, total	1	5.30E-02		0.42	7.34E-03	106.2
Miscellaneous						
Cyanide, total	1	7.65E-04		0.15	NA	26.02
Nitrate	NA	1.00E-03		NA	NA	62
Nitrate-Nitrite (values based on nitrite)	NA	1.00E-03		NA	NA	46.1
Sulfate	NA	NA		NA	NA	96.1

FA - fraction absorbed; Kp - permeability coefficient; tau - lag time for chemical to cross stratum corneum; NA - not applicable.

[a] Refer to toxicity profiles in Appendix E for documentation of the values.

[b] Values from: U.S. Environmental Protection Agency (2004) Risk Assessment Guidance for Superfund, Human Health Evaluati Manual, Part E - Supplemental Guidance for Dermal Risk Assessment, Office of Superfund Remediation and Technology Innov Washington, D.C., July, (EPA/540/R-99/005).

Table 4-1

COPC-Specific Toxicity Values[a] Used for Toxicity Assessment
Former Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	GAF	Chronic Oral RfD (mg/kg-day)	Dermal RfD (mg/kg-day)	Oral Target Organ	Chronic Inhalation RfD (mg/kg-day)	Inhalation Target Organ	Cancer Weight-of-Evidence Group	Oral SF[a] (/mg/kg-day)	Dermal SF[a] (/mg/kg-day)	Inhalation SF[a] (/mg/kg-day)
Metals										
Aluminum	NA	1.00E+00	NA	CNS	1.40E-03	NS	D	ND	ND	ND
Arsenic	NA	3.00E-04	3.00E-04	skin, PVS	ND	NA	A	1.50E+00	1.50E+00	1.50E+01
Chromium	0.025	3.00E-03	7.50E-05	GI, fetus & repro	2.30E-06	Lung	D	ND	ND	4.20E+01
Cobalt	0.2	2.00E-02	4.00E-03	erythropoiesis	5.70E-06	respiratory tract	B1	ND	ND	9.80E+00
Iron	1	3.00E-01	3.00E-01	iron overload	ND	NA	ND	ND	ND	ND
Lead	NA	ND	NA	NA	ND	NA	B2	ND	ND	ND
Manganese	NA	2.40E-02	NA	CNS	5.00E-05	CNS	D	ND	ND	ND
Nickel	0.04	2.00E-02	8.00E-04	reduced BW & OW	ND	NA	A	ND	ND	8.40E-01
Thallium	NA	6.50E-05	6.50E-05	skin, liver	ND	NA	D	ND	ND	ND
Vanadium	0.03	1.00E-03	3.00E-05	kidney	ND	NA	ND	ND	ND	ND
Explosives										
2,4,6-Trinitrotoluene	NA	5.00E-04	5.00E-04	erythrocyte, liver	ND	NA	C	3.00E-02	3.00E-02	ND
1,3-Dichlorobenzene	NA	1.00E-03	1.00E-03	thyroid & pituitary	ND	NA	D	ND	ND	ND
2,4-Dinitrotoluene	NA	2.00E-03	2.00E-03	CNS, erythrocyte, liver	ND	NA	B2	6.80E-01	6.80E-01	ND
2,6-Dinitrotoluene	NA	1.00E-03	1.00E-03	CNS, erythrocyte, liver, kidney	ND	NA	B2	6.80E-01	6.80E-01	ND
2-Nitrotoluene	NA	1.00E-02	1.00E-02	erythrocyte	ND	NA	B2	2.30E-01	2.30E-01	ND
4-Amino-2,6-dinitrotoluene	NA	2.00E-04	2.00E-04	liver, erythrocyte	ND	NA	D	ND	ND	ND
Nitrobenzene	1	5.00E-04	5.00E-04	liver, kidney, erythrocyte	5.70E-04	liver, kidney, erythrocyte	D	ND	ND	ND
Semivolatile Organic Compounds										
2-Methylnaphthalene	NA	2.00E-02	2.00E-02	erythrocyte, eye, reduced BW	8.60E-04	NOE	D	ND	ND	ND
4,6-Dinitro-2-methylphenol	NA	1.00E-04	1.00E-04	cellular respiration	ND	NA	ND	ND	ND	ND
2,4-Dinitrophenol	NA	2.00E-03	2.00E-03	eye, increased basal MR	ND	NA	ND	ND	ND	ND
3-Nitroaniline	NA	3.00E-04	3.00E-04	erythrocyte	2.90E-04	erythrocyte	C	2.10E-02	2.10E-02	ND
4-Methylphenol	NA	5.00E-03	5.00E-03	CNS	ND	NA	C	ND	ND	ND
Bis(2-ethylhexyl)phthalate	NA	2.00E-02	2.00E-02	liver	3.70E-03	lung, liver	B2	1.40E-02	1.40E-02	1.40E-02
Chrysene	NA	ND	ND	NA	ND	NA	B2	7.30E-03	7.30E-03	3.10E-03
Dibenzofuran	NA	2.00E-03	2.00E-03	kidney	ND	NA	D	ND	ND	ND
Fluorene	NA	4.00E-02	4.00E-02	erythrocyte	ND	NA	D	ND	ND	ND
Naphthalene	NA	2.00E-02	2.00E-02	erythrocyte, eye, reduced BW	8.60E-04	NOE	C	ND	ND	ND
Phenanthrene	NA	3.00E-02	3.00E-02	kidney tubule	ND	NA	D	ND	ND	ND
Volatile Organic Compounds										
1,1,2-Trichloroethane	NA	4.00E-03	4.00E-03	immune system	ND	NA	C	5.70E-02	5.70E-02	5.70E-02
Acetone	NA	9.00E-01	9.00E-01	kidney	ND	NA	Inadequate	ND	ND	ND
Benzene	NA	4.00E-03	4.00E-03	blood cells	8.60E-03	blood cells	A	5.50E-02	5.50E-02	2.70E-02
Bromomethane	NA	1.40E-03	1.40E-03	erythrocyte, kidney	1.40E-03	olfactory epithelium	D	ND	ND	ND
Chlorobenzene	NA	2.00E-02	2.00E-02	liver	5.70E-03	liver, kidney	D	ND	ND	ND
Chloromethane	NA	ND	ND	NA	2.60E-02	CNS	D	ND	ND	ND
Ethylbenzene	NA	1.00E-01	1.00E-01	liver, kidney	2.90E-01	liver, kidney, fetus	D	ND	ND	ND
Methylene chloride	NA	6.00E-02	6.00E-02	liver, erythrocyte	8.60E-01	liver, erythrocyte	B2	7.50E-03	7.50E-03	1.60E-03
Toluene	NA	2.00E-01	2.00E-01	liver, kidney, CNS	1.10E-01	GI, URT	D	ND	ND	ND
Xylenes, total	NA	2.00E-01	2.00E-01	Reduced BW & survival	2.90E-02	CNS	D	ND	ND	ND
Miscellaneous										
Cyanide, total	NA	2.00E-02	2.00E-02	Reduced BW, thyroid, NS	ND	ND	D	ND	ND	ND
Nitrate	0.5	1.60E+00	8.00E-01	erythrocyte	ND	ND	ND	ND	ND	ND

Table 4-1

COPC-Specific Toxicity Values[a] Used for Toxicity Assessment
Former Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	GAF	Chronic Oral RfD (mg/kg-day)	Dermal RfD (mg/kg-day)	Oral Target Organ	Chronic Inhalation RfD (mg/kg-day)	Inhalation Target Organ	Cancer Weight-of-Evidence Group	Oral SF[a] (/mg/kg-day)	Dermal SF[a] (/mg/kg-day)	Inhalation SF[a] (/mg/kg-day)
Nitrate-Nitrite (values based on nitrit	0.5	1.00E-01	5.00E-02	erythrocyte	ND	ND	ND	ND	ND	ND
Sulfate	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND - no data; NA - not applicable; COPC - chemical of potential concern.
[a] Please see toxicity profiles in Appendix E for documentation of the values.

Target Organs:
NS - nervous system; CNS - central nervous system, PVS - pulmonary vascular system; BW - body weight; OW - organ weight; MR - metabolic rate; NOE - nasal and olfactory;
GI - gastrointestinal; URT - upper repiratory tract.

Weight of Evidence Group:
A - Human carcinogen; B1 - Probable human carcinogen (human data); B2 - Probable human carcinogen (animal data);
C - Possible human carcinogen; D - Not classifiable as to carcinogenicity to humans.

Table 6-1

Summary of Groundwater Risk for the On-Site Worker
TNT Area A, Plum Brook Ordnance Works
Sandusky, Ohio

COPC[a]	Exposure Point Concentration (mg/L)	Oral HQ	Oral ILCR	Dermal HQ	Dermal ILCR	**HI All Pathways**	**ILCR All Pathways**
Metals							
Aluminum	8.30E+00	8.12E-02	ND	NA	ND	**8.12E-02**	**NA**
Arsenic	1.73E-02	5.64E-01	9.07E-05	1.86E-03	2.99E-07	**5.66E-01**	**9.10E-05**
Chromium	3.72E-02	1.21E-01	ND	1.60E-02	ND	**1.37E-01**	**NA**
Iron	3.34E+01	1.09E+00	ND	3.59E-03	ND	**1.09E+00**	**NA**
Lead	1.84E-02	NA	ND	NA	ND	**NA**	**NA**
Manganese	1.17E+01	4.77E+00	ND	NA	ND	**4.77E+00**	**NA**
Nickel	7.57E-02	3.70E-02	ND	6.11E-04	ND	**3.76E-02**	**NA**
Vanadium	3.69E-02	3.61E-01	ND	3.97E-02	ND	**4.01E-01**	**NA**
Explosives							
1,3-Dinitrobenzene	*1.00E-03*	*9.78E-03*	*ND*	*1.50E-04*	*ND*	***9.93E-03***	***NA***
2,4-Dinitrotoluene	*4.90E-04*	*2.40E-03*	*1.16E-06*	*7.18E-05*	*3.49E-08*	***2.47E-03***	***1.20E-06***
2,6-Dinitrotoluene	*3.60E-03*	*3.52E-02*	*8.55E-06*	*7.14E-04*	*1.73E-07*	***3.59E-02***	***8.73E-06***
2-Nitrotoluene	*3.10E-04*	*3.03E-05*	*2.49E-07*	*1.94E-06*	*1.59E-08*	***3.23E-05***	***2.65E-07***
4-Amino-2,6-dinitrotoluene	*1.30E-03*	*6.36E-02*	*ND*	*1.37E-03*	*ND*	***6.50E-02***	***NA***
Nitrobenzene	*2.00E-03*	*3.91E-02*	*ND*	*1.38E-03*	*ND*	***4.05E-02***	***NA***
Semivolatile Organic Compounds							
2-Methylnaphthalene	4.70E-01	2.30E-01	ND	1.52E-01	ND	**3.82E-01**	**NA**
Bis(2-ethylhexyl)phthalate	8.15E-03	3.99E-03	3.99E-07	2.97E-03	2.97E-07	**6.96E-03**	**6.96E-07**
Chrysene	1.50E-02	NA	3.83E-07	NA	2.34E-06	**NA**	**2.72E-06**
Dibenzofuran	1.20E-02	5.87E-02	ND	2.92E-02	ND	**8.79E-02**	**NA**
Fluorene	2.80E-02	6.85E-03	ND	6.33E-03	ND	**1.32E-02**	**NA**
Naphthalene	1.70E-01	8.32E-02	ND	2.67E-02	ND	**1.10E-01**	**NA**
Phenanthrene	7.40E-02	2.41E-02	ND	3.17E-02	ND	**5.59E-02**	**NA**
Volatile Organic Compounds							
Benzene	7.00E-01	1.71E+00	1.35E-04	1.26E-01	9.92E-06	**1.84E+00**	**1.44E-04**
Chloromethane	3.50E-02	NA	ND	NA	ND	**NA**	**NA**
Ethylbenzene	2.40E-01	2.35E-02	ND	6.80E-03	ND	**3.03E-02**	**NA**
Methylene chloride	3.30E-01	5.38E-02	8.65E-06	9.72E-04	1.56E-07	**5.48E-02**	**8.81E-06**
Toluene	7.30E-01	3.57E-02	ND	5.98E-03	ND	**4.17E-02**	**NA**
Xylenes, total	1.40E+00	6.85E-02	ND	2.15E-02	ND	**9.00E-02**	**NA**
Total HI		**9.48**		**0.480**		**10**	
Total ILCR			**2.45E-04**		**1.32E-05**		**3.E-04**
Site-Related HI		**0.15**		**0.004**		**0.2**	
Site-Related ILCR			**9.97E-06**		**2.24E-07**		**1.E-05**

COPC - Chemical of potential concern; HQ - Hazard quotient; HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
NA - Not applicable.
mg/L - Milligrams per liter.

[a] Shaded italics indicates that the COPC is regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-2

Summary of Target Organ Noncancer Hazard Evaluation
On-Site Worker Exposure to Groundwater
TNT Area A, Former Plum Brook Ordnance Works
Sandusky, Ohio

	Target Organs [a]	
COPC [b]	NS/CNS	Blood/ Blood cells
Metals		
Aluminum	0.08	
Manganese	4.77	
Explosives		
2,4-Dinitrotoluene	*0.002*	
2,6-Dinitrotoluene	*0.04*	
Volatile Organic Compounds		
Benzene		1.84
Toluene	0.04	
Total Target Organ HI	**5**	**2**
Site-Related Target Organ HI	**0.04**	**NA**

COPC - Chemical of potential concern.
HI - Hazard index.
Target Organs: NS/CNS - Nervous system/central nervous system.
NA - Not applicable.

[a] Only target organs and associated chemicals having a total HI greater than 1 are shown.

[b] Shaded italics indicates that the COPC is regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-3

Summary of Groundwater Noncancer Risk for the Child Resident
TNT Area A, Former Plum Brook Ordnance Works
Sandusky, Ohio

COPC[a]	Exposure Point Concentration (mg/L)	Oral HQ	Dermal HQ	Inhalation HQ	**HI All Pathways**
Metals					
Aluminum	8.30E+00	5.31E-01	NA	NA	**5.31E-01**
Arsenic	1.73E-02	3.69E+00	8.10E-03	NA	**3.69E+00**
Chromium	3.72E-02	7.93E-01	6.97E-02	NA	**8.62E-01**
Iron	3.34E+01	7.12E+00	1.56E-02	NA	**7.13E+00**
Lead	1.84E-02	NA	NA	NA	**NA**
Manganese	1.17E+01	3.12E+01	NA	NA	**3.12E+01**
Nickel	7.57E-02	2.42E-01	2.66E-03	NA	**2.45E-01**
Vanadium	3.69E-02	2.36E+00	1.73E-01	NA	**2.53E+00**
Explosives					
1,3-Dinitrobenzene	*1.00E-03*	*6.39E-02*	*1.13E-03*	*NA*	***6.51E-02***
2,4-Dinitrotoluene	*4.90E-04*	*1.57E-02*	*5.41E-04*	*NA*	***1.62E-02***
2,6-Dinitrotoluene	*3.60E-03*	*2.30E-01*	*5.39E-03*	*NA*	***2.36E-01***
2-Nitrotoluene	*3.10E-04*	*1.98E-04*	*7.32E-06*	*NA*	***2.05E-04***
4-Amino-2,6-dinitrotoluene	*1.30E-03*	*4.16E-01*	*1.03E-02*	*NA*	***4.26E-01***
Nitrobenzene	*2.00E-03*	*2.56E-01*	*5.20E-03*	*1.12E+00*	***1.38E+00***
Semivolatile Organic Compounds					
2-Methylnaphthalene	4.70E-01	1.50E+00	5.73E-01	1.74E+02	**1.76E+02**
Bis(2-ethylhexyl)phthalate	8.15E-03	2.61E-02	2.24E-02	NA	**4.84E-02**
Chrysene	1.50E-02	NA	NA	NA	**NA**
Dibenzofuran	1.20E-02	3.84E-01	1.10E-01	NA	**4.94E-01**
Fluorene	2.80E-02	4.47E-02	2.38E-02	NA	**6.86E-02**
Naphthalene	1.70E-01	5.43E-01	1.01E-01	6.31E+01	**6.37E+01**
Phenanthrene	7.40E-02	1.58E-01	1.20E-01	NA	**2.77E-01**
Volatile Organic Compounds					
Benzene	7.00E-01	1.12E+01	4.76E-01	2.60E+01	**3.76E+01**
Chloromethane	3.50E-02	NA	NA	4.30E-01	**4.30E-01**
Ethylbenzene	2.40E-01	1.53E-01	2.57E-02	2.64E-01	**4.43E-01**
Methylene chloride	3.30E-01	3.52E-01	3.66E-03	1.22E-01	**4.78E-01**
Toluene	7.30E-01	2.33E-01	2.25E-02	2.12E+00	**2.37E+00**
Xylenes, total	1.40E+00	4.47E-01	8.09E-02	1.54E+01	**1.59E+01**
Total HI		**61.9**	**1.87**	**283**	**347**
Site-Related HI		**0.98**	**0.02**	**1.12**	**2**

COPC - Chemical of potential concern.
HQ - Hazard quotient; HI - Hazard index.
NA - Not applicable.
mg/L - Milligrams per liter.

[a] Shaded italics indicates that the COPC is regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-4

Summary of Target Organ Noncancer Hazard Evaluation
Child Resident Exposure to Groundwater
TNT Area A, Former Plum Brook Ordnance Works
Sandusky, Ohio

	Target Organs [a]												
COPC[b]	NS/CNS	Skin	PVS	GI	URT/ Lung	Iron Overload	Kidney	Erythrocyte	Eye	Reduced BW/OW	NOE	Blood/ Blood cells	Liver
Metals													
Aluminum	0.53												
Arsenic		3.69	3.69										
Chromium				0.86									
Iron						7.13							
Manganese	31.16												
Nickel										0.24			
Vanadium							2.53						
Explosives													
1,3-Dinitrobenzene								*0.07*					
2,4-Dinitrotoluene	*0.02*							*0.02*					*0.02*
2,6-Dinitrotoluene	*0.24*						*0.24*	*0.24*					*0.24*
4-Amino-2,6-dinitrotoluene								*0.43*					*0.43*
Nitrobenzene							*1.38*	*1.38*					*1.38*
Semivolatile Organic Compounds													
2-Methylnaphthalene								2.08	2.08	2.08	174.40		
Bis(2-ethylhexyl)phthalate													0.05
Dibenzofuran							0.49						
Fluorene								0.07					
Naphthalene								0.64	0.64	0.64	63.08		
Phenanthrene							0.28						
Volatile Organic Compounds													
Benzene												37.64	
Chloromethane	0.43												
Ethylbenzene							0.44						0.44
Methylene chloride								0.48					0.48
Toluene	0.26			2.12	2.12		0.26						0.26
Xylenes, total	15.41									0.53			
Total Target Organ HI	**48**	**4**	**4**	**3**	**2**	**7**	**6**	**5**	**3**	**3**	**237**	**38**	**3**
Site-Related Target Organ HI	**0.3**	**NA**	**NA**	**NA**	**NA**	**NA**	**2**	**2**	**NA**	**NA**	**NA**	**NA**	**2**

COPC - Chemical of potential concern.
HI - Hazard Index.
Target Organs: NS/CNS - nervous system/central nervous system; BW/OW - body/organ weight; NOE - nasal and olfactory epithelia; PVS - pulmonary vascular system; GI - gastrointestinal.
NA - Not applicable.
[a] Only target organs and associated chemicals having a total HI greater than 1 are shown.
[b] Shaded italics indicates that the COPC is regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-5

Summary of Groundwater Noncancer Risk for the Adult Resident
TNT Area A, Former Plum Brook Ordnance Works
Sandusky, Ohio

COPC[a]	Exposure Point Concentration (mg/L)	Oral HQ	Dermal HQ	Inhalation HQ	**HI All Pathways**
Metals					
Aluminum	8.30E+00	2.27E-01	NA	NA	**2.27E-01**
Arsenic	1.73E-02	1.58E+00	3.16E-03	NA	**1.58E+00**
Chromium	3.72E-02	3.40E-01	2.72E-02	NA	**3.67E-01**
Iron	3.34E+01	3.05E+00	6.10E-03	NA	**3.06E+00**
Lead	1.84E-02	NA	NA	NA	**NA**
Manganese	1.17E+01	1.34E+01	NA	NA	**1.34E+01**
Nickel	7.57E-02	1.04E-01	1.04E-03	NA	**1.05E-01**
Vanadium	3.69E-02	1.01E+00	6.74E-02	NA	**1.08E+00**
Explosives					
1,3-Dinitrobenzene	*1.00E-03*	*2.74E-02*	*5.69E-04*	*NA*	***2.80E-02***
2,4-Dinitrotoluene	*4.90E-04*	*6.71E-03*	*2.72E-04*	*NA*	***6.98E-03***
2,6-Dinitrotoluene	*3.60E-03*	*9.86E-02*	*2.71E-03*	*NA*	***1.01E-01***
2-Nitrotoluene	*3.10E-04*	*8.49E-05*	*3.68E-06*	*NA*	***8.86E-05***
4-Amino-2,6-dinitrotoluene	*1.30E-03*	*1.78E-01*	*5.18E-03*	*NA*	***1.83E-01***
Nitrobenzene	*2.00E-03*	*1.10E-01*	*2.62E-03*	*4.80E-01*	***5.93E-01***
Semivolatile Organic Compounds					
2-Methylnaphthalene	4.70E-01	6.44E-01	2.88E-01	7.48E+01	**7.58E+01**
Bis(2-ethylhexyl)phthalate	8.15E-03	1.12E-02	1.13E-02	NA	**2.24E-02**
Chrysene	1.50E-02	NA	NA	NA	**NA**
Dibenzofuran	1.20E-02	1.64E-01	5.54E-02	NA	**2.20E-01**
Fluorene	2.80E-02	1.92E-02	1.20E-02	NA	**3.12E-02**
Naphthalene	1.70E-01	2.33E-01	5.06E-02	2.71E+01	**2.74E+01**
Phenanthrene	7.40E-02	6.76E-02	6.02E-02	NA	**1.28E-01**
Volatile Organic Compounds					
Benzene	7.00E-01	4.79E+00	2.39E-01	1.11E+01	**1.62E+01**
Chloromethane	3.50E-02	NA	NA	1.84E-01	**1.84E-01**
Ethylbenzene	2.40E-01	6.58E-02	1.29E-02	1.13E-01	**1.92E-01**
Methylene chloride	3.30E-01	1.51E-01	1.84E-03	5.25E-02	**2.05E-01**
Toluene	7.30E-01	1.00E-01	1.13E-02	9.09E-01	**1.02E+00**
Xylenes, total	1.40E+00	1.92E-01	4.07E-02	6.61E+00	**6.84E+00**
Total HI		**26.5**	**0.908**	**121**	**149**
Site-Related HI		**0.42**	**0.01**	**0.48**	**1**

COPC - Chemical of potential concern.
HQ - Hazard quotient; HI - Hazard index.
NA - Not applicable.
mg/L - Milligrams per liter.

[a] Shaded italics indicates that the COPC is regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-6

Target Organ Noncancer Hazard Evaluation
Adult Resident Exposure to Groundwater
TNT Area A, Former Plum Brook Ordnance Works
Sandusky, Ohio

	Target Organs [a]								
COPC[b]	NS/CNS	Skin	PVS	Iron Overload	Kidney	Erythrocyte	Reduced BW/OW	NOE	Blood/ Blood cells
Metals									
Aluminum	0.2								
Arsenic		2	2						
Iron				3					
Manganese	13								
Nickel							0.1		
Vanadium					1				
Explosives									
1,3-Dichlorobenzene						*0.03*			
2,4-Dinitrotoluene	*0.01*					*0.01*			
2,6-Dinitrotoluene	*0.1*				*0.1*	*0.1*			
4-Amino-2,6-dinitrotoluene						*0.2*			
Nitrobenzene					*0.6*	*0.6*			
Semivolatile Organic Compounds									
2-Methylnaphthalene						0.9	0.9	75	
Dibenzofuran					0.2				
Fluorene						0.03			
Naphthalene						0.3	0.3	27	
Phenanthrene					0.1				
Volatile Organic Compounds									
Benzene									16
Chloromethane	0.2								
Ethylbenzene					0.2				
Methylene chloride						0.2			
Toluene	0.1				0.1				
Xylenes, total	7						0.2		
Total Target Organ HI	**21**	**2**	**2**	**3**	**2**	**2**	**2**	**102**	**16**
Site-Related Target Organ HI	**0.1**	**NA**	**NA**	**NA**	**1**	**1**	**NA**	**NA**	**NA**

COPC - Chemical of potential concern.
HI - Hazard index.
Target Organs: NS/CNS - nervous system/central nervous system; BW/OW - body/organ weight; NOE - nasal and olfactory epithelia; PVS - pulmonary vascular system.
NA - Not applicable.
[a] Only target organs and associated chemicals having a total HI greater than 1 are shown.
[b] Shaded italics indicates that the COPC is regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-7

Summary of Groundwater Cancer Risk for the Resident
TNT Area A, Plum Brook Ordnance Works
Sandusky, Ohio

COPC[a]	Exposure Point Concentration (mg/L)	Adult Oral ILCR	Child Oral ILCR	Total Oral ILCR	Adult Dermal ILCR	Child Dermal ILCR	Total Dermal ILCR	Adult Inhalation ILCR	Child Inhalation ILCR	Total Inhalation ILCR	**ILCR All Pathways**
Metals											
Aluminum	8.30E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Arsenic	1.73E-02	2.44E-04	1.42E-04	3.86E-04	4.88E-07	3.13E-07	8.00E-07	NA	NA	NA	**3.87E-04**
Chromium	3.72E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Iron	3.34E+01	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Lead	1.84E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Manganese	1.17E+01	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Nickel	7.57E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Vanadium	3.69E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Explosives											
1,3-Dinitrobenzene	*1.00E-03*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	***NA***
2,4-Dinitrotoluene	*4.90E-04*	*3.13E-06*	*1.83E-06*	*4.96E-06*	*1.27E-07*	*6.31E-08*	*1.90E-07*	*NA*	*NA*	*NA*	***5.15E-06***
2,6-Dinitrotoluene	*3.60E-03*	*2.30E-05*	*1.34E-05*	*3.64E-05*	*6.32E-07*	*3.14E-07*	*9.46E-07*	*NA*	*NA*	*NA*	***3.74E-05***
2-Nitrotoluene	*3.10E-04*	*6.70E-07*	*3.91E-07*	*1.06E-06*	*2.90E-08*	*1.44E-08*	*4.35E-08*	*NA*	*NA*	*NA*	***1.10E-06***
4-Amino-2,6-dinitrotoluene	*1.30E-03*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	***NA***
Nitrobenzene	*2.00E-03*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	***NA***
Semivolatile Organic Compounds											
2-Methylnaphthalene	4.70E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Bis(2-ethylhexyl)phthalate	8.15E-03	1.07E-06	6.25E-07	1.70E-06	1.08E-06	5.37E-07	1.62E-06	NA	NA	NA	**3.32E-06**
Chrysene	1.50E-02	1.03E-06	6.00E-07	1.63E-06	8.52E-06	4.23E-06	1.27E-05	NA	NA	NA	**1.44E-05**
Dibenzofuran	1.20E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Fluorene	2.80E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Naphthalene	1.70E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Phenanthrene	7.40E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Volatile Organic Compounds											
Benzene	7.00E-01	3.62E-04	2.11E-04	5.73E-04	1.81E-05	8.97E-06	2.70E-05	8.87E-04	5.17E-04	1.40E-03	**2.00E-03**
Chloromethane	3.50E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Ethylbenzene	2.40E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Methylene chloride	3.30E-01	2.32E-05	1.36E-05	3.68E-05	2.85E-07	1.41E-07	4.26E-07	2.48E-05	1.44E-05	3.92E-05	**7.65E-05**
Toluene	7.30E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Xylenes, total	1.40E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Total ILCR		**6.58E-04**	**3.84E-04**	**1.04E-03**	**2.92E-05**	**1.46E-05**	**4.38E-05**	**9.12E-04**	**5.31E-04**	**1.44E-03**	**3.E-03**
Site-Related ILCR		**2.68E-05**	**1.56E-05**	**4.24E-05**	**7.88E-07**	**3.91E-07**	**1.18E-06**	**NA**	**NA**	**NA**	**4.E-05**

COPC - Chemical of potential concern.
ILCR - Incremental lifetime cancer risk.
NA - Not applicable.
mg/L - Milligrams per liter.

[a] Shaded italics indicates that the COPC is regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-8

Summary of Groundwater Risk for the On-Site Worker
TNT Area B, Plum Brook Ordnance Works
Sandusky, Ohio

COPC	Exposure Point Concentration (mg/L)	Oral HQ	Oral ILCR	Dermal HQ	Dermal ILCR	**HI All Pathways**	**ILCR All Pathways**
Metals							
Aluminum	1.69E+01	1.65E-01	NA	NA	NA	**1.65E-01**	**NA**
Arsenic	1.29E-02	4.21E-01	6.76E-05	1.39E-03	2.23E-07	**4.22E-01**	**6.78E-05**
Chromium	3.03E-02	9.90E-02	NA	1.31E-02	NA	**1.12E-01**	**NA**
Iron	2.56E+01	8.35E-01	NA	2.75E-03	NA	**8.37E-01**	**NA**
Lead	1.54E-02	NA	NA	NA	NA	**NA**	**NA**
Manganese	7.91E-01	3.23E-01	NA	NA	NA	**3.23E-01**	**NA**
Vanadium	2.50E-02	2.45E-01	NA	2.69E-02	NA	**2.72E-01**	**NA**
Semivolatile Organic Compounds							
2-Methylnaphthalene	4.80E-03	2.35E-03	NA	1.55E-03	NA	**3.90E-03**	**NA**
Naphthalene	2.80E-03	1.37E-03	NA	4.40E-04	NA	**1.81E-03**	**NA**
Volatile Organic Compounds							
Benzene	1.70E-02	4.16E-02	3.27E-06	3.06E-03	2.41E-07	**4.46E-02**	**3.51E-06**
Total HI		2.13		0.049		**2**	
Total ILCR			7.09E-05		4.64E-07		**7.E-05**
Site-Related HI[a]		NA		NA		**NA**	
Site-Related ILCR[a]			NA		NA		**NA**

COPC - Chemical of potential concern.
HQ - Hazard quotient; HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
NA - Not applicable.
mg/L - Milligrams per liter.

[a] None of the COPCs are regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-9

Summary of Groundwater Noncancer Risk for the Child Resident
TNT Area B, Former Plum Brook Ordnance Works
Sandusky, Ohio

COPC	Exposure Point Concentration (mg/L)	Oral HQ	Dermal HQ	Inhalation HQ	**HI All Pathways**
Metals					
Aluminum	1.69E+01	1.08E+00	NA	NA	**1.08E+00**
Arsenic	1.29E-02	2.75E+00	6.04E-03	NA	**2.75E+00**
Chromium	3.03E-02	6.47E-01	5.68E-02	NA	**7.03E-01**
Iron	2.56E+01	5.45E+00	1.20E-02	NA	**5.47E+00**
Lead	1.54E-02	NA	NA	NA	**NA**
Manganese	7.91E-01	2.11E+00	NA	NA	**2.11E+00**
Vanadium	2.50E-02	1.60E+00	1.17E-01	NA	**1.72E+00**
Semivolatile Organic Compounds					
2-Methylnaphthalene	4.80E-03	1.53E-02	5.85E-03	1.78E+00	**1.80E+00**
Naphthalene	2.80E-03	8.95E-03	1.66E-03	1.04E+00	**1.05E+00**
Volatile Organic Compounds					
Benzene	1.70E-02	2.72E-01	1.16E-02	6.31E-01	**9.14E-01**
Total HI		**13.9**	**0.211**	**3.45**	**18**
Site-Related HI[a]		**NA**	**NA**	**NA**	**NA**

COPC - Chemical of potential concern.
HQ - Hazard quotient; HI - Hazard index.
NA - Not applicable.
mg/L - Milligrams per liter.

[a] None of the COPCs are regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-10

Summary of Target Organ Noncancer Hazard Evaluation
Child Resident Exposure to Groundwater
TNT Area B, Former Plum Brook Ordnance Works
Sandusky, Ohio

	Target Organs [a]					
COPC	NS/CNS	Skin	PVS	Iron Overload	Kidney	NOE
Metals						
Aluminum	1.08					
Arsenic		2.75	2.75			
Iron				5.47		
Manganese	2.11					
Vanadium					1.72	
Semivolatile Organic Compounds						
2-Methylnaphthalene						1.78
Naphthalene						1.04
Total Target Organ HI	**3**	**3**	**3**	**5**	**2**	**3**
Site-Related Target Organ HI[b]	**2**	**NA**	**NA**	**5**	**NA**	**NA**

COPC - Chemical of potential concern.
HI - Hazard index.
Target Organs: NS/CNS - nervous system/central nervous system; NOE - nasal and olfactory epithelia; PVS - pulmonary vascular system.
[a] Only target organs and associated chemicals having a total HI greater than 1 are shown.
[b] None of the COPCs are regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-11

Summary of Groundwater Noncancer Risk for the Adult Resident
TNT Area B, Former Plum Brook Ordnance Works
Sandusky, Ohio

COPC	Exposure Point Concentration (mg/L)	Oral HQ	Dermal HQ	Inhalation HQ	**HI All Pathways**
Metals					
Aluminum	1.69E+01	4.63E-01	NA	NA	**4.63E-01**
Arsenic	1.29E-02	1.18E+00	2.36E-03	NA	**1.18E+00**
Chromium	3.03E-02	2.77E-01	2.22E-02	NA	**2.99E-01**
Iron	2.56E+01	2.34E+00	4.67E-03	NA	**2.34E+00**
Lead	1.54E-02	NA	NA	NA	**NA**
Manganese	7.91E-01	9.03E-01	NA	NA	**9.03E-01**
Vanadium	2.50E-02	6.85E-01	4.57E-02	NA	**7.31E-01**
Semivolatile Organic Compounds					
2-Methylnaphthalene	4.80E-03	6.58E-03	2.95E-03	7.64E-01	**7.74E-01**
Naphthalene	2.80E-03	3.84E-03	8.34E-04	4.46E-01	**4.50E-01**
Volatile Organic Compounds					
Benzene	1.70E-02	1.16E-01	5.81E-03	2.71E-01	**3.93E-01**
Total HI		**5.97**	**0.08**	**1.48**	**8**
Site-Related HI[a]		**3.24**	**0.005**	**NA**	**3**

COPC - Chemical of potential concern.
HQ - Hazard quotient; HI - Hazard index.
NA - Not applicable.
mg/L - Milligrams per liter.

[a] None of the COPCs are regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-12

Summary of Target Organ Noncancer Hazard Evaluation
Adult Resident Exposure to Groundwater
TNT Area B, Former Plum Brook Ordnance Works
Sandusky, Ohio

	Target Organ [a]
COPC	Iron Overload
Metals	
Iron	2.34
Total Target Organ HI	**2**
Site-Related Target Organ HI[b]	**2**

COPC - Chemical of potential concern.
HI - Hazard index.

[a] Only target organs and associated chemicals having a total HI greater than 1 are shown.
[b] None of the COPCs are regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-13

Summary of Groundwater Cancer Risk for the Resident
TNT Area B, Plum Brook Ordnance Works
Sandusky, Ohio

COPC	Exposure Point Concentration (mg/L)	Adult Oral ILCR	Child Oral ILCR	Total Oral ILCR	Adult Dermal ILCR	Child Dermal ILCR	Total Dermal ILCR	Adult Inhalation ILCR	Child Inhalation ILCR	Total Inhalation ILCR	**ILCR All Pathways**
Metals											
Aluminum	1.69E+01	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Arsenic	1.29E-02	1.82E-04	1.06E-04	2.88E-04	3.64E-07	2.33E-07	5.97E-07	NA	NA	NA	**2.88E-04**
Chromium	3.03E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Iron	2.56E+01	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Lead	1.54E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Manganese	7.91E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Vanadium	2.50E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Semivolatile Organic Compounds											
2-Methylnaphthalene	4.80E-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Naphthalene	2.80E-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Volatile Organic Compounds											
Benzene	1.70E-02	8.78E-06	5.12E-06	1.39E-05	4.39E-07	2.18E-07	6.56E-07	2.15E-05	1.26E-05	3.41E-05	**4.87E-05**
Total ILCR		**1.91E-04**	**1.11E-04**	**3.02E-04**	**8.02E-07**	**4.51E-07**	**1.25E-06**	**2.15E-05**	**1.26E-05**	**3.41E-05**	**3.E-04**
Site-Related ILCR[a]		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

COPC - Chemical of potential concern.
ILCR - Incremental lifetime cancer risk.
NA - Not applicable.
mg/L - Milligrams per liter.

[b] None of the COPCs are regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-14

Summary of Groundwater Risk for the On-Site Worker
TNT Area C, Former Plum Brook Ordnance Works
Sandusky, Ohio

COPC	Exposure Point Concentration (mg/L)	Oral HQ	Oral ILCR	Dermal HQ	Dermal ILCR	**HI All Pathways**	**ILCR All Pathways**
Semivolatile Organic Compounds							
2-Methylnaphthalene	2.66E-02	1.30E-02	NA	8.62E-03	ND	**2.17E-02**	**NA**
Bis(2-ethylhexyl)phthalate	5.50E-02	2.69E-02	2.69E-06	2.00E-02	2.00E-06	**4.69E-02**	**4.69E-06**
Naphthalene	3.40E-02	1.66E-02	NA	5.34E-03	ND	**2.20E-02**	**NA**
Volatile Organic Compounds							
Benzene	4.10E-01	1.00E+00	7.88E-05	7.39E-02	5.81E-06	**1.08E+00**	**8.46E-05**
Bromomethane	1.30E-02	9.09E-02	NA	1.39E-03	ND	**9.23E-02**	**NA**
Methylene chloride	1.60E-01	2.61E-02	4.19E-06	4.71E-04	7.57E-08	**2.66E-02**	**4.27E-06**
Toluene	3.00E-01	1.47E-02	NA	2.46E-03	ND	**1.71E-02**	**NA**
Xylenes, total	1.30E+00	6.36E-02	NA	1.99E-02	ND	**8.35E-02**	**NA**
Miscellaneous							
Sulfate	1.34E+03	NA	NA	NA	ND	**NA**	**NA**
Total HI		**1.25**		**0.132**		**1**	
Total ILCR			**8.57E-05**		**7.89E-06**		**9.E-05**
Site-Related HI[a]		**NA**		**NA**		**NA**	
Site-Related ILCR[a]			**NA**		**NA**		**NA**

COPC - Chemical of potential concern.
HQ - Hazard quotient; HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
NA - Not applicable.
mg/L - Milligrams per liter.

[a] None of the COPCs are regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-15

Summary of Groundwater Noncancer Risk for the Child Resident
TNT Area C, Former Plum Brook Ordnance Works
Sandusky, Ohio

COPC	Exposure Point Concentration (mg/L)	Oral HQ	Dermal HQ	Inhalation HQ	**HI All Pathways**
Semivolatile Organic Compounds					
2-Methylnaphthalene	2.66E-02	8.52E-02	3.25E-02	9.89E+00	**1.00E+01**
Bis(2-ethylhexyl)phthalate	5.50E-02	1.76E-01	1.51E-01	NA	**3.27E-01**
Naphthalene	3.40E-02	1.09E-01	2.01E-02	1.26E+01	**1.27E+01**
Volatile Organic Compounds					
Benzene	4.10E-01	6.55E+00	2.79E-01	1.52E+01	**2.20E+01**
Bromomethane	1.30E-02	5.94E-01	5.25E-03	2.96E+00	**3.56E+00**
Methylene chloride	1.60E-01	1.70E-01	1.78E-03	5.94E-02	**2.32E-01**
Toluene	3.00E-01	9.59E-02	9.26E-03	8.70E-01	**9.75E-01**
Xylenes, total	1.30E+00	4.16E-01	7.51E-02	1.43E+01	**1.48E+01**
Miscellaneous					
Sulfate	1.34E+03	NA	NA	NA	**NA**
Total HI		**8.20**	**0.574**	**55.9**	**65**
Site-Related HI[a]		**NA**	**NA**	**NA**	**NA**

COPC - Chemical of potential concern.
HQ - Hazard quotient; HI - Hazard index.
NA - Not applicable.
mg/L - Milligrams per liter.

[a] None of the COPCs are regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-16

Summary of Target Organ Noncancer Hazard Evaluation
Child Resident Exposure to Groundwater
TNT Area C, Former Plum Brook Ordnance Works
Sandusky, Ohio

	Target Organs[a]		
COPC	NS/CNS	NOE	Blood/ Blood cells
Semivolatile Organic Compounds			
2-Methylnaphthalene		9.89	
Naphthalene		12.62	
Volatile Organic Compounds			
Benzene			22.05
Bromomethane		2.96	
Toluene	0.11		
Xylenes, total	14.31		
Total Target Organ HI	**14**	**25**	**22**
Site-Related Target Organ HI	**NA**	**NA**	**NA**

COPC - Chemical of potential concern.
HI - Hazard index.
Target Organs: NS/CNS - nervous system/central nervous system; NOE - nasal and olfactory epithelia.

[a] Only target organs and associated chemicals having a total HI greater than 1 are shown.
[b] None of the COPCs are regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-17

Summary of Groundwater Noncancer Risk for the Adult Resident
TNT Area C, Former Plum Brook Ordnance Works
Sandusky, Ohio

COPC	Exposure Point Concentration (mg/L)	Oral HQ	Dermal HQ	Inhalation HQ	**HI All Pathways**
Semivolatile Organic Compounds					
2-Methylnaphthalene	2.66E-02	3.65E-02	1.63E-02	4.24E+00	**4.29E+00**
Bis(2-ethylhexyl)phthalate	5.50E-02	7.53E-02	7.60E-02	NA	**1.51E-01**
Naphthalene	3.40E-02	4.66E-02	1.01E-02	5.41E+00	**5.47E+00**
Volatile Organic Compounds					
Benzene	4.10E-01	2.81E+00	1.40E-01	6.53E+00	**9.48E+00**
Bromomethane	1.30E-02	2.54E-01	2.64E-03	1.27E+00	**1.53E+00**
Methylene chloride	1.60E-01	7.31E-02	8.94E-04	2.55E-02	**9.94E-02**
Toluene	3.00E-01	4.11E-02	4.66E-03	3.73E-01	**4.19E-01**
Xylenes, total	1.30E+00	1.78E-01	3.78E-02	6.14E+00	**6.35E+00**
Miscellaneous					
Sulfate	1.34E+03	NA	NA	NA	**NA**
Total HI		**3.51**	**0.289**	**24.0**	**28**
Site-Related HI[a]		**NA**	**NA**	**NA**	**NA**

COPC - Chemical of potential concern.
HQ - Hazard quotient; HI - Hazard index.
NA - Not applicable.
mg/L - Milligrams per liter.

[a] None of the COPCs are regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-18

Summary of Target Organ Noncancer Hazard Evaluation
Adult Resident Exposure to Groundwater
TNT Area C, Former Plum Brook Ordnance Works
Sandusky, Ohio

	Target Organs[a]		
COPC	NS/CNS	NOE	Blood/ Blood cells
Semivolatile Organic Compounds			
2-Methylnaphthalene		4.24	
Naphthalene		5.41	
Volatile Organic Compounds			
Benzene			9.48
Bromomethane		1.27	
Toluene	0.05		
Xylenes, total	6.14		
Total Target Organ HI	**6**	**11**	**9**
Site-Related Target Organ HI	**NA**	**NA**	**NA**

COPC - Chemical of potential concern.
HI - Hazard index.
Target Organs: NS/CNS - nervous system/central nervous system; NOE - nasal and olfactory epithelia.

[a] Only target organs and associated chemicals having a total HI greater than 1 are shown.
[b] None of the COPCs are regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-19

Summary of Groundwater Cancer Risk for the Resident
TNT Area C, Plum Brook Ordnance Works
Sandusky, Ohio

COPC	Exposure Point Concentration (mg/L)	Adult Oral ILCR	Child Oral ILCR	Total Oral ILCR	Adult Dermal ILCR	Child Dermal ILCR	Total Dermal ILCR	Adult Inhalation ILCR	Child Inhalation ILCR	Total Inhalation ILCR	**ILCR All Pathways**
Semivolatile Organic Compounds											
2-Methylnaphthalene	2.66E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Bis(2-ethylhexyl)phthalate	5.50E-02	7.23E-06	4.22E-06	1.15E-05	7.30E-06	3.62E-06	1.09E-05	NA	NA	NA	**2.24E-05**
Naphthalene	3.40E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Volatile Organic Compounds											
Benzene	4.10E-01	2.12E-04	1.24E-04	3.35E-04	1.06E-05	5.25E-06	1.58E-05	5.20E-04	3.03E-04	8.23E-04	**1.17E-03**
Bromomethane	1.30E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Methylene chloride	1.60E-01	1.13E-05	6.58E-06	1.78E-05	1.38E-07	6.85E-08	2.07E-07	1.20E-05	7.00E-06	1.90E-05	**3.71E-05**
Toluene	3.00E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Xylenes, total	1.30E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Miscellaneous											
Sulfate	1.34E+03	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Total ILCR		**2.30E-04**	**1.34E-04**	**3.65E-04**	**1.80E-05**	**8.95E-06**	**2.70E-05**	**5.32E-04**	**3.10E-04**	**8.42E-04**	**1.E-03**
Site-Related ILCR[a]		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

COPC - Chemical of potential concern.
ILCR - Incremental lifetime cancer risk.
NA - Not applicable.
mg/L - Milligrams per liter.

[a] None of the COPCs are regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-20

Summary of Groundwater Risk for the On-Site Worker
Pentolite Road Red Water Pond Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

COPC[a]	Exposure Point Concentration (mg/L)	Oral HQ	Oral ILCR	Dermal HQ	Dermal ILCR	**HI All Pathways**	**ILCR All Pathways**
Metals							
Chromium	2.06E-02	6.72E-02	ND	8.87E-03	ND	**7.61E-02**	**NA**
Iron	7.28E+00	2.37E-01	ND	7.84E-04	ND	**2.38E-01**	**NA**
Manganese	1.17E+00	4.77E-01	ND	NA	ND	**4.77E-01**	**NA**
Thallium	5.08E-02	7.65E+00	ND	2.52E-02	ND	**7.67E+00**	**NA**
Explosives							
2,4-Dinitrotoluene	*8.90E-04*	*4.35E-03*	*2.11E-06*	*1.30E-04*	*6.33E-08*	***4.48E-03***	***2.18E-06***
2,6-Dinitrotoluene	*8.90E-04*	*8.71E-03*	*2.11E-06*	*1.77E-04*	*4.29E-08*	***8.88E-03***	***2.16E-06***
4-Amino-2,6-dinitrotoluene	*9.70E-04*	*4.75E-02*	*ND*	*1.02E-03*	*ND*	***4.85E-02***	***NA***
Nitrobenzene	*3.50E-04*	*6.85E-03*	*ND*	*2.41E-04*	*ND*	***7.09E-03***	***NA***
Semivolatile Organic Compounds							
2-Methylnaphthalene	3.45E-02	1.69E-02	ND	1.12E-02	ND	**2.81E-02**	**NA**
4-Methylphenol	4.30E-02	8.41E-02	ND	3.88E-03	ND	**8.80E-02**	**NA**
Bis(2-ethylhexyl)phthalate	3.70E-02	1.81E-02	1.81E-06	1.35E-02	1.35E-06	**3.16E-02**	**3.16E-06**
Naphthalene	2.99E-02	1.46E-02	ND	4.70E-03	ND	**1.93E-02**	**NA**
Volatile Organic Compounds							
1,1,2-Trichloroethane	4.90E-03	1.20E-02	9.76E-07	5.42E-04	4.41E-08	**1.25E-02**	**1.02E-06**
Acetone	1.60E+00	1.74E-02	ND	3.87E-05	ND	**1.74E-02**	**NA**
Benzene	2.50E+00	6.12E+00	4.81E-04	4.51E-01	3.54E-05	**6.57E+00**	**5.16E-04**
Ethylbenzene	2.02E-01	1.98E-02	ND	5.74E-03	ND	**2.56E-02**	**NA**
Methylene chloride	1.60E-01	2.61E-02	4.19E-06	4.71E-04	7.57E-08	**2.66E-02**	**4.27E-06**
Toluene	9.46E-01	4.63E-02	ND	7.75E-03	ND	**5.40E-02**	**NA**
Xylenes, total	1.40E+00	6.84E-02	ND	2.14E-02	ND	**8.98E-02**	**NA**
Total HI		**14.9**		**0.556**		**15**	
Total ILCR			**4.92E-04**		**3.70E-05**		**5.E-04**
Site-Related HI		**0.067**		**0.002**		**0.07**	
Site-Related ILCR			**4.23E-06**		**1.06E-07**		**4.E-06**

COPC - Chemical of potential concern; HQ - Hazard quotient; HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
NA - Not applicable.
mg/L - Milligram per liter.

[a] Shaded italics indicates that the COPC is regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-21

Summary of Target Organ Noncancer Hazard Evaluation
On-Site Worker Exposure to Groundwater
Pentolite Road Red Water Pond Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

	Target Organs [a]		
COPC[b]	Skin	Blood/ Blood cells	Liver
Metals			
Thallium	7.67		7.67
Explosives			
2,4-Dinitrotoluene			*0.004*
2,6-Dinitrotoluene			*0.01*
4-Amino-2,6-dinitrotoluene			*0.05*
Nitrobenzene			*0.01*
Semivolatile Organic Compounds			
Bis(2-ethylhexyl)phthalate			0.03
Volatile Organic Compounds			
Benzene		6.57	
Ethylbenzene			0.03
Methylene chloride			0.03
Toluene			0.05
Xylenes, total			
Total Target Organ HI	**8**	**7**	**8**
Site-Related Target Organ HI	**NA**	**NA**	**0.07**

COPC - Chemical of potential concern.
HI - Hazard index.
Target Organs: NS/CNS - nervous system/central nervous system.
NA - Not applicable.
[a] Only target organs and associated chemicals having a total HI greater than 1 are shown.
[b] Shaded italics indicates that the COPC is regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-22

Summary of Groundwater Noncancer Risk for the Child Resident
Pentolite Road Red Water Pond Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

COPC[a]	Exposure Point Concentration (mg/L)	Oral HQ	Dermal HQ	Inhalation HQ	**HI All Pathways**
Metals					
Chromium	2.06E-02	4.39E-01	3.86E-02	NA	**4.78E-01**
Iron	7.28E+00	1.55E+00	3.41E-03	NA	**1.55E+00**
Manganese	1.17E+00	3.12E+00	NA	NA	**3.12E+00**
Thallium	5.08E-02	5.00E+01	1.10E-01	NA	**5.01E+01**
Explosives					
2,4-Dinitrotoluene	*8.90E-04*	*2.84E-02*	*9.83E-04*	*NA*	***2.94E-02***
2,6-Dinitrotoluene	*8.90E-04*	*5.69E-02*	*1.33E-03*	*NA*	***5.82E-02***
4-Amino-2,6-dinitrotoluene	*9.70E-04*	*3.10E-01*	*7.68E-03*	*NA*	***3.18E-01***
Nitrobenzene	*3.50E-04*	*4.47E-02*	*9.10E-04*	*1.96E-01*	***2.42E-01***
Semivolatile Organic Compounds					
2-Methylnaphthalene	3.45E-02	1.10E-01	4.21E-02	1.28E+01	**1.30E+01**
4-Methylphenol	4.30E-02	5.50E-01	2.92E-02	NA	**5.79E-01**
Bis(2-ethylhexyl)phthalate	3.70E-02	1.18E-01	1.02E-01	NA	**2.20E-01**
Naphthalene	2.99E-02	9.56E-02	1.77E-02	1.11E+01	**1.12E+01**
Volatile Organic Compounds					
1,1,2-Trichloroethane	4.90E-03	7.83E-02	2.04E-03	NA	**8.04E-02**
Acetone	1.60E+00	1.14E-01	1.46E-04	NA	**1.14E-01**
Benzene	2.50E+00	4.00E+01	1.70E+00	9.28E+01	**1.34E+02**
Ethylbenzene	2.02E-01	1.29E-01	2.16E-02	2.23E-01	**3.74E-01**
Methylene chloride	1.60E-01	1.70E-01	1.78E-03	5.94E-02	**2.32E-01**
Toluene	9.46E-01	3.02E-01	2.92E-02	2.74E+00	**3.08E+00**
Xylenes, total	1.40E+00	4.47E-01	8.08E-02	1.54E+01	**1.59E+01**
Total HI		**97.6**	**2.19**	**135**	**235**
Site-Related HI		**0.44**	**0.01**	**0.20**	**0.6**

HQ - Hazard quotient; HI - Hazard index.
COPC - Chemical of potential concern.
NA - Not applicable.
mg/L - Milligrams per liter.

[a] Shaded italics indicates that the COPC is regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-23

Summary of Target Organ Noncancer Hazard Evaluation
Child Resident Exposure to Groundwater
Pentolite Road Red Water Pond Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

	Target Organs[a]							
COPC[b]	NS/CNS	Skin	GI	URT/ Lung	Iron Overload	NOE	Blood/ Blood cells	Liver
Metals								
Chromium			0.48					
Iron					1.55			
Manganese	3.12							
Thallium		50.07						50.07
Explosives								
2,4-Dinitrotoluene	*0.03*							*0.03*
2,6-Dinitrotoluene	*0.06*							*0.06*
4-Amino-2,6-dinitrotoluene								*0.32*
Nitrobenzene								*0.24*
Semivolatile Organic Compounds								
2-Methylnaphthalene						12.82		
4-Methylphenol	0.58							
Bis(2-ethylhexyl)phthalate								0.22
Naphthalene						11.10		
Volatile Organic Compounds								
Benzene							134.42	
Ethylbenzene								0.37
Methylene chloride								0.23
Toluene	0.33		2.74	2.74				0.33
Xylenes, total	15.38							
Total Target Organ HI	**19**	**50**	**3**	**3**	**2**	**24**	**134**	**52**
Site-Related Target Organ HI	**0.1**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**1**

COPC - Chemical of potential concern.
HI - Hazard index.
Target Organs: NS/CNS - nervous system/central nervous system; BW/OW - body/organ weight; NOE - nasal and olfactory epithelia; GI - gastrointestinal; URT - Upper respiratory tract.
NA - Not applicable.
[a] Only target organs and associated chemicals having a total HI greater than 1 are shown.
[b] Shaded italics indicates that the COPC is regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-24

Summary of Groundwater Noncancer Risk for the Adult Resident
Pentolite Road Red Water Pond Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

COPC[a]	Exposure Point Concentration (mg/L)	Oral HQ	Dermal HQ	Inhalation HQ	**HI All Pathways**
Metals					
Chromium	2.06E-02	1.88E-01	1.51E-02	NA	**2.03E-01**
Iron	7.28E+00	6.65E-01	1.33E-03	NA	**6.66E-01**
Manganese	1.17E+00	1.34E+00	NA	NA	**1.34E+00**
Thallium	5.08E-02	2.14E+01	4.28E-02	NA	**2.15E+01**
Explosives					
2,4-Dinitrotoluene	*8.90E-04*	*1.22E-02*	*4.95E-04*	*NA*	***1.27E-02***
2,6-Dinitrotoluene	*8.90E-04*	*2.44E-02*	*6.70E-04*	*NA*	***2.51E-02***
4-Amino-2,6-dinitrotoluene	*9.70E-04*	*1.33E-01*	*3.87E-03*	*NA*	***1.37E-01***
Nitrobenzene	*3.50E-04*	*1.92E-02*	*4.58E-04*	*8.41E-02*	***1.04E-01***
Semivolatile Organic Compounds					
2-Methylnaphthalene	3.45E-02	4.73E-02	2.12E-02	5.50E+00	**5.57E+00**
4-Methylphenol	4.30E-02	2.36E-01	1.47E-02	NA	**2.50E-01**
Bis(2-ethylhexyl)phthalate	3.70E-02	5.07E-02	5.11E-02	NA	**1.02E-01**
Naphthalene	2.99E-02	4.10E-02	8.91E-03	4.76E+00	**4.81E+00**
Volatile Organic Compounds					
1,1,2-Trichloroethane	4.90E-03	3.36E-02	1.03E-03	NA	**3.46E-02**
Acetone	1.60E+00	4.87E-02	7.34E-05	NA	**4.88E-02**
Benzene	2.50E+00	1.71E+01	8.55E-01	3.98E+01	**5.78E+01**
Ethylbenzene	2.02E-01	5.55E-02	1.09E-02	9.56E-02	**1.62E-01**
Methylene chloride	1.60E-01	7.31E-02	8.94E-04	2.55E-02	**9.94E-02**
Toluene	9.46E-01	1.30E-01	1.47E-02	1.18E+00	**1.32E+00**
Xylenes, total	1.40E+00	1.91E-01	4.06E-02	6.60E+00	**6.83E+00**
Total HI		**41.8**	**1.08**	**58.0**	**101**
Site-Related HI		**0.19**	**0.005**	**0.084**	**0.3**

HQ - Hazard quotient; HI - Hazard index.
COPC - Chemical of potential concern.
NA - Not applicable.
mg/L - Milligrams per liter.
[a] Shaded italics indicates that the COPC is regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-25

Summary of Target Organ Noncancer Hazard Evaluation
Adult Resident Exposure to Groundwater
Pentolite Road Red Water Pond Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

	Target Organs[a]				
COPC[b]	NS/CNS	Skin	NOE	Blood/ Blood cells	Liver
Metals					
Chromium					
Manganese	1.34				
Thallium		21.45			21.45
Explosives					
2,4-Dinitrotoluene	*0.01*				*0.01*
2,6-Dinitrotoluene	*0.03*				*0.03*
4-Amino-2,6-dinitrotoluene					*0.14*
Nitrobenzene					*0.10*
Semivolatile Organic Compounds					
2-Methylnaphthalene			5.50		
4-Methylphenol	0.25				
Bis(2-ethylhexyl)phthalate					0.10
Naphthalene			4.76		
Volatile Organic Compounds					
Benzene				57.78	
Ethylbenzene					0.07
Methylene chloride					0.10
Toluene	0.14				0.14
Xylenes, total	6.60				
Total Target Organ HI	**8**	**21**	**10**	**58**	**22**
Site-Related Target Organ HI	**0.04**	**NA**	**NA**	**NA**	**0.3**

COPC - Chemical of potential concern.
HI - Hazard index.
Target Organs: NS/CNS - nervous system/central nervous system; NOE - nasal and olfactory epithelia.
URT - Upper respiratory tract.
NA - Not applicable.
[a] Only target organs and associated chemicals having a total HI greater than 1 are shown.
[b] Shaded italics indicates that the COPC is regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-26

Summary of Groundwater Cancer Risk for the Resident
Pentolite Road Red Water Pond Area, Plum Brook Ordnance Works
Sandusky, Ohio

COPC[a]	Exposure Point Concentration (mg/L)	Adult Oral ILCR	Child Oral ILCR	Total Oral ILCR	Adult Dermal ILCR	Child Dermal ILCR	Total Dermal ILCR	Adult Inhalation ILCR	Child Inhalation ILCR	Total Inhalation ILCR	**ILCR All Pathways**
Metals											
Chromium	2.06E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Iron	7.28E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Manganese	1.17E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Thallium	5.08E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Explosives											
2,4-Dinitrotoluene	*8.90E-04*	*5.68E-06*	*3.32E-06*	*9.00E-06*	*2.31E-07*	*1.15E-07*	*3.45E-07*	*NA*	*NA*	*NA*	***9.35E-06***
2,6-Dinitrotoluene	*8.90E-04*	*5.68E-06*	*3.32E-06*	*9.00E-06*	*1.56E-07*	*7.76E-08*	*2.34E-07*	*NA*	*NA*	*NA*	***9.23E-06***
4-Amino-2,6-dinitrotoluene	*9.70E-04*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	***NA***
Nitrobenzene	*3.50E-04*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	***NA***
Semivolatile Organic Compounds											
2-Methylnaphthalene	3.45E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
4-Methylphenol	4.30E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Bis(2-ethylhexyl)phthalate	3.70E-02	4.87E-06	2.84E-06	7.70E-06	4.91E-06	2.44E-06	7.35E-06	NA	NA	NA	**1.51E-05**
Naphthalene	2.99E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Volatile Organic Compounds											
1,1,2-Trichloroethane	4.90E-03	2.62E-06	1.53E-06	4.15E-06	8.04E-08	3.99E-08	1.20E-07	1.31E-05	7.64E-06	2.08E-05	**2.50E-05**
Acetone	1.60E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Benzene	2.50E+00	1.29E-03	7.53E-04	2.05E-03	6.45E-05	3.20E-05	9.65E-05	3.17E-03	1.85E-03	5.02E-03	**7.16E-03**
Ethylbenzene	2.02E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Methylene chloride	1.60E-01	1.13E-05	6.58E-06	1.78E-05	1.38E-07	6.85E-08	2.07E-07	1.20E-05	7.00E-06	1.90E-05	**3.71E-05**
Toluene	9.46E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Xylenes, total	1.40E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Total ILCR		**1.32E-03**	**7.71E-04**	**2.09E-03**	**7.00E-05**	**3.48E-05**	**1.05E-04**	**3.19E-03**	**1.86E-03**	**5.06E-03**	**7.E-03**
Site-Related ILCR		**1.14E-05**	**6.63E-06**	**1.80E-05**	**3.87E-07**	**1.92E-07**	**5.79E-07**	**NA**	**NA**	**NA**	**2.E-05**

COPC - Chemical of potential concern.
ILCR - Incremental lifetime cancer risk.
NA - Not applicable.
mg/L - Milligrams per liter.

[a] Shaded italics indicates that the COPC is regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-27

Summary of Groundwater Risk for the On-Site Worker
West Area Red Water Ponds Area, Plum Brook Ordnance Works
Sandusky, Ohio

COPC[a]	Exposure Point Concentration (mg/L)	Oral HQ	Oral ILCR	Dermal HQ	Dermal ILCR	**HI All Pathways**	**ILCR All Pathways**
Metals							
Arsenic	9.50E-03	3.10E-01	4.98E-05	1.02E-03	1.64E-07	**3.11E-01**	**5.00E-05**
Cobalt	*2.67E-01*	*1.31E-01*	*ND*	*2.16E-03*	*ND*	***1.33E-01***	***NA***
Nickel	*2.78E-01*	*1.36E-01*	*ND*	*2.24E-03*	*ND*	***1.38E-01***	***NA***
Vanadium	5.50E-03	5.38E-02	ND	5.92E-03	ND	**5.97E-02**	**NA**
Semivolatile Organic Compounds							
2,4-Dinitrotoluene	*1.90E-02*	*9.30E-02*	*4.51E-05*	*2.78E-03*	*1.35E-06*	***9.57E-02***	***4.65E-05***
4,6-Dinitro-2-methylphenol	*2.80E-02*	*2.74E+00*	*ND*	*9.12E-02*	*ND*	***2.83E+00***	***NA***
2,4-Dinitrophenol	*1.40E-02*	*6.85E-02*	*ND*	*1.01E-03*	*ND*	***6.95E-02***	***NA***
3-Nitroaniline	*1.50E-01*	*4.89E+00*	*1.10E-05*	*7.54E-02*	*1.70E-07*	***4.97E+00***	***1.12E-05***
Nitrobenzene	*5.80E-03*	*1.14E-01*	*ND*	*4.00E-03*	*ND*	***1.18E-01***	***NA***
Volatile Organic Compounds							
Benzene	1.10E-03	2.69E-03	2.11E-07	1.98E-04	1.56E-08	**2.89E-03**	**2.27E-07**
Miscellaneous							
Nitrate	*7.93E+01*	*4.85E-01*	*ND*	*3.20E-03*	*ND*	***4.88E-01***	***NA***
Nitrate-Nitrite	*3.00E-01*	*2.94E-02*	*ND*	*1.94E-04*	*ND*	***2.95E-02***	***NA***
Sulfate	2.66E+03	NA	ND	NA	ND	**NA**	**NA**
Total HI		**9.05**		**0.189**		**9**	
Total ILCR			**1.06E-04**		**1.70E-06**		**1.E-04**
Site-Related HI		**8.69**		**0.182**		**9**	
Site-Related ILCR			**5.62E-05**		**1.52E-06**		**6.E-05**

COPC - Chemical of potential concern.
HQ - Hazard quotient; HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
NA - Not applicable.
mg/L - Milligrams per liter.

[a] Shaded italics indicates that the COPC is regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-28

Summary of Target Organ Noncancer Hazard Evaluation
On-Site Worker Exposure to Groundwater
West Area Red Water Ponds Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

COPC[b]	Target Organs[a]	
	Erthropoiesis /Erythrocyte	Cellular Respiration
Metals		
Cobalt	*0.13*	
Semivolatile Organic Compounds		
2,4-Dinitrotoluene	*0.10*	
4,6-Dinitro-2-methylphenol		*2.83*
3-Nitroaniline	*4.97*	
Nitrobenzene	*0.12*	
Miscellaneous		
Nitrate	0.49	
Nitrate-Nitrite	0.03	
Total Target Organ HI	**6**	**3**
Site-Related Target Organ HI	**6**	**3**

COPC - Chemical of potential concern.
HI - Hazard index.
[a] Only target organs and associated chemicals having a total HI greater than 1 are shown.
[b] Shaded italics indicates that the COPC is regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-29

Summary of Groundwater Noncancer Risk for the Child Resident
West Area Red Water Ponds Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

COPC[a]	Exposure Point Concentration (mg/L)	Oral HQ	Dermal HQ	Inhalation HQ	**HI All Pathways**
Metals					
Arsenic	9.50E-03	2.02E+00	4.45E-03	NA	**2.03E+00**
Cobalt	*2.67E-01*	*8.53E-01*	*9.38E-03*	*NA*	***8.63E-01***
Nickel	*2.78E-01*	*8.89E-01*	*9.76E-03*	*NA*	***8.98E-01***
Vanadium	5.50E-03	3.52E-01	2.58E-02	NA	**3.77E-01**
Semivolatile Organic Compounds					
2,4-Dinitrotoluene	*1.90E-02*	*6.07E-01*	*2.10E-02*	*NA*	***6.28E-01***
4,6-Dinitro-2-methylphenol	*2.80E-02*	*1.79E+01*	*3.44E-01*	*NA*	***1.82E+01***
2,4-Dinitrophenol	*1.40E-02*	*4.47E-01*	*7.58E-03*	*NA*	***4.55E-01***
3-Nitroaniline	*1.50E-01*	*3.20E+01*	*5.68E-01*	*NA*	***3.25E+01***
Nitrobenzene	*5.80E-03*	*7.42E-01*	*1.51E-02*	*3.25E+00*	***4.00E+00***
Volatile Organic Compounds					
Benzene	1.10E-03	1.76E-02	7.48E-04	4.08E-02	**5.91E-02**
Miscellaneous					
Nitrate	*7.93E+01*	*3.17E+00*	*1.39E-02*	*NA*	***3.18E+00***
Nitrate-Nitrite	*3.00E-01*	*1.92E-01*	*8.43E-04*	*NA*	***1.93E-01***
Sulfate	2.66E+03	NA	NA	NA	**NA**
Total HI		**59.2**	**1.02**	**3.29**	**63**
Site-Related HI		**56.8**	**0.99**	**3.25**	**61**

COPC - Chemical of potential concern.
HQ - Hazard quotient; HI - Hazard index.
NA - Not applicable.
mg/L - Milligrams per liter.

[a] Shaded italics indicates that the COPC is regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-30

Summary of Target Organ Noncancer Hazard Evaluation
Child Resident Exposure to Groundwater
West Area Red Water Ponds Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

	Target Organs[a]					
COPC[b]	Skin	PVS	Kidney	Erthropoiesis /Erythrocyte	Cellular Respiration	Liver
Metals						
Arsenic	2.03	2.03				
Cobalt				*0.86*		
Vanadium			0.38			
Explosives						
2,4-Dinitrotoluene				*0.63*		*0.63*
4,6-Dinitro-2-methylphenol					*18.24*	
3-Nitroaniline				*32.53*		
Nitrobenzene			*4.00*	*4.00*		*4.00*
Miscellaneous						
Nitrate				*3.18*		
Nitrate-Nitrite				*0.19*		
Total Target Organ HI	**2**	**2**	**4**	**41**	**18**	**5**
Site-Related Target Organ HI	**NA**	**NA**	**4**	**41**	**18**	**5**

COPC - Chemical of potential concern.
HI - Hazard index.
Target Organs: PVS - pulmonary vascular system.
[a] Only target organs and associated chemicals having a total HI greater than 1 are shown.
[b] Shaded italics indicates that the COPC is regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-31

Summary of Groundwater Nonancer Risk for the Adult Resident
West Area Red Water Ponds Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

COPC[a]	Exposure Point Concentration (mg/L)	Oral HQ	Dermal HQ	Inhalation HQ	**HI All Pathways**
Metals					
Arsenic	9.50E-03	8.68E-01	1.74E-03	NA	**8.69E-01**
Cobalt	*2.67E-01*	*3.66E-01*	*3.66E-03*	*NA*	***3.69E-01***
Nickel	*2.78E-01*	*3.81E-01*	*3.81E-03*	*NA*	***3.85E-01***
Vanadium	5.50E-03	1.51E-01	1.00E-02	NA	**1.61E-01**
Semivolatile Organic Compounds					
2,4-Dinitrotoluene	*1.90E-02*	*2.60E-01*	*1.06E-02*	*NA*	***2.71E-01***
4,6-Dinitro-2-methylphenol	*2.80E-02*	*7.67E+00*	*1.73E-01*	*NA*	***7.84E+00***
2,4-Dinitrophenol	*1.40E-02*	*1.92E-01*	*3.81E-03*	*NA*	***1.96E-01***
3-Nitroaniline	*1.50E-01*	*1.37E+01*	*2.86E-01*	*NA*	***1.40E+01***
Nitrobenzene	*5.80E-03*	*3.18E-01*	*7.59E-03*	*1.39E+00*	***1.72E+00***
Volatile Organic Compounds					
Benzene	1.10E-03	7.53E-03	3.76E-04	1.75E-02	**2.54E-02**
Miscellaneous					
Nitrate	*7.93E+01*	*1.36E+00*	*5.43E-03*	*NA*	***1.36E+00***
Nitrate-Nitrite	*3.00E-01*	*8.22E-02*	*3.29E-04*	*NA*	***8.25E-02***
Sulfate	2.66E+03	NA	NA	NA	**NA**
Total HI		**25.4**	**0.506**	**1.41**	**27**
Site-Related HI		**24.3**	**0.494**	**1.39**	**26**

COPC - Chemical of potential concern.
HQ - Hazard quotient; HI - Hazard index.
NA - Not applicable.
mg/L - Milligrams per liter.

[a] Shaded italics indicates that the COPC is regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-32

Summary of Target Organ Noncancer Hazard Evaluation
Adult Resident Exposure to Groundwater
West Area Red Water Ponds Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

	Target Organs[a]			
COPC[b]	Kidney	Erythropoiesis /Erythrocyte	Cellular Respiration	Liver
Metals				
Cobalt		*0.37*		
Vanadium	0.16			
Semivolatile Organic Compounds				
2,4-Dinitrotoluene		*0.27*		*0.27*
4,6-Dinitro-2-methylphenol			*7.84*	
3-Nitroaniline		*13.98*		
Nitrobenzene	*1.72*	*1.72*		*1.72*
Miscellaneous				
Nitrate		*1.36*		
Nitrate-Nitrite		*0.08*		
Total Target Organ HI	**2**	**18**	**8**	**2**
Site-Related Target Organ HI	**2**	**18**	**8**	**2**

COPC - Chemical of potential concern.
HI - Hazard index.
[a] Only target organs and associated chemicals having a total HI greater than 1 are shown.
[b] Shaded italics indicates that the COPC is regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-33

Summary of Groundwater Cancer Risk for the Resident
West Area Red Water Ponds Area, Plum Brook Ordnance Works
Sandusky, Ohio

COPC[a]	Exposure Point Concentration (mg/L)	Adult Oral ILCR	Child Oral ILCR	Total Oral ILCR	Adult Dermal ILCR	Child Dermal ILCR	Total Dermal ILCR	Adult Inhalation ILCR	Child Inhalation ILCR	Total Inhalation ILCR	**ILCR All Pathways**
Metals											
Arsenic	9.50E-03	1.34E-04	7.81E-05	2.12E-04	2.68E-07	1.72E-07	4.39E-07	NA	NA	NA	**2.12E-04**
Cobalt	*2.67E-01*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	***NA***
Nickel	*2.78E-01*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	***NA***
Vanadium	5.50E-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Semivolatile Organic Compounds											
2,4-Dinitrotoluene	*1.90E-02*	*1.21E-04*	*7.08E-05*	*1.92E-04*	*4.92E-06*	*2.45E-06*	*7.37E-06*	*NA*	*NA*	*NA*	***2.00E-04***
4,6-Dinitro-2-methylphenol	*2.80E-02*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	***NA***
2,4-Dinitrophenol	*1.40E-02*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	***NA***
3-Nitroaniline	*1.50E-01*	*2.96E-05*	*1.73E-05*	*4.68E-05*	*6.18E-07*	*3.07E-07*	*9.25E-07*	*NA*	*NA*	*NA*	***4.78E-05***
Nitrobenzene	*5.80E-03*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	***NA***
Volatile Organic Compounds											
Benzene	1.10E-03	5.68E-07	3.32E-07	9.00E-07	2.84E-08	1.41E-08	4.25E-08	1.39E-06	8.12E-07	2.21E-06	**3.15E-06**
Miscellaneous											
Nitrate	*7.93E+01*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	***NA***
Nitrate-Nitrite	*3.00E-01*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	***NA***
Sulfate	2.66E+03	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Total ILCR		**2.85E-04**	**1.66E-04**	**4.52E-04**	**5.84E-06**	**2.94E-06**	**8.78E-06**	**1.39E-06**	**8.12E-07**	**2.21E-06**	**5.E-04**
Site-Related ILCR		**1.51E-04**	**8.81E-05**	**2.39E-04**	**5.54E-06**	**2.75E-06**	**8.29E-06**	**NA**	**NA**	**NA**	**2.E-04**

COPC - Chemical of potential concern.
ILCR - Incremental lifetime cancer risk.
NA - Not applicable.
mg/L - Milligrams per liter.

[a] Shaded italics indicates that the COPC is regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-34

Summary of Groundwater Noncancer Risk for the Child Resident
Downgradient Areas at the Facility Boundary, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Exposure Point Concentration (mg/L)	Oral HQ	Dermal HQ	Inhalation HQ	**Total HI All Pathways**
Metals					
Chromium	2.44E-02	5.20E-01	4.57E-02	NA	**5.66E-01**
Iron	2.57E+02	5.48E+01	1.20E-01	NA	**5.49E+01**
Manganese	4.66E+00	1.24E+01	NA	NA	**1.24E+01**
Explosives					
2,4-Dinitrotoluene	*1.50E-03*	*4.79E-02*	*1.66E-03*	*NA*	***4.96E-02***
2,6-Dinitrotoluene	*1.40E-03*	*8.95E-02*	*2.09E-03*	*NA*	***9.16E-02***
2-Nitrotoluene	*5.50E-04*	*3.52E-04*	*1.30E-05*	*NA*	***3.65E-04***
Nitrobenzene	*3.40E-04*	*4.35E-02*	*8.84E-04*	*1.90E-01*	***2.35E-01***
Semivolatile Organic Compounds					
2-Methylnaphthalene	2.40E-02	7.67E-02	2.93E-02	8.91E+00	**9.01E+00**
Bis(2-ethylhexyl)phthalate	9.70E-03	3.10E-02	2.66E-02	NA	**5.76E-02**
Naphthalene	1.80E-02	5.75E-02	1.07E-02	6.68E+00	**6.75E+00**
Volatile Organic Compounds					
Benzene	1.30E-01	2.08E+00	8.84E-02	4.82E+00	**6.99E+00**
Chlorobenzene	1.10E-02	3.52E-02	3.52E-03	6.16E-01	**6.55E-01**
Methylene chloride	9.80E-02	1.04E-01	1.09E-03	3.64E-02	**1.42E-01**
Toluene	1.80E-01	5.75E-02	5.56E-03	5.22E-01	**5.85E-01**
Xylenes, total	5.60E-01	1.79E-01	3.24E-02	6.16E+00	**6.37E+00**
Miscellaneous					
Cyanide, total	3.20E-01	1.02E+00	1.72E-03	NA	**1.02E+00**
Sulfate	1.28E+03	NA	NA	NA	**NA**
Total HI		**71.5**	**0.370**	**27.9**	**100**
Site-Related HI		**0.181**	**0.005**	**0.190**	**0.4**

COPC - Chemical of potential concern.
HQ - Hazard quotient; HI - Hazard index.
NA - Not applicable.

[a] Shaded italics indicates that the COPC is regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-35

Summary of Target Organ Noncancer Hazard Evaluation
Child Resident Exposure to Groundwater
Downgradient Areas at the Facility Boundary, Former Plum Brook Ordnance Works
Sandusky, Ohio

	Target Organs[a]			
COPC[b]	NS/CNS	Iron Overload	NOE	Blood/ Blood cells
Metals				
Iron		54.88		
Manganese	12.41			
Explosives				
2,4-Dinitrotoluene	*0.05*			
2,6-Dinitrotoluene	*0.09*			
Semivolatile Organic Compounds				
2-Methylnaphthalene			8.91	
Bis(2-ethylhexyl)phthalate	0.06			
Naphthalene			6.68	
Volatile Organic Compounds				
Benzene				6.99
Toluene	0.06			
Xylenes, total	6.16			
Miscellaneous				
Cyanide, total	1.02			
Total Target Organ HI	**20**	**55**	**16**	**7**
Site-Related Target Organ HI	**0**	**NA**	**NA**	**NA**

COPC - Chemical of potential concern.
HI - Hazard index.
Target Organs: NS/CNS - nervous system/central nervous system; NOE - nasal and olfactory epithelia.

[a] Only target organs and associated chemicals having a total HI greater than 1 are shown.
[b] Shaded italics indicates that the COPC is regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-36

Summary of Groundwater Noncancer Risk for the Adult Resident
Downgradient Areas at the Facility Boundary, Former Plum Brook Ordnance Works
Sandusky, Ohio

COPC[a]	Exposure Point Concentration (mg/L)	Oral HQ	Dermal HQ	Inhalation HQ	**HI All Pathways**
Metals					
Chromium	2.44E-02	2.23E-01	1.78E-02	NA	**2.41E-01**
Iron	2.57E+02	2.35E+01	4.69E-02	NA	**2.35E+01**
Manganese	4.66E+00	5.32E+00	NA	NA	**5.32E+00**
Explosives					
2,4-Dinitrotoluene	*1.50E-03*	*2.05E-02*	*8.33E-04*	*NA*	***2.14E-02***
2,6-Dinitrotoluene	*1.40E-03*	*3.84E-02*	*1.05E-03*	*NA*	***3.94E-02***
2-Nitrotoluene	*5.50E-04*	*1.51E-04*	*6.54E-06*	*NA*	***1.57E-04***
Nitrobenzene	*3.40E-04*	*1.86E-02*	*4.45E-04*	*8.17E-02*	***1.01E-01***
Semivolatile Organic Compounds					
2-Methylnaphthalene	2.40E-02	3.29E-02	1.47E-02	3.82E+00	**3.87E+00**
Bis(2-ethylhexyl)phthalate	9.70E-03	1.33E-02	1.34E-02	NA	**2.67E-02**
Naphthalene	1.80E-02	2.47E-02	5.36E-03	2.87E+00	**2.90E+00**
Volatile Organic Compounds					
Benzene	1.30E-01	8.90E-01	4.45E-02	2.07E+00	**3.00E+00**
Chlorobenzene	1.10E-02	1.51E-02	1.77E-03	2.64E-01	**2.81E-01**
Methylene chloride	9.80E-02	4.47E-02	5.48E-04	1.56E-02	**6.09E-02**
Toluene	1.80E-01	2.47E-02	2.80E-03	2.24E-01	**2.52E-01**
Xylenes, total	5.60E-01	7.67E-02	1.63E-02	2.64E+00	**2.74E+00**
Miscellaneous					
Cyanide, total	3.20E-01	4.38E-01	6.71E-04	NA	**4.39E-01**
Sulfate	1.28E+03	NA	NA	NA	**NA**
Total HI		**30.7**	**0.167**	**12.0**	**43**
Site-Related HI		**0.08**	**0.0023**	**0.08**	**0.2**

COPC - Chemical of potential concern.
HQ - Hazard quotient; HI - Hazard index.
NA - Not applicable.

[a] Shaded italics indicates that the COPC is regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-37

Summary of Target Organ Noncancer Hazard Evaluation
Adult Resident Exposure to Groundwater
Downgradient Areas at the Facility Boundary, Former Plum Brook Ordnance Works
Sandusky, Ohio

	Target Organs[a]			
COPC[b]	NS/CNS	Iron Overload	NOE	Blood/ Blood cells
Metals				
Iron		23.52		
Manganese	5.32			
Explosives				
2,4-Dinitrotoluene	*0.02*			
2,6-Dinitrotoluene	*0.04*			
Semivolatile Organic Compounds				
2-Methylnaphthalene			3.82	
Naphthalene			2.87	
Volatile Organic Compounds				
Benzene				3.00
Toluene	0.03			
Xylenes, total	2.64			
Miscellaneous				
Cyanide, total	0.44			
Total Target Organ HI	**8**	**24**	**7**	**3**
Site-Related Target Organ HI	**0.06**	**NA**	**NA**	**NA**

COPC - Chemical of potential concern.
HI - Hazard index; NA - Not applicable.
Target Organs: NS/CNS - nervous system/central nervous system; N & O - nasal and olfactory.

[a] Only target organs and associated chemicals having a total HI greater than 1 are shown.
[b] Shaded italics indicates that the COPC is regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-38

Summary of Groundwater Cancer Risk for the Resident
Downgradient Areas at the Facility Boundary, Plum Brook Ordnance Works
Sandusky, Ohio

COPC[a]	Exposure Point Concentration (mg/L)	Adult Oral ILCR	Child Oral ILCR	Total Oral ILCR	Adult Dermal ILCR	Child Dermal ILCR	Total Dermal ILCR	Adult Inhalation ILCR	Child Inhalation ILCR	Total Inhalation ILCR	**Total ILCR All Pathways**
Metals											
Chromium	2.44E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Iron	2.57E+02	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Manganese	4.66E+00	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Explosives											
2,4-Dinitrotoluene	*1.50E-03*	*9.58E-06*	*5.59E-06*	*1.52E-05*	*3.89E-07*	*1.93E-07*	*5.82E-07*	*NA*	*NA*	*NA*	***1.58E-05***
2,6-Dinitrotoluene	*1.40E-03*	*8.94E-06*	*5.22E-06*	*1.42E-05*	*2.46E-07*	*1.22E-07*	*3.68E-07*	*NA*	*NA*	*NA*	***1.45E-05***
2-Nitrotoluene	*5.50E-04*	*1.19E-06*	*6.93E-07*	*1.88E-06*	*5.15E-08*	*2.56E-08*	*7.71E-08*	*NA*	*NA*	*NA*	***1.96E-06***
Nitrobenzene	*3.40E-04*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	***NA***
Semivolatile Organic Compounds											
2-Methylnaphthalene	2.40E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Bis(2-ethylhexyl)phthalate	9.70E-03	1.28E-06	7.44E-07	2.02E-06	1.29E-06	6.39E-07	1.93E-06	NA	NA	NA	**3.95E-06**
Naphthalene	1.80E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Volatile Organic Compounds											
Benzene	1.30E-01	6.72E-05	3.92E-05	1.06E-04	3.35E-06	1.67E-06	5.02E-06	1.65E-04	9.60E-05	2.61E-04	**3.72E-04**
Chlorobenzene	1.10E-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Methylene chloride	9.80E-02	6.90E-06	4.03E-06	1.09E-05	8.45E-08	4.20E-08	1.26E-07	7.36E-06	4.29E-06	1.17E-05	**2.27E-05**
Toluene	1.80E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Xylenes, total	5.60E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Miscellaneous											
Cyanide, total	3.20E-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Sulfate	1.28E+03	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**
Total ILCR		**9.51E-05**	**5.54E-05**	**1.51E-04**	**5.41E-06**	**2.69E-06**	**8.10E-06**	**1.72E-04**	**1.00E-04**	**2.72E-04**	**4.E-04**
Site-Related ILCR		**1.97E-05**	**1.15E-05**	**3.12E-05**	**6.86E-07**	**3.41E-07**	**1.03E-06**	**NA**	**NA**	**NA**	**3.E-05**

COPC - Chemical of potential concern.
ILCR - Incremental lifetime cancer risk.
NA - Not applicable.

[a] Shaded italics indicates that the COPC is regarded as site related. Refer to Section 6.2 and Appendix H.

Table 6-39

Synopsis of Evaluation for Site Relatedness[a]
Former Plum Brook Ordnance Works
Sandusky, Ohio

TNT Area A		
COPC	**Identified as Site Related?**	**Rationale for Inclusion/Exclusion[b]**
Aluminum	No	Sampling method[c]
Arsenic	No	Sampling method
Chromium	No	Sampling method
Iron	No	Sampling method
Lead	No	Sampling method
Manganese	No	Sampling method
Nickel	No	Sampling method
Vanadium	No	Sampling method
2,4-Dintirotoluene	Yes	Site history[d]
2,6-Dinitrotoluene	Yes	Site history
4_amino-2,6-dinitrotoluene	Yes	Site history
2-Nitrotoluene	Yes	Site history
1,3-Dinitrobenzene	Yes	Site history
Nitrobenzene	Yes	Site history
Benzene	No	Natural petroleum[e]
Chloromethane	No	Infrequent, low detection; not found in other media
Ethylbenzene	No	Natural petroleum
Methylene chloride	No	Laboratory artifact[f]
Toluene	No	Natural petroleum
Xylenes	No	Natural petroleum
Naphthalene	No	Natural petroleum
2-Methylnaphthalene	No	Natural petroleum
Bis(2-ethylhexyl)phthalate	No	Laboratory artifact
Chrysene	No	Natural petroleum
Dibenzofuran	No	Natural petroleum
Fluorene	No	Natural petroleum
Phenanthrene	No	Natural petroleum
TNT Area B		
COPC	**Identified as Site Related?**	**Rationale for Inclusion/Exclusion**
Aluminum	No	Sampling method
Arsenic	No	Sampling method
Chromium	No	Sampling method
Iron	No	Natural reducing conditions responsible for dissolved iron
Lead	No	Sampling method
Manganese	No	Natural reducing conditions responsible for dissolved manganese
Vanadium	No	Sampling method; not found above background in soil
2-Methylnaphthalene	No	Natural petroleum
Naphthalene	No	Natural petroleum
Benzene	No	Natural petroleum

Table 6-39

Synopsis of Evaluation for Site Relatedness[a]
Former Plum Brook Ordnance Works
Sandusky, Ohio

TNT Area C		
COPC	**Identified as Site Related?**	**Rationale for Inclusion/Exclusion**
2-Methylnaphthalene	No	Natural petroleum
Bis(2-ethylhexyl)phthalate	No	Laboratory artifact
Naphthalene	No	Natural petroleum
Benzene	No	Natural petroleum
Bromomethane	No	Not present in duplicate or in other site media
Methylene chloride	No	Laboratory artifact
Toluene	No	Natural petroleum
Xylenes	No	Natural petroleum
Pentolite Road Red Water Pond Area		
COPC	**Identified as Site Related?**	**Rationale for Inclusion/Exclusion**
Chromium	No	Sampling method
Iron	No	Natural reducing conditions responsible for dissolved iron
Manganese	No	Only 1 well exceeds background and not greatly; wells generally at background; WRS results[g] indicate no difference; natural reducing conditions present
Thallium	No	Infrequent detection; not present in other media
2,4-Dintirotoluene	Yes	Site history
2,6-Dinitrotoluene	Yes	Site history
4-Amino-2,6-dinitrotoluene	Yes	Site history
Nitrobenzene	Yes	Site history
2-Methylnaphthalene	No	Natural petroleum
4-Methylphenol	No	Laboratory artifact
Bis(2-ethylhexyl)phthalate	No	Natural petroleum
Naphthalene	No	Natural petroleum
1,1,2-Trichloroethane	No	Infrequent, low detection; not present in other media
Acetone	No	Laboratory artifact (looks correlated with presence of natural petroleum-related compounds; not present in other media
Benzene	No	Natural petroleum
Ethylbenzene	No	Natural petroleum
Methylene chloride	No	Laboratory artifact
Toluene	No	Natural petroleum
Xylenes	No	Natural petroleum
West Area Red Water Ponds Area		
COPC	**Identified as Site Related?**	**Rationale for Inclusion/Exclusion**
Arsenic	No	Concentrations essentially same as background
Cobalt	Yes	Filtered samples exceed background
Nickel	Yes	Filtered samples exceed background
Vanadium	No	Laboratory artifact
2,4-Dinitrophenol	Yes	Site history
4,6-Dinitro-2-methylphenol	Yes	Site history
2,4-Dinitrotoluene	Yes	Site history

Table 6-39

Synopsis of Evaluation for Site Relatedness[a]
Former Plum Brook Ordnance Works
Sandusky, Ohio

3-Nitroaniline	Yes	Site history
Nitrobenzene	Yes	Site history
Benzene	No	Natural petroleum
Nitrate	Yes	Exceed background; site history
Nitrate-nitrite	Yes	Site history
Downgradient Bedrock Wells		
COPC	**Identified as Site Related?**	**Rationale for Inclusion/Exclusion**
Chromium	No	Sampling method
Iron	No	Sampling method
Manganese	No	Sampling method
2,4-Dinitrotoluene	Yes	Site history
2,6-Dinitrotoluene	Yes	Site history
2-Nitrotoluene	Yes	Site history
Nitrobenzene	Yes	Site history
2-Methylnaphthalene	No	Laboratory artifact
Bis(2-ethylhexyl)phthalate	No	Laboratory artifact
Naphthalene	No	Natural petroleum
Benzene	No	Natural petroleum
Chlorobenzene	No	Infrequent detection at low concentration; not present in on-site soil or groundwater
Methylene chloride	No	Laboratory artifact
Toluene	No	Natural petroleum
Xylenes	No	Natural petroleum
Cyanide	No	Infrequent detection at low concentration; not identified as a COPC in on-site groundwater.

COPC - Chemical of potential concern.

[a] Excerpted from Appendix H. As stated therein, an attempt was made to err on the side of inclusion as site-related, rather than exclusion.
[b] These rationale are presented in abbreviated format. Refer to Appendix H for a more complete evaluation of each COPC.
[c] "Sampling method" indicates that COPC is likely present at relatively high concentration due to the sampling method; this generally refers to the use of bailer-collected samples couple with likely high turbidity. [d] "Site history" means that the chemical is included based on the facility's former use as an ordnance manufacturing facility.
[e] "Natural petroleum" indicates that the COPC is likely associated with naturally occurring petroleum, prevalent in the local region.
[f] "Laboratory artifact" generally means that other data points within the data set were qualified "B" blank at comparable or greater concentrations.
[g] "WRS results" refers to the results of the Wilcoxon Rank-Sum comparison of site to background data (Appendix C). WRS results are only mentioned where they were appropriate for consideration. Unless stated otherwise. "WRS results" was used as a basis for inclusion as site-related; i.e., the WRS tests indicated that the site data set had greater concentrations than the background data set.

Table 6-40

Summary of Groundwater Risk Based on Modeled Groundwater Concentrations
TNT Area A, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Modeled Concentration[a] (mg/L)	HI All Pathways	ILCR All Pathways
On-Site Worker			
2,4-Dinitrotoluene	9.30E-03	0.047	2.28E-05
2,6-Dinitrotoluene	4.02E-02	0.40	9.76E-05
2,4,6-Trinitrotoluene[b]	4.69E-03	0.093	4.98E-07
Total HI		0.5	
Total ILCR			1E-04
Child Resident			
2,4-Dinitrotoluene	9.30E-03	0.31	NA
2,6-Dinitrotoluene	4.02E-02	2.6	NA
2,4,6-Trinitrotoluene[b]	4.69E-03	0.61	NA
Total HI		4	
Adult Resident			
2,4-Dinitrotoluene	9.30E-03	0.13	NA
2,6-Dinitrotoluene	4.02E-02	1.1	NA
2,4,6-Trinitrotoluene[b]	4.69E-03	0.26	NA
Total HI		1.53	
Adult/Child Resident			
2,4-Dinitrotoluene	9.30E-03	NA	9.77E-05
2,6-Dinitrotoluene	4.02E-02	NA	4.17E-04
2,4,6-Trinitrotoluene[b]	4.69E-03	NA	2.12E-06
Total ILCR			5.E-04

COPC - Chemical of potential concern; HQ - Hazard quotient; HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
NA - Not applicable.
mg/L - Milligrams per liter.

[a] Based on year of maximum combined nitroaromatics concentration as described in Appendix E (year 130).
[b] Chemical was not identified as a COPC.

Table 6-41

Summary of Groundwater Risk Based on Modeled Groundwater Concentrations
TNT Area B, Former Plum Brook Ordnance Works
Sandusky, Ohio

On-Site Worker			
Chemical	**Modeled Concentration[a] (mg/L)**	**HI All Pathways**	**ILCR All Pathways**
2,4-Dinitrotoluene	1.36E-03	0.007	3.33E-06
2,6-Dinitrotoluene	1.02E-03	0.010	2.48E-06
2,4,6-Trinitrotoluene[b]	4.00E-06	0.000	4.25E-10
Total HI		**0.02**	
Total ILCR			6.E-06
Child Resident			
Chemical	**Modeled Concentration (mg/L)**	**HI All Pathways**	**ILCR All Pathways**
2,4-Dinitrotoluene	1.36E-03	0.045	NA
2,6-Dinitrotoluene	1.02E-03	0.067	NA
2,4,6-Trinitrotoluene[b]	4.00E-06	0.001	NA
Total HI		0.1	
Adult Resident			
Chemical	**Modeled Concentration (mg/L)**	**HI All Pathways**	**ILCR All Pathways**
2,4-Dinitrotoluene	1.36E-03	0.019	NA
2,6-Dinitrotoluene	1.02E-03	0.029	NA
2,4,6-Trinitrotoluene[b]	4.00E-06	0.000	NA
Total HI		0.05	
Adult/Child Resident			
Chemical	**Modeled Concentration (mg/L)**	**HI All Pathways**	**ILCR All Pathways**
2,4-Dinitrotoluene	1.36E-03	NA	1.43E-05
2,6-Dinitrotoluene	1.02E-03	NA	1.06E-05
2,4,6-Trinitrotoluene[b]	4.00E-06	NA	1.81E-09
Total ILCR			2.E-05

COPC - Chemical of potential concern; HQ - Hazard quotient; HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
NA - Not applicable.
mg/L - Milligrams per liter.

[a] Based on year of maximum combined nitroaromatics concentration as described in Appendix E (year 130). The model assumes that remediation for direct contact of soils is complete.

[b] Chemical was not identified as a COPC.

Table 6-42

Summary of Groundwater Risk Based on Modeled Groundwater Concentrations
TNT Area C, Former Plum Brook Ordnance Works
Sandusky, Ohio

On-Site Worker			
Chemical	**Modeled Concentration[a] (mg/L)**	**HI All Pathways**	**ILCR All Pathways**
2,4-Dinitrotoluene	8.65E-02	0.44	2.12E-04
2,6-Dinitrotoluene	6.03E-02	0.60	1.46E-04
2,4,6-Trinitrotoluene[b]	1.30E-02	0.26	1.38E-06
Total HI		1.3	
Total ILCR			4.E-04
Child Resident			
Chemical	**Modeled Concentration (mg/L)**	**HI All Pathways**	**ILCR All Pathways**
2,4-Dinitrotoluene	8.65E-02	2.9	NA
2,6-Dinitrotoluene	6.03E-02	3.9	NA
2,4,6-Trinitrotoluene[b]	1.30E-02	1.7	NA
Total HI		8	
Adult Resident			
Chemical	**Modeled Concentration (mg/L)**	**HI All Pathways**	**ILCR All Pathways**
2,4-Dinitrotoluene	8.65E-02	1.2	NA
2,6-Dinitrotoluene	6.03E-02	1.7	NA
2,4,6-Trinitrotoluene[b]	1.30E-02	0.72	NA
Total HI		4	
Adult/Child Resident			
Chemical	**Modeled Concentration (mg/L)**	**HI All Pathways**	**ILCR All Pathways**
2,4-Dinitrotoluene	8.65E-02	NA	9.09E-04
2,6-Dinitrotoluene	6.03E-02	NA	6.25E-04
2,4,6-Trinitrotoluene[b]	1.30E-02	NA	5.89E-06
Total ILCR			2.E-03

COPC - Chemical of potential concern; HQ - Hazard quotient; HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
NA - Not applicable.
mg/L - Milligrams per liter.

[a] Based on year of maximum combined nitroaromatics concentration as described in Appendix E (year 145).
[b] Chemical was not identified as a COPC.

Table 6-43

Summary of Groundwater Risk Based on Modeled Groundwater Concentrations
Pentolite Road Red Water Pond Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

On-Site Worker			
Chemical	**Modeled Concentration[a] (mg/L)**	**HI All Pathways**	**ILCR All Pathways**
2,4-Dinitrotoluene	7.20E-03	0.036	1.76E-05
2,6-Dinitrotoluene	7.20E-03	0.072	1.75E-05
2,4,6-Trinitrotoluene[b]	2.00E-04	0.004	2.12E-08
Total HI		0.1	
Total ILCR			4.E-05
Child Resident			
Chemical	**Modeled Concentration (mg/L)**	**HI All Pathways**	**ILCR All Pathways**
2,4-Dinitrotoluene	7.20E-03	0.24	NA
2,6-Dinitrotoluene	7.20E-03	0.47	NA
2,4,6-Trinitrotoluene[b]	2.00E-04	0.026	NA
Total HI		0.7	
Adult Resident			
Chemical	**Modeled Concentration (mg/L)**	**HI All Pathways**	**ILCR All Pathways**
2,4-Dinitrotoluene	7.20E-03	0.10	NA
2,6-Dinitrotoluene	7.20E-03	0.20	NA
2,4,6-Trinitrotoluene[b]	2.00E-04	0.011	NA
Total HI		0.3	
Adult/Child Resident			
Chemical	**Modeled Concentration (mg/L)**	**HI All Pathways**	**ILCR All Pathways**
2,4-Dinitrotoluene	7.20E-03	NA	7.56E-05
2,6-Dinitrotoluene	7.20E-03	NA	7.47E-05
2,4,6-Trinitrotoluene[b]	2.00E-04	NA	9.06E-08
Total ILCR			1.5E-04

COPC - Chemical of potential concern; HQ - Hazard quotient; HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
NA - Not applicable; ND - Chemical was model at less that
mg/L - Milligrams per liter.

[a] Based on year of maximum combined nitroaromatics concentration as described in Appendix E (year 150). The model includes the partial remediation completed to date as described in Wastron Inc., 2005, *Interim Soil Removal Action Report* , Draft, Plum Brook Ordnance Works, Sandusky, Ohio, November.

[b] Chemical was not identified as a COPC.

Table 6-44

Summary of Groundwater Risk Based on Modeled Groundwater Concentrations
West Area Red Water Ponds Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Modeled Concentration[a] (mg/L)	HI All Pathways	ILCR All Pathways
On-Site Worker			
2,4-Dinitrotoluene	1.60E-02	0.081	3.92E-05
2,6-Dinitrotoluene	4.70E-04	0.005	1.14E-06
2,4,6-Trinitrotoluene[b]	2.00E-05	0.0004	2.12E-09
Total HI		0.09	
Total ILCR			4.E-05
Child Resident			
2,4-Dinitrotoluene	1.60E-02	0.53	NA
2,6-Dinitrotoluene	4.70E-04	0.031	NA
2,4,6-Trinitrotoluene[b]	2.00E-05	0.0026	NA
Total HI		0.6	
Adult Resident			
2,4-Dinitrotoluene	1.60E-02	0.23	NA
2,6-Dinitrotoluene	4.70E-04	0.013	NA
2,4,6-Trinitrotoluene[b]	2.00E-05	0.0011	NA
Total HI		0.2	
Adult/Child Resident			
2,4-Dinitrotoluene	1.60E-02	NA	1.68E-04
2,6-Dinitrotoluene	4.70E-04	NA	4.87E-06
2,4,6-Trinitrotoluene[b]	2.00E-05	NA	9.06E-09
Total ILCR			1.7E-04

COPC - Chemical of potential concern; HQ - Hazard quotient; HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
NA - Not applicable.
mg/L - Milligrams per liter.

[a] Based on year of maximum combined nitroaromatics concentration as described in Appendix E (year 105).
[b] Chemical was not identified as a COPC.

Table 6-45

Summary of Groundwater Risk Based on Modeled Groundwater Concentrations
Facility Boundary Downgradient of TNT Area A
Former Plum Brook Ordnance Works, Sandusky, Ohio

Child Resident			
Chemical	**Modeled Concentration[a] (mg/L)**	**HI All Pathways**	**ILCR All Pathways**
2,4-Dinitrotoluene	6.00E-06	0.0002	NA
2,6-Dinitrotoluene	3.00E-05	0.0020	NA
2,4,6-Trinitrotoluene[b]	1.00E-20	1.30E-18	NA
Total HI		0.002	
Adult Resident			
Chemical	**Modeled Concentration (mg/L)**	**HI All Pathways**	**ILCR All Pathways**
2,4-Dinitrotoluene	6.00E-06	0.00009	NA
2,6-Dinitrotoluene	3.00E-05	0.0008	NA
2,4,6-Trinitrotoluene[b]	1.00E-20	5.57E-19	NA
Total HI		0.0009	
Adult/Child Resident			
Chemical	**Modeled Concentration (mg/L)**	**HI All Pathways**	**ILCR All Pathways**
2,4-Dinitrotoluene	6.00E-06	NA	6.30E-08
2,6-Dinitrotoluene	3.00E-05	NA	3.11E-07
2,4,6-Trinitrotoluene[b]	1.00E-20	NA	4.53E-24
Total ILCR			4.E-07

COPC - Chemical of potential concern; HQ - Hazard quotient; HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
NA - Not applicable.
mg/L - Milligrams per liter.

[a] Based on year of maximum combined nitroaromatics concentration as described in Appendix E (year 150).
[b] Chemical was not identified as a COPC.

Table 6-46

Summary of Groundwater Risk Based on Modeled Groundwater Concentrations
Facility Boundary Downgradient of TNT Area B, TNT Area C, and Pentolite Road Red Water Pond Area
Plum Brook Ordnance Works, Sandusky, Ohio

Child Resident			
Chemical	**Modeled Concentration[a] (mg/L)**	**HI All Pathways**	**ILCR All Pathways**
2,4-Dinitrotoluene	1.30E-03	0.043	NA
2,6-Dinitrotoluene	6.00E-04	0.039	NA
2,4,6-Trinitrotoluene[b]	2.00E-23	2.6E-21	NA
Total HI		0.08	
Adult Resident			
Chemical	**Modeled Concentration (mg/L)**	**HI All Pathways**	**ILCR All Pathways**
2,4-Dinitrotoluene	1.30E-03	0.019	NA
2,6-Dinitrotoluene	6.00E-04	0.0169	NA
2,4,6-Trinitrotoluene[b]	2.00E-23	1.1E-21	NA
Total HI		0.04	
Adult/Child Resident			
Chemical	**Modeled Concentration (mg/L)**	**HI All Pathways**	**ILCR All Pathways**
2,4-Dinitrotoluene	1.30E-03	NA	1.37E-05
2,6-Dinitrotoluene	6.00E-04	NA	6.22E-06
2,4,6-Trinitrotoluene[b]	2.00E-23	NA	9.06E-27
Total ILCR			2.E-05

COPC - Chemical of potential concern; HQ - Hazard quotient; HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
NA - Not applicable.
mg/L - milligram per liter.

[a] Based on year of maximum combined nitroaromatics concentration as described in Appendix E (year 150).

[b] Chemical was not identified as a COPC.

Table 6-47

Summary of Groundwater Risk Based on Modeled Groundwater Concentrations
Facility Boundary Downgradient of West Area Red Water Ponds Area
Former Plum Brook Ordnance Works, Sandusky, Ohio

Child Resident			
Chemical	**Modeled Concentration[a] (mg/L)**	**HI All Pathways**	**ILCR All Pathways**
2,4-Dinitrotoluene	9.00E-05	0.0030	NA
2,6-Dinitrotoluene	4.00E-05	0.0026	NA
2,4,6-Trinitrotoluene[b]	6.00E-07	0.00008	NA
Total HI		0.006	
Adult Resident			
Chemical	**Modeled Concentration (mg/L)**	**HI All Pathways**	**ILCR All Pathways**
2,4-Dinitrotoluene	9.00E-05	0.0013	NA
2,6-Dinitrotoluene	4.00E-05	0.0011	NA
2,4,6-Trinitrotoluene[b]	6.00E-07	0.00003	NA
Total HI		0.002	
Adult/Child Resident			
Chemical	**Modeled Concentration (mg/L)**	**HI All Pathways**	**ILCR All Pathways**
2,4-Dinitrotoluene	9.00E-05	NA	9.46E-07
2,6-Dinitrotoluene	4.00E-05	NA	4.15E-07
2,4,6-Trinitrotoluene[b]	6.00E-07	NA	2.72E-10
Total ILCR			1.E-06

COPC - Chemical of potential concern; HQ - Hazard quotient; HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
NA - Not applicable.
mg/L - Milligrams per liter.

[a] Based on year of maximum combined nitroaromatics concentration as described in Appendix E (year 150).
[b] Chemical was not identified as a COPC.

Table 7-1

Comparison of Bedrock Groundwater Inorganics Concentrations to Those of Background
Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical of Potential Concern	Units	TNT Area A Groundwater: Frequency of Detection	TNT Area A Groundwater: Arithmetic Mean Concentration	TNT Area A Groundwater: Maximum Detected Concentration	PBOW Background Groundwater[a]: Frequency of Detection	PBOW Background Groundwater[a]: Arithmetic Mean Concentration	PBOW Background Groundwater[a]: Background UTL	PBOW Background Groundwater[a]: Maximum Detected Concentration	Wilcoxon Rank-Sum (WRS) Test p level	WRS Results Indicate Site-Relatedness?
Metals										
Aluminum	µg/L	3 / 5	1772	8300	11 / 28	90	329	309	0.039	Y
Arsenic	µg/L	2 / 6	31	17	4 / 28	4.9	8.4	7.4	0.002	Y
Iron	µg/L	4 / 5	6757	33400	24 / 28	402	2560	1550	0.481	N
Manganese	µg/L	6 / 6	2300	11700	28 / 28	81	636	688	0.133	N
Nickel	µg/L	2 / 6	34	76	4 / 28	18	41	9	0.091	N

Chemical of Potential Concern	Units	TNT Area B Groundwater: Frequency of Detection	TNT Area B Groundwater: Arithmetic Mean Concentration	TNT Area B Groundwater: Maximum Detected Concentration	PBOW Background Groundwater[a]: Frequency of Detection	PBOW Background Groundwater[a]: Arithmetic Mean Concentration	PBOW Background Groundwater[a]: Background UTL	PBOW Background Groundwater[a]: Maximum Detected Concentration	Wilcoxon Rank-Sum (WRS) Test p level	WRS Results Indicate Site-Relatedness?
Metals										
Aluminum	µg/L	7 / 7	3770	16900	11 / 28	90	329	309	0.003	Y
Arsenic	µg/L	3 / 8	9.1	23	4 / 28	4.9	8.4	7.4	0.036	Y
Iron	µg/L	7 / 8	15198	41700	24 / 28	402	2560	1550	0.008	Y
Manganese	µg/L	8 / 8	518	1140	28 / 28	81	636	688	0.013	Y

Chemical of Potential Concern	Units	PRRWP Area Groundwater: Frequency of Detection	PRRWP Area Groundwater: Arithmetic Mean Concentration	PRRWP Area Groundwater: Maximum Detected Concentration	PBOW Background Groundwater[a]: Frequency of Detection	PBOW Background Groundwater[a]: Arithmetic Mean Concentration	PBOW Background Groundwater[a]: Background UTL	PBOW Background Groundwater[a]: Maximum Detected Concentration	Wilcoxon Rank-Sum (WRS) Test p level	WRS Results Indicate Site-Relatedness?
Metals										
Iron	µg/L	5 / 6	3142	7280	24 / 28	402	2560	1550	0.086	N
Manganese	µg/L	6 / 6	261	1170	28 / 28	81	636	688	0.857	N

Chemical of Potential Concern	Units	Downgradient Groundwater: Frequency of Detection	Downgradient Groundwater: Arithmetic Mean Concentration	Downgradient Groundwater: Maximum Detected Concentration	PBOW Background Groundwater[a]: Frequency of Detection	PBOW Background Groundwater[a]: Arithmetic Mean Concentration	PBOW Background Groundwater[a]: Background UTL	PBOW Background Groundwater[a]: Maximum Detected Concentration	Wilcoxon Rank-Sum (WRS) Test p level	WRS Results Indicate Site-Relatedness?
Metals										
Iron	µg/L	16 / 27	12526	257000	24 / 28	402	2560	1550	0.414	N
Manganese	µg/L	25 / 27	269	4660	28 / 28	81	636	688	0.010	Y

µg/L- Micrograms per liter; UTL- Upper tolerance limit; MDC - Maximum detected concentration.
PRRWP - Pentolite Road Red Water Ponds.

[a] Background screening criteria are presented in the 2004 Data Summary and Evaluation Report (Shaw, 2005).
[b] Site relatedness is indicated if Wilcoxon Rank Sum test p level is less than 0.05.

Table 8-1

Summary of Aggregate Risks by Source Medium
TNT Area A
Former Plum Brook Ordnance Works, Sandusky, Ohio

	Noncancer Hazard			Cancer Risk		
	Groundskeeper[b]	Construction Worker[b]	On-Site Resident[c]	Groundskeeper[b]	Construction Worker[d]	On-Site Resident[e]
Source Medium[a]	Total HI	Total HI	Total HI	Total ILCR	Total ILCR	Total ILCR
Surface Soil	0.6	NA	NA	6.1E-06	NA	NA
Total Soil	NA	60	219	NA	3.5E-04	2.6E-02
Surface Water	NA	0.06	0.03	NA	5.1E-09	9.8E-08
Sediment	NA	NA	NA	NA	6.5E-08	2.4E-07
Groundwater - Overall	10	10	347	2.6E-04	1.0E-05	2.5E-03
Groundwater - Site Related	0.2	0.2	2	1.0E-05	4.1E-07	4.4E-05
Total Across All Media - Overall	**11**	**70**	**566**	**3.E-04**	**4.E-04**	**3.E-02**
Total Across All Media - Site Related	**0.8**	**61**	**221**	**2.E-05**	**4.E-04**	**3.E-02**

HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
NA - Not applicable.

[a] Source media risk results for media other than groundwater are from IT Corporation, 2001, *TNT Areas A and C Remedial Investigation, Volume 2, Human Health Risk Assessment*, Final, Former Plum Brook Ordnance Works, Sandusky, Ohio, Novembe

[b] Groundwater risk values are based on those found in this groundwater baseline human heealth risk assessment (BHHRA) for the site worker.

[c] Values shown are for the child. The adult was not evaluated for noncancer hazard in the TNT A and C BHHRA.

[d] Groundwater risk values shown are for the on-site worker, divided by 25 to reflect the difference in the exposure durations assumed for the on-site worker (25 years) in this BHHRA and the construction worker (1 year) scenario in the TNT Areas A and C BHHRA.

[e] Risk values are based on the combined child and adult exposure scenarios.

Table 8-2

Summary of Aggregate Risks by Source Medium
TNT Area B
Former Plum Brook Ordnance Works, Sandusky, Ohio

	Noncancer Hazard			Cancer Risk		
		Construction			Construction	
	Groundskeeper[b]	Worker[b]	On-Site Resident[c]	Groundskeeper[b]	Worker[d]	On-Site Resident[e]
Source Medium[a]	Total HI	Total HI	Total HI	Total ILCR	Total ILCR	Total ILCR
Surface Soil	16	NA	NA	1.1E-04	NA	NA
Total Soil	NA	71	244	NA	1.6E-05	1.2E-03
Surface Water	NA	0.2	0.04	NA	4.2E-08	4.0E-07
Sediment	NA	2	0.2	NA	8.3E-07	1.2E-06
Groundwater - Overall	2	2	18	7.1E-05	2.9E-06	3.4E-04
Groundwater - Site Related	NA	NA	NA	NA	NA	NA
Total Across All Media - Overall	**18**	**75**	**262**	**2.E-04**	**2.E-05**	**1.E-03**
Total Across All Media - Site Related	**16**	**73**	**244**	**1.E-04**	**2.E-05**	**1.E-03**

HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
NA - Not applicable.

[a] Source media risk results for media other than groundwater are from IT Corporation, 2001, *TNT Area B Remedial Investigation, Volume II, Baseline Human Health Risk Assessment*, Final, Former Plum Brook Ordnance Works, Sandusky, Ohio, August. Note that soil remediation efforts have commence The above soil risk values do not reflect the risk reduction resulting from these efforts.

[b] Groundwater risk values are based on those found in this groundwater baseline human heealth risk assessment (BHHRA) for the site worker.

[c] Values shown are for the child. The adult was not evaluated for noncancer hazard in the TNT Area B BHHRA.

[d] Groundwater risk values shown are for the on-site worker, divided by 25 to reflect the difference in the exposure durations assumed for the on-site worker (25 years) in this BHHRA and the construction worker (1 year) scenario in the TNT Area B BHHRA.

[e] Risk values are based on the combined child and adult exposure scenarios.

Table 8-3

Summary of Aggregate Risks by Source Medium
TNT Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

	Noncancer Hazard			Cancer Risk		
		Construction			Construction	
	Groundskeeper[b]	Worker[b]	On-Site Resident[c]	Groundskeeper[b]	Worker[d]	On-Site Resident[e]
Source Medium[a]	Total HI	Total HI	Total HI	Total ILCR	Total ILCR	Total ILCR
Surface Soil	95	NA	NA	5.4E-04	NA	NA
Total Soil	NA	360	1240	NA	5.0E-05	3.5E-03
Surface Water	NA	0.16	0.08	NA	1.8E-08	3.4E-07
Sediment	NA	14	6	NA	1.4E-06	1.2E-05
Groundwater - Overall	1	1	65	9.4E-05	3.7E-06	1.2E-03
Groundwater - Site Related	NA	NA	NA	NA	NA	NA
Total Across All Media - Overall	**97**	**361**	**1310**	**6.E-04**	**6.E-05**	**5.E-03**
Total Across All Media - Site Related	**95**	**374**	**1246**	**5.E-04**	**5.E-05**	**3.E-03**

HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
NA - Not applicable.

[a] Source media risk results for media other than groundwater are from IT Corporation, 2001, *TNT Areas A and C Remedial Investigation, Volume 2, Human Health Risk Assessment*, Final, Former Plum Brook Ordnance Works, Sandusky, Ohio, Novembe

[b] Groundwater risk values are based on those found in this groundwater baseline human heealth risk assessment (BHHRA) for the site worker.

[c] Values shown are for the child. The adult was not evaluated for noncancer hazard in the TNT A and C BHHRA.

[d] Groundwater risk values shown are for the on-site worker, divided by 25 to reflect the difference in the exposure durations assumed for the on-site worker (25 years) in this BHHRA and the construction worker (1 year) scenario in the TNT Areas A and C BHHRA.

[e] Risk values are based on the combined child and adult exposure scenarios.

Table 8-4

Summary of Aggregate Risks by Source Medium
Pentolite Road Red Water Pond Area
Former Plum Brook Ordnance Works, Sandusky, Ohio

	Noncancer Hazard			Cancer Risk		
	Groundskeeper[b]	Construction Worker[b]	On-Site Resident[c]	Groundskeeper[b]	Construction Worker[d]	On-Site Resident[e]
Source Medium[a]	Total HI	Total HI	Total HI	Total ILCR	Total ILCR	Total ILCR
Surface Soil	0.06	NA	NA	6.2E-07	NA	NA
Total Soil	NA	104	358	NA	1.1E-05	8,5E-4
Surface Water	NA	NA	NA	NA	NA	NA
Sediment	NA	NA	NA	NA	NA	NA
Groundwater - Overall	15	15	235	5.3E-04	2.1E-05	7.3E-03
Groundwater - Site Related	0.3	0.3	2	4.3E-06	1.7E-07	1.9E-05
Total Across All Media - Overall	**16**	**119**	**593**	**5.E-04**	**3.E-05**	**7.E-03**
Total Across All Media - Site Related	**0.06**	**104**	**358**	**5.E-06**	**1.E-05**	**2.E-05**

HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
NA - Not applicable.

[a] Source media risk results for media other than groundwater are from IT Corporation, 2006, *Risk Assessment and Direct-Push Investigation of Red Water Pond Areas*, Final, Former Plum Brook Ordnance Works, Sandusky, Ohio, Augus

[b] Groundwater risk values are based on those found in this groundwater baseline human heealth risk assessment (BHHRA) for the site worker.

[c] Values shown are for the child. The adult was not evaluated for noncancer hazard in the Red Water Pond areas risk assessment.

[d] Groundwater risk values shown are for the on-site worker, divided by 25 to reflect the difference in the exposure durations assumed for the on-site worker (25 years) in this BHHRA and the construction worker (1 year) scenario in the Red Water Pond areas risk assessment.

[e] Risk values are based on the combined child and adult exposure scenarios.

Table 8-5

Summary of Aggregate Risks by Source Medium
West Area Red Water Ponds Area
Former Plum Brook Ordnance Works, Sandusky, Ohio

	Noncancer Hazard			Cancer Risk		
		Construction			Construction	
	Groundskeeper[b]	Worker[b]	On-Site Resident[c]	Groundskeeper[b]	Worker[d]	On-Site Resident[e]
Source Medium[a]	Total HI	Total HI	Total HI	Total ILCR	Total ILCR	Total ILCR
Surface Soil	0.01	NA	NA	7.1E-06	NA	NA
Total Soil	NA	0.2	0.6	NA	5.8E-07	1.5E-05
Surface Water	NA	0.09	0.04	NA	2.3E-08	4.4E-07
Sediment	NA	0.07	0.005	NA	2.1E-07	3.1E-07
Groundwater - Overall	9	9	63	1.1E-04	4.3E-06	4.6E-04
Groundwater - Site Related	9	9	61	5.8E-05	2.3E-06	2.5E-04
Total Across All Media - Overall	**9**	**9**	**64**	**1.E-04**	**5.E-06**	**5.E-04**
Total Across All Media - Site Related	**9**	**9**	**62**	**6.E-05**	**3.E-06**	**3.E-04**

HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
NA - Not applicable.

[a] Source media risk results for media other than groundwater are from IT Corporation, 2006, *Risk Assessment and Direct-Push Investigation of Red Water Pond Areas*, Final, Former Plum Brook Ordnance Works, Sandusky, Ohio, Augus

[b] Groundwater risk values are based on those found in this groundwater baseline human heealth risk assessment (BHHRA) for the site worker.

[c] Values shown are for the child. The adult was not evaluated for noncancer hazard in the Red Water Pond areas risk assessment.

[d] Groundwater risk values shown are for the on-site worker, divided by 25 to reflect the difference in the exposure durations assumed for the on-site worker (25 years) in this BHHRA and the construction worker (1 year) scenario in the Red Water Pond areas risk assessment.

[e] Risk values are based on the combined child and adult exposure scenarios.

Table 9-1

Risk-Based Remediation Criteria for Bedrock Groundwater
TNT Area A, Former Plum Brook Ordnance Works
Sandusky, Ohio

Risk-Driver Chemical[a]	Exposure Point Concentration (mg/L)	Background Screening Concentration (mg/L)	On-Site Worker RBRCs[b] (mg/L)				On-Site Resident RBRCs[b] (mg/L)			
			Cancer		Noncancer		Cancer		Noncancer	
			Target Risk Level		Target Hazard Index		Target Risk Level		Target Hazard Index[c]	
			1.0E-06	1.0E-05	0.1	1	1.0E-06	1.0E-05	0.1	1
Metals										
Aluminum	8.3	0.31	--	--	10	102	--	--	1.6	16
Arsenic	0.017	0.0074	0.0002	0.0019	0.0031	0.031	0.00004	0.0004	0.0005	0.0047
Chromium	0.037	NA	--	--	0.027	0.27	--	--	0.0043	0.043
Iron	33	1.6	--	--	3.1	31	--	--	0.47	4.7
Manganese	12	0.64			0.25	2.5	--	--	0.038	0.38
Nickel	0.076	0.0086	--	--	0.20	2.0	--	--	0.031	0.31
Vanadium	0.037	NA	--	--	0.0092	0.092	--	--	0.0015	0.015
Explosives										
2,4-Dinitrotoluene	*0.0005*	NA	*0.0004*	*0.0041*	*0.020*	*0.20*	*0.0001*	*0.0010*	*0.0030*	*0.030*
2,6-Dinitrotoluene	*0.0036*	NA	*0.0004*	*0.0041*	*0.010*	*0.10*	*0.0001*	*0.0010*	*0.0015*	*0.015*
2-Nitrotoluene	*0.0003*	NA	*0.0012*	*0.012*	*0.96*	*9.6*	*0.0003*	*0.0028*	*0.15*	*1.5*
4-Amino-2,6-dinitrotoluene	*0.0013*	NA	--	--	*0.002*	*0.02*	--	--	*0.0003*	*0.0031*
Nitrobenzene	*0.0020*	NA	--	--	*0.0049*	*0.049*	--	--	*0.0001*	*0.0014*
Semivolatile Organic Compounds										
2-Methylnaphthalene	0.47	NA	--	--	0.12	1.2	--	--	0.0003	0.0027
Bis(2-ethylhexyl)phthalate	0.0082	NA	0.012	0.12	0.12	1.2	0.0025	0.025	0.017	0.17
Chrysene	0.015	NA	0.0055	0.055	--	--	0.0010	0.010	--	--
Dibenzofuran	0.012	NA	--	--	0.014	0.14	--	--	0.0024	0.024
Naphthalene	0.17	NA	--	--	0.15	1.5	--	--	0.0003	0.0027
Phenanthrene	0.074	NA	--	--	0.13	1.3	--	--	0.027	0.27
Volatile Organic Compounds										
Benzene	0.70	0.0024	0.0048	0.048	0.038	0.38	0.0003	0.0035	0.0019	0.019
Chloromethane	0.035	NA	--	--	--	--	--	--	0.0081	0.081
Ethylbenzene	0.24	0.00087	--	--	0.79	7.9	--	--	0.054	0.54
Methylene chloride	0.33	NA	0.037	0.37	0.60	6.0	0.0043	0.043	0.069	0.69
Toluene	0.73	0.0017	--	--	1.8	18	--	--	0.031	0.31
Xylenes, total	1.4	0.0055	--	--	1.6	16	--	--	0.0088	0.088

HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
NA - Background screening concentration is either unavailable or not applicable.
mg/L - Milligram per liter.
"--" indicates that no cancer and/or noncancer toxicity value is available, at least for the pathways represented by this receptor.

[a] Risk-driver chemicals are identified as those with an ILCR greater than 1E-6, or that contribute a noncancer hazard quotient of at least 0.1 to a target organ-specific total hazard index that is greater than 1. Shaded italics indicates that the chemical is regarded as site-related. Concerning site relatedness, refer to Section 6.2 and Appendix H.

[b] Risk-based remediation criteria (RBRC) are derived by back-calculation, using the baseline human health risk assessment methodologies and assumptions, and the specified target HI and ILCR values.

[c] For conservativeness, value is based on exposure during childhood.

Table 9-2

Risk-Based Remediation Criteria for Bedrock Groundwater
TNT Area B, Former Plum Brook Ordnance Works
Sandusky, Ohio

Risk-Driver Chemical[a]	Exposure Point Concentration (mg/L)	Background Screening Concentration (mg/L)	On-Site Worker RBRCs[b] (mg/L)				On-Site Resident RBRCs[b] (mg/L)			
			Cancer		Noncancer		Cancer		Noncancer	
			Target Risk Level		Target Hazard Index		Target Risk Level		Target Hazard Index[c]	
			1.0E-06	1.0E-05	0.1	1	1.0E-06	1.0E-05	0.1	1
Metals										
Aluminum	16.9	0.31	--	--	10	102	--	--	1.6	16
Arsenic	0.013	0.0074	0.00019	0.0019	0.0031	0.031	0.00004	0.0004	0.0005	0.0047
Chromium	0.030	NA	--	--	0.027	0.27	--	--	0.004	0.043
Iron	*25.6*	*1.6*	--	--	*3.1*	*31*	--	--	*0.47*	*4.7*
Manganese	*0.79*	*0.64*	--	--	*0.25*	*2.5*	--	--	*0.038*	*0.38*
Vanadium	0.025	NA	--	--	0.0092	0.092	--	--	0.0015	0.015
Semivolatile Organic Compounds										
2-Methylnaphthalene	0.0048	NA	--	--	0.12	1.2	--	--	0.0003	0.0027
Naphthalene	0.0028	NA	--	--	0.15	1.5	--	--	0.0003	0.0027
Volatile Organic Compounds										
Benzene	0.017	0.0024	0.0048	0.048	0.038	0.38	0.0003	0.0035	0.0019	0.019

HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
NA - Background screening concentration is either unavailable or not applicable.
mg/L - Milligrams per liter.
"--" indicates that no cancer toxicity value is available.

[a] Risk-driver chemicals are identified as those with an ILCR greater than 1E-6, or that contribute a noncancer hazard quotient of at least 0.1 to a target organ-specific total hazard index that is greater than 1. Shaded italics indicates that the chemical is regarded as site-related. Concerning site relatedness, refer to Section 6.2 and Appendix H.

[b] Risk-based remediation criteria (RBRC) are derived by back-calculation, using the baseline human health risk assessment methodologies and assumptions, and the specified target HI and ILCR values.

[c] For conservativeness, value is based on exposure during childhood.

Table 9-3

Risk-Based Remediation Criteria for Bedrock Groundwater
TNT Area C, Former Plum Brook Ordnance Works
Sandusky, Ohio

Risk-Driver Chemical[a,b]	Exposure Point Concentration (mg/L)	Background Screening Concentration (mg/L)	On-Site Worker RBRCs[c] (mg/L)				On-Site Resident RBRCs[c] (mg/L)			
			Cancer		Noncancer		Cancer		Noncancer	
			Target Risk Level		Target Hazard Index		Target Risk Level		Target Hazard Index[d]	
			1.0E-06	1.0E-05	0.1	1	1.0E-06	1.0E-05	0.1	1
Semivolatile Organic Compounds										
2-Methylnaphthalene	0.027	NA	--	--	0.12	1.2	--	--	0.0003	0.0027
Bis(2-ethylhexyl)phthalate	0.055	NA	0.012	0.12	0.12	1.2	0.0025	0.025	0.017	0.17
Naphthalene	0.034	NA	--	--	0.15	1.5	--	--	0.0003	0.0027
Volatile Organic Compounds										
Benzene	0.41	0.0024	0.0048	0.048	0.038	0.38	0.0003	0.0035	0.0019	0.019
Bromomethane	0.013	NA	--	--	0.014	0.14	--	--	0.0004	0.0036
Methylene chloride	0.16	NA	0.037	0.37	0.60	6.0	0.0043	0.043	0.069	0.69
Toluene	0.30	0.0017	--	--	1.8	18	--	--	0.031	0.31
Xylenes, total	1.3	0.0055	--	--	1.6	16	--	--	0.0088	0.088

HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
NA - Not applicable.
mg/L - Milligrams per liter.
"--" indicates that no cancer toxicity value is available.

[a] Risk-driver chemicals are identified as those with an ILCR greater than 1E-6, or that contribute a noncancer hazard quotient of at least 0.1 to a target organ-specific total hazard index that is greater than 1.

[b] None of the TNT Area C risk driver chemicals were identified as site related. Refer to Section 6.2 and Appendix H.

[c] Risk-based remediation criteria (RBRC) are derived by back-calculation, using the baseline human health risk assessment methodologies and assumptions, and the specified target HI and ILCR values.

[d] For conservativeness, value is based on exposure during childhood.

Table 9-4

Risk-Based Remediation Criteria for Bedrock Groundwater
Pentolite Road Red Water Pond Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

Risk-Driver Chemical[a]	Exposure Point Concentration (mg/L)	Background Screening Concentration (mg/L)	On-Site Worker RBRCs[b] (mg/L)				On-Site Resident RBRCs[b] (mg/L)			
			Cancer		Noncancer		Cancer		Noncancer	
			Target Risk Level		Target Hazard Index		Target Risk Level		Target Hazard Index[c]	
			1.0E-06	1.0E-05	0.1	1	1.0E-06	1.0E-05	0.1	1
Metals										
Chromium	0.021	NA	--	--	0.027	0.27	--	--	0.0043	0.043
Iron	*7.3*	*1.6*	--	--	*3.1*	*31*	--	--	*0.47*	*4.7*
Manganese	1.2	0.64	--	--	0.25	2.45	--	--	0.038	0.38
Thallium	0.051	NA	--	--	0.0007	0.0066	--	--	0.0001	0.0010
Explosives										
2,4-Dinitrotoluene	*0.0009*	*NA*	*0.0004*	*0.0041*	*0.020*	*0.20*	*0.0001*	*0.0010*	*0.0030*	*0.030*
2,6-Dinitrotoluene	*0.0009*	*NA*	*0.0004*	*0.0041*	*0.010*	*0.10*	*0.0001*	*0.0010*	*0.0015*	*0.015*
4-Amino-2,6-dinitrotoluene	*0.0010*	*NA*	--	--	*0.0020*	*0.020*	--	--	*0.0003*	*0.0031*
Nitrobenzene	*0.0004*	*NA*	--	--	*0.0049*	*0.049*	--	--	*0.0001*	*0.0014*
Semivolatile Organic Compounds										
2-Methylnaphthalene	0.035	NA	--	--	0.12	1.2	--	--	0.0003	0.0027
4-Methylphenol	0.043	NA	--	--	0.049	0.49	--	--	0.0074	0.074
Bis(2-ethylhexyl)phthalate	0.037	NA	0.012	0.12	0.12	1.2	0.0025	0.025	0.017	0.17
Naphthalene	0.03	NA	--	--	0.15	1.5	--	--	0.0003	0.0027
Volatile Organic Compounds										
1,1,2-Trichloroethane	0.0049	NA	0.0048	0.048	0.039	0.39	0.0002	0.0020	0.0061	0.061
Benzene	2.5	0.0024	0.0048	0.048	0.038	0.38	0.0003	0.0035	0.0019	0.019
Ethylbenzene	0.20	0.00087	--	--	0.79	7.9	--	--	0.054	0.54
Methylene chloride	0.16	NA	0.037	0.37	0.60	6.0	0.0043	0.043	0.069	0.69
Toluene	0.95	0.0017	--	--	1.8	18	--	--	0.031	0.31
Xylenes, total	1.4	0.0055	--	--	1.6	16	--	--	0.0088	0.088

HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
NA - Background screening concentration is either unavailable or not applicable.
mg/L - Milligrams per liter.
"--" indicates that no cancer toxicity value is available.

[a] Risk-driver chemicals are identified as those with an ILCR greater than 1E-6, or that contribute a noncancer hazard quotient of at least 0.1 to a target organ-specific total hazard index that is greater than 1. Shaded italics indicates that the chemical is regarded as site-related. Concerning site relatedness, refer to Section 6.2 and Appendix H.

[b] Risk-based remediation criteria (RBRC) are derived by back-calculation, using the baseline human health risk assessment methodologies and assumptions, and the specified target HI and ILCR values.

[c] For conservativeness, value is based on exposure during childhood.

Table 9-5

Risk-Based Remediation Criteria for Bedrock Groundwater
West Area Red Water Ponds Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

Risk-Driver Chemical[a]	Exposure Point Concentration (mg/L)	Background Screening Concentration (mg/L)	On-Site Worker RBRCs[b] (mg/L)				On-Site Resident RBRCs[b] (mg/L)			
			Cancer		Noncancer		Cancer		Noncancer	
			Target Risk Level		Target Hazard Index		Target Risk Level		Target Hazard Index[c]	
			1.0E-06	1.0E-05	0.1	1	1.0E-06	1.0E-05	0.1	1
Metals										
Arsenic	0.010	0.0074	0.0002	0.0019	0.0031	0.031	0.00004	0.0004	0.0005	0.0047
Cobalt	*0.27*	*0.012*	--	--	*0.2*	*2.0*	--	--	*0.031*	*0.31*
Vanadium	0.0055	NA	--	--	0.0092	0.092	--	--	0.0015	0.015
Explosives										
2,4-Dinitrotoluene	*0.019*	*NA*	*0.0004*	*0.0041*	*0.020*	*0.20*	*0.0001*	*0.0010*	*0.0030*	*0.030*
4,6-Dinitro-2-methylphenol	*0.028*	*NA*	--	--	*0.0010*	*0.010*	--	--	*0.0002*	*0.0015*
3-Nitroaniline	*0.15*	*NA*	*0.013*	*0.13*	*0.0030*	*0.030*	*0.0031*	*0.031*	*0.0005*	*0.0046*
Nitrobenzene	*0.0058*	*NA*	--	--	*0.0049*	*0.049*	--	--	*0.0001*	*0.0014*
Volatile Organic Compounds										
Benzene	0.0011	0.0024	0.0048	0.048	0.038	0.38	0.0003	0.0035	0.0019	0.019
Miscellaneous										
Nitrate	*79*	*NA*	--	--	*16*	*162*	--	--	*2.5*	*25*
Nitrate-Nitrite	*0.30*	*NA*	--	--	*1.0*	*10*	--	--	*0.16*	*1.6*

HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
NA - Background screening concentration is either unavailable or not applicable.
mg/L - Milligrams per liter.
"--" indicates that no cancer toxicity value is available.

[a] Risk-driver chemicals are identified as those with an ILCR greater than 1E-6, or that contribute a noncancer hazard quotient of at least 0.1 to a target organ-specific total hazard index that is greater than 1. Shaded italics indicates that the chemical is regarded as site-related. Concerning site relatedness, refer to Section 6.2 and Appendix H.

[b] Risk-based remediation criteria (RBRC) are derived by back-calculation, using the baseline human health risk assessment methodologies and assumptions, and the specified target HI and ILCR values.

[c] For conservativeness, value is based on exposure during childhood.

Table 9-6

Risk-Based Remediation Criteria for Bedrock Groundwater
Downgradient Areas at the Facility Boundary, Former Plum Brook Ordnance Works
Sandusky, Ohio

Risk-Driver Chemical[a]	Exposure Point Concentration (mg/L)	Background Screening Concentration (mg/L)	Resident RBRCs[b] (mg/L)			
			Cancer		Noncancer	
			Target Risk Level		Target Hazard Index[c]	
			1.00E-06	1.00E-05	0.1	1
Metals						
Iron	257	1.6	--	--	0.47	4.7
Manganese	4.7	0.64	--	--	0.038	0.38
Explosives						
2,4-Dinitrotoluene	*0.0015*	*NA*	*0.00010*	*0.0010*	*0.0030*	*0.030*
2,6-Dinitrotoluene	*0.0014*	*NA*	*0.00010*	*0.0010*	*0.0015*	*0.015*
Semivolatile Organic Compounds						
2-Methylnaphthalene	0.024	NA	--	--	0.00027	0.0027
Bis(2-ethylhexyl)phthalate	0.010	NA	0.0025	0.025	0.017	0.17
Naphthalene	0.018	NA	--	--	0.00027	0.0027
Volatile Organic Compounds						
Benzene	0.13	0.0024	0.00035	0.0035	0.0019	0.019
Xylenes, total	0.56	0.0055	--	--	0.0088	0.088
Miscellaneous						
Cyanide, total	0.32	NA	--	--	0.031	0.31

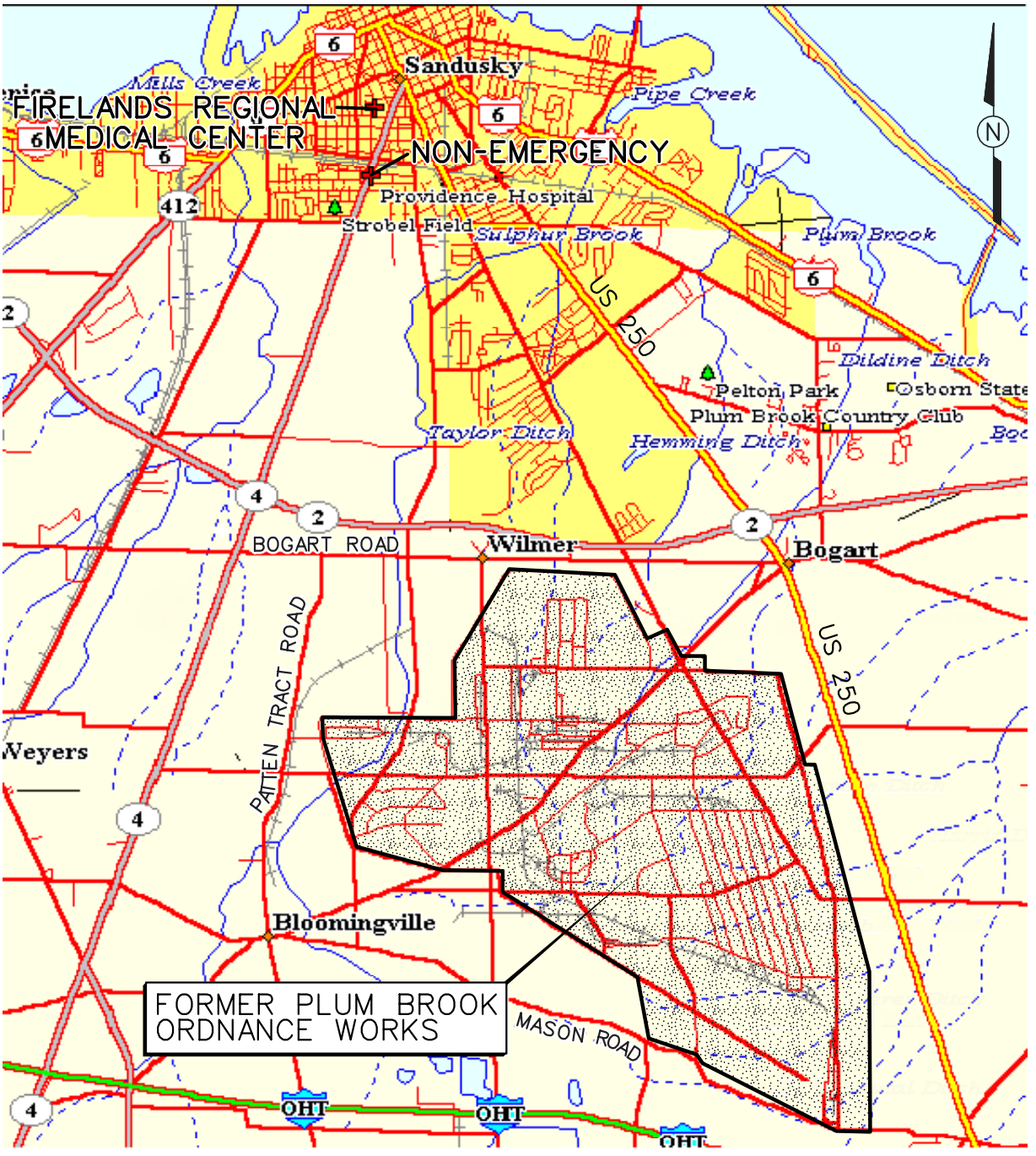
HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
NA - Background screening concentration is either unavailable or not applicable.
mg/L - Milligrams per liter.
"--" indicates that no cancer toxicity value is available.

[a] Risk-driver chemicals are identified as those with an ILCR greater than 1E-6, or that contribute a noncancer hazard quotient of at least 0.1 to a target organ-specific total hazard index that is greater than 1. Shaded italics indicates that the chemical is regarded as site-related. Concerning site relatedness, refer to Section 6.2 and Appendix H.

[b] Risk-based remediation criteria (RBRC) are derived by back-calculation, using the baseline human health risk assessment methodologies and assumptions, and the specified target HI and ILCR values.

[c] For conservativeness, value is based on exposure during childhood.

FIGURES



NOT TO SCALE

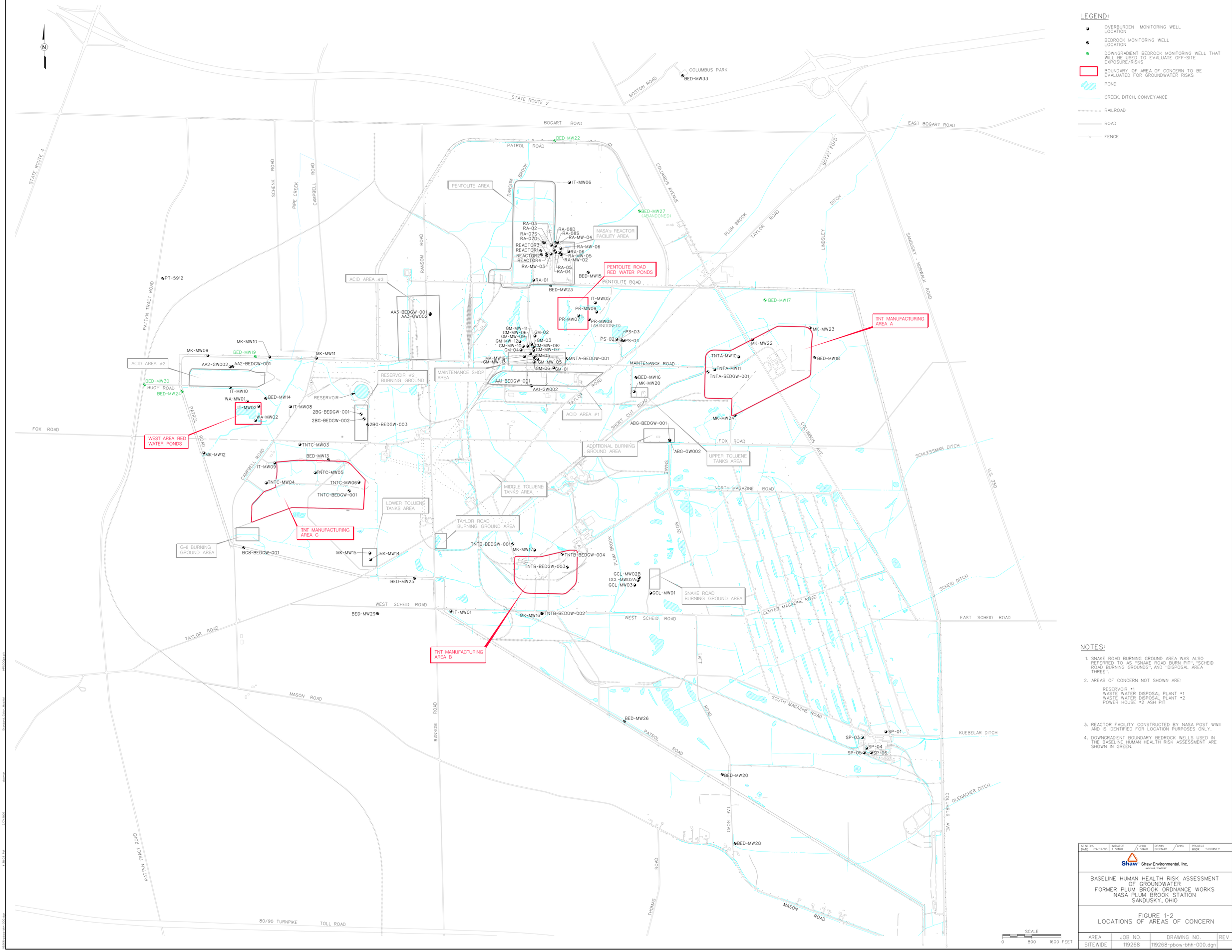
FIGURE 1-1
VICINITY MAP

BASELINE HUMAN HEALTH
RISK ASSESSMENT OF GROUNDWATER
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw® Shaw Environmental, Inc.

STARTING DATE: 09/26/06 | DATE LAST REV.: | DRAFT. CHCK. BY: | INITIATOR: T. SIARD | DWG. NO.: 833886ES.007
DRAWN BY: D. BOMAR | DRAWN BY: | ENGR. CHCK. BY: T. SIARD | PROJ. MGR.: S. DOWNEY | PROJ. NO.: 119268

Standard_Color_Mod.tbl dbomar 833886es.007 Canon-color-Letter.plt 10:24:13 AM 9/26/2006


LEGEND:
OVERBURDEN MONITORING WELL LOCATION
BEDROCK MONITORING WELL LOCATION
DOWNGRADIENT BEDROCK MONITORING WELL THAT WILL BE USED TO EVALUATE OFF-SITE EXPOSURE/RISKS
BOUNDARY OF AREA OF CONCERN TO BE EVALUATED FOR GROUNDWATER RISKS
POND
CREEK, DITCH, CONVEYANCE
RAILROAD
ROAD
FENCE
STATE ROUTE 2
BOGART ROAD
EAST BOGART ROAD
STATE ROUTE 4
SCHENK ROAD
PIPE CREEK
CAMPBELL ROAD
PATROL ROAD
RANSOM BROOK
COLUMBUS AVENUE
BOTAT ROAD
PLUM BROOK
TAYLOR ROAD
LINDSLEY DITCH
SANDUSKY - NORWALK ROAD
BOSTON ROAD
COLUMBUS PARK
BED-MW33
BED-MW22
BED-MW27 (ABANDONED)
IT-MW06
PENTOLITE AREA
NASA's REACTOR FACILITY AREA
RA-03
RA-02
RA-07S
RA-07D
RA-08D
RA-08S
RA-MW-04
REACTOR3
REACTOR1
REACTOR2
REACTOR4
RA-MW-06
RA-06
RA-MW-05
RA-MW-02
RA-MW-03
RA-05
RA-04
RA-01
BED-MW15
PENTOLITE ROAD RED WATER PONDS
PENTOLITE ROAD
BED-MW23
IT-MW05
PR-MW09
PR-MW07
PR-MW08 (ABANDONED)
BED-MW17
TNT MANUFACTURING AREA A
MK-MW23
MK-MW22
BED-MW18
PS-03
PS-02
PS-04
GM-MW-11
GM-MW-06
GM-MW-09
GM-MW-12
GM-MW-10
GM-MW-13
GM-04
GM-02
GM-03
GM-MW-08
GM-MW-07
GM-MW-05
GM-06
GM-01
MNTA-BEDGW-001
MK-MW19
TNTA-MW10
TNTA-MW11
TNTA-BEDGW-001
MAINTENANCE ROAD
MAINTENANCE SHOP AREA
BED-MW16
MK-MW20
AA1-BEDGW-001
AA1-GW002
TAYLOR ROAD
ACID AREA #1
SHORT CUT ROAD
MK-MW24
ABG-BEDGW-001
ABG-GW002
ADDITIONAL BURNING GROUND AREA
UPPER TOLUENE TANKS AREA
COLUMBUS AVE.
FOX ROAD
SCHLESSMAN DITCH
U.S. 250
NORTH MAGAZINE ROAD
MIDDLE TOLUENE TANKS AREA
LOWER TOLUENE TANKS AREA
TAYLOR ROAD BURNING GROUND AREA
PLUM BROOK ROAD
TNTB-BEDGW-001
MK-MW37
TNTB-BEDGW-004
TNTB-BEDGW-003
GCL-MW02B
GCL-MW02A
GCL-MW03
GCL-MW01
SNAKE ROAD BURNING GROUND AREA
SCHEID DITCH
CENTER MAGAZINE ROAD
EAST SCHEID ROAD
WEST SCHEID ROAD
BED-MW29
IT-MW01
MK-MW16
TNTB-BEDGW-002
TNT MANUFACTURING AREA B
TAFT ROAD
SOUTH MAGAZINE ROAD
BED-MW26
BED-MW20
BED-MW28
SP-01
SP-03
SP-04
SP-05
SP-06
KUEBELAR DITCH
OLENACHER DITCH
THOMAS ROAD
MASON ROAD
80/90 TURNPIKE
TOLL ROAD
PATTEN TRACT ROAD
PT-5912
ACID AREA #3
AA3-BEDGW-001
AA3-GW002
MK-MW10
MK-MW09
BED-MW19
MK-MW11
ACID AREA #2
AA2-GW002
AA2-BEDGW-001
BED-MW30
BUOY ROAD
BED-MW24
IT-MW10
WA-MW01
BED-MW14
RESERVOIR
RESERVOIR #2 BURNING GROUND
IT-MW02
WA-MW02
IT-MW08
2BG-BEDGW-001
2BG-BEDGW-002
2BG-BEDGW-003
WEST AREA RED WATER PONDS
MK-MW12
TNTC-MW03
BED-MW13
IT-MW09
TNTC-MW05
TNTC-MW04
TNTC-MW06
TNTC-BEDGW-001
TNT MANUFACTURING AREA C
G-8 BURNING GROUND AREA
BG8-BEDGW-001
MK-MW15
MK-MW14
BED-MW25
NOTES:
1. SNAKE ROAD BURNING GROUND AREA WAS ALSO REFERRED TO AS "SNAKE ROAD BURN PIT", "SCHEID ROAD BURNING GROUNDS", AND "DISPOSAL AREA THREE".
2. AREAS OF CONCERN NOT SHOWN ARE:
RESERVOIR #1
WASTE WATER DISPOSAL PLANT #1
WASTE WATER DISPOSAL PLANT #2
POWER HOUSE #2 ASH PIT
3. REACTOR FACILITY CONSTRUCTED BY NASA POST WWII AND IS IDENTIFIED FOR LOCATION PURPOSES ONLY.
4. DOWNGRADIENT BOUNDARY BEDROCK WELLS USED IN THE BASELINE HUMAN HEALTH RISK ASSESSMENT ARE SHOWN IN GREEN.
SCALE
0 800 1600 FEET
STARTING DATE 09/07/06
INITIATOR T. SIARD
CHKD / T. SIARD
DRAWN D.BOMAR
CHKD
PROJECT MNGR S.DOWNEY
Shaw Environmental, Inc.
KNOXVILLE, TENNESSEE
BASELINE HUMAN HEALTH RISK ASSESSMENT OF GROUNDWATER FORMER PLUM BROOK ORDNANCE WORKS NASA PLUM BROOK STATION SANDUSKY, OHIO
FIGURE 1-2
LOCATIONS OF AREAS OF CONCERN
AREA SITEWIDE
JOB NO. 119268
DRAWING NO. 119268-pbow-bhh-000.dgn
REV

DRAFT. CHCK. BY:
ENGR. CHCK. BY:
INITIATOR: T. SIARD
PROJ. MGR.: S. DOWNEY
STARTING DATE: 09/07/06
DRAWN BY: D. BOMAR
DATE LAST REV.:
DRAWN BY:
PROJ. NO.: 119268
DWG NO.: 119268-pbow-bhh-001.dgn
Standard_Color_Mod.tbl Canon-color-tabloid.plt
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119268-pbow-bhh-001.dgn 9/22/2006

N

TNTA-DP23
TNTA-DP24
TNTA-DP26
MK-MW23
WASTEWATER SETTLING TANKS & PUMP HOUSE NO. BUILDING 187
NAILING HOUSE BUILDING 128
CONVEYOR
WASH HOUSE BUILDING BUILDING 116
TNTA-GW04
MK-MW22
TNTA-GW06
WASH HOUSE BUILDING 126
FORTIFIER HOUSE BUILDING 113
TNTA-DP25
BI-TRI HOUSE BUILDING 112
TNTA-GW02
FORTIFIER HOUSE BUILDING 123
ACID FUME RECOVERY BUILDING 129
TNTA-DP29
MONO HOUSE BUILDING 111
BI-TRI HOUSE BUILDING 122
TNTA-GW01
NAILING HOUSE BUILDING 148
TNTA-MW10
TNTA-DP22
ACID & FUME RECOVERY BUILDING 119
BED-MW18
WASH HOUSE LINE 3 BUILDING 136
WATER CLARIFICATION BUILDING 186
DNT NITRATING BUILDING 185
TNTA-GW10
TNTA-GW03
CHANGE HOUSE BUILDING 117
MONO HOUSE BUILDING 121
TNTA-DP18
TNTA-DP19
SUPT. BUILDING 114
TNTA-MW11
TNTA-DP20
TNTA-DP21
TNTA-BEDGW-001
FORTIFIER HOUSE BUILDING 133
BI-TRI HOUSE BUILDING 132
TIME CLOCK ALLEY BUILDING 127-A
TNTA-GW05
CURRENT NASA ADMINISTRATION BUILDING AND PARKING AREA
WASH HOUSE LINE 4 BUILDING 146
TNTA-DP17
ACID & FUME RECOVERY BUILDING 139
FORTIFIER HOUSE BUILDING 143
DNT SWEATING & GRAINING HOUSE BUILDING 182
TNTA-DP14
LINE SUPT. BUILDING 124
CONTROL LAB BUILDING 120
TNTA-GW08
MONO HOUSE BUILDING 131
LINE SUPT. BUILDING 144
BI-TRI HOUSE BUILDING 142
CONTROL LAB BUILDING140
ACID & FUME RECOVERY BUILDING 149
TNTA-DP11
MONO HOUSE BUILDING 141
DNT NITRATING BUILDING 195
CHANGE HOUSE BUILDING 147
MAINT. SHOP BUILDING 197
TNTA-GW07
DNT SWEATING & GRAINING HOUSE BUILDING 192
MK-MW24

LEGEND

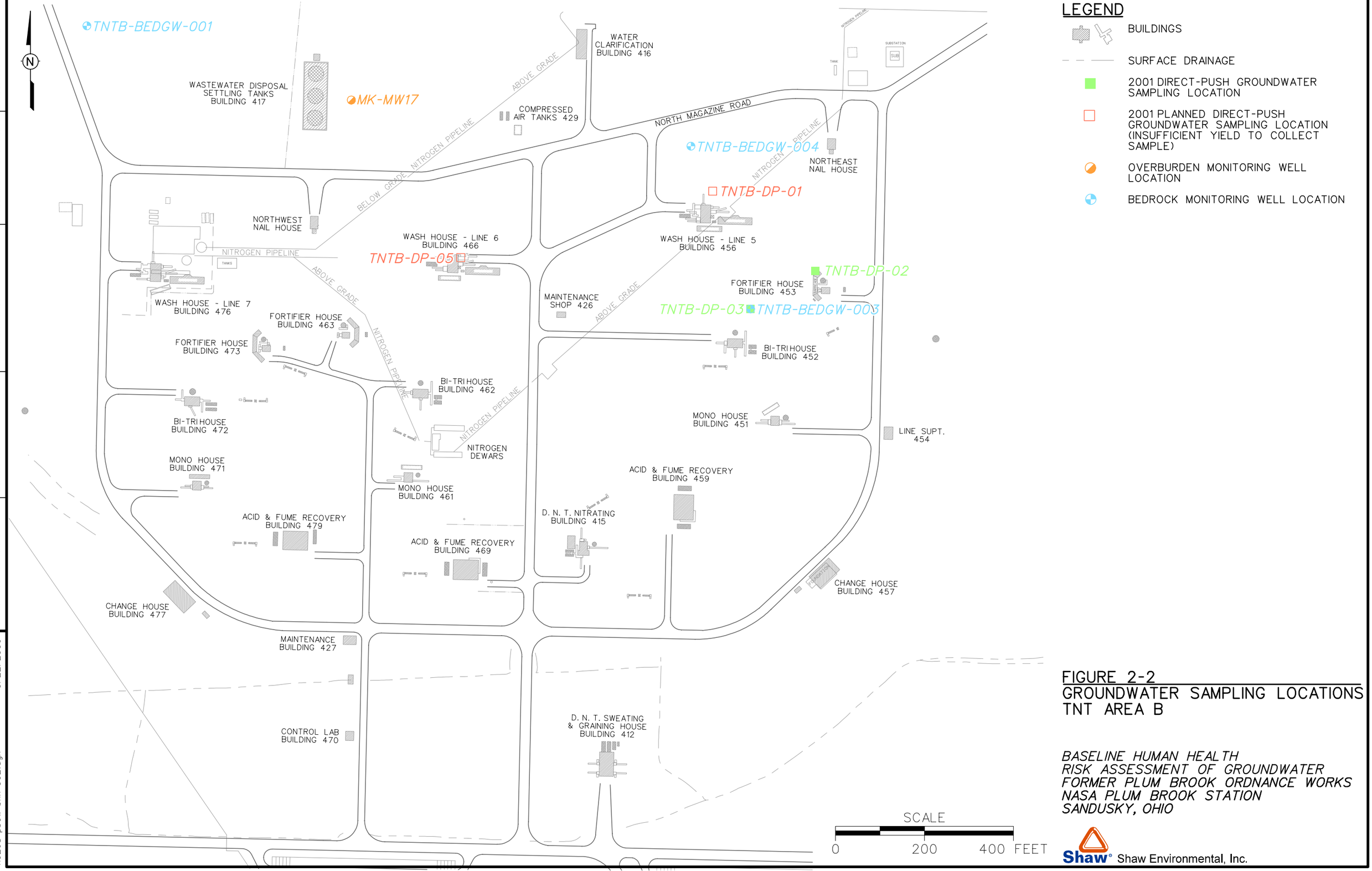
- BUILDINGS
- SURFACE DRAINAGE
- SURFACE WATER
- 2000 DIRECT-PUSH GROUNDWATER SAMPLING LOCATION
- 2001 DIRECT-PUSH GROUNDWATER SAMPLING LOCATION
- 2001 PLANNED DIRECT-PUSH GROUNDWATER SAMPLING LOCATION (INSUFFICIENT YIELD TO COLLECT SAMPLE)
- OVERBURDEN MONITORING WELL LOCATION
- BEDROCK MONITORING WELL LOCATION

SCALE
0 300 600 FEET

FIGURE 2-1
GROUNDWATER SAMPLING LOCATIONS TNT AREA A

BASELINE HUMAN HEALTH RISK ASSESSMENT OF GROUNDWATER FORMER PLUM BROOK ORDNANCE WORKS NASA PLUM BROOK STATION SANDUSKY, OHIO

Shaw® Shaw Environmental, Inc.



LEGEND

- BUILDINGS
- SURFACE DRAINAGE
- 2001 DIRECT-PUSH GROUNDWATER SAMPLING LOCATION
- 2001 PLANNED DIRECT-PUSH GROUNDWATER SAMPLING LOCATION (INSUFFICIENT YIELD TO COLLECT SAMPLE)
- OVERBURDEN MONITORING WELL LOCATION
- BEDROCK MONITORING WELL LOCATION

FIGURE 2-2
GROUNDWATER SAMPLING LOCATIONS TNT AREA B

BASELINE HUMAN HEALTH RISK ASSESSMENT OF GROUNDWATER FORMER PLUM BROOK ORDNANCE WORKS NASA PLUM BROOK STATION SANDUSKY, OHIO

Shaw® Shaw Environmental, Inc.

DRAWN BY: dbomar
STARTING DATE: 08/31/06
DRAWN BY: D. BOMAR
DATE LAST REV.:
DRAFT. CHCK. BY:
ENGR. CHCK. BY:
INITIATOR: T. SIARD
PROJ. MGR.: S. DOWNEY
PROJ. NO.: 119268
Standard_Color_Mod.tbl Canon-color-tabloid.plt 8:35:20 AM 9/22/2006
119268-pbow-bhh-002.dgn

DRAFT. CHCK. BY:
ENGR. CHCK. BY:
INITIATOR: T. SIARD
PROJ. MGR.: S. DOWNEY
STARTING DATE: 09/07/06
DRAWN BY: D. BOMAR
DATE LAST REV.:
DRAWN BY:
PROJ. NO.: 119268
Standard_Color_Mod.tbl Canon-color-tabloid.plt
dbomar 8:37:41 AM 9/22/2006
119268-pbow-bhh-003.dgn

N

WASTEWATER SETTLING BASINS BUILDING 657
TNTC-MW03
PUMP HOUSE
BED-MW13
IT-MW09
NAILING HOUSE BUILDING 618
NAILING HOUSE BUILDING 628
CAMPBELL STREET
TNTC-DP13
TNTC-MW05
COMPRESSED AIR RECEIVER TANKS BUILDING 679
NAILING HOUSE BUILDING 698
WASH HOUSE BUILDING 616
TNTC-DP16
TNTC-DP17
TNTC-GW05
WASH HOUSE - LINE 10 BUILDING 606
TNTC-DP18
TNTC-DP19
TNTC-DP20
MAINTENANCE SHOP
WASH HOUSE - LINE 9 BUILDING 696
TNTC-MW06
WASH HOUSE - LINE 8 BUILDING 686
TNTC-MW04
WASH HOUSE - LINE 12 BUILDING 626
TNTC-DP11
TNTC-DP15
TNTC-GW04
TNTC-DP14
FORTIFIER HOUSE BUILDING 613
FORTIFIER HOUSE BUILDING 603
TNTC-GW03
BI-TRI BUILDING 602
BI-TRI BUILDING 692
TNTC-GW06
TNTC-GW07
BEDGW-001
TNTC-GW08
TNTC-GW02
FORTIFIER HOUSE BUILDING 693
FORTIFIER HOUSE BUILDING 683
BI-TRI HOUSE BUILDING 612
TNTC-DP12
FORTIFIER HOUSE BUILDING 623
ACID & FUME RECOVERY BUILDING 609
MONO HOUSE BUILDING 601
ACID & FUME RECOVERY BUILDING 699
TNTC-DP22
TNTC-DP24
MAINTENANCE SHOP BUILDING 667
TNTC-DP29
MONO HOUSE BUILDING 611
TNTC-GW10
MONO HOUSE BUILDING 691
TNTC-DP31
BI-TRI HOUSE BUILDING 622
ACID & FUME RECOVERY BUILDING 629
TNTC-GW01
ACID & FUME RECOVERY BUILDING 619
TNTC-GW09
ACID & FUME RECOVERY BUILDING 689
MONO HOUSE BUILDING 621
CONTROL LAB
LINE SUPT. BUILDING 604
CONTROL LAB BUILDING 690
CHANGE HOUSE BUILDING 687
MAINTENANCE SHOP BUILDING 668
LINE SUPT. BUILDING 614
PARKING 150 CARS
INTER TOLUENE STORAGE TANK BUILDING 695
LINE SUPT. BUILDING 684
INTER TOLUENE STORAGE TANK BUILDING 615
CHANGE HOUSE BUILDING 627
TIME CLOCK ALLEY 627-A

LEGEND

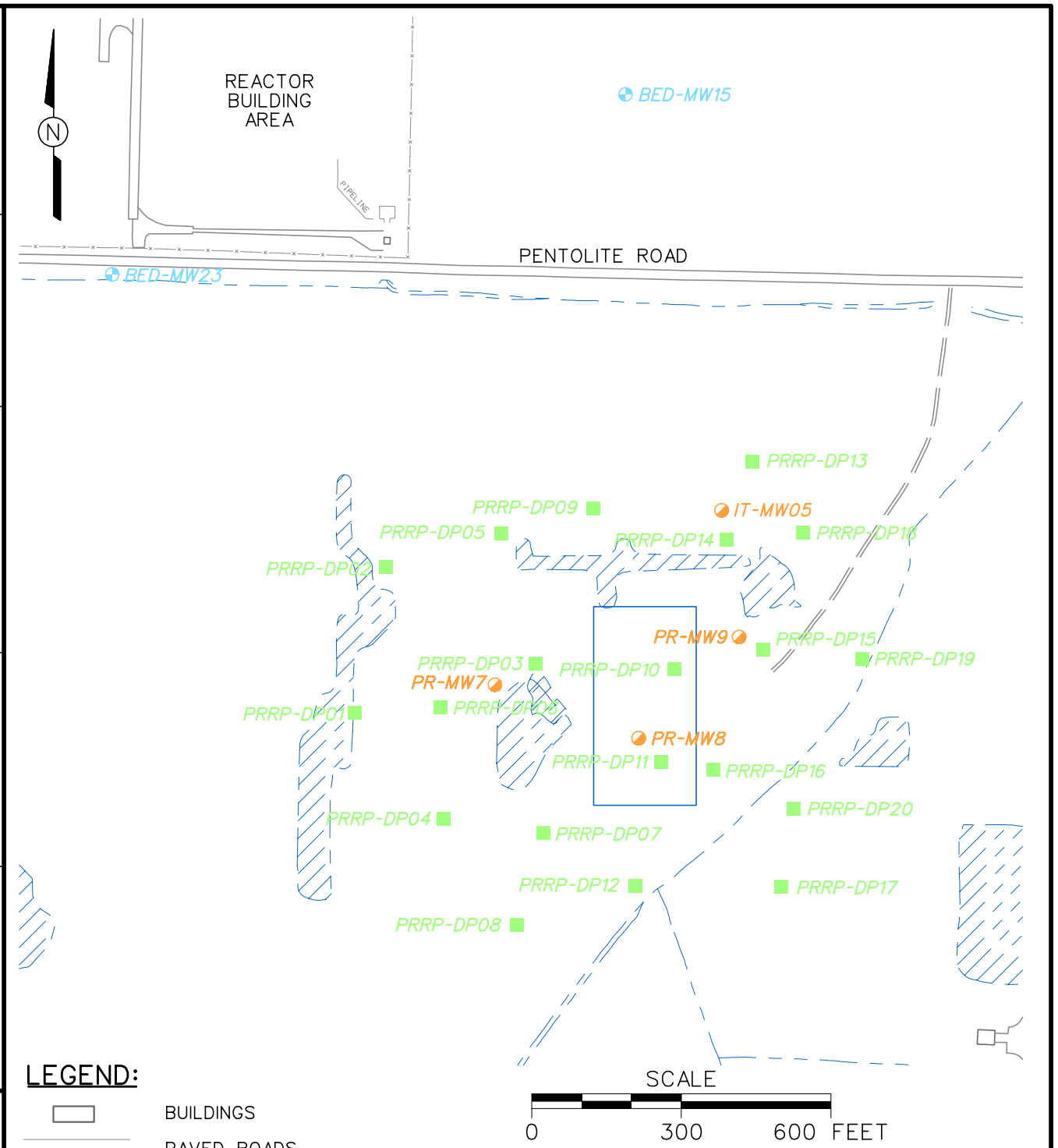
- BUILDINGS
- RAILROAD
- SURFACE DRAINAGE
- SURFACE WATER
- 2000 DIRECT-PUSH GROUNDWATER SAMPLING LOCATION
- 2001 DIRECT-PUSH GROUNDWATER SAMPLING LOCATION
- 2001 PLANNED DIRECT-PUSH GROUNDWATER SAMPLING LOCATION (INSUFFICIENT YIELD TO COLLECT SAMPLE)
- OVERBURDEN MONITORING WELL LOCATION
- BEDROCK MONITORING WELL LOCATION

SCALE
0 300 600 FEET

FIGURE 2-3
GROUNDWATER SAMPLING LOCATIONS TNT AREA C

BASELINE HUMAN HEALTH RISK ASSESSMENT OF GROUNDWATER FORMER PLUM BROOK ORDNANCE WORKS NASA PLUM BROOK STATION SANDUSKY, OHIO

Shaw® Shaw Environmental, Inc.



LEGEND:

- BUILDINGS
- PAVED ROADS
- SURFACE WATER
- SURFACE WATER DRAINAGE
- APPROXIMATE HISTORICAL LOCATION OF PONDS
- FENCE (PBOW BOUNDARY)
- DIRECT-PUSH GROUNDWATER SAMPLING LOCATION
- OVERBURDEN MONITORING WELL LOCATION
- BEDROCK MONITORING WELL LOCATION

FIGURE 2-4
PENTOLITE ROAD RED WATER PONDS SAMPLE LOCATIONS

BASELINE HUMAN HEALTH RISK ASSESSMENT OF GROUNDWATER FORMER PLUM BROOK ORDNANCE WORKS NASA PLUM BROOK STATION SANDUSKY, OHIO

Shaw® Shaw Environmental, Inc.

STARTING DATE: 09/06/06 | DATE LAST REV.: | DRAFT. CHCK. BY: | INITIATOR: T. SIARD | PROJ. NO.: 119268
DRAWN BY: D. BOMAR | DRAWN BY: | ENGR. CHCK. BY: | PROJ. MGR.: S. DOWNEY

Standard_Color_Mod.tbl dbomar 119268-pbow-bhh-004.dgn
Canon-color-Letter.plt 10:49:44 AM 9/20/2006

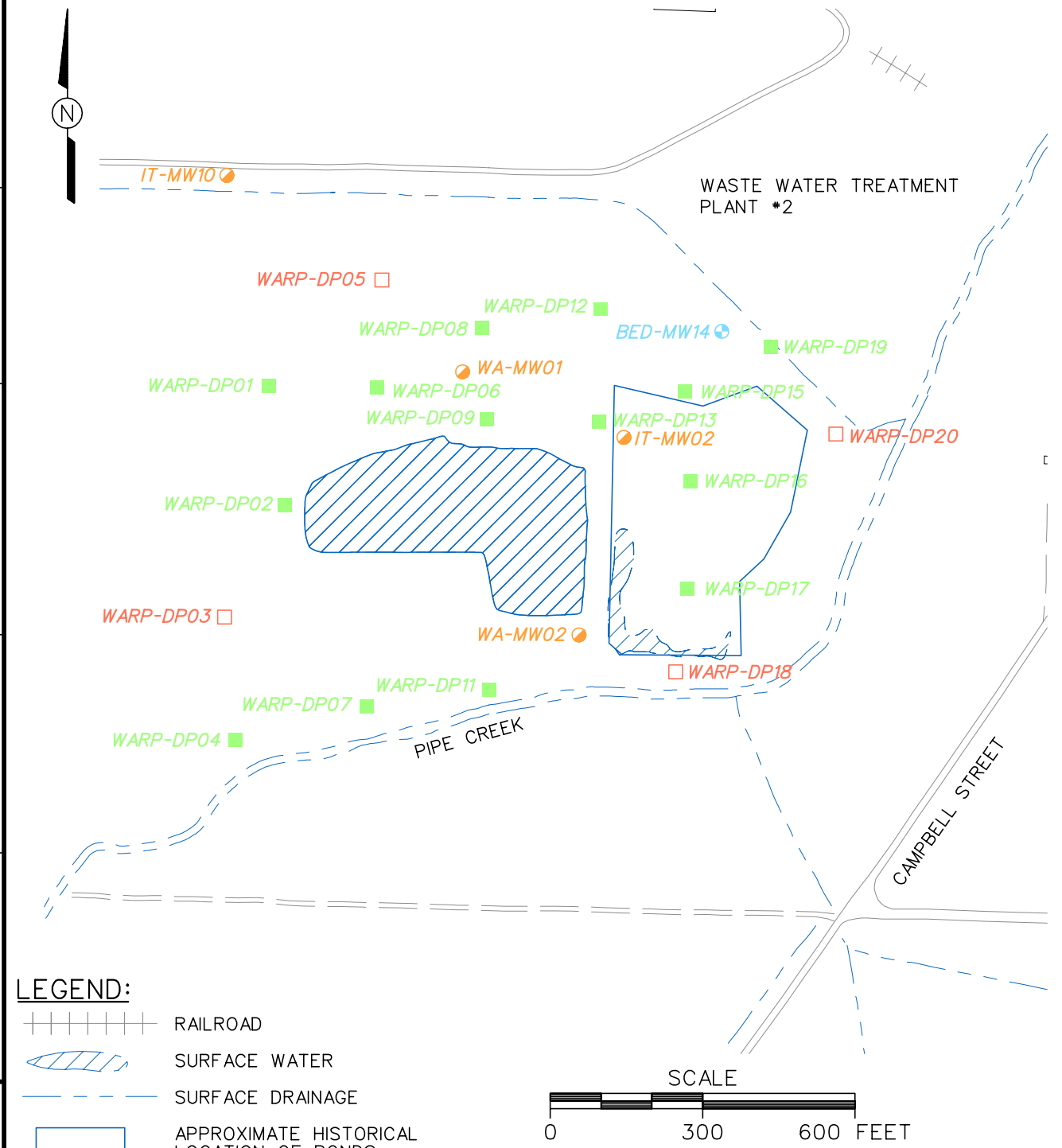


FIGURE 2-5
WEST AREA RED WATER PONDS SAMPLE LOCATIONS

BASELINE HUMAN HEALTH RISK ASSESSMENT OF GROUNDWATER FORMER PLUM BROOK ORDNANCE WORKS NASA PLUM BROOK STATION SANDUSKY, OHIO

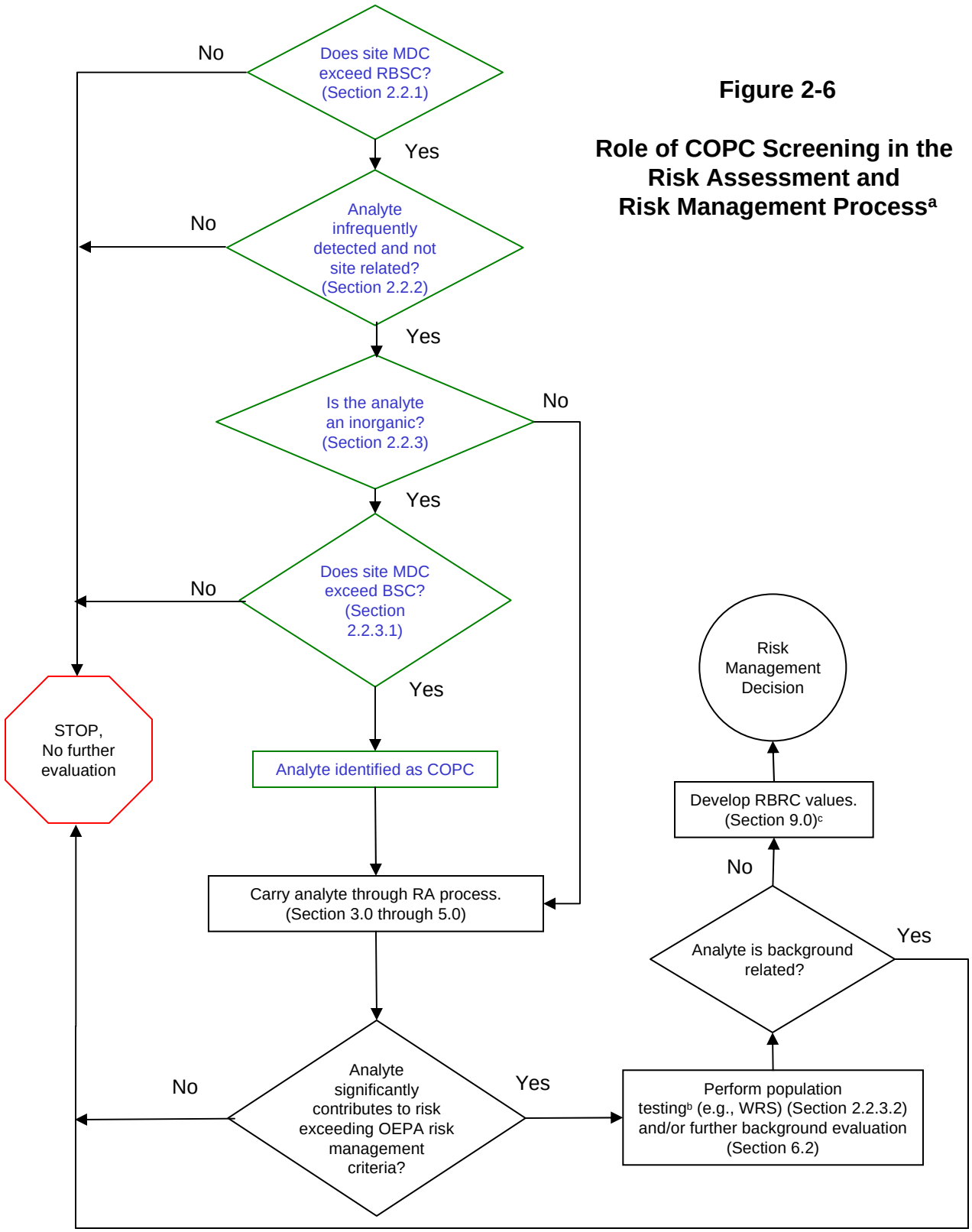
Shaw® Shaw Environmental, Inc.

STARTING DATE: 09/06/06 | DATE LAST REV.: | DRAFT. CHCK. BY: | INITIATOR: T. SIARD | PROJ. NO.: 119268
DRAWN BY: D. BOMAR | DRAWN BY: | ENGR. CHCK. BY: | PROJ. MGR.: S. DOWNEY | 119268-PBOW-BHH-005.DGN

Standard_Color_Mod.tbl dbomar 119268-pbow-bhh-005.dgn Canon-color-Letter.plt 8:38:55 AM 9/22/2006

Figure 2-6

Role of COPC Screening in the Risk Assessment and Risk Management Process[a]



Notes:

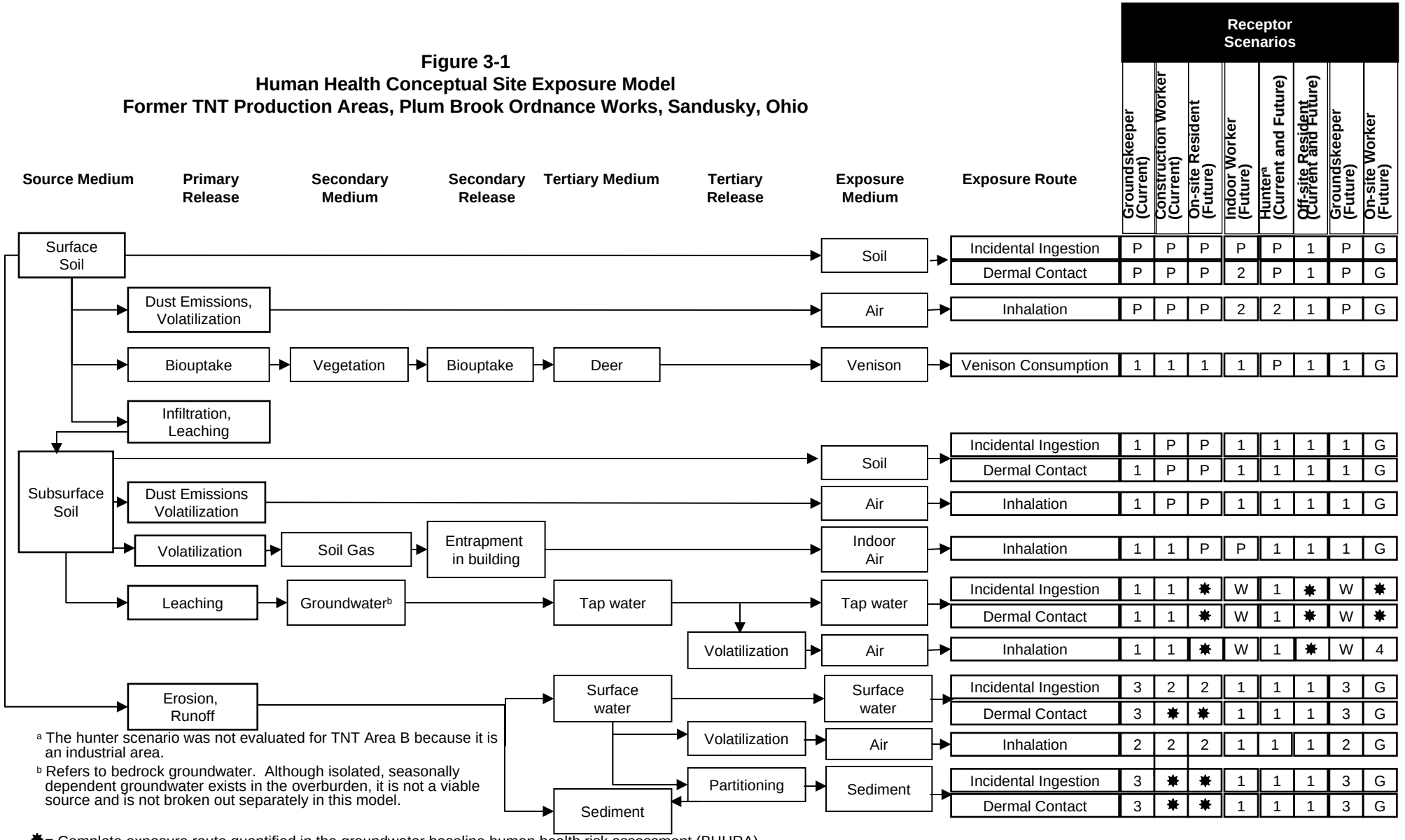
[a] COPC screening steps are shown in blue.

[b] A judgment may be made at this step to forego or modify population testing if the site data is clearly greater than background and/or individual exceedances suggest the presence of a hot spot.

[c] Note that Section 9.0 of the text lists RBRCs for all "risk drivers" but that site-related compounds are highlighted.

BSC - Background screening concentration.
COPC - Chemical of potential concern.
MDC - Maximum detected concentration.
OEPA - Ohio Environmental Protection Agency.
RA - Risk assessment.
RBRC - Risk-based remediation criterion.
RBSC - Risk-based screening concentration.
WRS - Wilcoxon rank sum (test).

Figure 3-1
Human Health Conceptual Site Exposure Model
Former TNT Production Areas, Plum Brook Ordnance Works, Sandusky, Ohio



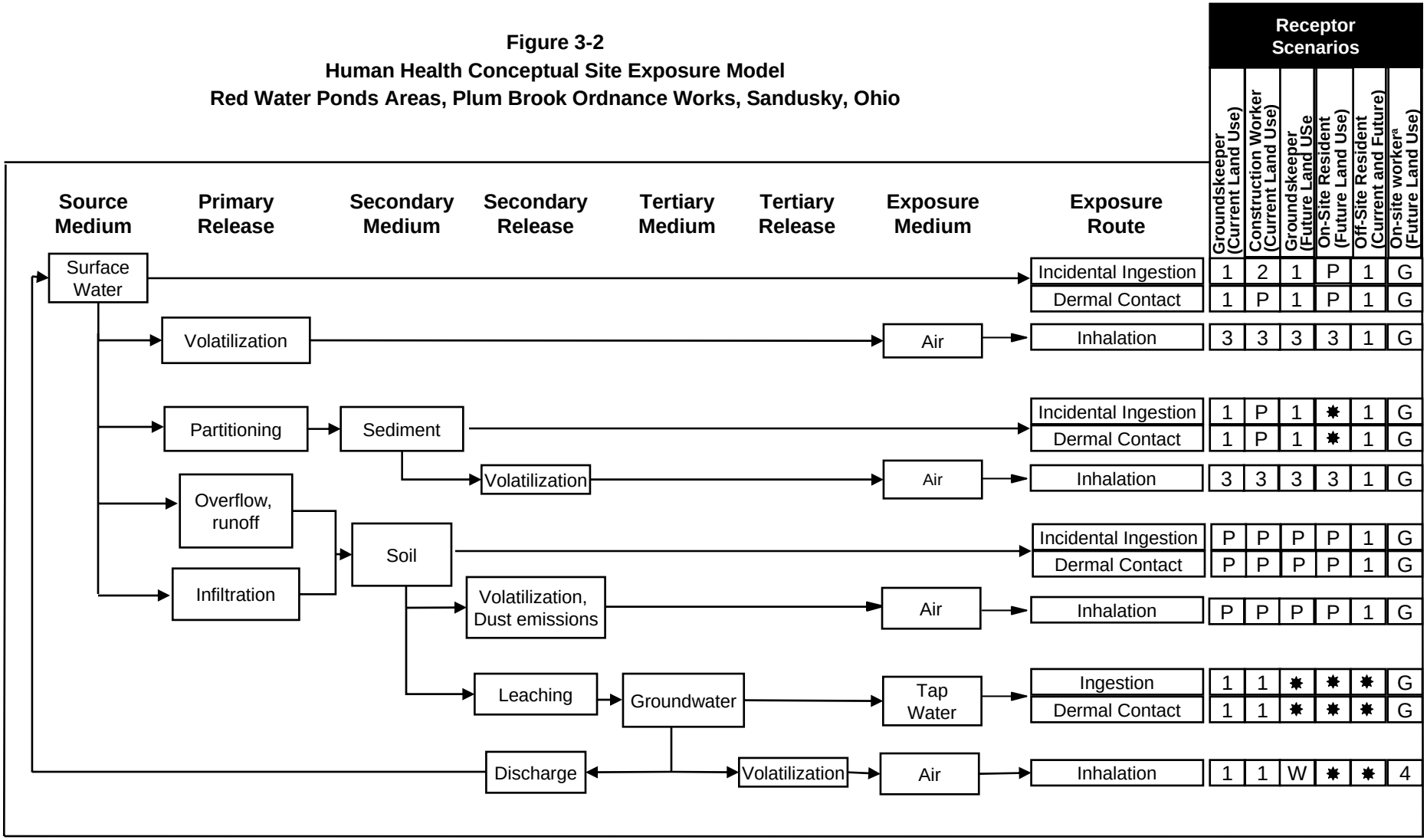
[a] The hunter scenario was not evaluated for TNT Area B because it is an industrial area.

[b] Refers to bedrock groundwater. Although isolated, seasonally dependent groundwater exists in the overburden, it is not a viable source and is not broken out separately in this model.

✸ = Complete exposure route quantified in the groundwater baseline human health risk assessment (BHHRA).
1 = There is no plausible pathway for exposure to this medium.
2 = Although theoretically complete, this pathway is not quantified as explained in text of the previous BHHRAs.
3 = Contact with this medium, although plausible, is not part of this receptor's normal or expected activities therefore, contact would be sporadic and is not quantified.
4 = Although theoretically complete, large dilution factor of ambient air obviates the need to quantify this pathway for an outdoor worker. Exposure to future indoor worker using site groundwater would not be quantifiable but would likely be insignificant compared to other pathways.
P = Complete exposure pathway evaluated in the previous BHHRAs for the former TNT production areas.
G = On-site worker evaluated for groundwater only. Risk results for this receptor were combined with those from previous BHHRAs to determine aggregate risks to the future groundskeeper (Chapter 8.0).
W = Groundwater exposure/risks evaluated as future on-site worker (see note for "G").

KN6\PBOW\GW BHHRA\Final\Figure 3-1.ppt/9/26/2006 10:53 AM

Figure 3-2
Human Health Conceptual Site Exposure Model
Red Water Ponds Areas, Plum Brook Ordnance Works, Sandusky, Ohio



1 = Incomplete exposure pathway.
2 = Incidental ingestion of surface water is expected to be insignificant compared with dermal exposure. Pathway not quantitatively evaluated.
3 = Although theoretically complete, large dilution factor of ambient air obviates the need to quantify this pathway.
4 = Although theoretically complete, large dilution factor of ambient air obviates the need to quantify this pathway for an outdoor worker. Exposure to a future indoor worker using site groundwater would not be quantifiable but would likely be insignificant compared to other pathways.
✸ = Complete exposure pathway evaluated in the groundwater baseline human health risk assessment (BHHRA).
P = Complete exposure pathways evaluated previously in the Red Water Ponds Areas BHHRA.
G = On-site worker evaluated for groundwater only. Risk results for the receptor were combined with those for the future groundskeeper from the previous BHHRAs for aggregate risk estimates (Chapter 8.0).
W = Groundwater exposure/risks evaluated as future on-site worker (see note for "G").

KN6\PBOW\GW BHHRA\Final\Figure 3-2.ppt\9/26/2006 10:56 AM

APPENDIX A

RESIDENTIAL WELL SURVEY SUMMARY

LETTER SENT FROM THE U.S. ARMY CORPS OF ENGINEERS, HUNTINGTON DISTRICT TO PRIVATE WELL SURVEY PARTICIPANTS

In September 2003, the US Army Corps of Engineers (USACE) Huntington District conducted a survey of property owners in the proximity of the former Plum Brook Ordnance Works (PBOW) to determine if they had water wells on their property. The USACE sent out 293 surveys and 83 were returned, with the majority of property owners indicating there was no well on their property. However, there were 8 property owners with wells and 7 were willing to participate in the survey.

The purpose of the survey was to evaluate groundwater offsite for the potential presence of nitroaromatics. Nitroaromatic compounds are by-products of the manufacture of trinitrotoluene (TNT), dinitrotoluene (DNT) and pentolite, all forms of explosives manufactured at the former ordnance works during WWII. USACE's goal was to identify whether offsite groundwater was impacted by the historic operations at the former PBOW.

Nitroaromatic compounds were not detected in the water collected from the wells that were sampled. One duplicate sample collected as part of the USACE Quality Control program, indicated the presence of 1,3-dinitrobenzene at a concentration of 0.00138 milligrams per liter (mg/L) or parts per million (ppm). No other compounds were detected in that sample; therefore this concentration is attributed to either background levels or it was a analytical error in the laboratory. USACE will be resampling this well to further evaluate this finding. Please see the table below for the analytical results and property owner names.

The USACE appreciates your willingness to participate in the survey. Should you have any questions regarding the results or the USACE's environmental restoration activities at PBOW, please contact Mrs. Lisa Humphreys, USACE Technical Project Coordinator at (800) 822-8413.

Sincerely,
Streamborn Environmental Services, Inc. (formerly with ICI)

Helen J. Owens
Program Manager
USACE Support Contractor

PBOW Off-Site Well Survey
Summary of Results

	SAMPLE IDENTIFICATION						
ANALYTE	Speer PB-03-RW-01-01	Galloway PB-03-RW-02-01	Van Ness PB-03-RW-03-01	Dahm PB-03-RW-04-01	Dahm (Duplicate) PB-03-RW-04-02	Langan PB-03-RW-05-01	Pimsner PB-03-RW-06-01
1,3,5-trinitrobenzene	ND	ND	ND	ND	ND	ND	ND
1,3-Dinitrobenzene	ND	ND	ND	ND	0.00138 mg/L	ND	ND
2,4,6-Trinitrotoluene	ND	ND	ND	ND	ND	ND	ND
2,4-Dinitrotoluene	ND	ND	ND	ND	ND	ND	ND
2-Amino-4,6-dinitrotoluene	ND	ND	ND	ND	ND	ND	ND
2-Nitrotoluene	ND	ND	ND	ND	ND	ND	ND
3-Nitrotoluene	ND	ND	ND	ND	ND	ND	ND
4-Amino-2,6-dinitrotoluene	ND	ND	ND	ND	ND	ND	ND
4-Nitrotoluene	ND	ND	ND	ND	ND	ND	ND
HMX	ND	ND	ND	ND	ND	ND	ND
Nitrobenzene	ND	ND	ND	ND	ND	ND	ND
RDX	ND	ND	ND	ND	ND	ND	ND
Tetryl	ND	ND	ND	ND	ND	ND	ND
Note: ND = Not Detected; Mg/L = milligrams per liter or parts per million (ppm)							

RESAMPLING RESULTS OF THE DAHMS WELL

Ms. Helen Owens

Streamborn Environmental

Project ID: PBOW Residential Wells
Off-Site Survey Resample

REI #: 0410479

-Level II Data Package-

Index

- *Case Narrative*
- *Analytical Results*
- *Chain-of-Custody*
- *Level II QC Summary*

REI Consultants, Inc. PO Box 286 Beaver WV 25813 1-800-999-0105 fax: 1-304-255-2572 e-mail: rlabs@reiclabs.com

Streamborn Environmental

REIC Work Order: 0410479

Case Narrative

REI Consultants, Inc. PO Box 286 Beaver WV 25813 1-800-999-0105 fax: 1-304-255-2572 e-mail: rlabs@reiclabs.com

REI Consultants Inc. **Date:** *02-Nov-04*

CLIENT: STREAMBORN ENVIRONMENTAL SER
Project: OFF- SITE SURVEY-RESAMPLE
Lab Order: 0410479

CASE NARRATIVE

Samples were analyzed using the methods stated in the analytical report without modification unless otherwise noted.

Analytical methods contained in this report referencing Standard Methods are taken from the 20th Edition.

All method blanks, laboratory spikes, and/or matrix spikes met quality assurance objectives and no problems or anomalies were noted during analyses.

All samples analyzed on an "as-received" basis unless otherwise noted in the analytical report.

The Laboratory Director or his designee, as verified by the signature contained in the analytical report, has authorized the release of the data contained in this hard copy data package.

In compliance with federal guidelines and standard operating procedures, all reports, including raw data and supporting quality control, will be disposed of after three years unless otherwise arranged by the client via written notification or contract requirement.

REI Consultants Inc.

Date: *02-Nov-04*

CLIENT:	STREAMBORN ENVIRONMENTAL SER
Project:	OFF- SITE SURVEY-RESAMPLE
Lab Order:	0410479

Work Order Sample Summary

Lab Sample ID	Client Sample ID	Tag Number	Collection Date	Date Received
0410479-01A	PB-03-RW-04-03		10/11/2004	10/13/2004

Lab Order: 0410479
Client: STREAMBORN ENVIRONMENTAL SERVICE
Project: OFF- SITE SURVEY-RESAMPL

DATES REPORT

Sample ID	Client Sample ID	Collection Date	Matrix	Test Name	Prep Batch	Prep Date	DF	Analysis Date
0410479-01A	PB-03-RW-04-03	10/11/2004	Liquid	EXPLOSIVES	26815	10/18/2004	1	10/25/2004

Streamborn Environmental

REIC Work Order: 0410479

Analytical Results

REI Consultants, Inc. PO Box 286 Beaver WV 25813 1-800-999-0105 fax: 1-304-255-2572 e-mail: rlabs@reiclabs.com

REIC

RESEARCH ENVIRONMENTAL & INDUSTRIAL CONSULTANTS, INC.

Improving the environment, one client at a time...

225 Industrial Park Rd.
Post Office Box 286
Beaver, WV 25813
800.999.0105
304.255.2500 • 304.255.2572 (fax)
website: www.reiclabs.com

Member:

American Chemical Society

Association of Official Analytical Chemists

Petroleum Marketers Association

Rural Water Association

Mining & Reclamation Association

American Water Works Association

The Solid Waste Association of North America

West Virginia Manufacturers Association

Association of West Virginia Solid Waste Authorities

West Virginia Oil Marketers & Grocers Association

October 28, 2004

Ms. Helen Owens
STREAMBORN ENVIRONMENTAL SERVICE
724 S MIAMI STREET
WEST MILTON, OH 45383

TEL:
FAX

RE: OFF- SITE SURVEY-RESAMPLE Order No.: 0410479

Dear Ms. Helen Owens:

REI Consultants Inc. received 1 sample on 10/13/2004 for the analyses presented in the following report.

If you have any questions regarding these results, please do not hesitate to call.

Sincerely,

Ray Erickson
Vice President

CC:
Ms Lisa Humphreys,USACE

REI Consultants Inc.

Date: 28-Oct-04

CLIENT: STREAMBORN ENVIRONMENTAL SE
Project: OFF- SITE SURVEY-RESAMPLE
Lab Order: 0410479

CASE NARRATIVE

Samples were analyzed using the methods stated in the analytical report without modification unless otherwise noted.

Analytical methods contained in this report referencing Standard Methods are taken from the 20th Edition.

All samples analyzed on an "as-received" basis unless otherwise noted in the analytical report.

The Laboratory Director or his designee, as verified by the signature contained in the analytical report, has authorized the release of the data contained in this hard copy data package.

In compliance with federal guidelines and standard operating procedures, all reports, including raw data and supporting quality control, will be disposed of after three years unless otherwise arranged by the client via written notification or contract requirement.

REI Consultants Inc.

Date: *28-Oct-04*

Client:	STREAMBORN ENVIRONMENTAL SERV	**Lab Order:**	0410479
Client Sample ID:	PB-03-RW-04-03	**Lab ID:**	0410479-01A
Project:	OFF- SITE SURVEY-RESAMPLE	**Collection Date:**	10/11/2004
Site ID:	PBOW RESIDENTIAL WELLS	**Matrix:**	LIQUID

Analyses	Result	Units	MDL	PQL	Qual	Date Analyzed	Analyst
EXPLOSIVES			**SW8330**				
1,3,5-Trinitrobenzene	ND	mg/L	NA	0.000250		10/25/04 11:47 AM	TM
1,3-Dinitrobenzene	ND	mg/L	NA	0.000250		10/25/04 11:47 AM	TM
2,4,6-Trinitrotoluene	ND	mg/L	NA	0.000250		10/25/04 11:47 AM	TM
2,4-Dinitrotoluene	ND	mg/L	NA	0.000250		10/25/04 11:47 AM	TM
2,6-Dinitrotoluene	ND	mg/L	NA	0.000250		10/25/04 11:47 AM	TM
2-Amino-4,6-dinitrotoluene	ND	mg/L	NA	0.000250		10/25/04 11:47 AM	TM
2-Nitrotoluene	ND	mg/L	NA	0.000250		10/25/04 11:47 AM	TM
3-Nitrotoluene	ND	mg/L	NA	0.000250		10/25/04 11:47 AM	TM
4-Amino-2,6-dinitrotoluene	ND	mg/L	NA	0.000250		10/25/04 11:47 AM	TM
4-Nitrotoluene	ND	mg/L	NA	0.000250		10/25/04 11:47 AM	TM
HMX	ND	mg/L	NA	0.000250		10/25/04 11:47 AM	TM
Nitrobenzene	ND	mg/L	NA	0.000250		10/25/04 11:47 AM	TM
RDX	ND	mg/L	NA	0.000250		10/25/04 11:47 AM	TM
Tetryl	ND	mg/L	NA	0.000250		10/25/04 11:47 AM	TM

Qualifiers:

- ND - Not Detected at the PQL or MDL
- PQL - Practical Quantitation Limit
- MDL - Minimum Detection Limit
- NA - Not Applicable
- TIC - Tentatively Identified Compounds
- J - Analyte detected below PQL
- S - Spike Recovery outside accepted recovery limits
- E - Value Estimated
- B - Analyte detected in the associated Method Blank
- H - Sample extraction/analysis holding time exceeded

REI Consultants Inc.

Date: 28-Oct-04

Client: STREAMBORN ENVIRONMENTAL SERVICE **Lab Order:** 0410479

Project: OFF- SITE SURVEY-RESAMPLE

Site ID: PBOW RESIDENTIAL WELLS

Data Review

Approved: Joseph Robertson 10-29-04

Joseph Robertson - Organic Lab Manager Date

Qualifiers:

ND - Not Detected at the PQL or MDL

PQL - Practical Quantitation Limit

MDL - Minimum Detection Limit

NA - Not Applicable

TIC - Tentatively Identified Compounds

J - Analyte detected below PQL

S - Spike Recovery outside accepted recovery limits

E - Value Estimated

B - Analyte detected in the associated Method Blank

H - Sample extraction/analysis holding time exceeded

Streamborn Environmental

REIC Work Order: 0410479

Chain-of-Custody

REI Consultants, Inc. PO Box 286 Beaver WV 25813 1-800-999-0105 fax: 1-304-255-2572 e-mail: rlabs@reiclabs.com

REIC

CHAIN OF CUSTODY RECORD NO. 154464

REI Consultants, Inc.
225 Industrial Park Rd.
P.O. Box 286, Beaver, WV 25813
Phone: 304-255-2500 or 800-999-0105
FAX: 304-255-2572
e-mail: rlabs@reiclabs.com

CLIENT: Streamborn Environmental services
ADDRESS: 724 S. Miami St.
CITY/STATE/ZIP: West Milton, OH 45383
BILL TO: ↑ SAME ↑
CITY/STATE/ZIP:
PURCHASE ORDER #
QUOTE #

CONTACT PERSON: Helen Owens
TELEPHONE #: 937 698-5090
FAX #:
E-MAIL ADDRESS: howens10@woh.rr.com
SITE ID & STATE: PBOW Residential wells
PROJECT ID: Off-site survey - resample
SAMPLER: H. Owens

SAMPLE LOG AND ANALYSIS REQUEST

TURNAROUND TIME REQUIREMENTS
REGULAR: ✓
*RUSH: ___ 5-Day ___ 3-Day ___ 2-Day ___ 1-Day
*Rush work needs prior Laboratory approval and will include surcharges

PRESERVATIVES
0 No Preservative
1 Hydrochloric Acid
2 Nitric Acid
3 Sulfuric Acid
4 Sodium Thiosulfate
5 Sodium Hydroxide
6 Zinc Acetate
7 EDTA

PRESERVATIVE CODES — NOTE PRESERVATIVES → 0

SAMPLE ID	NO. & TYPE OF CONTAINERS	SAMPLING DATE / TIME	MATRIX	SAMPLE COMP / GRAB	ANALYSIS REQUESTED & METHOD: Nitroaromatics	COMMENTS
PB-03-RW-04-03	1 Amber	10/11/04 0915	H_2O	Gr	1	Send report to: Lisa Humphreys USACE (304) 399 5953 Lisa.A.Humphreys@usace.army.mil

Report instructions

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time
Helen Owens	10/11/04 1530		
Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time
			10-13-04 1100

Temperature Upon Arrival: 4.1 °C

☐ FAX Results ☐ Email Results

Streamborn Environmental

REIC Work Order: 0410479

Level II QC Summary

REI Consultants, Inc. PO Box 286 Beaver WV 25813 1-800-999-0105 fax 1-304-255-2572 e-mail: rlabs@reiclabs.com

Nitroaromatics: 8330

Level II QC Summary

REI Consultants Inc.

Date: *02-Nov-04*

CLIENT: STREAMBORN ENVIRONMENTAL SER
Work Order: 0410479
Project: OFF- SITE SURVEY-RESAMPLE

ANALYTICAL QC SUMMARY REPORT

TestCode: 8330_L

Sample ID: **MB-26815**	SampType: **mblk**	TestCode: **8330_L**	Units: **mg/L**	Prep Date: **10/18/2004**	Run ID: **SVHPLC3_041025A**
Client ID: **ZZZZZ**	Batch ID: **26815**	TestNo: **SW8330**	**(SW8330)**	Analysis Date: **10/25/2004**	SeqNo: **1206228**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
1,3,5-Trinitrobenzene	ND	0.000250									
1,3-Dinitrobenzene	ND	0.000250									
2,4,6-Trinitrotoluene	ND	0.000250									
2,4-Dinitrotoluene	ND	0.000250									
2,6-Dinitrotoluene	ND	0.000250									
2-Amino-4,6-dinitrotoluene	ND	0.000250									
2-Nitrotoluene	ND	0.000250									
3-Nitrotoluene	ND	0.000250									
4-Amino-2,6-dinitrotoluene	ND	0.000250									
4-Nitrotoluene	ND	0.000250									
HMX	ND	0.000250									
Nitrobenzene	ND	0.000250									
RDX	ND	0.000250									
Tetryl	ND	0.000250									

Qualifiers:
ND - Not Detected at the Reporting Limit
J - Analyte detected below quantitation limits
S - Spike Recovery outside accepted recovery limits
R - RPD outside accepted recovery limits
B - Analyte detected in the associated Method Blank

CLIENT: STREAMBORN ENVIRONMENTAL SER
Work Order: 0410479
Project: OFF- SITE SURVEY-RESAMPLE

ANALYTICAL QC SUMMARY REPORT

TestCode: 8330_L

Sample ID: **LCS-26815**	SampType: **lcs**	TestCode: **8330_L**	Units: **mg/L**	Prep Date: **10/18/2004**	Run ID: **SVHPLC3_041025A**
Client ID: **ZZZZZ**	Batch ID: **26815**	TestNo: **SW8330**	**(SW8330)**	Analysis Date: **10/25/2004**	SeqNo: **1206230**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
1,3,5-Trinitrobenzene	0.0269	0.000250	0.025	0	108	70	130	0	0		
2,4-Dinitrotoluene	0.02	0.000250	0.025	0	80.1	70	130	0	0		
4-Amino-2,6-dinitrotoluene	0.0223	0.000250	0.025	0	89.2	70	130	0	0		
HMX	0.0286	0.000250	0.025	0	115	70	130	0	0		
Tetryl	0.0194	0.000250	0.025	0	77.5	70	130	0	0		

Sample ID: **LCSD-26815**	SampType: **lcsd**	TestCode: **8330_L**	Units: **mg/L**	Prep Date: **10/18/2004**	Run ID: **SVHPLC3_041025A**
Client ID: **ZZZZZ**	Batch ID: **26815**	TestNo: **SW8330**	**(SW8330)**	Analysis Date: **10/25/2004**	SeqNo: **1206231**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
1,3,5-Trinitrobenzene	0.0252	0.000250	0.025	0	101	70	130	0.02691	6.41	30	
2,4-Dinitrotoluene	0.0197	0.000250	0.025	0	78.7	70	130	0.02003	1.86	30	
4-Amino-2,6-dinitrotoluene	0.0194	0.000250	0.025	0	77.5	70	130	0.02231	14.1	30	
HMX	0.0259	0.000250	0.025	0	104	70	130	0.02864	9.93	30	
Tetryl	0.019	0.000250	0.025	0	75.9	70	130	0.01938	2.09	30	

Qualifiers:
ND - Not Detected at the Reporting Limit
J - Analyte detected below quantitation limits
S - Spike Recovery outside accepted recovery limits
R - RPD outside accepted recovery limits
B - Analyte detected in the associated Method Blank

REI Consultants Inc.

Date: *02-Nov-04*

CLIENT: STREAMBORN ENVIRONMENTAL SER
Work Order: 0410479
Project: OFF- SITE SURVEY-RESAMPLE

QC SUMMARY REPORT

Approved By: _____ **Date:** 11-03-04

APPENDIX B

TECHNICAL MEMORANDUM AND ASSOCIATED RESPONSE TO COMMENTS

Technical Memorandum

TO: L. Ingram, Project Manager, U.S. Army Corps of Engineers, Nashville District

FROM: M. Gunderson (Technical Leader) and T. Siard (Risk Assessor), Shaw Environmental, Inc.

DATE: May 23, 2005

SUBJECT: Use of Groundwater Analytical Data in the Groundwater Baseline Human Health Risk Assessment, Plum Brook Ordnance Works, Sandusky, Ohio

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This technical memorandum was prepared in response to Comment No. 1 in the March 3, 2005 Ohio Environmental Protection Agency (OEPA) comment letter on the draft Baseline Human Health Risk Assessment for Groundwater (BHHRA) Work Plan (Shaw, 2005) concerning the use of samples other than unfiltered samples collected using low flow methodology (OEPA, 2005). Consistent with the 2004 Groundwater Data Summary and Evaluation Report (Shaw, 2004), the BHHRA will include analytical data from 1997 through the most recent samples collected. During this period, groundwater sampling has been conducted at the former Plum Brook Ordnance Works (PBOW) using two sampling methods: bailer and low flow. It is our intent to make best use of the data sets so that the most representative data are used in the evaluation of groundwater associated with PBOW. The analytical data files accompany the electronic transmission of this memo.

Prior to September 2001, monitoring wells were purged of three to five well volumes of groundwater using either submersible pumps or bailers, and groundwater samples were collected with a bailer. It has long been recognized that this approach may not produce representative groundwater analytical data due to higher turbidity generated by the surging action of bailer insertion and removal. In particular, inorganics data can be significantly elevated in samples collected with a bailer. Beginning in September 2001, groundwater sampling was conducted using the low flow (minimal drawdown) method unless groundwater recharge was insufficient. Low flow sampling minimizes disturbance in the well and is thought to produce more representative data and minimize the need for sample filtration. Note that a number of the wells, especially the overburden wells, were collected only by bailer either due to insufficient recharge or because all samples from these wells were collected prior to September 2001.

The objectives of this technical memorandum are to provide a review of existing site data, evaluate the appropriateness of using bailer-collected data in the BHHRA, and provide recommendations as to which samples should be used to characterize each well. This memorandum makes a recommendation for each sample from each well as to whether filtered or unfiltered bailer-collected data are more appropriate for inclusion in the final data set. Even though the perched overburden groundwater will not be

quantitatively evaluated in the BHHRA, analytical results from overburden wells are also included in this evaluation so that the most appropriate concentrations are used for the qualitative evaluation and groundwater modeling efforts. Further, the memorandum also presents an evaluation of all the data, including low flow, to determine whether any of the samples appear to be inconsistent with the rest of the data from that well and should, thus, be eliminated from the data set.

1.0 Data Evaluation Process

Under the groundwater investigation programs at PBOW, a total of 18 overburden and 15 bedrock wells identified in the draft BHHRA work plan were sampled from 1997 through 2004. Each of these wells was sampled at least twice, and some were sampled as many as 10 times during this period. Unfiltered samples were collected from these wells using either low flow or bailer. Where sufficient water quantity was available, which was typically the case, an aliquot was also collected from each well for filtered inorganics analysis. Sample filtration was conducted in the field using a 0.45-micron filter. In-line filters were used for samples collected by low flow sampling. For bailer collected samples, a hand operated vacuum pump was used.

Low flow has been used since September 2001, except under conditions of insufficient recharge. The discrepancies between filtered and unfiltered data in PBOW wells sampled using low flow methodologies indicate that low flow sampling cannot reduce turbidity under certain hydrogeologic conditions. Specifically, wells installed in the Delaware Limestone have naturally occurring hydrogen sulfide. A review of the data indicates that wells with elevated hydrogen sulfide do not show consistent patterns of turbidity. These variations are thought to be the result of changing water levels during the sampling periods which influence the amount of hydrogen sulfide released by the formation. Release of gaseous hydrogen sulfide into the monitoring well causes turbulent flow and may elevate the concentrations of inorganics.

Interpretation of the turbidity data does not provide a consistent "bright line" above which one can attribute to sampling artifacts. However, it was observed during a review of all the groundwater data from the wells identified in the BHHRA work plan that low flow sampling generally produces data with turbidities of less than 150 NTUs. Based on the recommendation that all unfiltered low flow data will be used in the risk evaluation, the turbidity value of 150 NTUs is used as the criteria above which further evaluation of the sampling data was conducted in this technical memorandum.

In addition to turbidity, the reproducibility of groundwater data is evaluated using the Relative Percent Difference (RPD) between two samples. Typically, this is used to evaluate the reproducibility of analytical results for primary and duplicate samples. For the PBOW site, a RPD of less than 30% is considered acceptable for sample duplicates. Similarly, an RPD of less than 30% for a filtered and unfiltered sample pair would suggest that the results are within the acceptable range of analytical variation. The RPD in this evaluation is used to aid the evaluation of the affects of turbidity on inorganics

concentrations. If the criterion of 30% is exceeded for any given filtered/unfiltered sample pair, it can be assumed that this is due to turbidity. There are no set guidelines however, that would indicate if the observed turbidity and/or the difference in RPDs is artificially induced by sampling methodology or if it is characteristic of the aquifer. But, if numerous sampling rounds are conducted on a given well, the evaluation of the turbidity and the RPD values can be used to assess the potential impacts of the sampling methods used.

The RPD is calculated as follows:

$$RPD = 100 \times (S1-S2)/[(S1 + S2)/2]$$

Where: S1 = primary (unfiltered) sample concentration
S2 = duplicate (filtered) sample concentration

By the convention stated above for the RPD calculation, a negative RPD indicates that the filtered sample concentration is higher than the unfiltered sample concentration. Two factors can affect the relevance of the RPD calculation. First, data having contamination in the associated sample blank is not relevant. Second, for analytes detected at very low concentrations (e.g., less than 5 ppb), the samples RPD may be greater than 30% but this is a less significant variation than a similar RPD at much higher concentrations. This is because variations of low magnitude (attributable to analytical or other sources) can more significantly affect the RPD at low concentrations.

2.0 Well-by-Well Evaluation

A well-by-well evaluation of the analytical results was conducted based on turbidities, comparison of unfiltered versus filtered data for each sampling event, and comparison across sampling events. The following evaluation presents the analytical evaluation of wells that had at least one sample with a turbidity measurement of greater than 150 NTUs. The evaluations are organized by area to be evaluated in the BHHRA. The results and recommendations of this evaluation, as well as the potential bias associated with accepting these recommendations are presented below and are summarized on Table 1. Note that for completeness, Table 1 also includes wells in which no sample had a turbidity reading exceeding 150 NTU; these wells are not evaluated in the text below.

2.1 TNTA Wells

TNTA-MW11. Overburden well TNTA-MW11 was sampled four times (1997, 1998, 2001 and 2002). Because of insufficient recharge, each of these samples was collected by bailer. Turbidity was elevated (536 NTUs) in the sample collected in 1998 but was much lower (77 and 56.4 NTUs) in 1997 and 2002. Because of limited water in the well during the 2001 sampling event, the filtered sample and the water quality parameters could not be collected. With the exception of the 2001 data, the concentrations of

analytes detected were relatively consistent in all of the samples. In the 2001 data, cadmium, cobalt, and copper were detected in addition to the analytes detected in the other sampling events. In situations where insufficient water is available to collect all samples, the sample is typically very turbid. It is likely that the detection of cadmium, cobalt and copper as well as elevated concentrations of other parameters are likely due to suspended sediment. Therefore, the sample collected in 2001 should be removed from the data set.

Based on these findings, all of the unfiltered data appears to be representative of the overburden groundwater in this location except for the 2001 results. Because of the limited water in this well during 2001 and the correspondingly high turbidity, it is recommended that this sample be removed from the data set. Based on review of the analytical results, use of only the three remaining unfiltered samples introduces no apparent bias.

MK-MW22. Turbidity was measured at 132 and 988 NTUs in the bailer samples collected from this overburden well in 1997 and 1998, respectively. Unlike most of the other overburden wells that have this great a variation in measured turbidities, the inorganics detected and the actual concentrations in both filtered and unfiltered samples in these two sampling events are nearly identical. The reason for this is unclear, but it suggests that most of the inorganics are in dissolved form and are likely to be representative of overburden groundwater at this location. Based on the similarity of the data, the results from both unfiltered samples are recommended for inclusion in the final data set. Based on review of the analytical results, use of the two unfiltered samples introduces no apparent bias.

MK-MW23. This overburden well was sampled by bailer in 1997 and 1998. The turbidity measured in 1997 was 602 NTUs compared to 154 NTUs in 1998. Both samples show RPDs exceeding 30% for numerous analytes. With the exception of sodium, the concentrations of inorganics in the unfiltered sample from 1998 were higher than those detected in 1997. In the filtered samples from both events, only arsenic, calcium, magnesium, manganese, and potassium were detected. The detections in the filtered samples are more consistent with other PBOW wells.

Based on the elevated turbidity in both wells and the large discrepancies in the unfiltered and filtered samples, entrained sediment has affected both samples. However, between the two unfiltered samples, the sample with the lower turbidity (1998) had higher concentrations than the sample with the higher turbidity (1997). Even though the turbidities in these unfiltered samples are relatively high, it is recommended that the results of these unfiltered samples be included in the BHHRA because: 1) Low-flow methodology has not been used to collect samples from this well to provide a basis for comparison, 2) Based on the limited number of samples collected from this well, it cannot be definitively stated that the levels of turbidity encountered in 1997 and 1998 are uncharacteristic of this well, 3) Correlation of concentrations between the two unfiltered samples indicate an inexplicable negative relationship with turbidity, and 4) No other information suggests that analytical results from this well are questionable. Inclusion of

the unfiltered samples, especially the 1998 sample, may introduce a high bias to the analytical data evaluation for numerous inorganics.

2.2 TNTB Wells

TNTB-BED-GW003. Bedrock well TNTB-BED-GW003 was sampled in 2001 and 2002 by bailer because of insufficient recharge. Turbidities were 370 and 9250 NTUs, respectively. Aluminum, arsenic, barium, calcium, chromium, cobalt copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, sodium, vanadium and zinc were detected in the unfiltered 2001 sample; each of these except mercury was also detected in the 2002 sample. The filtered samples had fewer detections and, for most analytes, had much lower concentrations. This indicates that inorganics concentrations observed in the unfiltered samples are associated with suspended sediments resulting from bailing this low-producing well with a limited water column. Based on the following, it is recommended that the unfiltered samples be used in the final data set: 1) Low-flow methodology could not be used to collect samples from this well to provide a basis for comparison, 2) Based on the limited number of samples collected from this well and limited water column, it is likely that high turbidity is characteristic of this well. 3) No other information suggests that analytical results from this well are questionable. Inclusion of the unfiltered samples from this well in the final data set introduces a high bias.

2.3 TNTC Wells

TNTC-MW3. This well was sampled in 1997, 1998 and 2002. The turbidity in the 1998 sample was measured at >999 NTUs, with the 1997 and 2002 samples having turbidity values of 9 and 59 NTUs, respectively. Because of insufficient recharge, each of these samples was collected by bailer. The results from the 1997 and 2002 sampling events are consistent in terms of the analytes detected. In addition to the high turbidity reported in the 1998 sample, elevated concentrations of aluminum and iron as well detections of arsenic, chromium, copper and lead not seen in the other sampling events suggest that these are the result of suspended sediment. The filtered 1998 sample was more consistent with the unfiltered 1997 and 2002 data, but generally had lower concentrations.

It is recommended that the unfiltered 1998 sample be excluded from the data set for the following reasons: 1) Excessively high turbidity was not encountered during the other sampling events, 2) Concentrations of analytes were high in comparison to the other sampling events, and 3) Detection of analytes that were not encountered in the other sampling events. It is recommended that the filtered 1998 sample not be included because the associated concentrations are generally less than those detected in the unfiltered 1997 and 2002 samples.

The 1997 and 2002 unfiltered samples are interpreted to be representative of the overburden groundwater in this area and are recommended for inclusion in the final data set; thus, no particular high or low bias is interpreted as associated with the use of these two samples to represent groundwater in this area.

TNTC-MW4. Overburden well TNTC-MW4 was sampled four times (1997, 1998, 2001 and 2002). Because of insufficient recharge, each of these samples was collected by bailer. Elevated turbidities were observed in the 1998 (>999 NTUs) and 2002 (178 NTUs) data. In the other two samples, turbidity ranged from 19 to 22 NTUs. The analytical data however, is relatively consistent in all samples, both in the analytes detected and in their concentrations in the unfiltered samples. Because of the consistent concentrations, it is recommended that all unfiltered samples be retained in the final data set. Based on review of the analytical results, use of the four unfiltered samples introduces no apparent bias.

IT-MW09. Overburden well IT-MW09 was purged and sampled by bailer in 1997 and 1998. In the 1997 unfiltered sample, aluminum, chromium, and iron exceeded the RPD criteria. The turbidity in the sample was 256 NTUs. In the 1998 unfiltered sample, the same analytes were detected with the exception of chromium and zinc. The concentrations were lower however, presumably due to the lower turbidity (154 NTUs) in this sample. All of the analytes that were detected in the 1998 unfiltered sample were also detected in the 1997 filtered sample, albeit the filtered sample had higher concentrations detected. Additionally, the 1997 filtered samples included a detection of zinc whereas the 1998 unfiltered sample did not. These observations may be due to some seasonal variation in groundwater since the 1997 sample was collected in November, and the 1998 sample was collected in May. The data suggests that the unfiltered, highly turbid 1997 sample is not representative of the groundwater. The only analytes affected by this are aluminum, chromium and iron. The similarities in concentrations between the filtered and unfiltered data sets also indicate that most of the inorganics are in dissolved form.

It is recommended that the 1998 unfiltered sample be included in the data set. Even though the turbidity of the 1997 unfiltered samples is relatively high, it is recommended that the results of this sample be included in the BHHRA because: 1) Low-flow methodology has not been used to collect samples from this well to provide a basis for comparison, 2) Based on the limited number of samples collected from this well, it cannot be definitively stated that the turbidity encountered in 1997 is uncharacteristic of this well, 3) The concentrations associated with the unfiltered 1997 sample do not appear to be excessively high, and 4) No other information suggests that analytical results from this well are questionable. Inclusion of the 1997 unfiltered sample may introduce a high bias to the analytical data evaluation, especially with respect to aluminum, chromium, and iron.

PB-BED-MW13. Bedrock well PB-BED-MW13 was sampled four times (1997, 1998, 2001 and 2002) with turbidity ranging from 50 to 585 NTUs. All of the samples were collected with a bailer. The analytical data however, is relatively consistent in all samples, both in the analytes detected and in their concentrations in the unfiltered samples. Because of the consistent concentrations, it is recommended that all unfiltered samples be retained in the final data set. Based on review of the analytical results, use of the four unfiltered bailer samples introduces a no apparent bias.

2.4 Pentolite Road Red Water Pond Area Wells

IT-MW05. Overburden well IT-MW05 was purged and sampled by bailer in 1997 and 1998. Turbidity was high in both samples, with recorded readings of 78 and 380 NTUs, respectively. Both samples had numerous exceedances of the RPD criteria, suggesting both have been affected by the sampling method. With the exception of barium and copper in the 1998 sample, both samples had the same analytes detected, although the actual concentrations were much higher in the more turbid 1998 sample. The filtered aliquot from the 1998 sampling event had calcium, magnesium, manganese and sodium detected at similar concentrations as the 1997 unfiltered sample. However, arsenic, chromium, and lead were not detected in the filtered 1998 sample, but were reported in the unfiltered 1997 sample. Lower concentrations were detected in the unfiltered 1997 samples than in the unfiltered 1998 sample, corresponding with the lower turbidity of the former. Even though the turbidity of the 1998 unfiltered sample is relatively high, it is recommended that the results of this sample be included in the BHHRA because: 1) Low-flow methodology has not been used to collect samples from this well to provide a basis for comparison, 2) Based on the limited number of samples collected from this well, it cannot be definitively stated that the turbidity encountered in 1998 is uncharacteristic of this well, 3) The concentrations associated with the unfiltered 1998 sample do not appear to be excessively high in comparison to the 1997 sample, and 4) No other information suggests that analytical results from this well are questionable. Inclusion of the 1998 unfiltered sample may introduce a high bias to the analytical data evaluation, especially with respect to aluminum, barium, chromium, copper, and manganese.

PR-MW7. This overburden well was sampled by bailer in 1997 and 1998 and had turbidities of >999 and 3 NTUs. Data from the two sampling events are nearly identical both in terms of the analytes detected and their concentrations in both the unfiltered and filtered samples. Again, this is likely the result of most of the inorganics being in dissolved form. Because of the similarity of the data, both unfiltered samples are recommended for inclusion in the final data set. Based on review of the analytical results, use of the two unfiltered samples introduces no apparent bias.

PR-MW8. Overburden well PB-PR-MW8 was sampled by bailer in 1997 and 1998 and had turbidities of >999 and 99 NTUs. Data from the two sampling events are nearly identical both in terms of the analytes detected and their concentrations in both the unfiltered and filtered samples. As with the data from well PB-PR-MW7, most of the inorganics are in dissolved form. Because of the similarity of the data, both unfiltered samples are recommended for inclusion in the final data set. Based on review of the analytical results, use of the two unfiltered samples introduces no apparent bias.

PR-MW9. This overburden well was sampled by bailer in 1997 and 1998 and had turbidities of 170 and 9 NTUs. Data from the 1997 sampling event is anomalous, with only manganese and sodium reported in both filtered and unfiltered samples. In the1998 unfiltered sample, cobalt, copper, iron, magnesium, manganese, nickel and sodium were detected. Concentrations observed in the 1998 filtered and unfiltered samples were

similar, except for iron which was not detected in the filtered sample. Because of the similarities of the two samples with respect to comparison between filtered and unfiltered aliquots, it is recommended that both unfiltered samples be included in the final data set. Despite this consistency, however, the 1997 data appear to be anomalously low.

2.5 West Area Red Water Ponds Wells

WA-MW2. Overburden well PB-WA-MW2 was sampled by bailer in 1997 and 1998, and each of the unfiltered samples had a turbidity of greater than 999 NTUs. In the 1998 unfiltered sample, aluminum, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, selenium, sodium, and zinc were detected were detected. These same analytes, minus selenium and zinc, were detected in the 1998 unfiltered sample. Detected concentrations were very similar for the 1997 and 1998 unfiltered samples. The list of detected compounds and concentrations were likewise very similar for the 1998 filtered and unfiltered samples. However, only calcium, manganese, magnesium, and sodium were detected in the 1997 filtered sample.

It is recommended that both unfiltered samples be used in the final data set for the following reasons: 1) Despite very high turbidity measurements, little or no effect of filtration was observed in the 1998 samples, and 2) Concentrations of the 1997 and 1998 unfiltered samples were consistent. It is possible that inclusion of these samples with high turbidity may introduce a high bias; however, based on the similarity between the unfiltered and filtered 1998 samples, these samples are likely characteristic of site conditions.

IT-MW10. This overburden well was sampled by bailer in 1997 and 1998 with turbidities of the unfiltered samples at 1 and >999 NTUs, respectively. This great variation in turbidity readings indicates that sampling methodology probably affected the data quality in the latter sample. In 1997, aluminum, calcium, iron, lead, magnesium, manganese, and sodium were detected in the unfiltered samples. In 1998, the same analytes were detected as well as arsenic, barium, chromium, copper, potassium, vanadium and zinc. The concentration of iron and lead were much higher in the 1997 unfiltered sample than in the 1998 unfiltered sample. Aluminum, iron and lead exceeded 30% RPD in the 1997 samples. In 1998, aluminum, barium, chromium, copper, iron, lead, potassium, vanadium and zinc exceeded the RPD of 30%. The higher number of analytes exceeding the RPD in the 1998 sample was probably due to entrained sediment.

Based on this review, it is recommended that the unfiltered 1997 data and the filtered sample from the 1998 sampling event be used in the data set. Exclusion of the 1998 unfiltered sample is recommended for the following reasons: 1) Excessively high turbidity (>999 NTU) as compared to the low turbidity of the 1997 unfiltered sample (1 NTU), 2) Among the two filtered and two unfiltered samples, five analytes were detected only in the unfiltered 1998 sample and two were detected at much higher concentrations in this sample than in any of the other three. Because only two samples were collected from this well, it is better to include the 1998 filtered sample than to use only the 1997 unfiltered sample. Use of the filtered 1998 sample may introduce a low bias to the

analytical data evaluation; however, the magnitude of the bias with respect to the samples from this well likely do not correspond with the magnitude of difference between the unfiltered 1998 sample and the other three sample aliquots collected from this well.

BED-MW14. Bedrock well PB-BED-MW14 was sampled four times (1997, 1998, 2001 and 2002). The samples collected in 1997 and 1998 were collected by bailer, and the remaining two were collected by low flow. The turbidities of the samples were 269, 36, 5, and 9 NTUs, respectively. Review of the analytical data indicates that most of the analytes were detected at their highest concentrations in the sample collected in 2002 (9 NTU) using low flow methodology. Results of the unfiltered and filtered results for the 2002 samples indicate a high degree of consistency. This consistency is also observed in the 1998 and 2001 filtered versus unfiltered results.

Aluminum, chromium, and iron were detected at their highest concentrations in the PB-BED-MW14 sample collected in 1997. None of these analytes were detected in the corresponding 1997 filtered sample. However, each of the other analytes detected in the unfiltered 1997 sample was also detected in the filtered sample at a similar concentration. Therefore, concentrations of aluminum, chromium, and iron in this sample are evidently associated with turbidity.

It is recommended that the unfiltered sample results for the 1998, 2001, and 2002 be retained in the final data set, along with the filtered results for the 1997 sample based on the following: 1) Turbidity measurement for the 1998, 2001, and 2002 samples are less than 150 NTU and show consistency between filtered and unfiltered samples, 2) The unfiltered sample result from 1997 showed high turbidity, 3) High concentrations of three analytes (aluminum, chromium, and iron) in the 1997 unfiltered samples were associated with turbidity, and 4) Other analytes detected in the 1997 samples showed no effects from filtration, and 5) Inclusion of the filtered sample from 1997 helps to better characterize this data set. Based on review of the analytical results, inclusion of the filtered data from 1997 introduces a potential low bias.

2.6 Downgradient Boundary Wells

BED-MW17. Bedrock well BED-MW17 was sampled in 1997 and 1998 by bailer and in 2001, 2002, and 2004 (twice) using low flow. Turbidities ranged from 11 NTUs to 412 NTUs at the time of sampling. While the three lowest turbidity readings (11, 21 and 134 NTUs) were obtained using low flow sampling, the highest turbidity reading of 412 NTUs was also seen during low flow sampling. The remaining two sampling events were completed using bailers and the turbidity readings were 213 and 318 NTUs. The high turbidity observed in the low flow sample as well as the two bailer samples was due to the release of hydrogen sulfide in the aquifer, which tends to create turbulent flow in the well and hence, more suspended sediment. Regardless, review of the analytical results for this well does not indicate a great variation in either the analytes detected or their concentrations between sampling events. This similarity suggests that most inorganics are present in dissolved form, as does a comparison between filtered and unfiltered aliquots collected during each sampling event. The interpretation of inorganics

present chiefly in dissolved form is consistent with the reducing conditions present in this well as evident by the hydrogen sulfide. Based on these observations, it is recommended that all six unfiltered samples be used in the final data set. Use of these six unfiltered samples, including two low flow samples, introduces no apparent bias.

BED-MW24. Bedrock well PB-BED-MW24 was sampled a total of ten times in 2001, 2002 and 2004. Nine of these were collected using low flow sampling. Review of the analytical data indicates the data from the sample collected in July 2002 is anomalous. This was the only unfiltered sample with an elevated turbidity reading (350 NTUs). The concentration of numerous analytes including aluminum and iron are much higher than the other samples. In addition, chromium and vanadium were detected in this sample but not the remaining samples. Review of the sample collection logs indicate that this well can produce hydrogen sulfide which likely resulted in the elevated turbidity reading and higher concentrations in this single sampling period. It is recommended that this single sample collected in 2002 be removed from the data set. The remaining nine unfiltered samples provide adequate characterization for this well, and their use introduces no apparent bias.

3.0 References

Ohio Environmental Protection Agency (OEPA), 2005, Comment letter from Ron Nabors (OEPA Site Coordinator) to Linda Ingram (USACE Project Manager) regarding the Plum Brook Baseline Human Health Risk Assessment of Groundwater Work Plan, March 3.

Shaw Environmental, Inc. (Shaw), 2005, ***Baseline Human Health Risk Assessment for Groundwater Work Plan***, Draft, Former Plum Brook Ordnance Works, January.

Shaw Environmental, Inc. (Shaw), 2005, ***2004 Data Summary and Evaluation Report***, Final, Former Plum Brook Ordnance Works, April.

Table 1
Summary and Recommendations for the BHHRA Groundwater Data Set

Overburden Wells			
Well ID	**Recommendation[a]**	**Size of Resulting Data Set[b]**	**Direction of Potential Bias[c]**
TNT Area A			
TNTA-MW10	Use all unfiltered samples	3 (bailer)	None apparent
TNTA-MW11*	Eliminate 2001 unfiltered sample	3 (bailer)	None apparent
MK-MW22*	Use all unfiltered samples	2 (bailer)	None apparent
MK-MW23*	Use all unfiltered samples	2 (bailer)	High
MK-MW24	Use all unfiltered samples	11 (2 bailer; 9 low flow)	None apparent
TNT Area B			
MK-MW17	Use all unfiltered samples	5 (3 bailer; 2 low flow)	None apparent
TNA Area C			
TNTC-MW03*	Eliminate 1998 unfiltered sample	2 (bailer)	None apparent
TNTC-MW04*	Use all unfiltered samples	4 (bailer)	None apparent
TNTC-MW05	Use all unfiltered samples	4 (bailer)	None apparent
TNTC-MW06	Use all unfiltered samples	2 (bailer)	None apparent
IT-MW09*	Use all unfiltered samples	2 (bailer)	High
Pentolite Road Red Water Pond Area			
IT-MW05*	Use all unfiltered samples	2 (bailer)	High
PR-MW07*	Use all unfiltered samples	2 (bailer)	None apparent
PR-MW08*	Use all unfiltered samples	2 (bailer)	None apparent
PR-MW09*	Use all unfiltered samples	2 (bailer)	Low[e]
West Area Red Water Pond Area			
PB-WA-MW01	Use all unfiltered samples	2 (bailer)	None apparent
PB-WA-MW02*	Use all unfiltered samples	2 (bailer)	High[f]
IT-MW02	Use all unfiltered samples	2 (bailer)	None apparent
IT-MW10*	Use 1997 unfiltered and 1998 filtered sample	2 (bailer)	Low[d]
Bedrock Wells			
Well ID	**Recommendation[a]**	**Size of Resulting Data Set[b]**	**Direction of Potential Bias[c]**
TNT Area A			
BED-MW18	Use all unfiltered samples	4 (2 bailer; 2 low flow)	None apparent
TNTA-BEDGW-001	Use all unfiltered samples	2 (bailer)	None apparent
TNT Area B			
TNTB-BEDGW-001	Use all unfiltered samples	4 (2bailer; 2 low flow)	None apparent
TNTB-BEDGW-003*	Use all unfiltered samples	2 (bailer)	High
TNTB-BEDGW-004	Use all unfiltered samples	2 (low flow)	None apparent
TNTC Area C			
TNTC-BEDGW-001	Use all unfiltered samples	2 (low flow)	None apparent
BED-MW13*	Use all unfiltered samples	4 (bailer)	None apparent
Pentolite Road Red Water Pond Area			
BED-MW15	Use all unfiltered samples	4 (bailer)	None apparent
BED-MW-23	Use all unfiltered samples	2 (1 bailer; 1 low flow)	None apparent
West Area Red Water Ponds Area			
BED-MW14*	Use filtered 1997 sample	4 (2 bailer; 2 low flow)	Low[d]

Bedrock Wells (cont'd)			
Well ID	**Recommendation[a]**	**Size of Resulting Data Set[b]**	**Direction of Potential Bias[c]**
Downgradient Boundary Wells			
BED-MW17*	Use all unfiltered samples	6 (2 bailer; 4 low flow)	None apparent
BED-MW19	Use all unfiltered samples	6 (2 bailer; 4 low flow)	None apparent
BED-MW22	Use all unfiltered samples	4 (low flow)	None apparent
BED-MW24*	Eliminate July 2002 sample	9 (1 bailer; 8 low flow)	None apparent
BED-MW27	Use all unfiltered samples	3 (bailer)	None apparent
BED-MW30	Use all unfiltered samples	2 (low flow)	None apparent

[a] The default position is to use all unfiltered samples. Reasons for differing from the default are substantially high concentrations that accompany high turbidity measurements. See text for details.
[b] Sample collection method(s) shown in parentheses.
[c] See text for details.
[d] Use of the unfiltered data was judged as nonrepresentative would have introduced an unnecessarily high bias. The filtered data are recommended because: 1) they were generally consistent with the remaining unfiltered data and whatever low bias their inclusion brings is minimal, and 2) exclusion of the filtered sample would have severely limited the size and, thus, representativeness of the data set.
[e] The 1997 data set appears to be anomalously low. However, this determination cannot be definitively made because only two samples were collected from this well.
[f] Samples had very high turbidity. The 1998 filtered sample yielded similar analytical results, but the 1997 filtered sample did not. Thus, the high bias is regarded as possible but not likely.

Note: Each well marked with an asterisk had at least one sample with a turbidity reading exceeding 150 NTU and was, thus, specifically evaluated in this review.

RESPONSE TO COMMENTS ON THE MAY 23, 2005 TECHNICAL MEMORANDUM, "USE OF GROUNDWATER ANALYTICAL DATA IN THE GROUNDWATER BASELINE HUMAN HEALTH RISK ASSESSMENT"

Responses to Comments
Technical Memorandum
"Use of Groundwater Analytical Data in the
Groundwater Baseline Human Health Risk Assessment"
Plum Brook Ordnance Works, Sandusky, Ohio,
May 23, 2005

The May 23, 2005 Technical Memorandum was written in response to OEPA Comment No. 1 on the January 31, 2005 Baseline Human Health Risk Assessment for Groundwater (BHHRA) Work Plan. These Comments on the BHHRA Work Plan were sent to the U.S. Army Corps of Engineers (USACE) Nashville District on March 3, 2005. Note that these responses were approved by the Ohio Environmental Protection Agency (OEPA) during the September 15, 2005 team meeting at Sandusky, Ohio.

Comments by OEPA, Division of Emergency and Remedial Response (DERR) on the Technical Memorandum.

Reviewer: Ron Nabors

Ohio EPA has reviewed the technical memorandum and corresponding ground water dataset evaluation and have the following comments. For clarification, the shallow overburden saturated zone will not be quantitatively evaluated in the baseline human health risk assessment; only the bedrock (shale/carbonate) zone.

Comment 1a: **Filtered and unfiltered ground water analytical results should not be pooled into one dataset for the purpose of developing a ground water exposure point concentration (EPC). The two types of data are inherently different due to sample collection techniques (i.e., use of a 0.45 micron filter) and potential differences in exposures to receptors (e.g., filtered ingestion of ground water by an adult and unfiltered dermal contact by a construction worker). USACE/Shaw should develop ground water datasets at each well that are comprised totally of unfiltered ground water analytical results for use in the risk assessment.**

Response 1a: It is recognized that low-flow sampling is generally regarded as superior to a bailer method because of the turbidity that may be generated through use of a bailer. We also recognize that unfiltered analytical data are generally preferable, unless excessive turbidity associated with the sampling method is encountered. That is why the second bullet on page 2-2 of the Work Plan recommended that filtered bailer data be used rather than unfiltered as a starting point, and that the unfiltered bailer data be considered if the filtered bailer concentrations are obviously less than the unfiltered low-flow concentrations. OEPA responded with the excellent suggestion that a table be developed to compare data so that all team members can agree on a data set prior to performing risk calculations. The Technical Memorandum and accompanying tables were prepared responsive to the OEPA suggestion.

There was apparently a miscommunication between USACE/Shaw and OEPA on the issue of combining data. USACE/Shaw did not understand the OEPA comment to indicate that filtered data could not be combined with unfiltered data under any circumstance, but rather that the data should be evaluated individually to make this determination. The conclusions of the Technical Memorandum recommended the inclusion of only two filtered samples in the BHHRA. These are the 1998 filtered sample from IT-MW10 and the 1997 filtered sample from BED-MW14. The Technical Memorandum well-by-well comparison gives the reasoning behind these recommendations.

Based on OEPA Comment No. 1a on the Technical Memorandum, USACE/Shaw will remove the unfiltered samples from IT-MW10 collected in 1998 and the unfiltered sample from BED-MW14 collected in 1997 without replacement by the associated filtered samples.

Comment 1b: **Ohio EPA is amenable with pooling unfiltered ground water analytical results collected using bailer and low-flow sampling techniques. Ohio EPA supports this decision due to the fact that many of the wells (both overburden and bedrock) display minimal recharge thus prohibiting the use of low-flow sampling techniques. The amount of time, funding, and other resources necessary to collect a database entirely of unfiltered low-flow ground water analytical results at each area of concern does not appear to be justified for the purposes of the sitewide ground water investigation (GWI) at the NASA Plum Brook Station (NPBS).**

Response 1b: Comment noted.

Comment 1c: **Ohio EPA is unclear as to why the shallow overburden saturated zone will not be quantitatively evaluated in the risk assessment. Ohio EPA requests that Shaw provide them with the rationale for excluding this zone from the *(sic)*.**

Response 1c: Groundwater in the overburden is very continuous and seasonal. During the 2001 groundwater remedial investigation the installation of 135 temporary piezometers were planned. After the installation of only 32 piezometers, the USACE and OEPA agreed that further installation of temporary overburden piezometers was not required because of a paucity of groundwater. Note that groundwater was encountered during drilling in only 1 (TNTA-GW21) of the 32 piezometers that were installed. After letting the temporary piezometers stand for up to 7 days, 26 of these wells were dry and 1 piezometer had only a few inches of water in it (TNTB-GW02).

Even though perched groundwater is present in some areas and potentially could be contacted by construction workers, such exposure would be limited. The limited extent and seasonality of the groundwater would result in any groundwater exposure to be of a very short term. Because of the temperature conductance of water and the temperate climate of northern Ohio, a worker would not be expected to have prolonged contact with water during most of

the year. The majority of the warmer months, when worker contact would otherwise be more plausible, are dry months (e.g., July, August, September) at PBOW when little water would typically be expected in the overburden. Generally, at PBOW the water table is several feet below ground surface, even during wet months. Therefore, because of safety concerns (i.e., wall collapse) at these depths, it is expected that time spent in an excavation, where groundwater may be present, would be minimal. Any exposure to site-related chemicals via groundwater contact (if present) would be accordingly minimal in comparison to risks associated with direct contact of site soils.

Based on potential site-related human health risks associated with direct contact with soil, soil removal and remediation has largely been completed at TNTB and the Pentolite Road Red Water Pond Area, and is planned for TNTA and TNTC. Such removal and remediation is being performed following the site health and safety plan to minimize human health risks. Removal of the soil represents a removal of a potential source to groundwater contamination in the overburden groundwater where it exists. Thus, post-remediation contact with overburden groundwater should minimize risks even further. Analytical results from the overburden groundwater are being used in a site-wide groundwater transport model to determine the potential impact of site-related chemicals in the overburden groundwater on future concentrations in the bedrock aquifer.

Comment 1d: **In summary, Ohio EPA is amenable with the ground water datasets proposed in the technical memorandum with the modifications noted in items a. and b. above.**

Response 1d: See responses to 1a and 1b.

Comment 2a: **Once the ground water datasets for each well have been established, Ohio EPA is unclear as to how the datasets will be used in the risk assessment. For example, will a statistical upper confidence limit be developed for each well at each area of concern (AOC) for use as a ground water exposure point concentration (EPC)?**

Response 2a: Sufficient data are not available to perform a statistical evaluation at each well.

Comment 2b: **Will the datasets for all the wells at a particular AOC be pooled to calculate a single statistical value for use as an EPC?**

Response 2b: Section 3.2.1 of the Work Plan states that a 95th percent upper confidence limit on the mean will be calculated for each data set having at least five samples. This protocol is the same as that used for previous human health risk assessments and work plans associated with PBOW (IT Corporation, 1998a,b; 2000a,b; 2001). For groundwater, there are no identified plumes, so the USACE considers it appropriate to pool all of the data for each AOC; for the overburden, this includes both monitoring well and direct-push results for

organics. As stated in the Work Plan, the overburden and bedrock units will be evaluated separately.

Comment 2c: **Will a maximum contaminant concentration or a statistical upper confidence limit be used as an EPC at each well, whichever is higher, or will the corresponding EPC be obtained from pooling all data from all wells at a particular AOC?**

Response 2c: As stated in the response to Comment No. 2b., it is the intention of the USACE to pool all appropriate data for each water bearing unit.

Comments 2d: **Is the risk assessment going to be completed at each well individually at each AOC or will the wells be 'pooled' in some manner as to evaluate each AOC as a whole?**

Response 2d: The risk assessment will be based on the EPC of the pooled data of all appropriate analytical data for each AOC. This EPC will either be a UCL of the arithmetic mean concentration or the maximum detected concentration, whichever is lower.

Comment 2e: **How will the risk associated with the downgradient boundary wells be compared or evaluated against the risk associated with the AOCs located further upgradient at the NPBS?**

Response 2e: The Scope of Work for the groundwater risk assessment includes a single evaluation of all combined downgradient locations to determine whether the potential exists for adverse human health effects at any downgradient well. The Work Plan will be revised to specify that the maximum detected concentrations will be used in the determination of the EPCs for the downgradient wells.

Comment 2f: **The items noted above (i.e., 2a through 2 e) should be clarified in some form of sitewide GWI risk assessment work plan.**

Response 2f: Based on the contract between Shaw and the USACE, the current Work Plan pertains only to the three TNT manufacturing, the two red water pond areas, and wells downgradient of these areas at the facility boundary.

Comment 3: **For reference, Ohio EPA has developed an approach for the calculation of ground water EPCs for use in risk assessments for portions of facilities subject to the requirements of a RCRA/Ohio EPA Division of Hazardous Waste Management closure. The EPC is calculated using the 95% upper confidence limit (UCL) of the mean where the dataset consists of 12 samples from three monitoring wells over four quarters of sampling at each well. These wells should be located within the center of the contaminant plume. If less than 3 wells are contaminated, then the maximum concentration (taken from the well with the highest concentration of the contaminant) should be used as the ground water**

EPC. If the maximum contaminant concentration is lower than the 95% UCL, then the maximum contaminant concentration should be used as the EPC.

For inorganic constituents of concern (COCs), the type of ground water data (filtered vs. unfiltered) to be used in the risk assessment is based upon an evaluation of turbidity. If the turbidity of the ground water can be reduced to a level below 5 nephelometric turbidity units (NTUs) by using low flow purging and sampling techniques, then the inorganic background database shall consist of total metals results. If the turbidity of the shallow ground water cannot be reduced to a level below 5 NTUs, then the facility may generate an inorganic background database based upon filtered metals results.

Response 3: Each organic compound with a maximum detected concentration (MDC) exceeding the U.S. Environmental Protection Agency Region 9 Preliminary Remediation Goal (PRG) for tap water (EPA, 2004), based on a hazard quotient of 0.1 or incremental lifetime cancer risk of 1 by 10^{-6} (whichever results in a lower concentration), will be selected as a chemical of potential concern (COPC). Groundwater risks associated with each organic COPC in the BHHRA will be based on the exposure point concentration (EPC). Either the 95th percent upper confidence limit of the arithmetic mean (UCL) or the maximum detected concentration (MDC) of the data set, whichever is less, will represent the EPC for that COPC. Consistent with the human health risks assessments performed for other media at TNTA, TNTB, TNTC, and the Red Water Pond Areas, the MDC will be used as the EPC for all data sets with fewer than five samples.

For the BHHRA, only unfiltered groundwater data will be evaluated. Groundwater risks associated with inorganics will be assessed as described above for organic compounds, except that the MDC of each unfiltered inorganic will also be screened against the background screening concentration (BSC) (Shaw, 2005). Only an inorganic whose MDC exceeds the BSC will be further evaluated in the BHHRA.

With respect to the first paragraph of Comment No. 3, quarterly sampling was not performed in any of the former TNT or red water pond areas. A brief review of the nitroaromatics analytical results reveals no plumes in bedrock groundwater among the TNT manufacturing areas and the red water pond areas. With respect to the overburden, either no plume is apparent or too few wells are present to identify a plume (e.g., only one overburden well is present in TNTB). It is also noted that groundwater may be too intermittent in the overburden to identify a plume.

In addition to monitoring wells, groundwater samples were collected from temporary piezometers that were installed using direct-push technology. With respect to organics in overburden groundwater, one-time samples have been collected from numerous temporary piezometers. For organics, the USACE

plans to use these along with the monitoring well samples for risk evaluation. Note that because only a qualitative screening evaluation is planned for overburden groundwater, the MDC for each organic analyte would be used in the screening evaluation.

The second paragraph of Comment No. 3 presents the possibility of screening filtered site data against filtered background data for those unfiltered samples or wells in which NTU readings cannot be reduced to a value below 5 NTUs. The USACE will consider screening of filtered site data against filtered background data, as appropriate, in the uncertainties analysis. For instance, if the MDC of unfiltered arsenic were to exceed the BSC and PRG, arsenic would be carried through the risk assessment. However, if it were shown that the observed concentrations of arsenic in unfiltered groundwater were associated with excessive turbidity (based on a comparison of filtered data for the site versus the filtered data for the background samples), then it might be stated that, in this case, arsenic is unlikely to be truly site related and should not be regarded as a COC.

Comment 4: **Shaw should be preparing responses to the remainder of the Ohio EPA letter dated March 3, 2005 on the January 2005 Baseline Human Health Risk Assessment for Groundwater Work Plan for submittal and review by the agency.**

Response 4: Shaw has prepared responses to the remainder of the March 3, 2003 letter. These are included in this same submittal.

APPENDIX C

STATISTICAL OUTPUT FOR COMPARISONS TO BACKGROUND

Site-To-Background WRS Test Results for TNT Area A

Aluminum TNT A GW

	Rank Sum	Rank Sum	U	Z	p-level	Z	p-level	Valid N	Valid N	2*1sided
Var2	126.0000	435.0000	29.00000	2.058595	0.039534	2.062217	0.039188	5	28	0.039193

Arsenic TNT A GW

	Rank Sum	Rank Sum	U	Z	p-level	Z	p-level	Valid N	Valid N	2*1sided
Var2	161.0000	434.0000	28.00000	2.529822	0.011413	3.141275	0.001682	6	28	0.009345

Iron TNT A GW

	Rank Sum	Rank Sum	U	Z	p-level	Z	p-level	Valid N	Valid N	2*1sided
Var2	71.00000	490.0000	56.00000	-0.702935	0.482097	-0.704113	0.481363	5	28	0.509497

Manganese TNT A GW

	Rank Sum	Rank Sum	U	Z	p-level	Z	p-level	Valid N	Valid N	2*1sided
Var2	139.0000	456.0000	50.00000	1.535963	0.124548	1.536081	0.124520	6	28	0.132827

Nickel TNT A GW

	Rank Sum	Rank Sum	U	Z	p-level	Z	p-level	Valid N	Valid N	2*1sided
Var2	143.0000	452.0000	46.00000	1.716665	0.086041	2.429402	0.015124	6	28	0.090705

Site-To-Background WRS Test Results for TNT Area B

Aluminum TNT B GW

	Rank Sum	Rank Sum	U	Z	p-level	Z	p-level	Valid N	Valid N	2*1sided
Var2	197.0000	433.0000	27.00000	2.927991	0.003412	2.929016	0.003401	7	28	0.002140

Arsenic TNT B GW

	Rank Sum	Rank Sum	U	Z	p-level	Z	p-level	Valid N	Valid N	2*1sided
Var4	190.0000	476.0000	70.00000	1.598141	0.110013	2.101401	0.035607	8	28	0.115644

Iron TNT B GW

	Rank Sum	Rank Sum	U	Z	p-level	Z	p-level	Valid N	Valid N	2*1sided
Var6	218.0000	448.0000	42.00000	2.663568	0.007732	2.667003	0.007653	8	28	0.006302

Manganese TNT B GW FDs Averaged

	Rank Sum	Rank Sum	U	Z	p-level	Z	p-level	Valid N	Valid N	2*1sided
Var8	213.0000	453.0000	47.00000	2.473313	0.013387	2.473472	0.013381	8	28	0.011957

Manganese Alt TNT B GW

	Rank Sum	Rank Sum	U	Z	p-level	Z	p-level	Valid N	Valid N	2*1sided
Var10	177.0000	453.0000	47.00000	2.103205	0.035449	2.103352	0.035436	7	28	0.035152

Site-To-Background WRS Test Results for PRRWP

Iron PRRWP GW

	Rank Sum	Rank Sum	U	Z	p-level	Z	p-level	Valid N	Valid N	2*1sided
Var2	143.0000	452.0000	46.00000	1.716665	0.086041	1.719294	0.085562	6	28	0.090705

Manganese PRRWP GW

	Rank Sum	Rank Sum	U	Z	p-level	Z	p-level	Valid N	Valid N	2*1sided
Var4	109.0000	486.0000	80.00000	0.180702	0.856602	0.180715	0.856591	6	28	0.877611

Site-To-Background WRS Test Results for DBW

Iron DBW GW

	Rank Sum	Rank Sum	U	Z	p-level	Z	p-level	Valid N	Valid N	2*1sided
Var2	708.0000	832.0000	330.0000	-0.808122	0.419021	-0.816411	0.414266	27	28	0.426919

Manganese DBW GW

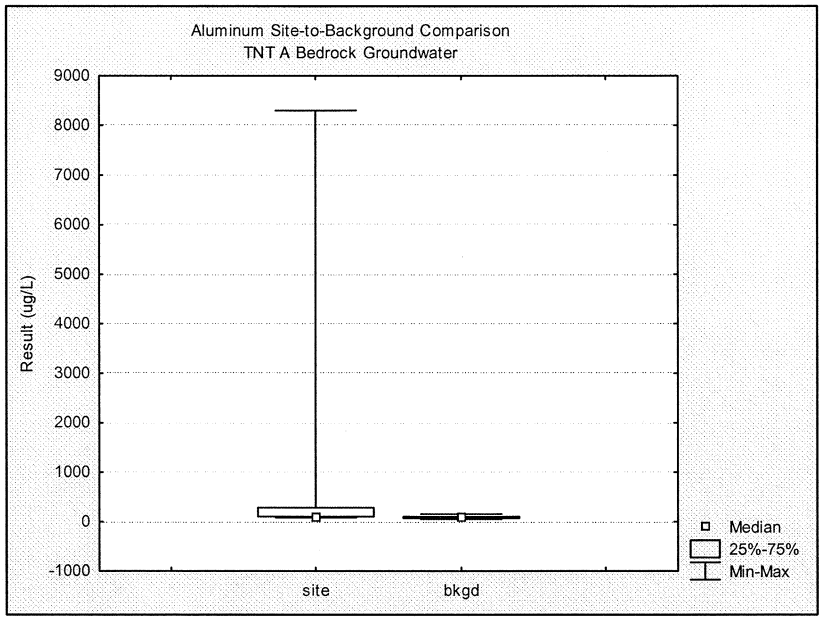
	Rank Sum	Rank Sum	U	Z	p-level	Z	p-level	Valid N	Valid N	2*1sided
Var4	604.0000	936.0000	226.0000	-2.55905	0.010496	-2.55915	0.010493	27	28	0.009965

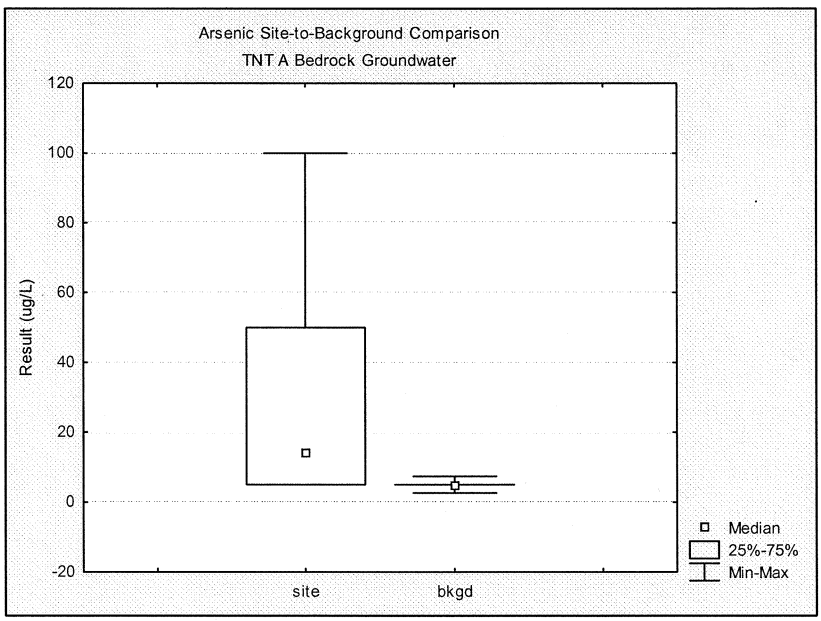
Iron DBW w/o MW27 samples

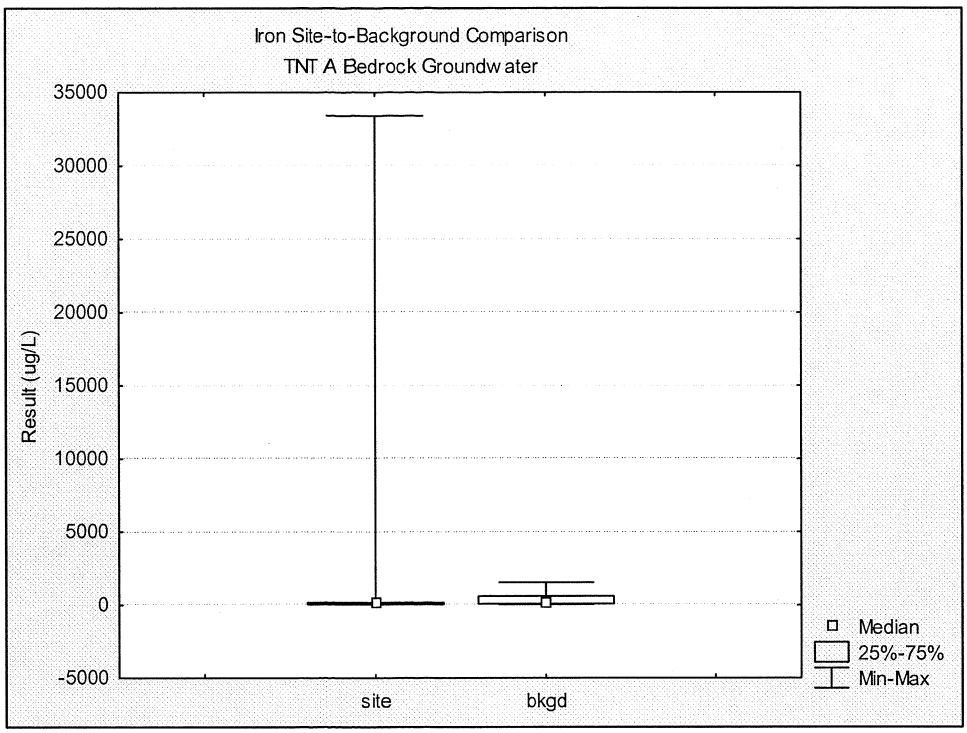
	Rank Sum	Rank Sum	U	Z	p-level	Z	p-level	Valid N	Valid N	2*1sided
Var2	546.0000	832.0000	246.0000	-1.65200	0.098535	-1.67211	0.094504	24	28	0.100729

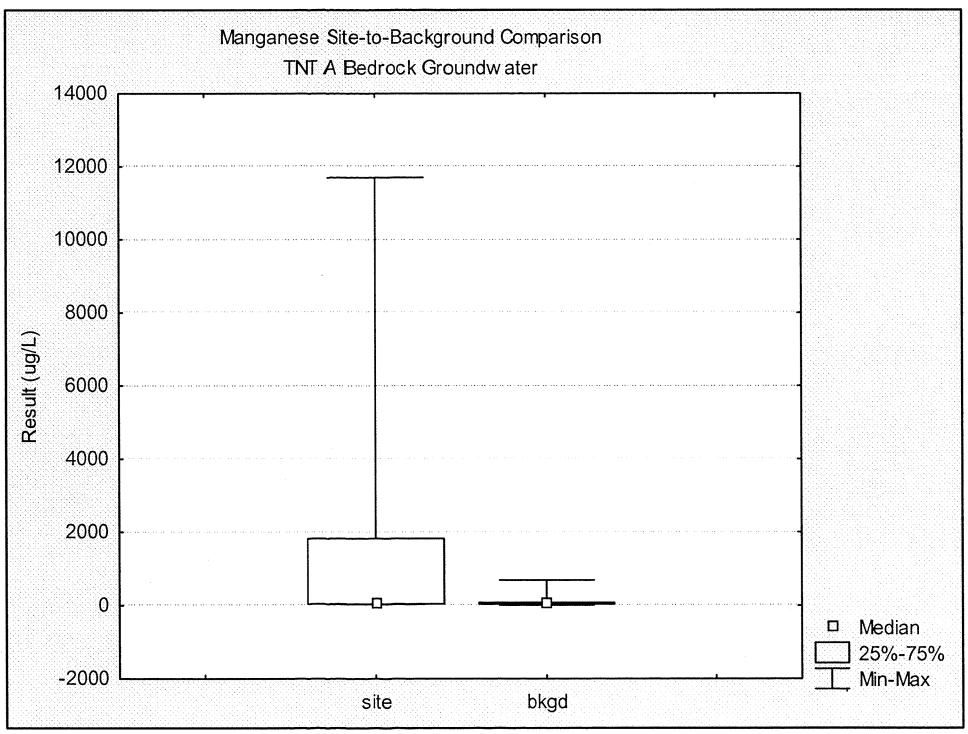
Manganese DBW w/o MW27 samples

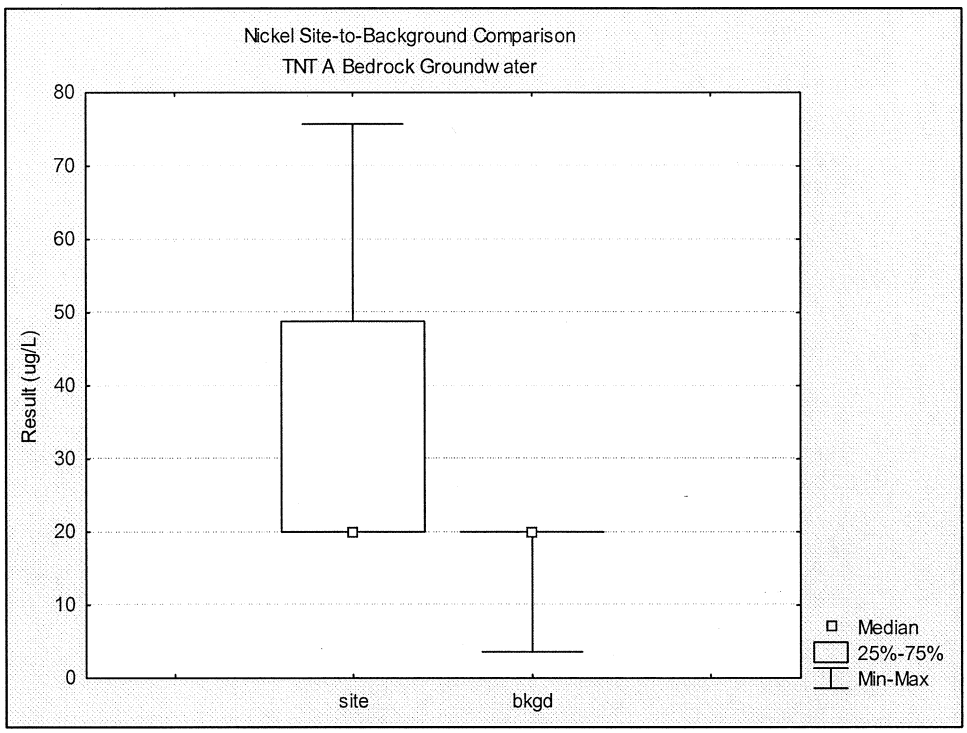
	Rank Sum	Rank Sum	U	Z	p-level	Z	p-level	Valid N	Valid N	2*1sided
Var4	443.0000	935.0000	143.0000	-3.54263	0.000396	-3.54278	0.000396	24	28	0.000264

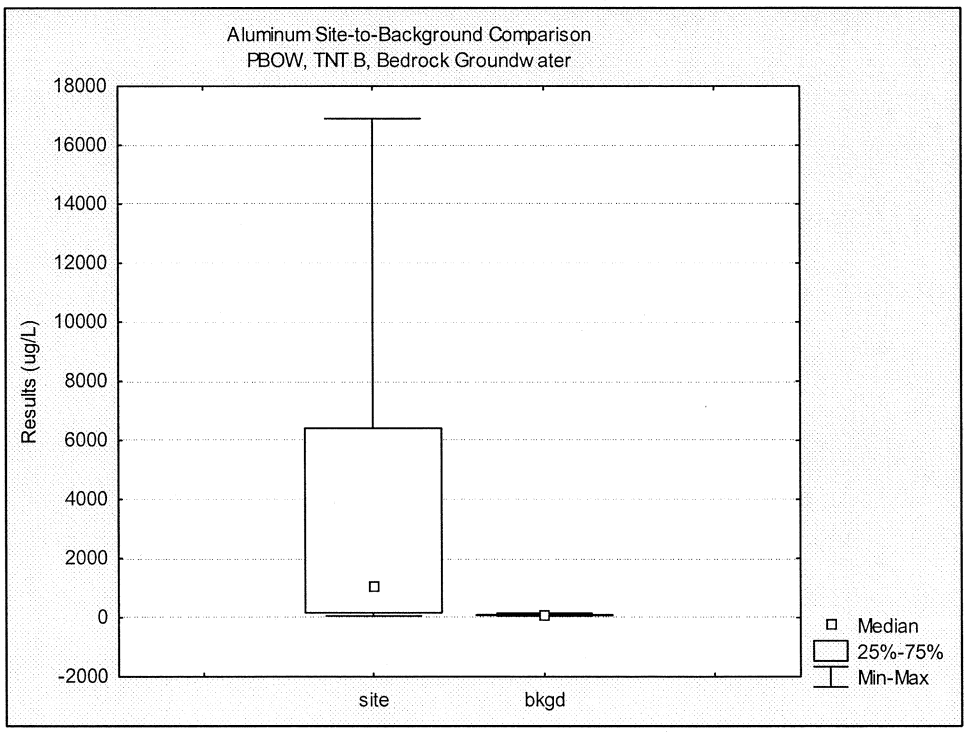

Aluminum Site-to-Background Comparison
TNT A Bedrock Groundwater
Result (ug/L)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
site
bkgd
Median
25%-75%
Min-Max

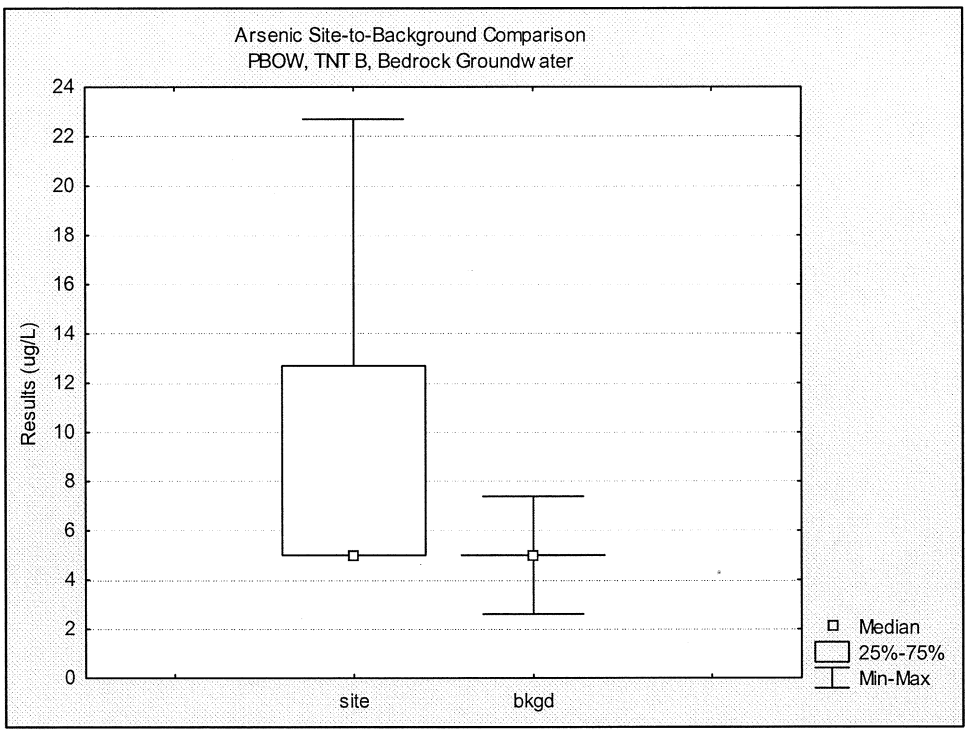

Arsenic Site-to-Background Comparison
TNT A Bedrock Groundwater
Result (ug/L)
120
100
80
60
40
20
0
-20
site
bkgd
Median
25%-75%
Min-Max

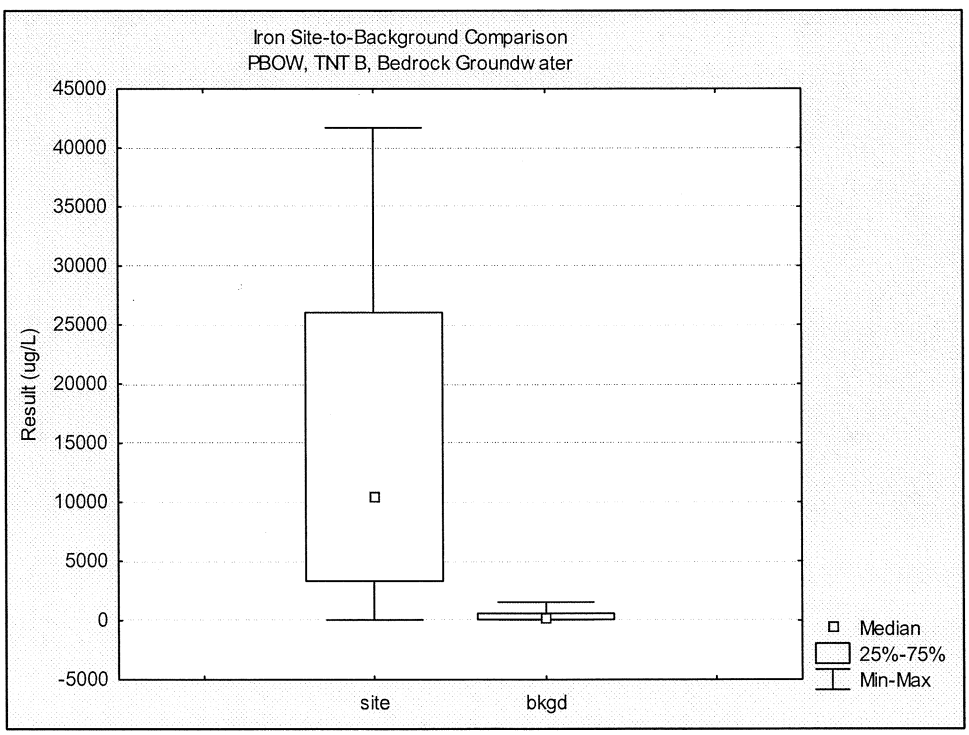

Iron Site-to-Background Comparison
TNT A Bedrock Groundwater
35000
30000
25000
20000
15000
10000
5000
0
-5000
Result (ug/L)
site
bkgd
Median
25%-75%
Min-Max

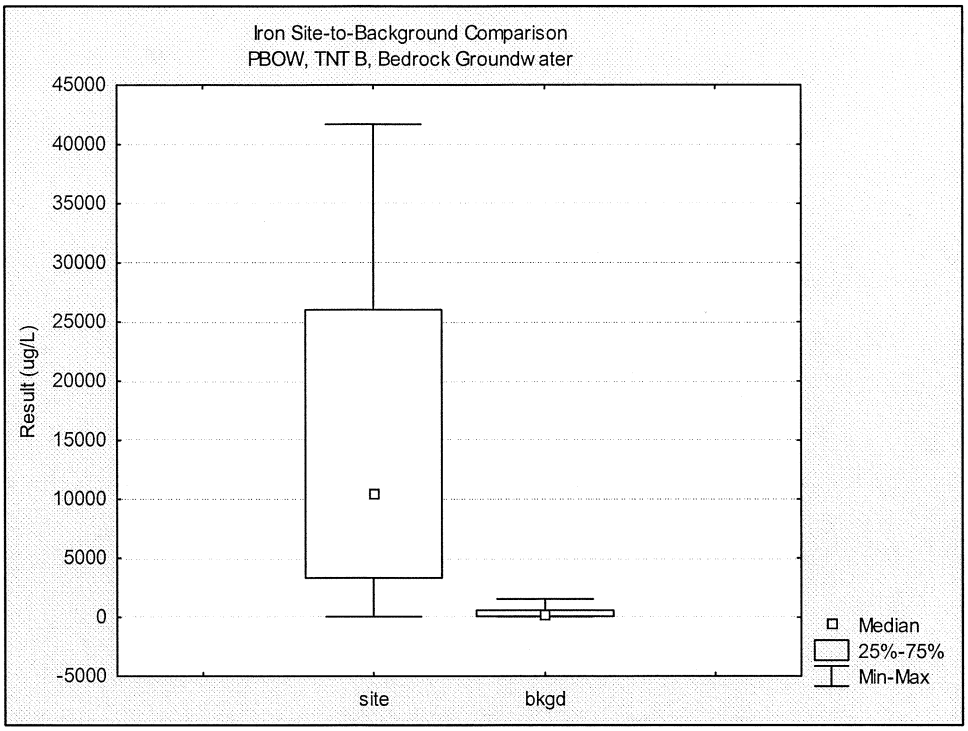

Manganese Site-to-Background Comparison
TNT A Bedrock Groundwater
14000
12000
10000
8000
6000
4000
2000
0
-2000
Result (ug/L)
site
bkgd
Median
25%-75%
Min-Max

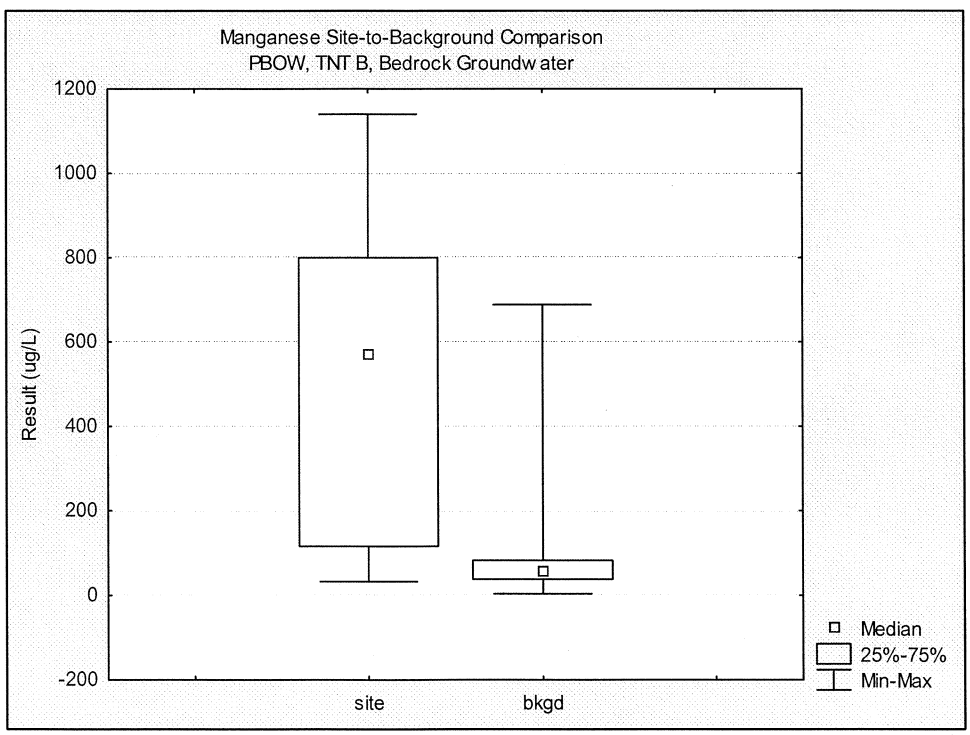

Nickel Site-to-Background Comparison
TNT A Bedrock Groundwater
Result (ug/L)
80
70
60
50
40
30
20
10
0
site
bkgd
Median
25%-75%
Min-Max

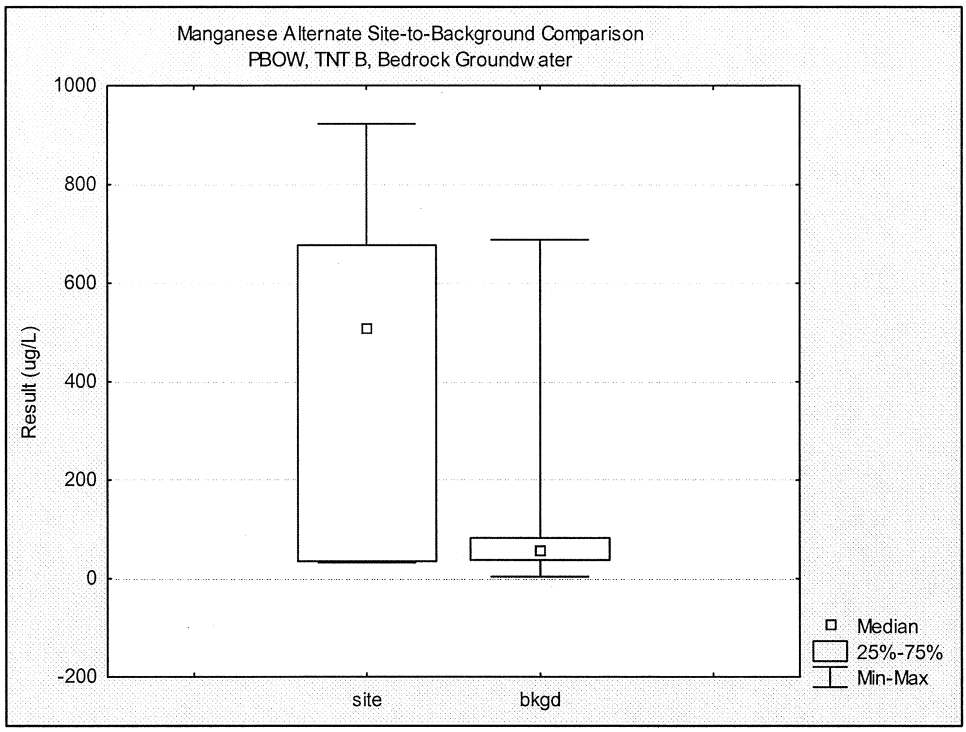

Aluminum Site-to-Background Comparison
PBOW, TNT B, Bedrock Groundwater
Results (ug/L)
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000
site
bkgd
Median
25%-75%
Min-Max

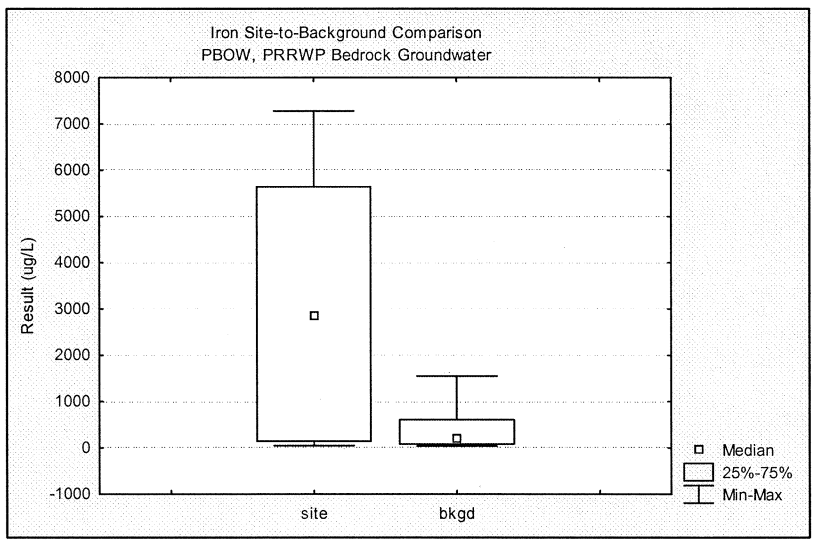

Arsenic Site-to-Background Comparison
PBOW, TNT B, Bedrock Groundwater
Results (ug/L)
24
22
20
18
16
14
12
10
8
6
4
2
0
site
bkgd
Median
25%-75%
Min-Max

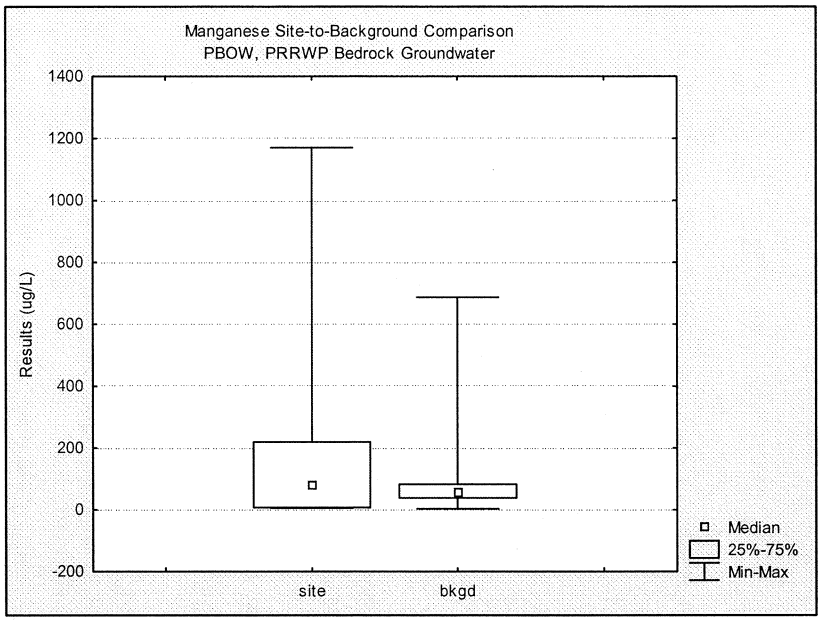

Iron Site-to-Background Comparison
PBOW, TNT B, Bedrock Groundwater
Result (ug/L)
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
site
bkgd
Median
25%-75%
Min-Max

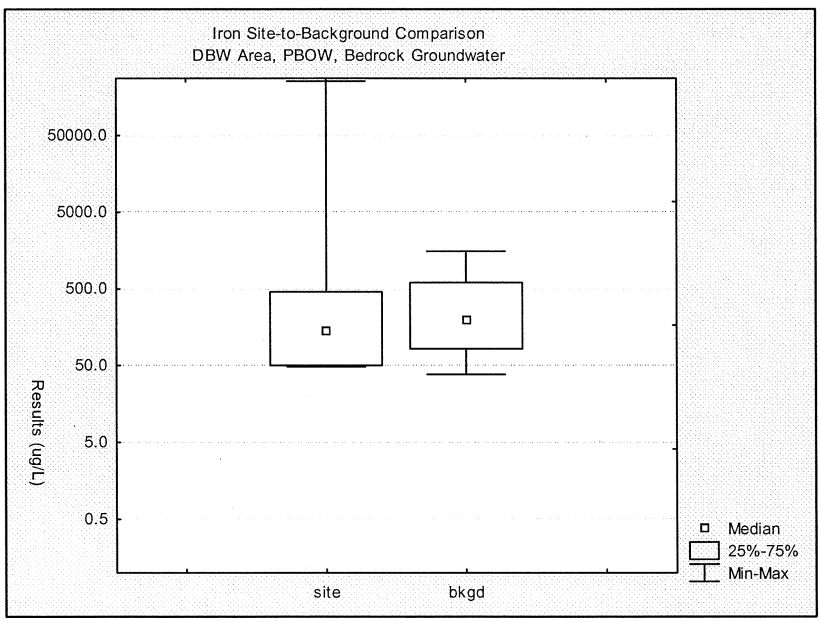

Iron Site-to-Background Comparison
PBOW, TNT B, Bedrock Groundwater
Result (ug/L)
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
site
bkgd
Median
25%-75%
Min-Max

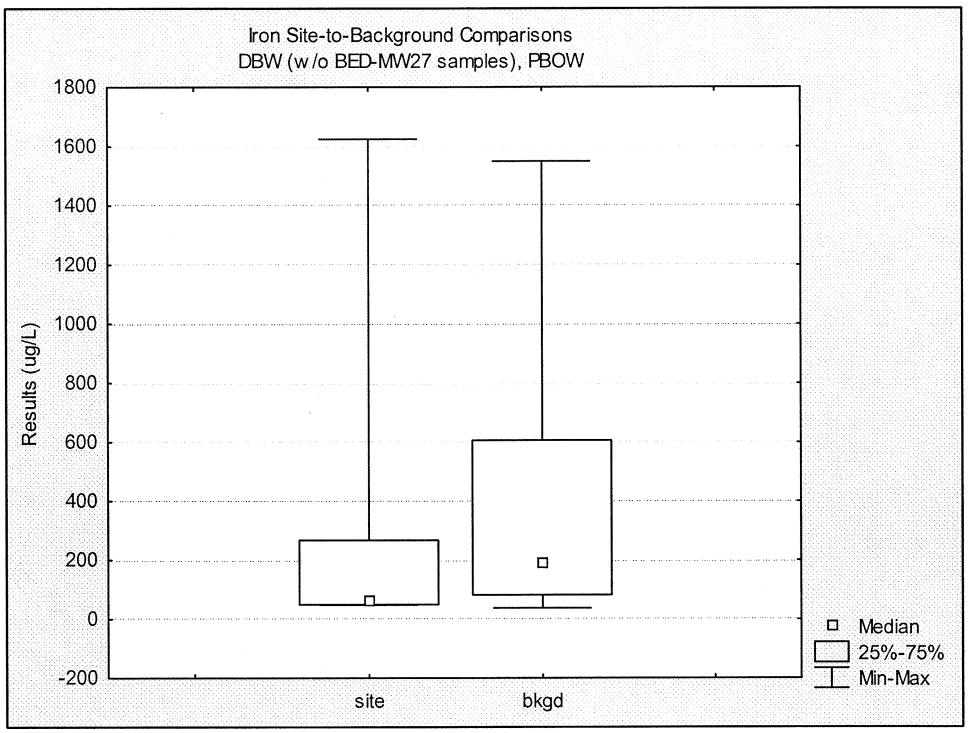

Manganese Site-to-Background Comparison
PBOW, TNT B, Bedrock Groundwater
Result (ug/L)
1200
1000
800
600
400
200
0
-200
site
bkgd
Median
25%-75%
Min-Max

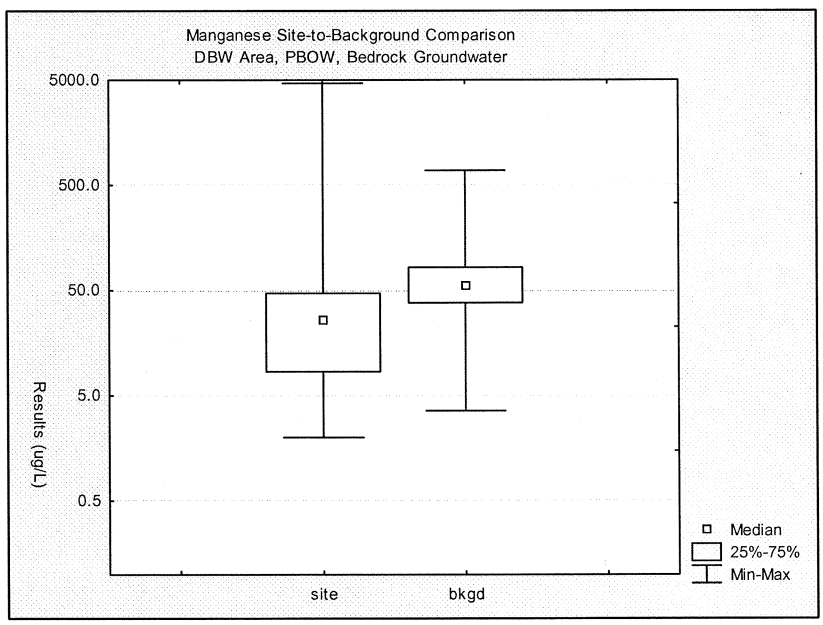

Manganese Alternate Site-to-Background Comparison
PBOW, TNT B, Bedrock Groundwater
Result (ug/L)
1000
800
600
400
200
0
-200
site
bkgd
Median
25%-75%
Min-Max

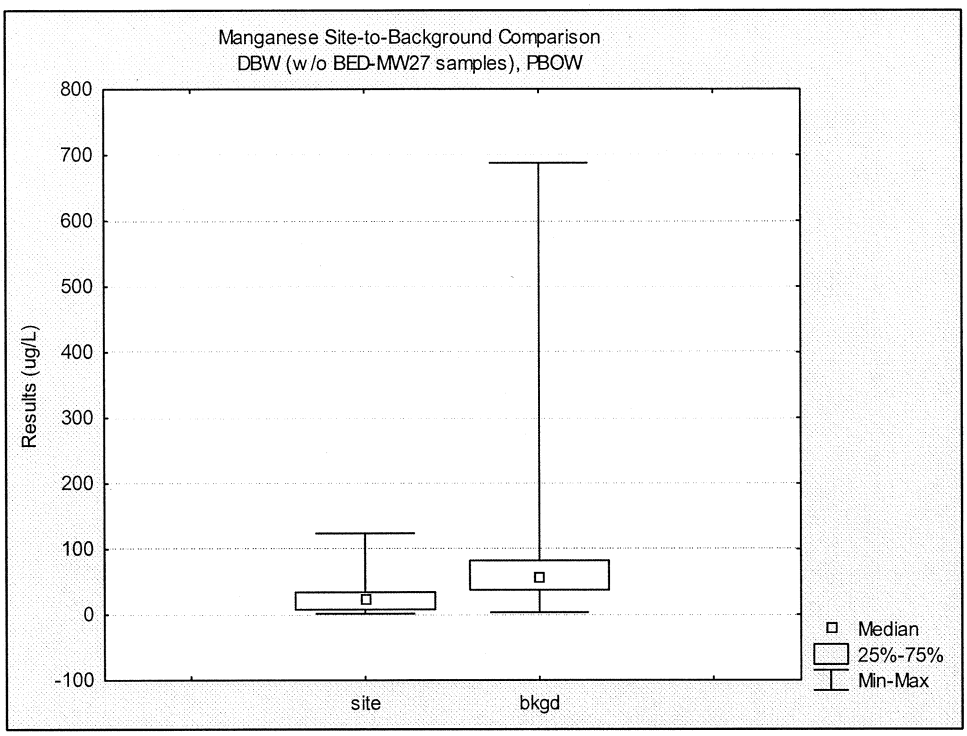

Iron Site-to-Background Comparison
PBOW, PRRWP Bedrock Groundwater
Result (ug/L)
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
site
bkgd
Median
25%-75%
Min-Max


Manganese Site-to-Background Comparison
PBOW, PRRWP Bedrock Groundwater
Results (ug/L)
1400
1200
1000
800
600
400
200
0
-200
site
bkgd
Median
25%-75%
Min-Max


Iron Site-to-Background Comparison
DBW Area, PBOW, Bedrock Groundwater
Results (ug/L)
50000.0
5000.0
500.0
50.0
5.0
0.5
site
bkgd
Median
25%-75%
Min-Max


Iron Site-to-Background Comparisons
DBW (w/o BED-MW27 samples), PBOW
Results (ug/L)
1800
1600
1400
1200
1000
800
600
400
200
0
-200
site
bkgd
Median
25%-75%
Min-Max


Manganese Site-to-Background Comparison
DBW Area, PBOW, Bedrock Groundwater
Results (ug/L)
5000.0
500.0
50.0
5.0
0.5
site
bkgd
Median
25%-75%
Min-Max


Manganese Site-to-Background Comparison
DBW (w/o BED-MW27 samples), PBOW
Results (ug/L)
800
700
600
500
400
300
200
100
0
-100
site
bkgd
Median
25%-75%
Min-Max

APPENDIX D

INTEGRATED EXPOSURE UPDATE BIOKINETIC MODEL OUTPUT FOR LEAD

LEAD MODEL FOR WINDOWS Version 1.0

Model Version: 1.0 Build 263
User Name: Tom Siard
Date: 02/22/2006
Site Name: PBOW
Operable Unit: TNTA
Run Mode: Site Risk Assessment

Water Data
Mean TNTA GW Lead Conc.
Soil/Dust Data
Mean TNTA Soil Lead COnc.

The time step used in this model run: 1 - Every 4 Hours (6 times a day).

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	5.530
1-2	5.780
2-3	6.490
3-4	6.240
4-5	6.010
5-6	6.340
6-7	7.000

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 12.300 ug Pb/L

****** Soil & Dust ******

Multiple Source Analysis Used
Average multiple source concentration: 273.900 ug/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700
Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	377.000	273.900
1-2	377.000	273.900
2-3	377.000	273.900
3-4	377.000	273.900
4-5	377.000	273.900
5-6	377.000	273.900
6-7	377.000	273.900

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

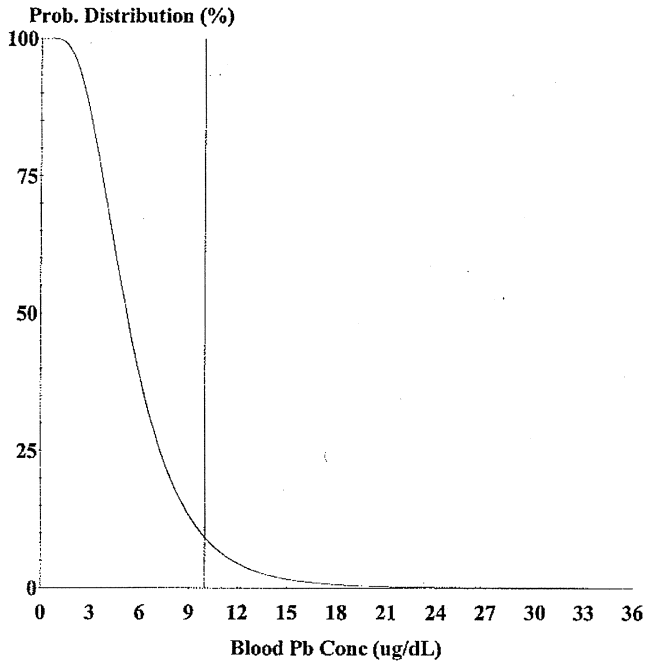
****** Maternal Contribution: Infant Model ******

Maternal Blood Concentration: 2.500 ug Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	2.443	0.000	1.087
1-2	0.034	2.498	0.000	2.658
2-3	0.062	2.853	0.000	2.811
3-4	0.067	2.791	0.000	2.916
4-5	0.067	2.770	0.000	3.118
5-6	0.093	2.955	0.000	3.325
6-7	0.093	3.282	0.000	3.403

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	7.216	10.766	5.8
1-2	11.211	16.401	6.7
2-3	11.403	17.129	6.3
3-4	11.605	17.379	6.0
4-5	8.858	14.812	5.2
5-6	8.062	14.437	4.5
6-7	7.659	14.437	4.1



Cutoff = 10.000 ug/dl
Geo Mean = 5.473
GSD = 1.600
% Above = 9.986

Age Range = 0 to 84 months
Time Step = Every 4 Hours
Run Mode = Site Risk Assessment

LEAD MODEL FOR WINDOWS Version 1.0

Model Version: 1.0 Build 263
User Name: Tom Siard
Date: 02/22/2006
Site Name: PBOW
Operable Unit: TNTA (Post-Remediation)
Run Mode: Site Risk Assessment

Water Data
Mean TNTA GW Lead Conc.
Soil/Dust Data
Mean TNTA Soil Lead COnc.
GSD, Cutoff and Age Type
graph
Water Data
TNTA Mean Groundwater Lead Conc.
Soil/Dust Data
Estimated Post-Remediation Soil Lead Conc. from TNT A&C Feasibility Study
Water Data
Mean TNTA GW Lead Conc.
Soil/Dust Data
Estimated Post-Remediation Mean Soil Lead Conc. from TNT A&C Feasibility Study

The time step used in this model run: 1 - Every 4 Hours (6 times a day).

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	5.530
1-2	5.780
2-3	6.490
3-4	6.240
4-5	6.010
5-6	6.340
6-7	7.000

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550

5-6	0.580
6-7	0.590

Drinking Water Concentration: 12.300 ug Pb/L

****** Soil & Dust ******

Multiple Source Analysis Used
Average multiple source concentration: 58.650 ug/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700
Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	69.500	58.650
1-2	69.500	58.650
2-3	69.500	58.650
3-4	69.500	58.650
4-5	69.500	58.650
5-6	69.500	58.650
6-7	69.500	58.650

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

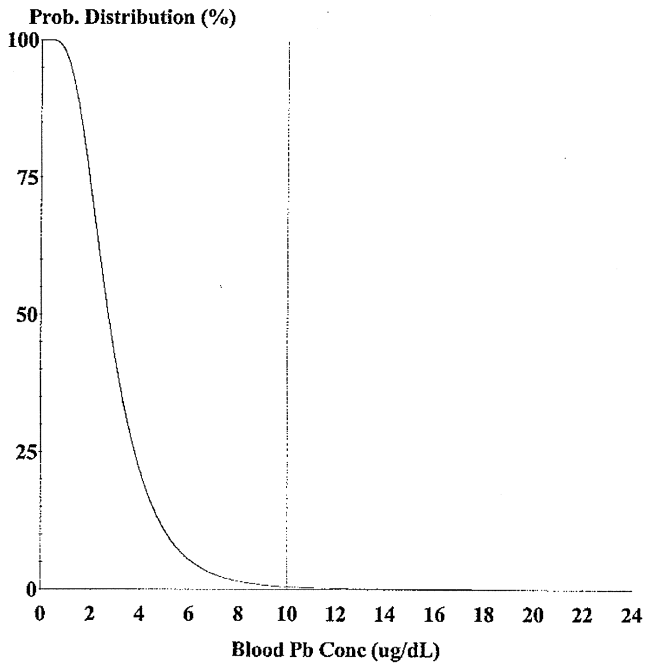
****** Maternal Contribution: Infant Model ******

Maternal Blood Concentration: 2.500 ug Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	2.603	0.000	1.158
1-2	0.034	2.695	0.000	2.867
2-3	0.062	3.047	0.000	3.003
3-4	0.067	2.956	0.000	3.088
4-5	0.067	2.877	0.000	3.239
5-6	0.093	3.047	0.000	3.429
6-7	0.093	3.371	0.000	3.495

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	1.525	5.308	2.9
1-2	2.399	7.996	3.3
2-3	2.416	8.527	3.2
3-4	2.438	8.549	3.0
4-5	1.825	8.007	2.7
5-6	1.649	8.219	2.5
6-7	1.560	8.520	2.4



Cutoff = 10.000 ug/dl
Geo Mean = 2.864
GSD = 1.600
% Above = 0.391

Age Range = 0 to 84 months
Time Step = Every 4 Hours
Run Mode = Site Risk Assessment

APPENDIX E

PBOW SITE GROUNDWATER MODEL

Groundwater Modeling for the Unsaturated and Saturated Zones Plum Brook Ordnance Works Sandusky, Ohio

Table of Contents

Page

List of Attachments ii
List of Tables iii
List of Figures iv
List of Acronyms vii
1.0 Introduction 1-1
2.0 Model Selection 2-1
2.1 Vadose Zone Leaching and Saturated Zone Mixing Model (VLEACHSM) 2-1
2.2 MODFLOW and MT3D 2-1
3.0 Site Conceptual Model 3-1
3.1 TNT Manufacturing Process and Potential Sources of Contamination 3-1
3.2 Modes of Contaminant Release 3-1
3.3 Contaminant Transport in Groundwater 3-2
3.4 Site-Specific Data for Model Inputs 3-2
3.5 Model Layers and Grids 3-3
3.6 Surface Streams and Ditches 3-3
3.7 Current Pump and Treat System 3-3
4.0 Flow and Transport Modeling in the Unsaturated Zone 4-1
4.1 Model Construction 4-1
4.2 Model Input Parameters 4-1
4.3 Transport Calibration of TNT in Soil 4-2
4.4 Flow Modeling in the Saturated Zone Using MODFLOW 4-4
5.0 Transport Modeling in the Saturated Zone Using MT3D 5-1
5.1 Input Parameters in the Transport Model 5-1
5.1.1 Advection 5-1
5.1.2 Dispersivity 5-1
5.1.3 Retardation Factor 5-2
5.2 Transport Modeling 5-4
5.2.1 TNT 5-4
5.2.2 2,4-DNT 5-4
5.2.3 2,6-DNT 5-5
6.0 Conclusions and Discussion 6-1
7.0 References 7-1

List of Attachments

Attachment A – Compiled Soil Analytical Data for Nitroaromatic Compounds (TNT, 2,4-DNT, and 2,6-DNT) Based on 2004 Sampling Event

Attachment B – Geotechnical Test Results

List of Tables

Table	Title	Follows Tab
4-1	Summary of Hydraulic Conductivities	
4-2	Mass Balance for the Calibrated Flow Model	
5-1	Maximum Simulated Concentrations of 2,4,6-TNT, 2,4-DNT, and 2,6-DNT	
5-2	Maximum Simulated Concentrations of 2,4,6-TNT, 2,4-DNT, and 2,6-DNT In TNT Manufacturing Area A	
5-3	Maximum Simulated Concentrations of 2,4,6-TNT, 2,4-DNT, and 2,6-DNT In TNT Manufacturing Area B	
5-4	Maximum Simulated Concentrations of 2,4,6-TNT, 2,4-DNT, and 2,6-TNT, TNT Manufacturing Area C	
5-5	Maximum Simulated Concentrations of 2,4,6-TNT, 2,4-DNT, and 2,6-DNT, Pentolite Road Red Water Ponds	
5-6	Maximum Simulated Concentrations of 2,4,6-TNT, 2,4-DNT, and 2,6-DNT, West Area Red Water Ponds	
5-7	Modeled Concentrations at the Downgradient Boundary	

List of Figures

Figure	Title	Follows Tab
3-1	Overburden/Shale Groundwater Elevation Contour Map (August 2004)	
3-2	Delaware Limestone Groundwater Elevation Contour Map (August 2004)	
3-3	Potentiometric Surface Contour Map for Overburden/Shale Based on August 2004 Water Level Measurements	
3-4	Potentiometric Surface Contour Map for Delaware Limestone Based on August 2004 Water Level Measurements	
3-5	2,4,6-TNT Plumes in the Overburden/Shale Water Bearing Zone in the TNT Manufacturing Area A	
3-6	2,4,6-TNT Plumes in the Overburden/Shale Water Bearing Zone in the TNT Manufacturing Area B	
3-7	2,4,6-TNT Plumes in the Overburden/Shale Water Bearing Zone in the TNT Manufacturing Area C	
3-8	2,4,6-TNT Plumes in the Overburden/Shale Water Bearing Zone in the Pentolite Road Red Water Ponds Area (PRRWP)	
3-9	2,4,6-TNT Plumes in the Overburden/Shale Water Bearing Zone in the West Area Red Water Ponds Area (WARWP)	
3-10	2,4-DNT Plumes in the Overburden/Shale Water Bearing Zone in the TNT Manufacturing Area A	
3-11	2,4-DNT Plumes in the Overburden/Shale Water Bearing Zone in the TNT Manufacturing Area B	
3-12	2,4-DNT Plumes in the Overburden/Shale Water Bearing Zone in the TNT Manufacturing Area C	
3-13	2,4-DNT Plumes in the Overburden/Shale Water Bearing Zone in the Pentolite Road Red Water Ponds Area (PRRWP)	
3-14	2,4-DNT Plumes in the Overburden/Shale Water Bearing Zone in the West Area Red Water Ponds Area (WARWP)	
3-15	2,4-DNT Plumes in the Delaware Limestone Bedrock Water Bearing Zone in the TNTA Area, Pentolite Road Red Water Ponds Area (PRRWP), and West Area Red Water Ponds Area (WARWP)	
3-16	2,6-DNT Plumes in the Overburden/Shale Water Bearing Zone in the TNT Manufacturing Area A	
3-17	2,6-DNT Plumes in the Overburden/Shale Water Bearing Zone in the TNT Manufacturing Area B	
3-18	2,6-DNT Plumes in the Overburden/Shale Water Bearing Zone in the TNT Manufacturing Area C	

List of Figures *(Continued)*

Figure	Title	Follows Tab
3-19	2,6-DNT Plumes in the Overburden/Shale Water Bearing Zone in the Pentolite Road Red Water Ponds Area (PRRWP)	
3-20	2,6-DNT Plumes in the Overburden/Shale Water Bearing Zone in the West Area Red Water Ponds Area (WARWP)	
3-21	2,6-DNT Plumes in the Delaware Limestone Bedrock Water Bearing Zone in the TNTA Area, Pentolite Road Red Water Ponds Area (PRRWP), and West Area Red Water Ponds Area (WARWP)	
3-22	Model Grid	
3-23	Surface Streams/Ditches Considered in the Model	
4-1	TNT Sorbed Concentration Profile in Soil at TNTA-SO080 in the TNTA Area	
4-2	TNT Leachate Concentration to Groundwater at TNTA-SO080 in the TNTA Area, Calibration Run	
4-3	TNT Sorbed Concentration Profile at TNTC-SO165 in the TNTC Area	
4-4	TNT Leachate From Soil to Groundwater at TNTC-SO165 in the TNTC Area	
4-5	2,4-DNT Sorbed Concentration Profile in Soil at TNTA-SO105 in the TNTA Area	
4-6	2,4-DNT Leachate From Soil to Groundwater at TNTA-SO105 in the TNTA Area	
4-7	2,6-DNT Sorbed Concentration Profile in Soil at TNTA-S25 in the TNTA Area	
4-8	2,6-DNT Leachate From Soil to Groundwater at TNTA-S25 in the TNTA Area	
4-9	Comparison of Simulated and Observed Head Distributions in the Overburden and Weathered Shale Formation	
4-10	Comparison of Simulated and Observed Head Distributions in the Delaware Limestone	
4-11	Goodness-of-Fit Plot for the Flow Calibration Results	
5-1	Locations of TNT Leachate from Soil with TNT Plumes in the Overburden	
5-2	Locations of 2,4-DNT Leachate from Soil with 2,4-DNT Plumes in the Overburden	
5-3	Locations of 2,6-DNT Leachate from Soil with 2,6-DNT Plumes in the Overburden	
5-4	Simulated 2,4,6-TNT Plumes in the Five Operable Sites After 10 Years, Overburden	
5-5	Simulated 2,4,6-TNT Plumes in the Five Operable Sites After 50 Years, Overburden	
5-6	Simulated 2,4,6-TNT Plumes in the Five Operable Sites After 100 Years, Overburden	

List of Figures *(Continued)*

Figure	Title	Follows Tab
5-7	Simulated 2,4,6-TNT Plumes in the Five Operable Sites After 150 Years, Overburden	
5-8	Simulated 2,4,6-TNT Plumes in the Five Operable Sites After 100 Years, Bedrock	
5-9	Simulated 2,4,6-TNT Plumes in the Five Operable Sites After 150 Years, Bedrock	
5-10	Simulated 2,4-DNT Plumes in the Five Operable Sites After 10 Years, Overburden	
5-11	Simulated 2,4-DNT Plumes in the Five Operable Sites After 50 Years, Overburden	
5-12	Simulated 2,4-DNT Plumes in the Five Operable Sites After 100 Years, Overburden	
5-13	Simulated 2,4-DNT Plumes in the Five Operable Sites After 150 Years, Overburden	
5-14	Simulated 2,4-DNT Plumes in the Five Operable Sites After 10 Years, Bedrock	
5-15	Simulated 2,4-DNT Plumes in the Five Operable Sites After 50 Years, Bedrock	
5-16	Simulated 2,4-DNT Plumes in the Five Operable Sites After 100 Years, Bedrock	
5-17	Simulated 2,4-DNT Plumes in the Five Operable Sites After 150 Years, Bedrock	
5-18	Simulated 2,6-DNT Plumes in the Five Operable Sites After 10 Years, Overburden	
5-19	Simulated 2,6-DNT Plumes in the Five Operable Sites After 50 Years, Overburden	
5-20	Simulated 2,6-DNT Plumes in the Five Operable Sites After 100 Years, Overburden	
5-21	Simulated 2,6-DNT Plumes in the Five Operable Sites After 150 Years, Overburden	
5-22	Simulated 2,6-DNT Plumes in the Five Operable Sites After 10 Years, Bedrock	
5-23	Simulated 2,6-DNT Plumes in the Five Operable Sites After 50 Years, Bedrock	
5-24	Simulated 2,6-DNT Plumes in the Five Operable Sites After 100 Years, Bedrock	
5-25	Simulated 2,6-DNT Plumes in the Five Operable Sites After 150 Years, Bedrock	

List of Acronyms

cm^2/sec	centimeters per second
cm^3/g	cubic centimeters per gram
COC	chemical of concern
DNT	dinitrotoluene
EPA	U.S. Environmental Protection Agency
f_{oc}	fractional organic carbon
ft^2/day	square feet per day
g/cm^3	grams per cubic centimeter
gpm	gallons per minute
K_d	distribution coefficient
K_{oc}	soil sorption coefficient
µg/L	microgram(s) per liter
mg/kg	milligram(s) per kilogram
mg/L	milligram(s) per liter
MMOC	modified method of characteristic
MOC	method of characteristic
PBOW	Plum Brook Ordnance Works
PRRWP	Pentolite Road Red Water Ponds
RMSE	root mean squared error
Shaw	Shaw Environmental, Inc.
TNT	trinitrotoluene
TNTA	TNT Area A
TNTB	TNT Area B
TNTC	TNT Area C
TOC	total organic carbon
WARWP	West Area Red Water Ponds

1.0 Introduction

Elevated levels of nitroaromatic contaminants have been detected in the subsurface soil and groundwater in the five areas of Plum Brook Ordnance Works (PBOW), the site location of which is shown on Figure 1-1. Site investigation of soil and groundwater were performed during the past 12 years. In the current study, soil analytical data from 2000 to 2002 and groundwater analytical data obtained from 1997 through 2004 at five areas were used. This study used groundwater flow data from August 2004. These five areas are: TNT Area A (TNTA), TNT Area B (TNTB), TNT Area C (TNTC), Pentolite Road Red Water Ponds (PRRWP), and West Area Red Water Ponds (WARWP) (Figure 1-2). A 2,4,6-trinitrotoluene (TNT) concentration of 55,000 milligrams per liter (mg/L) was found at a soil boring (TNTC-SO165) in the TNTC area and high 2,4-dinitrotoluene (DNT) and 2,6-DNT concentrations in soil were found at 11,000 milligrams per kilogram (mg/kg) and 12,000 mg/kg, respectively, in the TNTB area (Shaw Environmental, Inc. [Shaw], 2005). Even though high concentration contaminants in TNTB and PRRWP areas have been partially excavated or are planned to be excavated, high concentration contaminants in other untreated areas still exist.

The highest concentrations of the three chemicals of concern (COC) detected in groundwater that exceeded 1000 micrograms per liter (µg/L) were:

- TNT: 32,400 µg/L at GW-06, 11,500 µg/L at GW-05 in TNTA, 20,100 µg/L at GW-08, and 9,720 µg/L at GW-05 in the TNTC
- 2,4-DNT: 37,600 µg/L at GW-08, 4,610 µg/L at GW-02 in TNTC, 6,900 µg/L at GW-10 in the TNTA, and 9,200 µg/L at PR-MW08 in the PRRWP Area
- 2,6-DNT: 10,550 µg/L at GW-08, 1,330 µg/L at GW-02 in TNTC, 6,900 µg/L at GW-10 in TNTA, and 550 µg/L at PR-MW08 in the PRRWP Area.

The three contaminants were not detected at high concentrations in the limestone bedrock water bearing zone. Maximum concentrations were only 1.6 µg/L of TNT in the PRRWP area; 19 µg/L and 1.5 µg/L of 2,4-DNT in the WARWP area and PRRWP area, respectively; and 3.6 µg/L and 1.4 µg/L in the TNTA and PRRWP, respectively. All the analytical results of the three contaminants detected in soil during the 2000 to 2002 investigation are included as Attachment A (refer also to Shaw, 2005).

The purpose of this current modeling effort was to estimate soil leachate and simulate the extent of groundwater plumes within 150 years under no action conditions and to support the preparation of the feasibility study for the entire PBOW site, which may include different remedial options to clean up contaminants in soil and groundwater.

2.0 Model Selection

To evaluate the migration of specific nitroaromatic compounds in soil and groundwater, flow and transport modeling was performed using VLEACHSM (U.S. Environmental Protection Agency [EPA], 1997), MODFLOW (McDonald and Harbaugh, 1988) and MT3D (Zheng, 1992) models.

2.1 Vadose Zone Leaching and Saturated Zone Mixing Model (VLEACHSM)

VLEACHSM is a one-dimensional finite difference vadose zone leaching model. The model estimates impact to groundwater due to the mobilization of contaminant in the vadose zone and subsequently estimates mixing in the saturated zone.

VLEACHSM simulates the transport processes, including liquid-phase advection, liquid- and vapor-phase dispersion, sorption, and decay of the contaminant. The model input parameters for the hydrogeologic and chemical properties are assumed to be uniform and homogeneous throughout the simulation.

Initial contaminant concentration distribution in the vertical polygon (soil column) from land surface to water table is used as input to the model. Other input parameters include duration of the source release, chemical distribution coefficient (partition coefficient), Henry's law coefficient, solubility of contaminant, free air diffusion coefficient, longitudinal dispersion coefficient, bulk density of soil, water-filled porosity, air-filled porosity, decay rate, recharge rate, Darcy velocity of groundwater, and background concentration in groundwater. Wherever site-specific data is not available, literature values will be used. Two types of results are provided by VLEACHSM simulation: contaminant profile in soil varying with time and the mixing concentration in groundwater varying with time.

2.2 MODFLOW and MT3D

Upon obtaining leaching and mixing concentration distribution results from VLEACHSM, flow and transport modeling in the saturated zone were performed using MODFLOW and MT3D.

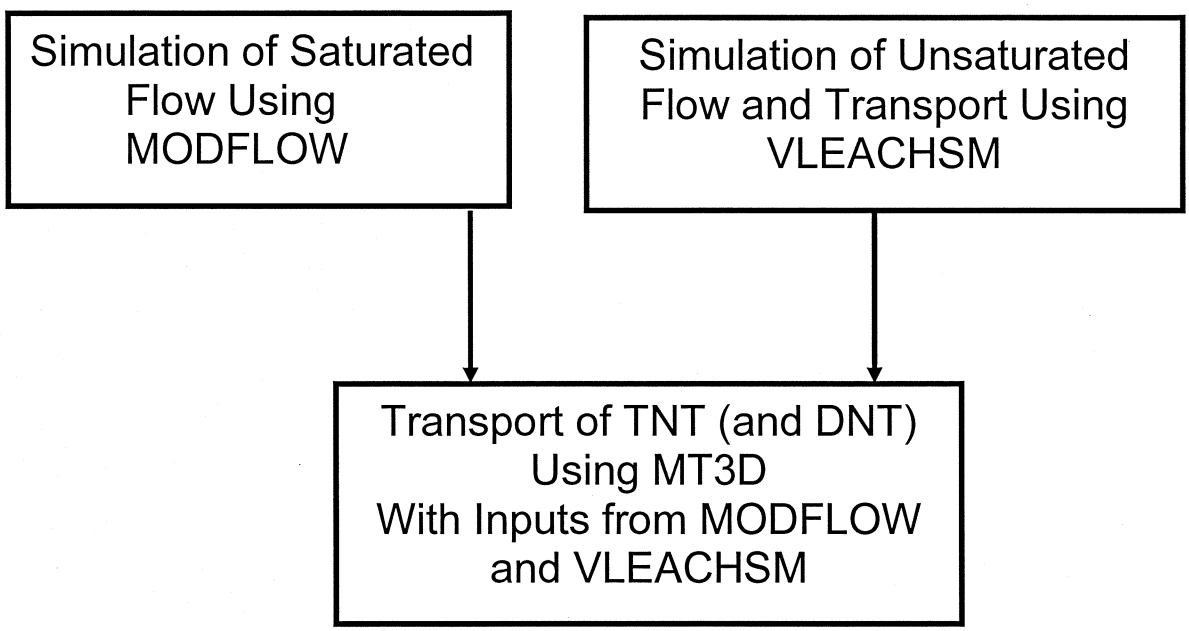
The site geology suggests that the overburden is underlain by a layer of weathered shale, and below the weathered rock is the Delaware Limestone bedrock. Because of the flow characteristics observed in both overburden and the weathered shale, modeling each layer as a heterogeneous porous media is a reasonable assumption. There is a lack of definitive data concerning fracture density and orientation in the bedrock. If indeed fractures are well developed and the information regarding the nature of fractures is investigated, then a dual

porosity model has to be performed. Currently, however, it is impossible to do that with the limited available data. Therefore, a preliminary assumption was that the bedrock was considered as a continuous "equivalent porous media" model, assuming all the fractures, if any, behave the same way as regular porous media. As such, a porous media flow model code, MODFLOW, was selected. The MODFLOW model was developed by U.S. Geological Survey. It is a three-dimensional numerical groundwater flow model and is the most popular one currently in use (Rumbaugh and Ruskauff, 1993). MODFLOW can be applied to heterogeneous, anisotropic saturated subsurface flow condition. Groundwater is simulated using a block-centered, finite-difference approach. Layers can be simulated as confined, unconfined, or a combination of both. Flow associated with external influences, such as wells, areal recharge, evapotranspiration, drains, rivers, lakes, and horizontal flow barrier (e.g., slurry wall) can also be simulated. The partial differential equations describing the flow system can be solved by either the strong implicit procedure, the slice-successive over-relaxation procedure, the preconditioned conjugate gradient, or Waterloo Hydrogeologic Software solver.

The simulated head and flux distributions obtained from MODFLOW are then input to MT3D to simulate contaminant transport in the saturated zone.

MT3D model is a three-dimensional transport model developed by Papadopulos & Associates, Inc., and sponsored by the EPA. MT3D simulates the migration of contaminant with dispersion, retardation, and chemical reaction that includes equilibrium-controlled linear or non-linear sorption and first order irreversible decay or biodegradation over time and space. MT3D is also a widely used, user-friendly program that has also undergone extensive verification and field validation and therefore is acceptable by regulatory agencies. All the pre- and post processors for MODFLOW can also be used for MT3D.

MODFLOW and MT3D were run with Visual MODFLOW (Waterloo Hydrogeologic, Inc, 2004). Essentially, this approach allowed simulation of the concentration of nitroaromatics leaching from soil (VLEACHSM results) coupled with attenuation processes that occur in groundwater transport model. The procedures of the modeling are shown in the following flow chart:


Simulation of Saturated Flow Using MODFLOW
Simulation of Unsaturated Flow and Transport Using VLEACHSM
Transport of TNT (and DNT) Using MT3D With Inputs from MODFLOW and VLEACHSM

3.0 Site Conceptual Model

The following sections present the site conceptual model for the site-wide model. The site conceptual model includes discussion of the potential sources of contamination and factors affecting leaching and transport time in the unsaturated and saturated zones.

3.1 TNT Manufacturing Process and Potential Sources of Contamination

During PBOW operation, 12 process lines were used in the manufacture of explosives: 4 lines at TNTA, 3 lines at TNTB, and 5 lines at TNTC. Manufacturing waste water ("red water") from these production lines was stored at the two ponds on the WARWP Area and the single pond at the PRRWP Area. The three former production areas, together with the WARWP and PRRWP Areas, are the potential source areas of concern. In addition to the wastewater ponds, potential sources of contamination include spills and leaks of nitroaromatics from process lines, catch basins, and drowning tanks.

3.2 Modes of Contaminant Release

Based on investigations at PBOW as well as other TNT manufacturing sites (West Virginia Ordnance Works, Volunteer Army Ammunition Plant), two basic modes of contaminant release along the TNT process lines are suspected. The first involves minor leaks and spills of liquid wastes onto the soil or spills of solid wastes (e.g., TNT) onto the soil. While the contaminant concentrations in soil from these type of spills may be relatively high, the limited volumes of the liquid wastes would not be sufficient to significantly affect the vertical transport through the vadose zone beyond that caused by natural precipitation. That is, there would be no significant hydraulic force to facilitate downward migrations. Thus, the only transport mechanism for this contamination is leaching from soil to the groundwater due to precipitation. These types of releases would represent a long-term source to groundwater and may take years or decades for the contamination to actually reach the groundwater from near surface sources through leaching. The amount of time required to leach to the groundwater would be dependent on soil properties and infiltration rates.

The second mode of contaminant release would be a high-volume, rapid loss of contaminants to the environment during the time of PBOW operations (i.e., 1941 to 1945). These areas would include any storage area for liquid wastes, including wash house catch basins, wastewater lines, and drowning tanks. There is the potential that these contaminant sources released larger volumes of wastewater over short time periods. This, in effect, would result in faster initial

infiltration to the water table, given that the releases would act as artificial recharge to the groundwater. This mode of release would also leave residual soil contamination that would leach due to precipitation.

In reality, there would be a gradation between the two extremes for contaminant release described above. It should be noted that leaching of residual soil contamination is important in addressing soil cleanup levels. The residual soil contamination would present the longer-term impact to groundwater quality.

3.3 Contaminant Transport in Groundwater

Two main water-bearing zones (the overburden/shale and the bedrock) are present in the PBOW site. Groundwater in both the overburden and bedrock water-bearing zones essentially flow in a north-northeast direction based on August 2004 groundwater level measurements (Figures 3-1 and 3-2). The overburden water-bearing zone is under water table conditions and is, therefore, directly impacted by contamination leaching from the source areas. There is no obvious aquitard structure between the overburden and the Delaware limestone bedrock. However, due to the relatively low permeability of the bedrock, contaminants have not been able to travel downwards into the bedrock at larger quantity. The actual concentrations and rate of movement in groundwater are dictated by dilution, dispersion, adsorption/desorption, and degradation.

3.4 Site-Specific Data for Model Inputs

In order to support the modeling effort, vadose and saturated zone data specific to the PBOW were needed as input. Data already available for the saturated zone include: water table distribution, hydraulic conductivity, lithology, total and effective porosities, storage coefficient, and contaminant plume coverage and concentrations. Required parameters used in VLEACHSM modeling in the unsaturated zone are the recharge, maximum water solubility of contaminant, free air diffusion coefficient, longitudinal dispersivity, decay rates in soil as well as in source, bulk density of soil, air-filled and water-filled porosities, Henry's law constant, soil sorption coefficient (K_{oc}) and fraction of organic carbon (f_{oc}). Other parameters needed in the saturated zone for mixing purposes are the hydraulic conductivity, hydraulic gradient and the depth of penetration of contaminant.

The digitized potentiometric surfaces for the overburden and the bedrock were based on August 2004 water level measurements (Figures 3-3 and 3-4) and the contaminants plumes in groundwater used for initial inputs to the model were based on 2004 groundwater monitoring results (Shaw, 2005). The digitized plume maps for TNT, 2,4-DNT, and 2,6-DNT are presented

on Figures 3-5 through 3-21. The other input parameters are presented in Sections 2.0 and 4.0. Note that some of the site-specific parameters were not available; literature values were used instead.

3.5 Model Layers and Grids

The study area encompasses five contaminant sites: TNTA, TNTB, TNTC, PRRWP, and WARWP. In order to assure that the flow condition at the boundaries had minimum impact on these areas and that flow to the north had enough space for the transport of contaminants, the study area was designated to cover an area of 23,733 feet (east-west) by 24,930 feet (north-south), much larger than the areas of these five sites combined. The entire study area extended 2,400 feet to the north from Bogart Road, 1,143 feet to the west from Patrol Road, approximately 200 to 1,000 feet to the east from Sandusky-Norwalk Road, and intersected at Mason Road to the south. The entire study area was discretized into grids, the finest of which would cover the contaminant sites and the coarser ones would extend to the boundaries where no contaminants would migrate to. Thus, the grid size varied from 59 by 62 feet to 237 by 248 feet (see Figure 3-22). The vertical discretization of the study area followed that of the lithology of the site geology. Two model layers were assigned to the overburden/shale formation. The top land surface elevation ranges from 632 to 682 feet. The top model layer basically represents the overburden formation, the bottom elevation of which varies from 580 feet to 660 feet. This latter range of elevation also represents the top elevation of the weathered shale (model layer 2). Two layers were assigned to the Delaware limestone, the top elevation of which is approximately from 550 to 595 feet and the bottom elevation is from 514 to 530 feet.

3.6 Surface Streams and Ditches

There are several surface creeks and ditches that drain surface water and groundwater in the dry seasons and replenish groundwater in the wet seasons. The interaction between surface water and groundwater supported the necessity to incorporate these water bodies in the flow model. The streams and ditches considered in the model from the west to the east are: Pipe Creek, Ransom Brook, Plum Brook, Linsley Ditch, and Sheid Ditch, as shown on Figure 3-23.

3.7 Current Pump and Treat System

Currently, the National Aeronautics and Space Administration is monitoring the pumping rates of the Reactor Area sump in the bedrock layer and Reactor Area recovery well in the overburden layer. The recovery well is reported to pump at 0.1 gallon per minute (gpm) (a total of 45,260 gallons per year) and the sump is pumped at 1.84 gpm (i.e., 967,250 gallons per year) (Restoration Advisory Board, 2005).

4.0 Flow and Transport Modeling in the Unsaturated Zone

High concentrations of contaminants have been detected in the unsaturated subsurface soil. In order to estimate the contribution of the amount of contaminant to groundwater, the flow and transport of contaminant in the unsaturated soil over time had to be simulated.

4.1 Model Construction

The process of vertical migration of contaminants from a certain depth in soil to the water table is conceptualized as occurring in a number of distinct, user-defined polygons that are vertically divided into a series of user-defined cells. In the current modeling, a 5-by-5-foot polygon with 1-foot cell intervals was assigned to every sampled location in the five contaminated areas where soil samples were collected and analyzed. The depth of the polygons varied depending on the depth to water table based on the topographic and groundwater contour maps (see tables in Attachment A). Based on soil sampling results, concentration distributions along the depth of the polygon were allocated. Because several samples at different locations within a model cell might be collected, a conservative (i.e., highest concentrations) and representative soil concentration profile was selected for that cell.

4.2 Model Input Parameters

Model input parameters include the physical and chemical properties of the contaminants as well as the subsurface media. The required parameters used in VLEACHSM modeling in the unsaturated zone are recharge, maximum water solubility of contaminant, free air diffusion coefficient, longitudinal dispersivity, decay rates in soil as well as in source, bulk density of soil, air-filled and water-filled porosities, Henry's law constant, K_{oc} and f_{oc}. Because VLEACHSM calculates the mixing concentration in the saturated zone, it requires Darcy velocity of groundwater, which is a function of hydraulic conductivity and hydraulic gradient.

The recharge rate of the model describes the velocity of water movement through the vadose zone in which the hydraulic conductivity of the soil is a function of the water content in the soil. This is different from vertical recharge to groundwater originated from precipitation. This parameter is very sensitive and actually determines how fast the contaminant would move vertically through the polygon.

The other input parameters are the soil concentration distributions along the depth of polygons (Attachment A) and those that are listed in the table presented below. The maximum TNT concentration detected was 54,969 mg/kg at TNTC-SO165 soil boring location 1 to 2 feet below

ground surface in the TNTC area. The maximum 2,4-DNT and 2,6-DNT concentrations detected were 11,000 and 12,000 mg/kg, respectively, both from soil boring TNTB-S24 in the TNTB area. However, these high concentrations soil in the TNTB have been excavated or are to be excavated soon. The current highest concentration thus shifted to TNTA-SO012 in the TNTA area where 8,912 mg/kg and 10,274 mg/kg have been detected at 3 to 4 feet below ground surface for 2,4-DNT and 2,6-DNT, respectively.

The major input parameters for VLEACHSM are listed in the following table:

Chemical	Hydraulic Conductivity (ft/day)	Bulk Density (g/cm^3)	Longitudinal Dispersivity (ft) [1]	Soil Sorption Coefficient [2] (cm^3/g)	Henry's law Constant [3] (unitless)	Water Solubility (mg/L)	Degradation Rate[4] (1/day)
TNT			0.017 to 0.783	302 [3]	0.0000187	330[3]	0
2,4-DNT			0.017 to 0.783	61.7 [3]	0.0000308	352[3]	0
2,6-DNT			0.017 to 0.783	61.7 [3]	0.0000308	352[3]	0
Unsaturated Zone	(recharge rate: 0.025 ft/yr)	106	0.017 to 0.783				
Saturated Zone	Approx. 0.8						

Notes:
(1) Longitudinal dispersivity varies with depth to groundwater based on equations in VLEACHSM.
(2) Soil sorption coefficient multiplied by fraction of organic carbon (f_{oc}) is equal to distribution coefficient (K_d); f_{oc} was assumed 0.1 percent.
(3) Montgomery, J.H., 2000, "Groundwater Chemicals Desk Reference," 3rd edition, Lewis Publishers.
(4) No evidence of contaminant degradation is observed.
ft/day – Feet per day.
g/cm^3 – Grams per cubic centimeter.
ft – Feet.
cm^3/g – Cubic centimeters per gram.
1/day – Per day (degradation rate = Ln2 / half-life; half-life in days).

Other parameters not listed in the above table are the free air diffusivity (0.0245 square centimeters per second [cm^2/sec] for TNT and 0.0327 cm^2/sec for DNT), effective porosity (0.25), and saturation (0.2).

4.3 Transport Calibration of TNT in Soil

Some of the model input parameters described in the preceding section were site specific, others were literature or estimated values (recharge rate, soil sorption coefficient, longitudinal dispersivity, etc). Consequently, the model parameters have to be calibrated such that after 60 years since the cessation of operation, the simulated concentration in the soil would match those of current observed data. However, such calibration requires the estimate of initial spill amount, either it be continuous or instantaneous, and the timing of the spill; the hydrologic process during the 60-year period in terms of precipitation and its contribution to the recharge to groundwater etc. These factors are unknowns, and if estimated by some means, the degree of uncertainty would be high. In addition, concurrent, collocated soil and groundwater analytical data is required for calibration.

As mentioned in Section 4.2, TNT was detected in the soil at a maximum concentration of 54,969 mg/kg at 1 to 2 feet below ground surface from boring TNTC-SO165 at TNTC during the 2000 sampling event. However, groundwater concentration at this boring location was not available. Another high soil concentration location was found at TNTA-SO080 in the TNTA area. The maximum concentration in soil at this location was found to be 12,000 mg/kg at 1 to 2 feet below ground surface. The concurrent groundwater concentration was found to be 11,500 μg/L at GW-05 (the same location as TNTA-SO080), which is one of the highest in this area, next to the 32,400 μg/L at GW06, where no soil concentration was available. Therefore, this was the only location where the calibration of TNT soil leachate could be performed even with high degree of uncertainty.

In order to determine the more realistic transport parameters associated with the migration of TNT in the soil, the following calibration criteria and assumptions were considered:

- In the course of 60 years after the plant stopped its production, TNT has migrated from the surface through the soil column at TNTA-SO080 and the current soil concentration at 1 to 2 feet below ground surface still maintained a high concentration as high as 12,000 mg/kg. This soil concentration, together with the groundwater concentration of 11,500 μg/L at the same location (GW-05), have to be matched in the 60-year simulation to within acceptable levels.

- The amount of the initial spill of TNT and the initial concentration in soil at the time of spill were unknown. In order to simulate the transport process, an initial concentration in soil had to be assumed. This assumed concentration was adjusted until the concentrations in soil and in water matched those current observed data after 60 years of simulation. It was determined that the maximum concentration of pure TNT in the soil was approximately 280,000 mg/kg based on the densities of soil and TNT.

- The duration of TNT release was assumed to be 3 years, the length of time that the plant was in operation.

The major transport parameters include the chemical properties (e.g., K_{oc}, f_{oc}, Henry's Law constant, air diffusion coefficient, degradation rate, dispersivity, solubility and initial concentration) and physical properties (hydraulic conductivity, porosity, bulk density, recharge rate, etc). Of these parameters, initial concentration, recharge rate, K_{oc}, f_{oc}, and degradation rate are the most sensitive parameters.

By adjusting the above parameters and assuming an initial concentration of 280,000 mg/kg in soil at the depth of 1 to 2 feet, a "satisfactory" calibration result was achieved. Figure 4-1 shows the TNT distribution of soil concentration profile over time at TNTA-SO080 location. Note that after 60 years since 1945, the simulated maximum concentration in soil at 3 to 4 feet below ground surface reached 12,377 mg/kg, close to the observed concentration of 12,000 mg/kg, but occur slightly deeper. Figure 4-2 shows the variation of concentrations of TNT in groundwater caused by leachate from soil at the same location in 150 years. Note that after 60 years since 1945, the simulated TNT concentration in groundwater increased to 11,266 μg/L, close to 11,500 μg/L, the observed concentration at GW-05 in 2000. The simulated peak concentration is 134,200 μg/L in the calibration run and the time of occurrence is about 46 years from now. If the calibration was indeed correct, the maximum concentration of TNT in groundwater at this location is yet to come in about 46 years, reaching approximately 130,000 μg/L. However, this calibration was limited to only one location and some subjective assumptions. Different locations have different soil properties, different recharge rates, different spill concentration, and different f_{oc} carbons; hence, different distribution factors. Therefore the current "calibration" was only one of the many solutions that could have had happened during the past 60 years. It could not be used to represent the numerous locations in all the areas. However, this exercise provided a range of values these parameters should be within an acceptable range, but the occurrence of the highest peak is yet to come is not conclusive due to lack of many site-specific data over the years since the spill.

Figures 4-3 through 4-8 show some of the soil concentration profiles and mixing concentration over time at some high-soil concentration locations resulted from VLEACHSM runs.

4.4 Flow Modeling in the Saturated Zone Using MODFLOW

Leachate obtained from VLEACHSM is incorporated into the transport model MT3D to simulate the migration of the contaminants in the saturated zone. But before using MT3D to perform the transport modeling, a 3-D saturated flow model using MODFLOW was developed so that the flow regime for the site could be established.

Flow Model Calibration. Model calibration is stipulated by EPA (1992) and American Society for Testing and Materials (1993) and is defined as the process of determining a set of model parameters, boundary conditions, and stresses that can result in matching the simulated heads and fluxes with field observations to an acceptable level. Currently, there is no clear cut standard for the "acceptable level." Rather, it is based on a comprehensive professional judgement which involves the following aspects:

- Agreeable matching of the simulated flow gradient and flow direction with observation

- Difference of head residuals (difference between simulated heads and observed heads at monitoring locations) within 5 to 10 percent

- Agreeable closeness of simulated heads versus observed heads to the 45° straight line

- Good statistical results that include mean error, mean absolute error, standard error, root mean squared error (RMSE), and normalized RMSE. It is a general practice in the modeling community to accept a "less than 10 percent normalized RMSE" level as an indicator of good calibration (Geraghty & Miller, Inc., 1993).

- The overall mass balance percent discrepancy less than 1 percent (Anderson, 1992).

Conventionally, the set of parameters (hydraulic conductivity, vertical leakance, conductance of river, drain, and general head boundaries, etc.) are changed manually over the model domain by trial and error to match the targets. Targets are heads and fluxes at specific locations where observations are available. However, this is a tedious endeavor and the results of matching the heads and fluxes are often very crude and sometimes subjective. Several parameter estimation codes such as MODFLOWP, PEST and UCODE have been developed in the past decades but the methods for estimating the parameters are based on non-linear regression approach which is mathematically sound but does not consider the law that governs groundwater flow at each cell (i.e., Darcy's law).

In the current modeling, the flow model was calibrated with an "automatic-calibration" tool, called MODAC, developed by Guo and Zhang (1994; 1998; 2000) under steady-state conditions. Unlike the other automatic calibration tools, this calibration model actually tries to match not only all the available targets but also the entire potentiometric surface. The physical law of flow in each model cell is the basis of this approach. The model parameters are input into MODAC, which in turn calls for the execution of MODFLOW. The heads and gradient in every model cell are then calculated based on Darcy's law and compared with the observed heads and gradients. MODAC will run as many iterations as deemed necessary until close agreement is reached based on the overall statistics such as RMSE and by professional judgement.

In theory, the simulated and observed potentiometric surfaces can be matched perfectly if there are no constraints on the hydraulic and hydrologic parameters. However, based on aquifer tests,

the range of the parameters are defined and cannot be expanded without limitations. MODAC requires the upper and lower limits of the hydraulic conductivity, the recharge values, and the vertical leakance to be established by the user. In doing so, the potentiometeric surfaces in each model layer will no longer be matched perfectly but to an acceptable extent as constrained by the user defined parameter range. In the current study, the observed and extrapolated potentiometric surface contours for the overburden and bedrock, based on August 2004 measurements were used as the target contours (see Figures 3-1 through 3-4). The initial recharge rate used in the model was obtained from the previous estimation of monthly infiltration rates from 1994 through 2004 (Shaw, 2005). This monthly rate ranged from 0 to 2.25 inches with an average monthly rate of approximately 0.5 inches. This might be not realistic for the areal recharge, but since the model would be calibrated and the value of recharge rate would be adjusted, the calibrated rate would be finalized to a more reasonable range. Site-wide slug tests conducted from 1997 through 2004 showed that the average hydraulic conductivity was 1.04 feet/day for the overburden that ranged from as low as 0.0024 feet/day to as high as 212 feet/day; and 0.48 feet/day for the Delaware Limestone that varied from 0.03 feet/day to 5.48 feet/day (Table 4-1). These values were the initial inputs to the flow model but were adjusted through model calibration. The range of the initial general head boundary conductance and river conductance were from 500 to 3,500 square feet per day (ft^2/day) estimated from the hydraulic conductivity, the thickness of the layer, and the model cell dimensions. These parameters would also be calibrated in the calibration runs.

After more than 2,500 iterations, the simulated contours were in close agreement with the observed contours with an RMSE of only 0.8 and 0.6 feet for the overburden and bedrock layers, respectively.

To verify the calibration results, to obtain other statistics about the simulation results, and to run the solute transport model MT3D, the calibrated hydraulic conductivity, vertical leakance, conductance of river, drain and general head boundaries generated by MODAC were imported to VISUAL MODFLOW and the flow model was rerun in VISUAL MODFLOW. The simulated head distributions were compared to the observed head contours as shown on Figures 4-9 and 4-10. These figures also verify the close agreement of the match between the simulation and observations. This implies that the simulated flow gradient and flow direction were in close agreement with the observations.

Water levels from 82 locations were used as targets for matching purposes. The statistics, as calculated by VISUAL MODFLOW for the calibration run are as follows: 0.11 feet for the

mean error, 1.34 feet for the mean absolute, 0.184 feet for the standard error of the estimate, 1.664 feet for the root mean squared (error), and 1.29 percent for the normalized RMSE. This latter result (normalized RMSE) was considered acceptable since it is within the 5 percent range normally accepted by the groundwater modeling community (Rumbaugh and Ruskauff, 1993). These statistics show that consistent acceptable levels have been achieved for model calibration. Note that these statistics also pertain to the 82 head targets defined in the calibration. Figure 4-11 shows these statistics together with the simulated heads plotted against the observed heads along a 45 degree straight line. The closeness of data points to the straight line implies the goodness of fit in the calibration.

The mass balance of the calibrated flow model is 0.81 percent, which is within 1.0 percent suggested by Anderson and Woessner (1992) (see Table 4-2).

The calibrated hydraulic conductivity is in the range of 0.34 to 22.51 feet/day for the overburden and 0.04 to 20.24 feet/day for the bedrock layers. These calibrated values fall in the range of the aquifer test results. The calibrated recharge rate is 2.2 inches per year for the majority of the area. The ranges of the calibrated general boundary conductance ranged from 373 to 2,400 ft^2/day, and the calibrated river conductance ranged from 1,200 to 2,375 ft^2/day.

5.0 Transport Modeling in the Saturated Zone Using MT3D

The soil-to-groundwater leachate concentration distribution for each time step obtained from VLEACHSM was considered a time-varying point source for groundwater, as shown on Figures 4-6 and 4-8. These mixing concentrations, considered as constant concentrations within each time step, were then mixed with the current contaminant plume(s) from one time step to the next and the resultant concentration distribution over time was simulated under processes of dilution, dispersion, adsorption, and degradation. The locations of these "point sources" are distributed over all the five sites. Maps showing these locations for TNT and DNT in the five sites, together with the respective digitized plumes, are plotted on Figures 5-1 through 5-3 in the overburden layer. In the current model, no degradation (biological or chemical) was considered because no significant reduction of contamination over time was observed. The existing TNT and DNT plume concentration distributions for the overburden and bedrock layers were based on 2004 sampling events. These plumes, shown on Figures 3-5 through 3-21, together with the vertical incoming time-varying leachate from the soil, constituted the basis for the migration of these plumes.

5.1 Input Parameters in the Transport Model

The transport of TNT and DNT are governed by the following transport parameters: advection, dispersivity, retardation factor, and degradation. These parameters are discussed in the following sections. As mentioned previously, degradation was not considered.

5.1.1 Advection

Advection is the movement of a solute at the average linear velocity of groundwater. The calculation scheme selected for the advection in MT3D was the hybrid MOC/MMOC method or the finite difference method. The Method of Characteristics (MOC) (Konikow and Bredehoeft, 1978; Goode and Konikow, 1989) is the most widely used solution technique to the advection term in the transport equation. The Modified MOC (MMOC) which is the latest refinement of MOC has been incorporated into MT3D and is useful because it reduces the computer memory required and essentially eliminates artificial oscillations during the computation. In the current flow modeling, the hybrid MOC/MMOC was used to increase the efficiency of computation.

5.1.2 Dispersivity

Dispersivity in porous media refers to the spreading, or mixing, of the constituents over a region greater than would be predicted solely from the groundwater velocity vectors. The longitudinal dispersivity is usually obtained from field tracer tests and the results are related to field scale.

Since no test values were available, a value of 10 feet was assumed for the present study. This value is approximately one-tenth of the current plume travel distance from the source (EPA, 1985). Horizontal lateral and vertical dispersivities were assigned a value of 10 percent and 1 percent of the horizontal longitudinal dispersivity. Therefore, lateral and vertical dispersivities were 1 foot and 0.1 feet, respectively, in the other two directions perpendicular to the central flow path (Gelhar, et al., 1992).

5.1.3 Retardation Factor

The chemical reactions included in the MT3D transport model are equilibrium-controlled linear or non-linear sorption and first order irreversible rate reactions. Retardation factor is a function of sorption. Sorption refers to the transfer of chemical mass between the contaminants dissolved in the groundwater and the contaminants sorbed onto the surface of the particles of the porous media. Many organic chemicals are attracted (sorbed) to the soil particles. In the current study, the linear sorption isotherm option in MT3D was assigned, i.e., the concentration sorbed was considered to be directly proportional to the dissolved concentration at equilibrium. By using linear sorption, a retardation factor, which is a function of the distribution coefficient (K_d) can be expressed as follows:

$$R = 1 + (K_d \rho_b)/\theta$$

where,

ρ_b is the bulk density of soil
θ is the effective porosity.

The retardation factor determines how fast the organic compound can move in relation to groundwater flow (Zheng, 1992). The K_d factor estimates the volume of water that can be affected by the contaminant, i.e., the larger the value the less mobile the contaminant. K_d was calculated using the following relationship for organics (Freeze and Cherry, 1979):

$$K_d = K_{oc}\, f_{oc}$$

where,

K_d is the partition coefficient; K_{oc} is the chemical-specific adsorption coefficient, i.e., the ratio of the amount of chemical adsorbed per unit weight of organic carbon; and f_{oc} is the dimensionless fraction of organic carbon.

In the present study, K_{oc} values of 302 cubic centimeters per gram (cm^3/g) for TNT and 61.7 cm^3/g for DNT were used (Montgomery, 2000). Field test data showed that the total organic carbon (TOC) (see Attachment B) in the overburden and bedrock ranged from 1 mg/L to over 93,400 mg/L. The f_{oc} value, derived from TOC, has a range from 0.001 percent to over 9 percent. This value was adjusted within this range in order to acquire the response of the contaminant migration as close as possible to reality.

Two additional parameters required as input in the flow model under transient state flow condition are specific storage and specific yield. The specific storage of a saturated aquifer is defined as the volume of water that a unit volume of aquifer releases from storage under a unit decline in hydraulic head. Visual Modflow (a pre-processor and post-processor used in the current study) calculates the primary storage coefficient for the flow model – MODFLOW. The storage coefficient required for the unconfined aquifer in MODFLOW is actually the specific yield. The specific yield is defined as the volume of water that an unconfined aquifer releases from storage per unit surface area per unit decline in the water. A specific storage value of 0.25 per foot was assigned for the shallow sand, which is an unconfined aquifer. The specific storage values for both the intermediate sand and the deep sand were assigned a value of 0.005 per foot. The effective porosity of the sand was assigned a value of 0.25.

The input parameters in the transport model are listed in the following table:

Chemical	Specific Storage (1/ft)/ Specific yield	Hydraulic Conductivity (ft/day)	Bulk Density (g/cm^3)	Longitudinal Dispersivity (ft)	Soil Sorption Coefficient* Koc (cm^3/g)	Fraction of Organic Carbon foc	Degradation Rate*** (1/day)
2,4,6-TNT				10	302**	1% to 5 %	0
2,4-DNT				10	61.7**	1% to 5 %	0
2,6-DNT				10	61.7**	1% to 5 %	0
Saturated Zones	0.25-0.005/ 0.20	0.04 to 30	1.6	10			

* Soil sorption coefficient (K_{oc}) multiplied by fraction of organic carbon (f_{oc}) is equal to distribution coefficient (K_d); f_{oc} was assumed 0.1%.
** Montgomery, J.H., 2000, "Groundwater Chemicals Desk Reference," 3rd edition, Lewis Publishers.
*** No evidence of contaminant degradation is observed.
ft/day – Feet per day.
g/cm^3 – Grams per cubic centimeter.
ft – Feet.
cm^3/g – Cubic centimeters per gram.
1/day – Per day (degradation rate = Ln2 / half-life; half-life in days).
1/ft – Per foot (storage coefficient divided by the thickness).

5.2 Transport Modeling

After flow model calibration, several model runs were performed to obtain the contaminant distribution after migration in both horizontal and vertical directions. In the current runs, no remedial action was assumed.

The "no action" alternative for soil and groundwater implied that no additional measures or actions were taken other than the operation of the existing reactor recovery well, pumping at a very low rate of 0.1 gpm from the overburden formation and the excavation in the TNTB and PRRWP areas. The simulation results of contaminant transport obtained from MT3D using Visual MODFLOW software for this no action option are summarized in the following sections.

5.2.1 TNT

Under the no action scenario, the modeling results show that the maximum concentration of TNT for the entire PBOW site drops from the current 32,400 μg/L in the TNTA area but still remains at a high concentration of 18,659 μg/L after 150 years in the overburden. The second highest concentration location was found in the TNTC area with a current maximum concentration of 20,100 μg/L (GW-08) in the overburden but decreases to 4,703 μg/L in 150 years based on the simulation result. There are two main reasons for this slow reduction: one is the low permeability of groundwater, and the other is the fact that no degradation was considered in the model. Table 5-1 presents the simulated maximum concentrations of TNT, 2,4-DNT and 2,6-DNT in every layer over 150 years at 5-year intervals for the entire PBOW site. Tables 5-2 through 5-6 list the maximum concentration at each of the five contaminated areas. Table 5-7 shows the maximum modeled concentration along the PBOW facility boundary downgradient of the five site areas. Figures 5-4 through 5-7 show simulated TNT plumes after 10, 50, 100, and 150 years in the overburden and Figures 5-8 and 5-9 show simulated TNT plumes after 100 and 150 years in the bedrock. Currently, only 1.6 μg/L of TNT was found in the bedrock at the PRRWP site. As can be seen from Figure 5-9, TNT has migrated to the bedrock in the areas of TNTA and TNTC sites, with 4.6 μg/L and 11.3 μg/L, respectively, in 150 years.

5.2.2 2,4-DNT

The modeling results show that the maximum concentration of 2,4-DNT for the entire PBOW site drops from the current 37,600 μg/L at GW-08 in the TNTC area but still remains at a high concentration of 11,392 μg/L after 150 years in the overburden. The second highest concentration location was also found in the TNTC area with a current maximum concentration of 4,610 μg/L (GW-02) but decreases to 763 μg/L in 150 years. The simulated maximum

concentrations of 2,4-DNT over the 150-year period are presented in Table 5-1 for the entire PBOW site and Tables 5-2 through 5-6 for each individual site. As in the case of TNT, without further remedial action, 2,4-DNT will not be reduced significantly over a period of 150 years and beyond. Figures 5-10 through 5-13 show simulated 2,4-DNT plumes in the overburden and Figures 5-14 and 5-17 show simulated 2,4-DNT plumes in the bedrock after 10, 50, 100 and 150 years. Currently, the maximum concentration of 2,4-DNT at a level of 19 μg/L was found in the bedrock at the WARWP site. As can be seen from Figures 5-17, 2,4-DNT has migrated to the bedrock in the area of TNTC to a higher level of 87 μg/L in 150 years while increasing or decreasing its concentration slightly at other sites.

5.2.3 2,6-DNT

The modeling results show that the maximum concentration of 2,6-DNT for the entire PBOW site drops significantly from the current 10,550 μg/L at GW-08 in the TNTC to only 125.5 μg/L after 150 years in the overburden. The reason for this reduction was due to the very small area that was close to a point initially designated for this high concentration. The second highest concentration location in the overburden was found in the TNTA area with a current maximum concentration of 6,900 μg/L at GW-10 and would decrease to 103 μg/L in 150 years in the TNTA area but not at the same spot due to northward movement of plume with groundwater. The simulated maximum concentrations of 2,6-DNT over a 150-year period are presented in Table 5-1 for the entire PBOW site and Tables 5-2 through 5-6 for each individual site. Without further remedial action, though 2,6-DNT reduced significantly over a period of 150 years but will not fall below its risk-based concentration or remedial goal objective. Figures 5-18 through 5-21 show simulated 2,6-DNT plumes in the overburden and Figures 5-22 and 5-25 show simulated 2,6-DNT plumes in the bedrock after 10, 50, 100 and 150 years. Note that the current maximum concentration of 2,6-DNT occurred at TNTA site with 3.6 μg/L in the bedrock. However, after 150 years the maximum concentration at TNTA site increases to 30 μg/L while the maximum concentrations at TNTC site increases from the current 0.7 μg/L to 56.3 μg/L.

6.0 Conclusions and Discussion

Groundwater flow and transport modeling in the overburden and bedrock at the PBOW site showed that concentrations of TNT, 2,4-DNT, and 2,6-DNT would not reduce significantly without further remedial action in the overburden/shale layer. Vertical migration of contaminants would also continue, both from soil leachate as well as from overburden to bedrock, and consequently would increase the degree of contaminant in the bedrock to within 90 μg/L for all three COCs.

Uncertainties of the geology in terms of the degree of fracture in bedrock, hydrogeologic and chemical parameters such as hydraulic conductivity, vertical leakance, boundary condition, organic carbon content, soil-water partition coefficient, storage coefficient, etc. made it certain that the current modeling results were not unique and there exists a range of solutions that may deviate significantly from the current results. In order to reduce the uncertainty of the modeling results, further site investigation will be needed. However, a set of conservative and more realistic parameters were considered in the current modeling after performing flow calibration and leachate calibration (though only at one location) and therefore the simulation results have a relatively high degree of certainty.

Through the performance of soil leachate calibration, the increasing TNT concentration at TNTA in the overburden could be possible. Due to the uncertainty of input parameters, the magnitude and timing of the occurrence of the peak may not be as high as what the modeling result has shown.

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TABLES

Table 4-1

Summary of Hydraulic Conductivities
Plum Brook Ordnance Works, Sandusky, Ohio

Well No.	Date Tested	Aquifer Response	Saturated Aquifer Thickness (Assumed)	Test Type	Transmisivities T (ft^2/day)	Hydraulic Conductivities K (ft/min)	Hydraulic Conductivities K (cm/sec)	Hydraulic Conductivities K (ft/day)
Monitoring Wells Screened in Overburden								
IT-AA1-GW-002	10/13/1997	Unconfined	22.13	Rising	1.63E+01	5.13E-04	2.61E-04	7.39E-01
IT-AA2-GW-002	10/13/1997	Unconfined	----		----	----	----	----
IT-AA3-GW-002	10/13/1997	Unconfined	11.24	Rising	4.76E+01	2.94E-03	1.49E-03	4.23E+00
IT-ABG-GW-002	10/13/1997	Unconfined	3.17	Rising	6.71E+02	1.47E-01	7.47E-02	2.12E+02
Monitoring Wells Screened in Shale								
IT-BG8-BEDGW-001	10/13/1997	Unconfined	16.64	Rising	5.73E+00	2.39E-04	1.21E-04	3.44E-01
IT-ABG-BEDGW-001	10/13/1997	Unconfined	17.65	Rising	3.91E+02	1.54E-02	7.83E-03	2.22E+01
PB-BED-MW26	slug test was not performed due to low water column in the well							
PB-BED-MW28	5/4/2004	Unconfined	35.03	Falling	2.61E+01	5.18E-04	2.63E-04	7.46E-01
				Rising	1.77E+01	3.50E-04	1.78E-04	5.04E-01
PB-BED-MW29	5/4/2004	Confined	16.00	Falling	8.51E+00	3.69E-04	1.88E-04	5.32E-01
				Rising	9.54E+00	4.14E-04	2.11E-04	5.96E-01
IT-TNTB-BEDGW-001	10/13/1997	Unconfined	22.73	Rising	1.33E+00	4.07E-05	2.07E-05	5.86E-02
IT-TNTB-BEDGW-002	10/13/1997	Unconfined	19.68	Rising	3.51E+02	1.24E-02	6.30E-03	1.79E+01
TNTB-BEDGW-003	11/13/2001	Unconfined	11.68	Falling	insufficient data			
				Rising	2.82E-02	1.68E-06	8.52E-07	2.41E-03
Maximum					***6.71E+02***	***1.47E-01***	***7.47E-02***	***2.12E+02***
Minimum					***2.82E-02***	***1.68E-06***	***8.52E-07***	***2.41E-03***
Geometric Mean K					***1.70E+01***	***7.19E-04***	***3.66E-04***	***1.04E+00***
Monitoring Wells Screened in Delaware Limestone								
IT-AA1-BEDGW-001	10/13/1997	Unconfined	35.82	Rising	2.67E+00	5.17E-05	2.63E-05	7.44E-02
IT-AA2-BEDGW-001	10/13/1997	Unconfined	31.4	Rising	1.02E+00	2.26E-05	1.15E-05	3.25E-02
IT-MNTA-BEDGW-001	10/13/1997	Unconfined	38.14	Rising	1.19E+00	2.17E-05	1.10E-05	3.12E-02
IT-AA3-BEDGW-001	10/13/1997	Unconfined	30.81	Rising	1.14E+01	2.58E-04	1.31E-04	3.72E-01
PB-BED-MW22	11/13/2001	Unconfined	14.21	Rising	3.69E+00	1.80E-04	9.16E-05	2.59E-01
PB-BED-MW23	11/14/2001	Unconfined	8.27	Rising	5.41E-01	4.54E-05	2.31E-05	6.54E-02
PB-BED-MW24	11/13/2001	Unconfined	15.32	Falling	2.35E+01	1.07E-03	5.42E-04	1.54E+00
				Rising	2.81E+01	1.28E-03	6.48E-04	1.84E+00
PB-BED-MW25	11/14/2001	Unconfined	25.55	Falling	1.40E+02	3.81E-03	1.94E-03	5.48E+00
				Rising	1.23E+02	3.33E-03	1.69E-03	4.80E+00
PB-BED-MW30	5/4/2004	Unconfined	34.30	Falling	1.33E+01	2.70E-04	1.37E-04	3.89E-01
				Rising	1.35E+01	2.74E-04	1.39E-04	3.94E-01
PB-BED-MW33	5/4/2004	Unconfined	9.61	Rising	1.19E+01	8.57E-04	4.36E-04	1.23E+00
TNTA-BEDGW-001	slug test was not performed due to low water column in the well							
TNTB-BEDGW-004	11/13/2001	Unconfined	18.36	Falling	4.03E+01	1.53E-03	7.75E-04	2.20E+00
				Rising	8.51E+01	3.22E-03	1.64E-03	4.63E+00
TNTC-BEDGW-001	11/14/2001	Unconfined	28.59	Falling	9.36E+00	2.27E-04	1.16E-04	3.27E-01
				Rising	5.46E+00	1.33E-04	6.74E-05	1.91E-01
Maximum					***1.40E+02***	***3.81E-03***	***1.94E-03***	***5.48E+00***
Minimum					***5.41E-01***	***2.17E-05***	***1.10E-05***	***3.12E-02***
Geometric Mean					***1.07E+01***	***3.36E-04***	***1.71E-04***	***4.83E-01***

ft2/day - Square feet per day.
ft/min - Feet per minute.
cm/sec - Centimeters per second.
ft/day - Feet per day.

Table 4-2

Mass Balance for the Calibrated Flow Model
Plum Brook Ordnance Works, Sandusky, Ohio

VOLUMETRIC BUDGET FOR ENTIRE MODEL AT END OF TIME STEP 1 IN STRESS PERIOD 1

CUMULATIVE VOLUMES	L**3	RATES FOR THIS TIME STEP	L**3/T
IN:		IN:	
CONSTANT HEAD =	0.0000	CONSTANT HEAD =	0.0000
WELLS =	0.0000	WELLS =	0.0000
DRAINS =	0.0000	DRAINS =	0.0000
RIVER LEAKAGE =	2026604.7500	RIVER LEAKAGE =	2026604.7500
HEAD DEP BOUNDS =	1473266.7500	HEAD DEP BOUNDS =	1473266.7500
RECHARGE =	294016.2812	RECHARGE =	294016.2812
TOTAL IN =	3793887.7500	TOTAL IN =	3793887.7500
OUT:		OUT:	
CONSTANT HEAD =	0.0000	CONSTANT HEAD =	0.0000
WELLS =	1348.0000	WELLS =	1348.0000
DRAINS =	0.0000	DRAINS =	0.0000
RIVER LEAKAGE =	184559.6406	RIVER LEAKAGE =	184559.6406
HEAD DEP BOUNDS =	1895723.8750	HEAD DEP BOUNDS =	1895723.8750
RECHARGE =	0.0000	RECHARGE =	0.0000
TOTAL OUT =	2081631.5000	TOTAL OUT =	2081631.5000
IN - OUT =	1712256.2500	IN - OUT =	1712256.2500
PERCENT DISCREPANCY =	58.28	PERCENT DISCREPANCY =	58.28

TIME SUMMARY AT END OF TIME STEP 1 IN STRESS PERIOD 1

	SECONDS	MINUTES	HOURS	DAYS	YEARS
TIME STEP LENGTH	86400.	1440.0	24.000	1.0000	2.73785E-03
STRESS PERIOD TIME	86400.	1440.0	24.000	1.0000	2.73785E-03
TOTAL TIME	86400.	1440.0	24.000	1.0000	2.73785E-03

1

Table 5-1

Maximum Simulated Concentrations of 2,4,6-TNT, 2,4-DNT, and 2,6-DNT
Former Plum Brook Ordnance Works, Sandusky, Ohio

Year	Layer 1			Layer 2			Layer 3			Layer 4		
	TNT	24 DNT	26 DNT	TNT	24 DNT	26 DNT	TNT	24 DNT	26 DNT	TNT	24 DNT	26 DNT
Initial	32400	37600	10550				1.6	19	3.6			
1	30818.2	29111.5	7244	2.8	3.5	66.7		16.2	3.54			
5	30675.1	28599.2	4571.3	39.5	76.9	70.8		16.2	3.5			
10	30497	27234.2	4001.5	39.6	106.6	123.8		16.2	5			
15	30320.8	25379.8	3540.5	37.3	105.2	109		16.2	10.8			0.36
20	29800.4	24431.3	3198.7	57	103.6	114.4		16.2	17.4			0.37
25	28144.9	23232	2945.8	56.9	101.7	93.3		16.1	31.3			0.39
30	27667.1	21334.3	2681.5	56.8	99.6	87.2		16.1	37.8			0.43
35	27472.6	19670.5	2447.3	56.7	89.1	138.8		17.1	43.5			1.7
40	27279.4	18319.3	2244.9	56.6	87.1	132.6	1.8	22.1	45.4			3.03
45	24254	18818.5	1997.7	56.5	89.6	160.3	2.2	22.6	45			3.08
50	24085.2	18577.1	1789.5	56.4	99.3	100.6	2.2	23.2	44.3			3.1
55	23917.5	17795.8	1308.7	56.3	477.3	94.2	3.7	30.4	43.7			3.2
60	23750.9	17994.8	1308.9	56.3	473.4	67.8	5.1	31.4	43.4			4.3
65	23585.7	16976.3	967.1	56.2	469.1	71.5	6.4	32.4	43.1			6
70	23422	16300.8	919.1	56.1	464.5	64.1	6.5	33.6	46.4			8
75	23259.7	15443	817.5	56	420.7	99.9	8.8	40.8	46.5			9.4
80	23099.3	15792.9	688.7	55.9	416.1	96.4	8.9	41.9	44			10.1
85	22940.5	15173.7	554.8	55.9	411.5	95.6	10	49.2	43.7			10.9
90	22783.8	14969.6	430.4	193.8	407.1	96.6	10.1	50.3	42		0.11	14.5
95	22628.3	15266.7	354.2	213.8	402.8	106.7	11.2	51.6	40.5		0.12	15.9
100	22474.1	14720.8	341.5	214.4	369.2	112.7	11.3	52.8	39.6		0.67	16.1
105	22321.1	14676.1	275.6	214.8	364.3	141.2	11.3	54	42.9		0.68	27.2
110	22169	13771.8	257.7	214.9	388.4	122.2	11.4	59.2	56.5		0.69	29.3
115	22018	13969.2	248.2	214.7	347.9	99.8	12.5	60.6	62.3		0.71	29.2
120	21868.4	13322.6	230.7	214.4	333.9	95.5	12.6	63.6	68.6		1.03	29.2
125	20280.5	12830.5	193.4	214	327.2	94.3	12.7	65.1	69.6		1.06	29.15
130	20145	12358.8	182.1	213.6	320.6	73.3	12.7	66.6	65		1.09	29.1
135	20016.7	11796.1	161.2	213.2	289.5	70.4	12.8	75.1	62.8		1.11	25.1
140	18868	11550.3	141.9	212.6	312.5	94.8	12.9	81	62.2		1.14	24.4
145	18763.4	11162.2	136.2	212	310.7	90.7	13	86.5	60.3		1.2	24.3
150	18659.4	11391.8	125.5	211.4	308.3	84.4	13.1	87	56.3		1.4	24.2

All results are in units of micrograms per liter (µg/L).

[ ]---- concentration below 1.0 µg/L

ND ---- Non-detect

Table 5-2

Maximum Simulated Concentrations of 2,4,6-TNT, 2,4-DNT, and 2,6-DNT in TNT Manufacturing Area A Former Plum Brook Ordnance Works, Sandusky, Ohio

Year	Layer 1			Layer 2			Layer 3			Layer 4		
	TNT	24 DNT	26 DNT	TNT	24 DNT	26 DNT	TNT	24 DNT	26 DNT	TNT	24 DNT	26 DNT
Initial	**32400**	**6900**	**6900**				**ND**	**0.49**	**3.6**			
1	30818.2	5801.2	5802.9	0.6	0.2	66.7		0.47	3.54			
5	30675.1	5660.1	4571.3	2.9	76.9	70.8		0.48	3.49			
10	30497	5589.5	4001.5	5.4	80.7	123.8		0.48	3.4			
15	30320.8	5507.9	3540.5	8.2	88.6	98.5		0.48	6			
20	29800.4	5423.2	3198.7	57	88.5	97.6		0.48	11.1			
25	28144.9	5339.9	2945.8	56.9	88.4	90.5		0.48	11.2			0.18
30	27667.1	5252.1	2681.5	56.8	88.2	83.7		0.48	11.3			0.18
35	27472.6	5160.9	2447.3	56.7	88	76.4		0.48	13			0.21
40	27279.4	5114.3	2244.9	56.6	93.5	69.3		0.47	13.5			0.24
45	24254	5039.1	1997.7	56.5	93.3	74.5		0.57	26.6			0.24
50	24085.2	4956.1	1789.5	56.4	93	69.3		0.6	28.8			0.24
55	23917.5	4889.7	1308.7	56.3	92.8	71.9		0.7	28.5			0.24
60	23750.9	4783.5	1308.9	56.3	92.5	67.8		0.7	28			0.23
65	23585.7	4545.3	967.1	56.2	92.3	71.5		3	24.2			0.23
70	23422	4155.6	919.1	56.1	92	64.1		3	24			0.23
75	23259.7	4137.7	817.5	56	107.5	99.9	1.62	3	25			0.2
80	23099.3	3944.2	688.7	55.9	106.9	96.4	1.63	2.9	24.8			1.99
85	22940.5	3864.9	554.8	55.8	106.3	95.6	1.64	5.2	24.6			1.87
90	22783.8	3939.3	430.4	55.7	105.8	96.6	2.4	5.2	24.4			1.8
95	22628.3	3734.1	323.4	55.6	105.2	106.7	4.3	5.2	24.3			1.7
100	22474.1	3761	276.1	55.5	104.7	112.7	4.6	5.2	22.5			1.65
105	22321.1	3654.6	244.7	55.4	104.1	117	4.61	5.3	26.3			1.6
110	22169	3444.2	217.7	55.3	103.6	119.7	4.63	5.3	27.2			3.1
115	22018	3499.8	183.6	55.2	103	99.8	4.64	9.3	32.1			4.1
120	21868.4	3441.9	188.2	55.2	102.5	95.5	4.66	9.3	35			7.3
125	20280.5	3167.5	171.9	55.1	102.1	94.3	4.67	9.3	39.1			9.2
130	20145	3130.8	157.6	56.4	101.7	73.3	4.69	9.3	40.2			8.6
135	20016.7	3091.2	149.7	58.2	101.2	65.5	4.71	9.3	36			11.2
140	18868	3016.7	140.5	59.9	100.8	66.1	4.72	9.4	35.5			11.3
145	18763.4	2983.9	127.8	61.7	100.3	65.7	4.73	9.4	35.9			14.2
150	18659.4	2772.5	103	63.4	99.8	66.2	4.74	10.1	30			15.8

All results are in units of micrograms per liter (µg/L).

---- concentration below 1.0 µg/L

ND ---- Non-detect

Table 5-3

Maximum Simulated Concentrations of 2,4,6-TNT, 2,4-DNT, and 2,6-DNT in TNT Manufacturing Area B Former Plum Brook Ordnance Works, Sandusky, Ohio

Year	Layer 1			Layer 2			Layer 3			Layer 4		
	TNT	24 DNT	26 DNT	TNT	24 DNT	26 DNT	TNT	24 DNT	26 DNT	TNT	24 DNT	26 DNT
Initial	68	5.8	11				ND	ND	ND			
1	49.6	3.8	7.9									
5	49.3	53.8	32		0.1	0.9						
10	49	841.7	45.4		0.3	1.8			0.5			
15	48.7	1572	33.4		0.8	1.6			0.9			
20	48.4	1606.6	25.1		1.4	1.4			1			
25	48.1	1274.8	102.7		1.9	1.35		0.15	1.1			
30	46.2	890.3	226.6		2.2	1.3		0.2	1.2			
35	44.5	578.7	348.5		2.4	1.3		0.3	1.2			
40	44.2	410.1	426.4		2.6	1		0.4	1.1			
45	44	327.9	447.4		2.69	1		0.5	1			
50	40.7	513.5	421.3		2.74	1.8		0.6	0.98			
55	39.4	669.9	379.9		2.77	2		0.68	0.95			
60	38.6	760.8	317.3		2.77	1.8		0.75	0.93			
65	38.4	776.1	259.2		2.77	1.9		0.8	0.93			
70	35.7	727.4	219.4		2.76	2.1		0.88	0.94			
75	34.7	698.1	188.3		2.75	2.2		0.93	0.92			
80	33.7	662.4	179.8		2.43	2.6		0.99	0.89			0.13
85	33.6	598.6	159.7		2.42	2.5		1.04	0.9			0.2
90	31.8	519.5	143.6		2.4	2.6		1.08	0.8			0.5
95	31.6	435.9	125.9		2.39	2.5		1.1	0.9			0.6
100	31.5	355.4	106.4		2.38	2.7		1.17	0.93			0.65
105	31.9	324.2	103.9		2.37	2.8		1.2	0.93			0.64
110	32	317.7	93.9		2.36	2.59		1.24	0.9			0.65
115	32.2	311	78.7		2.34	2.55		1.27	0.95			0.75
120	32	290.2	69.4		2.33	2.51		1.3	0.95			0.73
125	31.3	268.5	59.9		2.3	2.5		1.32	1			0.7
130	32	260.8	57.3		2.29	2.4	0.004	1.36	1.02			0.7
135	31.2	223	55.5		2.92	2.6		1.38	1			0.77
140	31.4	202	50.1		2.94	2.5		1.4	0.95			0.82
145	31.5	161.3	47		2.95	2.62		1.42	0.92			0.79
150	32	158	40.8		2.96	2.6		1.44	0.9			0.8

All results are in units of micrograms per liter (µg/L).

[ ] ---- concentration below 1.0 µg/L

ND ----- non-detect

Table 5-4

Maximum Simulated Concentrations of 2,4,6-TNT, 2,4-DNT, and 2,6-DNT
TNT Manufacturing Area C
Former Plum Brook Ordnance Works, Sandusky, Ohio

Year	Layer 1			Layer 2			Layer 3			Layer 4		
	TNT	24 DNT	26 DNT	TNT	24 DNT	26 DNT	TNT	24 DNT	26 DNT	TNT	24 DNT	26 DNT
Initial	20100	37600	10550				ND	0.1	0.7			
1	16362.9	29111.5	7244	2.8	3.5	4.6			0.7			
5	16110	28599.2	4126.9	39.5	76.9	22.7			1.9			
10	15796	27234.2	3654.9	39.6	106.6	27.3		2.3	5			
15	15337.8	25379.8	2164.4	37.3	105.2	109		16.2	10.8			0.36
20	14994.2	24431.3	1907.3	37.3	103.6	114.4		16.2	17.4			0.37
25	14558.9	23232	1621	37.4	101.7	93.3		16.1	31.3			0.39
30	13875.4	21334	1800.5	38.5	99.6	87.2		16.1	37.8			0.43
35	13655.2	19670.5	1258.5	41.4	89.1	138.8		17.1	43.5			1.7
40	13303.7	18319.3	958.9	43.8	87.1	132.6	1.8	22.1	45.4			3.03
45	12933.7	18818.5	861.2	42.9	89.6	160.3	2.2	22.6	45			3.08
50	12148.9	18577.1	778.1	44.5	99.3	100.6	2.2	23.2	44.3			3.1
55	9949.4	17795.8	665.7	45.6	477.3	94.2	3.7	30.4	43.7			3.2
60	9755	17994.8	644.9	43.5	473.4	67.3	5.1	31.4	43.4			4.3
65	8851.5	16976.3	560.4	44.2	469.1	71.5	6.4	32.4	43.1			6
70	8105.6	16300.8	520.6	44.9	464.5	64.1	6.5	33.6	46.4			8
75	7420.7	15443	450.3	42.7	420.7	62.8	8.8	40.8	46.5			9.4
80	6697.8	15792.9	400.4	43.1	416.1	68	8.9	41.9	44			10.1
85	6517	15173.7	381.9	43.4	411.5	67.2	10	49.2	43.7			10.9
90	6401.2	14969.6	392.3	193.8	407.1	63.2	10.1	50.3	42		0.11	14.5
95	6087.8	15266.7	354.2	213.8	402.8	66.6	11.2	51.6	40.5		0.12	15.9
100	5707.9	14720.8	341.5	214.4	369.2	83.5	11.3	49.9	39.6		0.67	16.1
105	5430.6	14676.1	275.6	214.8	364.3	141.2	11.3	54	42.9		0.68	27.2
110	5340.1	13771.8	257.7	214.9	388.4	122.2	11.4	59.2	56.5		0.69	29.3
115	5323	13969.2	248.2	214.7	347.9	87.2	12.5	60.6	62.3		0.71	29.2
120	5234.4	13322.6	230.7	214.4	333.9	73.1	12.6	63.6	68.6		1.03	29.2
125	5119.7	12830.5	193.4	214	327.2	69	12.7	65.1	69.6		1.06	29.15
130	5128.2	12358.8	182.1	213.6	320.6	70.7	12.7	66.6	65		1.09	29.1
135	5126	11796.1	161.2	213.2	289.5	70.4	12.8	75.1	62.8		1.11	25.1
140	5641.7	11550.3	141.9	212.6	312.5	94.8	12.9	81	62.2		1.14	24.4
145	5411.9	11162.2	136.2	212	310.7	90.7	13	86.5	60.3		1.2	24.3
150	4702.8	11391.8	125.5	211.4	308.3	84.4	13.1	87	56.3		1.4	24.2

All results are in units of micrograms per liter (µg/L).

---- concentration below 1.0 µg/L

ND ----- non-detect

Table 5-5

Maximum Simulated Concentrations of 2,4,6-TNT, 2,4-DNT, and 2,6-DNT
Pentolite Road Red Water Ponds
Former Plum Brook Ordnance Works, Sandusky, Ohio

Year	Layer 1			Layer 2			Layer 3			Layer 4		
	TNT	24 DNT	26 DNT	TNT	24 DNT	26 DNT	TNT	24 DNT	26 DNT	TNT	24 DNT	26 DNT
Initial	160	9200	550				1.6	1.5	1.4			
1	28.8	8069.3	418.1		0.2	0.1		1.5	1.35			
5	28.2	7903.3	313.8		1.2	8.5		1.49	1.32			
10	67.1	7219.7	309.5		2.5	11.5		1.47	1.3			
15	121.5	6193.8	304		3.8	9.7		1.48	1.2			
20	138.9	6041.9	321		5	11.3		1.47	1.2			
25	128.6	5892.7	279.8		6.3	11		1.46	1.2			
30	105.7	5748.1	200.5		7.7	20.5		1.45	1.3			
35	80.7	4608.6	130		8.9	19.8		1.45	1.5			
40	58.6	4437.3	100.1		17.6	19.2		1.44	1.5			
45	41.2	4414.3	82.2	1	17.9	18.7		1.43	1.5			
50	30.7	4292.3	77.8	1.1	17.5	18.2		1.43	1.7			
55	32.2	4325	70.7	1.2	17.7	21.2		1.42	1.8			
60	44	4495.9	66.6	1.3	18.8	20.7		1.41	1.9			
65	54.4	4261.6	58.5	1.4	19	16.9		1.4	2.7			
70	62.1	4140.5	54.2	1.5	18.5	16.6		1.4	4.3			
75	66.5	3875.1	49	1.55	19.5	18.7		1.4	4.6			
80	67.4	3765.7	44.1	1.63	19.8	18.2		1.4	4.7			
85	65.4	3412.4	39.2	1.7	19.9	17.2		1.39	5.1			
90	61.2	3226.2	35.5	1.78	20.1	15.5		1.38	5.2			
95	55.4	2952.9	31.1	1.84	20.3	15.2		1.4	5.6			
100	48.9	2769.5	26.8	1.91	207.4	15		1.6	5.68			
105	42.1	2649	23.3	1.97	207.3	14.8		1.9	5.76			
110	35.6	2479.6	20.5	2.03	221.9	14.6		2.8	5.8			
115	29.5	2256.1	17.5	2.1	239	16.6		3.7	6.1			
120	24.1	2193	14.5	2.15	259.2	16.3		4.5	6.16			
125	23.3	2076.1	13.5	2.2	258.7	14.5		4.9	6.2			13
130	23	1996.8	12	2.26	258.1	14.1		5.2	6.2			0.13
135	22.8	1859.8	11	2.3	257.5	14		5.6	6.06			0.14
140	22.5	1807.6	10.8	2.36	281.9	13.4		6.3	6.1			0.14
145	22.3	1745.6	8.9	2.4	281.1	14.3		6.7	6.8			0.4
150	22	1695.5	7.4	2.44	280.3	13.8	0.2	7.2	7.2			0.5

All results are in units of micrograms per liter (µg/L).

---- concentration below 1.0 µg/L

ND -----non-detect

Table 5-6

Maximum Simulated Concentrations of 2,4,6-TNT, 2,4-DNT, and 2,6-DNT
West Area Red Water Ponds
Former Plum Brook Ordnance Works, Sandusky, Ohio

Year	Layer 1			Layer 2			Layer 3			Layer 4		
	TNT	24 DNT	26 DNT	TNT	24 DNT	26 DNT	TNT	24 DNT	26 DNT	TNT	24 DNT	26 DNT
Initial	34	950	63				0.081	19	0.43			
1	99.4	1054	243.2		2.1	0.2		16.2				
5	81.4	828.3	199		2.1	1.7		16.19				
10	63.4	813.7	146.1		3.5	2.2		16.18				
15	49.4	783.9	91.8		3.4	2.8		16.17	0.25			
20	38.4	764.4	68.8		3.4	2.6		16.15	0.2			
25	30.7	728	78.3		3.38	2.7		16.14	0.25			
30	30.4	710.5	62.8		3.35	2.5		16.13	0.32			
35	30.2	706.9	47.5		3.3	2.3		16.12	0.36			
40	29.8	698.4	44.9		3.3	2.2		16.1	0.4			
45	29.5	690	39.4		3.3	1.94		16.09	0.43			
50	29.2	681.7	29.5		3.1	1.57		16.08	0.46			
55	29	661.3	24.9		3.3	1.49		16.07	0.47			
60	28.8	651.8	20.2		3.6	1.4		16.06	0.48			
65	28.3	640	18.8		3.9	1.9		16.04	0.48			
70	28	632.1	16.7		17.5	1.89		16.03	0.47			
75	27.8	625.8	14.2		18.6	1.85		16	0.46			
80	27.4	619.7	13.1		17.62	1.83		16	0.45			
85	27	611.7	11.5		17.62	1.81		16	0.45			
90	26.8	605	10.5		17.61	1.78		16	0.46			
95	26.4	598.2	10.3		17.61	1.76		16	0.46			
100	26	590.5	9.2		17.61	1.74		16	0.46			
105	25.7	587.5	9.9		17.6	1.72	0.004	16	0.47			
110	25.5	578.6	9.1		16.76	1.73		16	0.47			
115	25.1	573	8		16.76	1.7		16	0.47			
120	24.8	563.9	7.2		16.76	1.7		16	0.47			
125	24.6	577.1	6.3		16	1.12		16	0.47			13
130	24.3	567.7	5.5		16	1.1		16	0.47			0.13
135	24.7	558.8	5.2		16	1.09		16	0.47			0.14
140	24.5	548.8	4.1		15.31	1.02		16	0.47			0.14
145	24.6	539	3.7		15.32	1		16	0.47			0.4
150	24.3	511.6	2.8		15.3	1		16	0.47			0.5

All results are in units of micrograms per liter (µg/L).

[ ] ---- concentration below 1.0 µg/L

ND ----- Non-detect

Table 5-7

Modeled Concentrations at the Downgradient Boundary
Former Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Downgradient of the West Area Red Water Ponds Area	Downgradient of TNT Area B, TNT Area C, and the Pentolite Road Red Water Pond Area	Downgradient of TNT Area A
TNT	0.0006	2E-20	1E-17
2,4-DNT	0.09	1.3	0.006
2,6-DNT	0.04	0.6	0.03

All results are in units of micrograms per liter (µg/L). Each downgradient area was modeled at year 150, which was the year of maximum concentration.

FIGURES

13 12 11 10 9 8 7 6 5 4 3 2 1

A B C D E F G H I

E 1,907,000 E 1,911,000 E 1,915,000 E 1,919,000 E 1,923,000 E 1,927,000

N 629,000 N 625,000 N 621,000 N 617,000 N 613,000 N 609,000

SCALE
0 1200 2400 FEET

LEGEND:

ABG-GW002	OVERBURDEN/SHALE MONITORING WELL
TNTC-BEDGW-001 (LS)	BEDROCK MONITORING WELL SCREENED IN LIMESTONE
ABG-BEDGW-001 (SH)	BEDROCK MONITORING WELL SCREENED IN SHALE
	BUILDING
	RAILROAD
	SURFACE WATER
	DITCH
	FENCE (PBOW BOUNDARY)
(630.45)	GROUNDWATER ELEVATION (FT-MSL)
630	GROUNDWATER ELEVATION CONTOUR (FT-MSL) (DASHED WHERE INFERRED)
G.W. FLOW	GROUNDWATER FLOW DIRECTION
(NM)	NOT MEASURED

NOTES:

1. MONITORING WELLS PB-MW01, PB-MW02, PB-MW03, AND PB-MW04 ARE NOT SHOWN (SURVEY COORDINATES NOT AVAILABLE).
2. GROUNDWATER ELEVATION CONTOURS REFLECT THE INFLUENCE OF TOPOGRAPHY, INCLUDING DITCHES AND STREAMS; HOWEVER, TOPOGRAPHIC ELEVATION CONTOURS HAVE BEEN OMITTED FOR CLARITY.
3. MONITORING WELL BED-MW26 WAS NOT USED FOR GROUNDWATER ELEVATION CONTOURING.
4. BEDROCK MONITORING WELLS WITH (SH) DESIGNATION INDICATE THAT WELL IS SCREENED IN SHALE BEDROCK. GROUNDWATER LEVELS FROM (SH) WELLS AND OVERBURDEN WELLS USED IN CONTOUR MAP CONSTRUCTION.
5. LINES DASHED WHERE OVERBURDEN GROUNDWATER EXISTENCE OR LOCATION IS UNCERTAIN.
6. GROUNDWATER LEVELS WERE MEASURED ON AUGUST 10 AND 11, 2004.

NO	DATE	REVISION	BY	CHKD	DSGN ENGR	ENGR	PROJ MGR	APPR

STARTING DATE	INITIATOR	CHKD	DRAWN	CHKD	PROJECT MNGR
03/09/06	T. SIARD		D. BOMAR		S. DOWNEY

Shaw® Shaw Environmental, Inc.
KNOXVILLE, TENNESSEE

GROUNDWATER MODELING IN THE UNSATURATED AND SATURATED ZONES FORMER PLUM BROOK ORDNANCE WORKS NASA PLUM BROOK STATION SANDUSKY, OHIO

FIGURE 3-1
OVERBURDEN/SHALE GROUNDWATER ELEVATION CONTOUR MAP (AUGUST 2004)

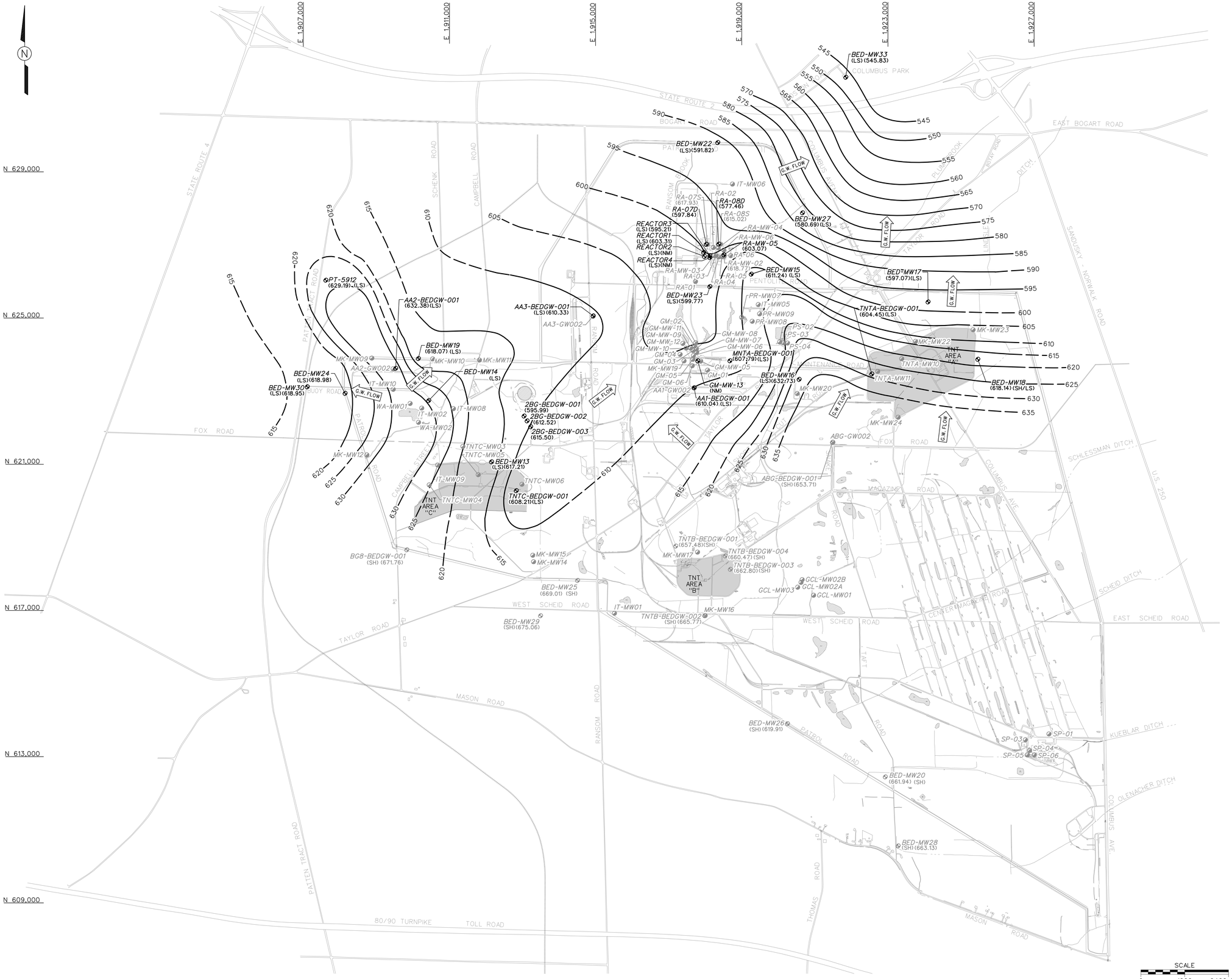
AREA	JOB NO.	DRAWING NO.	REV
SITEWIDE	843656	843656_046.dgn	

13 12 11 10 9 8 7 6 5 4 3 2 1

A B C D E F G H I

E 1,907,000 E 1,911,000 E 1,915,000 E 1,919,000 E 1,923,000 E 1,927,000

N 629,000 N 625,000 N 621,000 N 617,000 N 613,000 N 609,000



LEGEND:

ABG-GW002	OVERBURDEN/SHALE MONITORING WELL
TNTC-BEDGW-001 (LS)	BEDROCK MONITORING WELL SCREENED IN LIMESTONE
ABG-BEDGW-001 (SH)	BEDROCK MONITORING WELL SCREENED IN SHALE
	BUILDING
	RAILROAD
	SURFACE WATER
	DITCH
	FENCE (PBOW BOUNDARY)
(630.45)	GROUNDWATER ELEVATION (FT-MSL)
630	GROUNDWATER ELEVATION CONTOUR (FT-MSL) (DASHED WHERE INFERRED)
G.W. FLOW	GROUNDWATER FLOW DIRECTION
(NM)	NOT MEASURED

NOTES:

1. MONITORING WELLS PB-MW01, PB-MW02, PB-MW03, AND PB-MW04 ARE NOT SHOWN. (SURVEY COORDINATES NOT AVAILABLE).
2. MONITORING WELLS REACTOR2 AND REACTOR4 WERE NOT USED FOR GROUNDWATER ELEVATION CONTOURING.
3. TYPE OF BEDROCK MONITORING WELLS ARE SCREENED IN IS INDICATED BY (SH) - SHALE AND (LS) - LIMESTONE.
4. MONITORING WELLS WITH (SH) DESIGNATION NOT INCLUDED IN CONTOURING.
5. DASHED LINES INDICATE UNCERTAIN GROUNDWATER LEVEL ELEVATION.
6. STATIC GROUNDWATER LEVELS WERE MEASURED AUGUST 10 AND 11, 2004 UNLESS OTHERWISE INDICATED.
7. WATER LEVELS IN MONITORING WELLS 2BG-BEDGW-001, -002, AND -003 WERE NOT IN STATIC CONDITIONS, THEREFORE GROUNDWATER ELEVATIONS WERE NOT USED IN CONTOUR MAP CONSTRUCTION.
8. DEPTH TO GROUNDWATER IN WELL PT-5912 WAS MEASURED AUGUST 24, 2004, AND COMPARED TO BED-MW19 AND BED-MW30 AUGUST 10, 2004 DEPTH TO WATER MEASUREMENTS. 0.9 FEET WAS SUBTRACTED FROM THE AUGUST 24, 2004 MEASUREMENT.
9. DEPTH TO GROUNDWATER IN WELLS REACTOR1 AND REACTOR3 WERE MEASURED AUGUST 17, 2004 AND COMPARED TO RA-01 AUGUST 10, 2004 DEPTH TO WATER MEASUREMENTS. 0.6 FEET WAS ADDED TO THE AUGUST 17, 2004 MEASUREMENT.
10. WATER LEVEL ELEVATION OF TNTA-BEDGW-001 NOT USED IN CONTOUR MAP CONSTRUCTION DUE TO ERRATIC WATER LEVEL CHANGES ASSOCIATED WITH >14 FEET OF NATURAL PETROLEUM.
11. A WATER LEVEL ELEVATION CALCULATION FOR WELL BED-MW27 WAS DETERMINED TO BE 580.69 FOR AUGUST 2004.

SCALE
0 1200 2400 FEET

NO	DATE	REVISION	BY	CHKD	DSGN ENGR	ENGR	PROJ MGR	APPR

STARTING DATE	INITIATOR	CHKD	DRAWN	CHKD	PROJECT MNGR
03/09/06	T. SIARD		D. BOMAR		S. DOWNEY

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KNOXVILLE, TENNESSEE

GROUNDWATER MODELING IN THE UNSATURATED AND SATURATED ZONES FORMER PLUM BROOK ORDNANCE WORKS NASA PLUM BROOK STATION SANDUSKY, OHIO

FIGURE 3-2
DELAWARE LIMESTONE GROUNDWATER ELEVATION CONTOUR MAP (AUGUST 2004)

AREA	JOB NO.	DRAWING NO.	REV
SITEWIDE	833886	833886ES.015	

Figure 3-3
Potentiometric Surface Contour Map for Overburden/Shale
Based on August 2004 Water Level Measurements
Plum Brook Ordnance Works

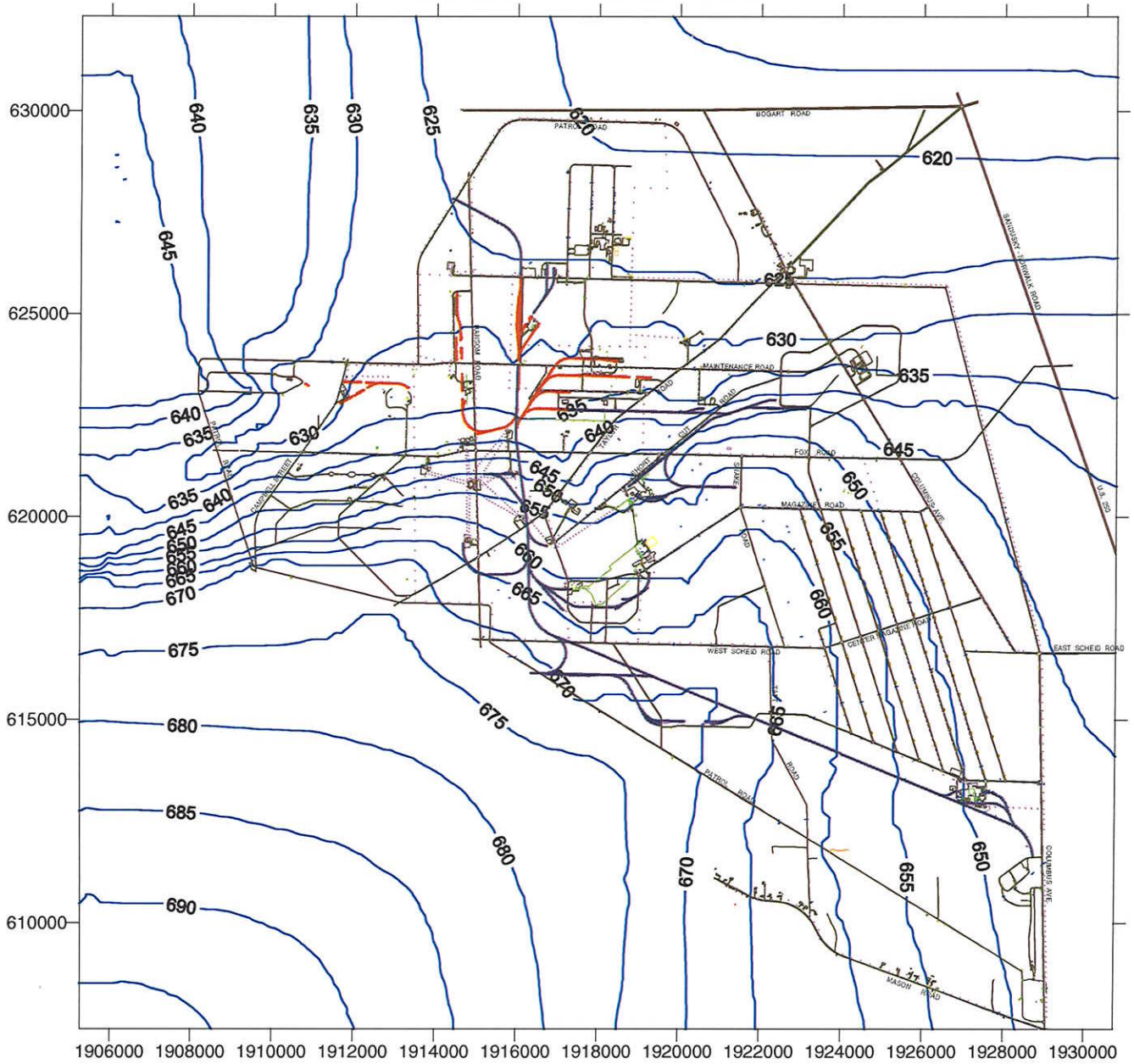


Figure 3-4
Potentiometric Surface Contour Map for Delaware Limestone
Based on August 2004 Water Level Measurements
Plum Brook Ordnance Works

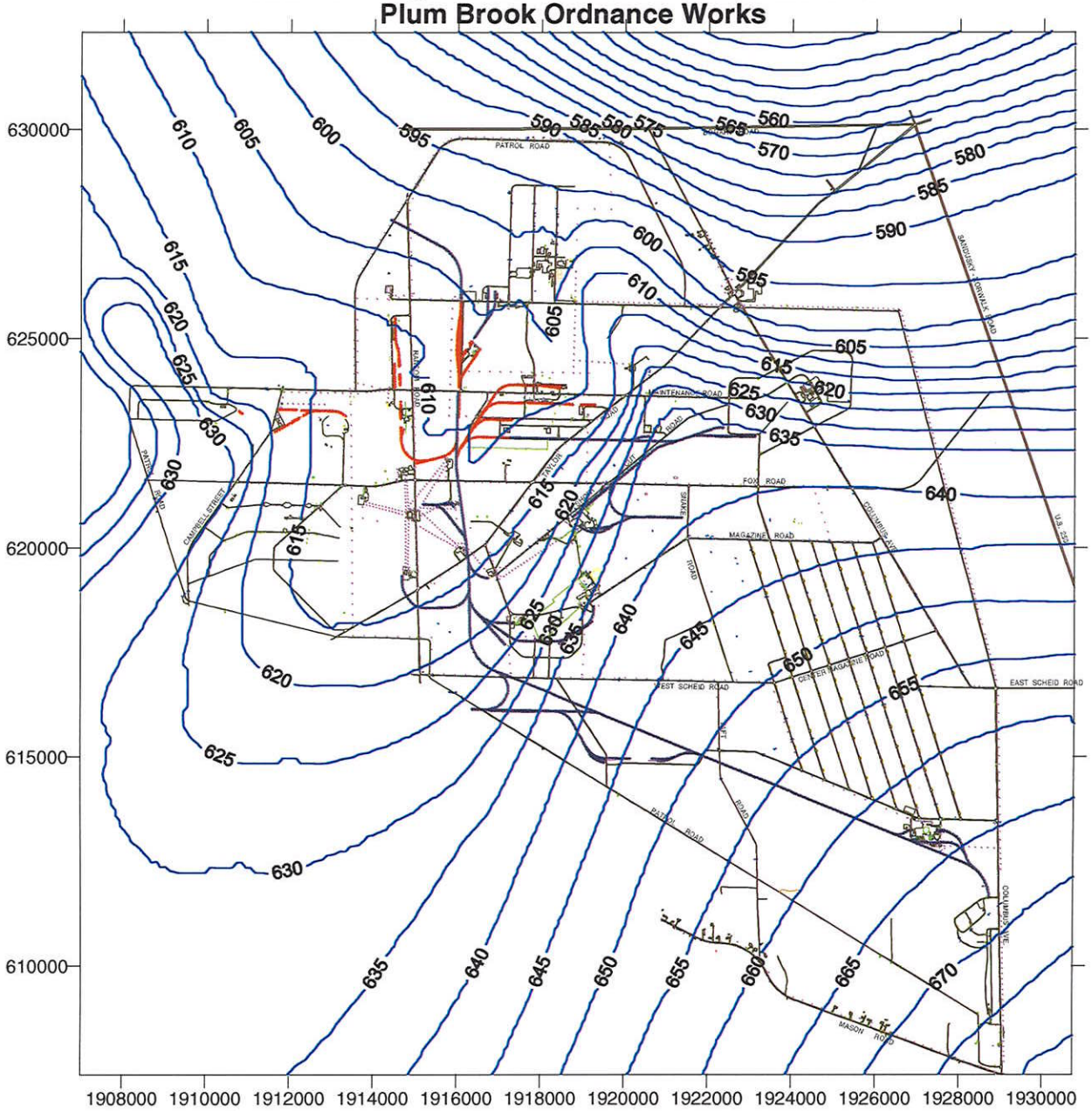


Figure 3- 5
2,4,6-TNT Plumes in the Overburden/Shale Water Bearing Zone
in the TNT Manufacturing Area A
Plum Brook Ordnance Works, Sandusky, Ohio

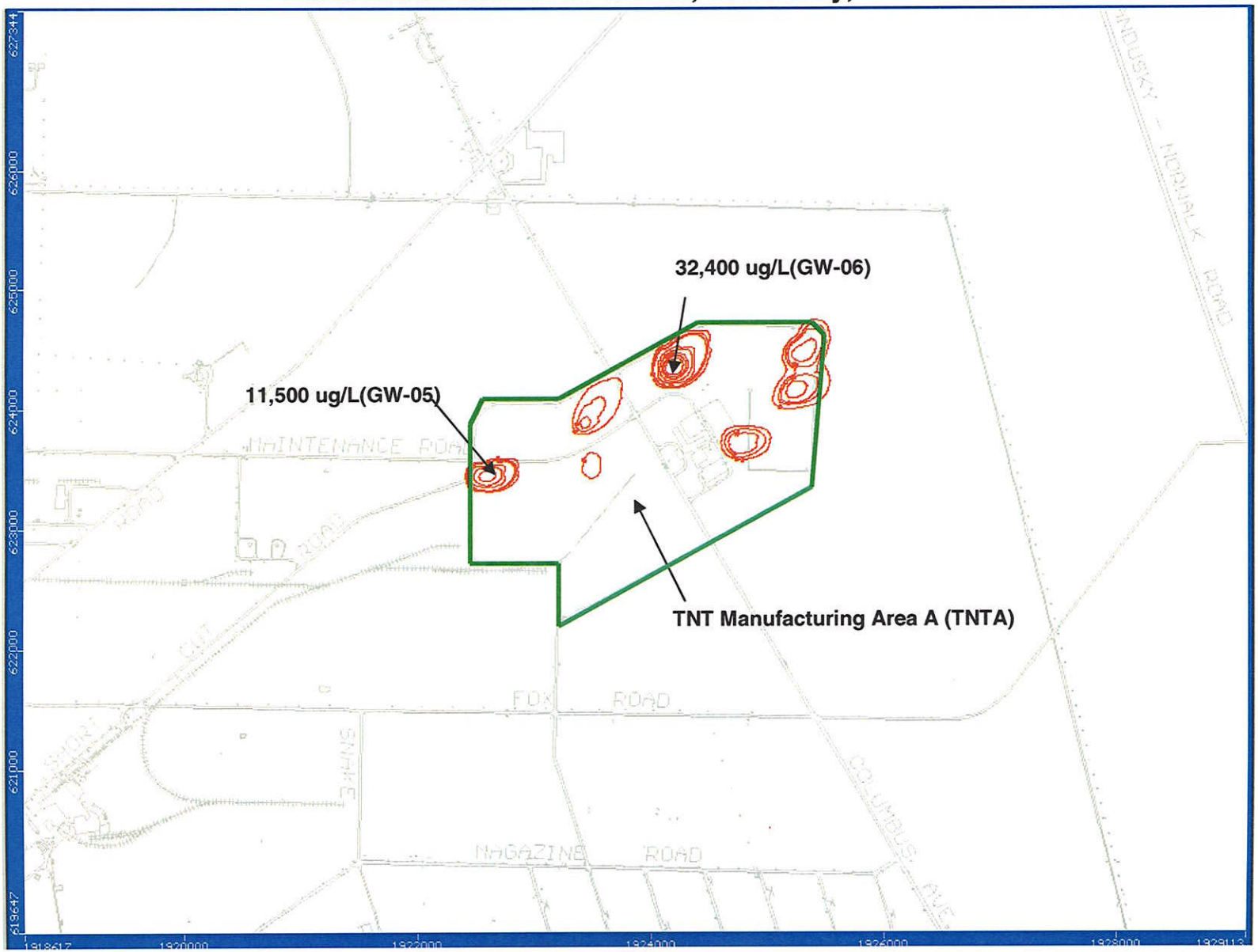


Figure 3- 6
2,4,6-TNT Plume in the Overburden/Shale Water Bearing Zone
in the TNT Manufacturing Area B
Plum Brook Ordnance Works, Sandusky, Ohio

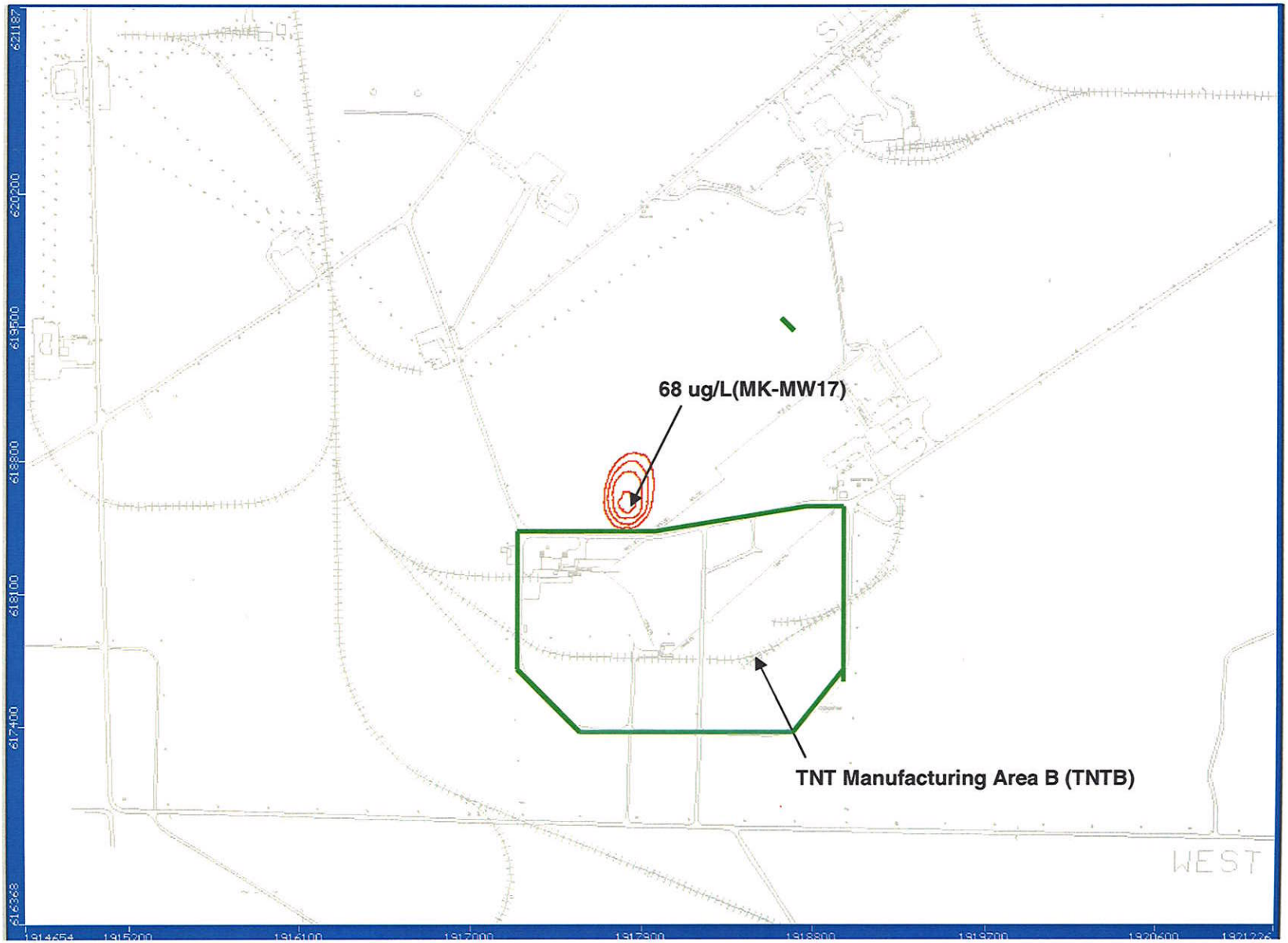


Figure 3- 7
2,4,6-TNT Plumes in the Overburden/Shale Water Bearing Zone
in the TNT Manufacturing Area C
Plum Brook Ordnance Works, Sandusky, Ohio

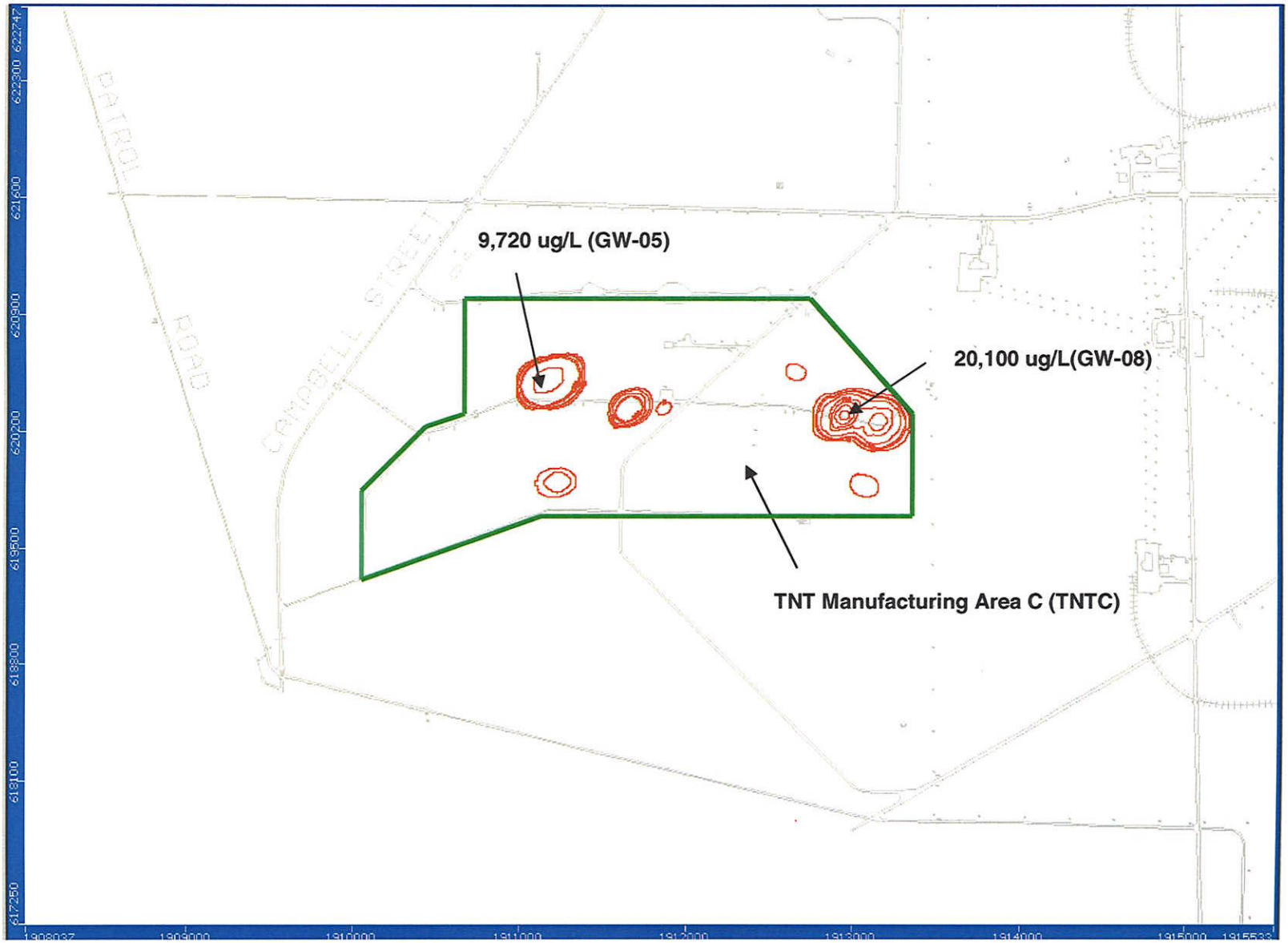


Figure 3- 8
2,4,6-TNT Plumes in the Overburden/Shale Water Bearing Zone
in the Pentolite Road Red Water Ponds Area (PRRWP)
Plum Brook Ordnance Works, Sandusky, Ohio

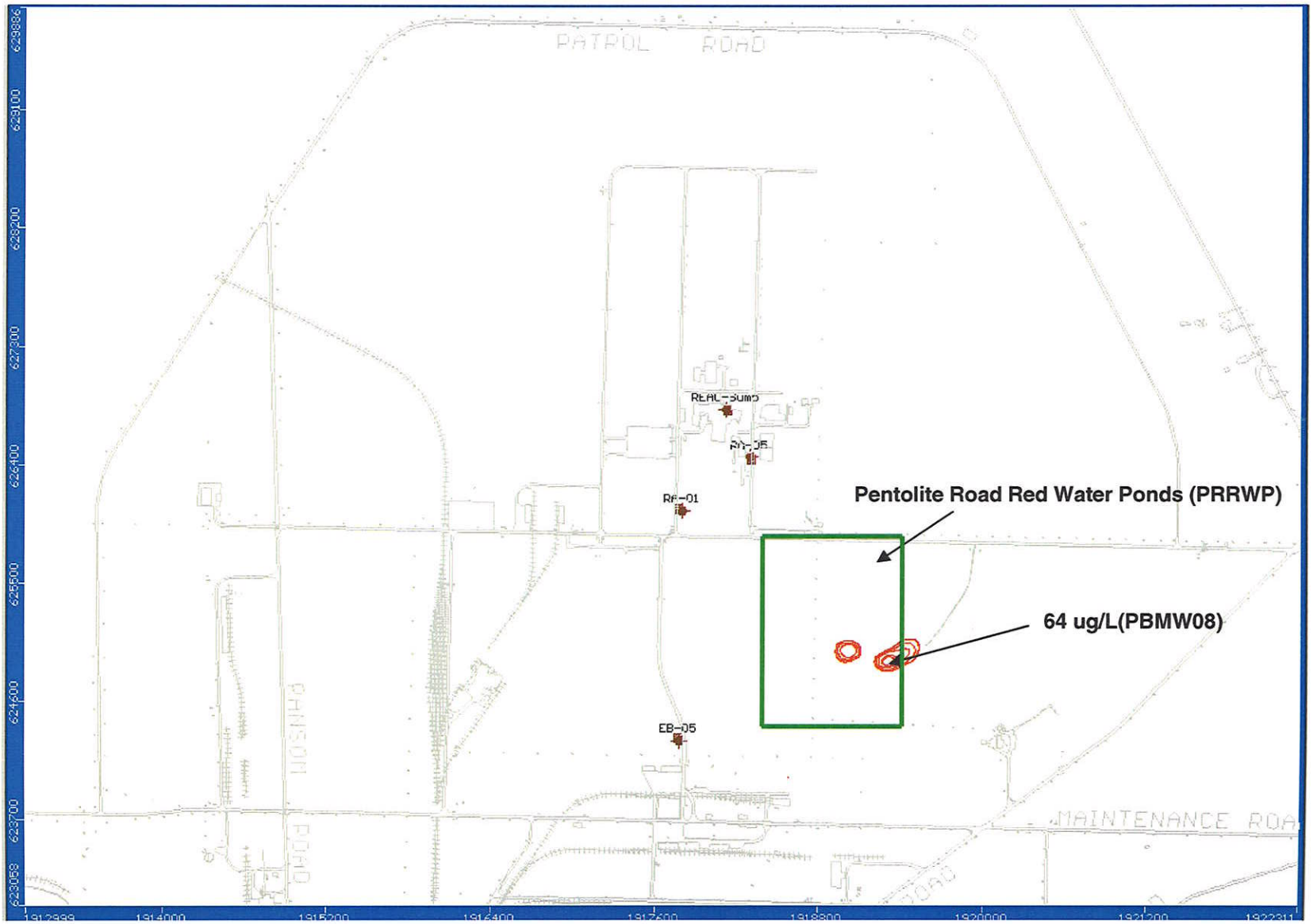


Figure 3- 9
2,4,6- TNT Plumes in the Overburden/Shale Water Bearing Zone
in the West Area Red Water Ponds Area (WARWP)
Plum Brook Ordnance Works, Sandusky, Ohio

Figure 3- 10
2,4- DNT Plumes in the Overburden/Shale Water Bearing Zone
in the TNT Manufacturing Area A
Plum Brook Ordnance Works, Sandusky, Ohio

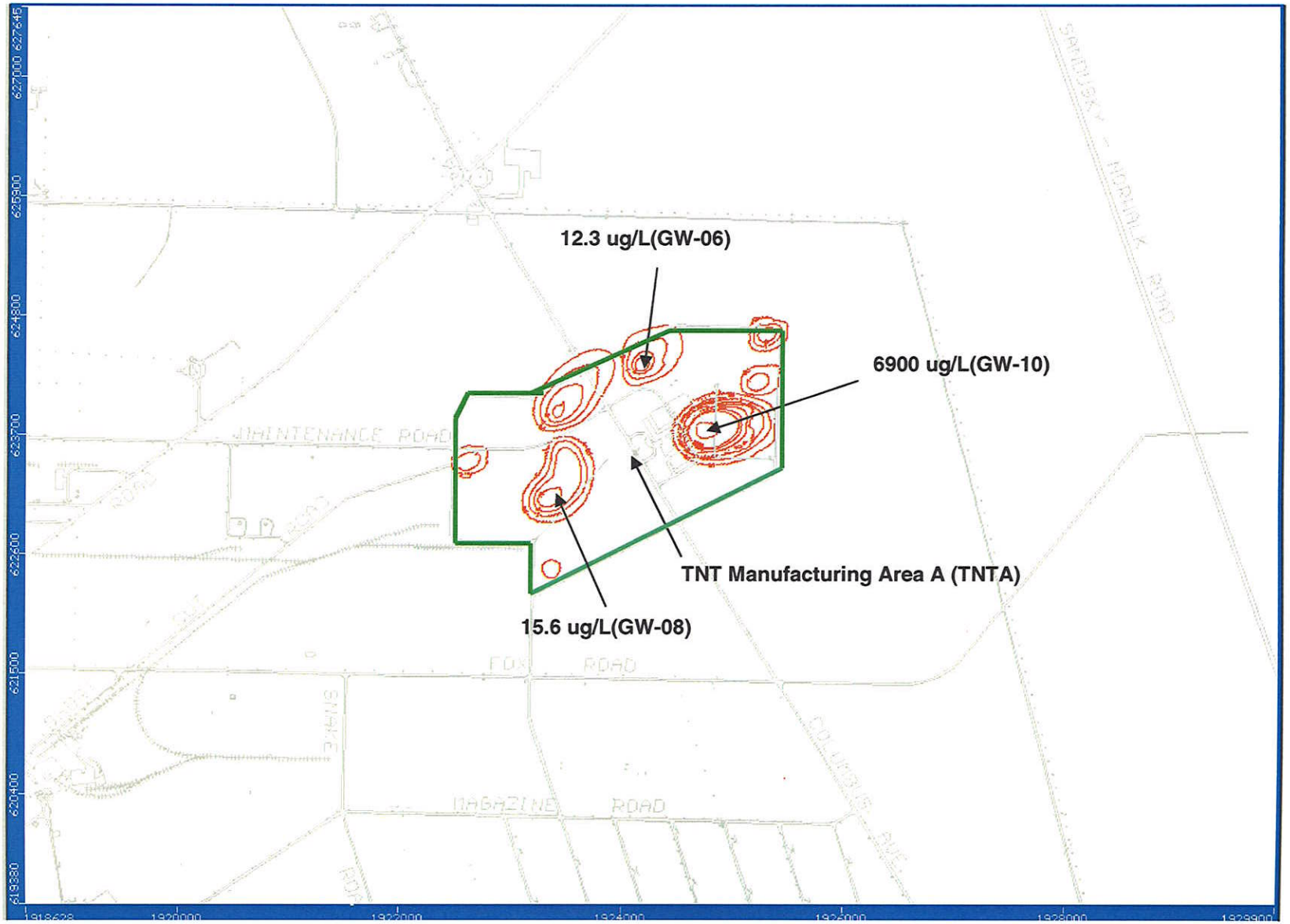


Figure 3- 11
2,4-DNT Plumes in the Overburden/Shale Water Bearing Zone
in the TNT Manufacturing Area B
Plum Brook Ordnance Works, Sandusky, Ohio

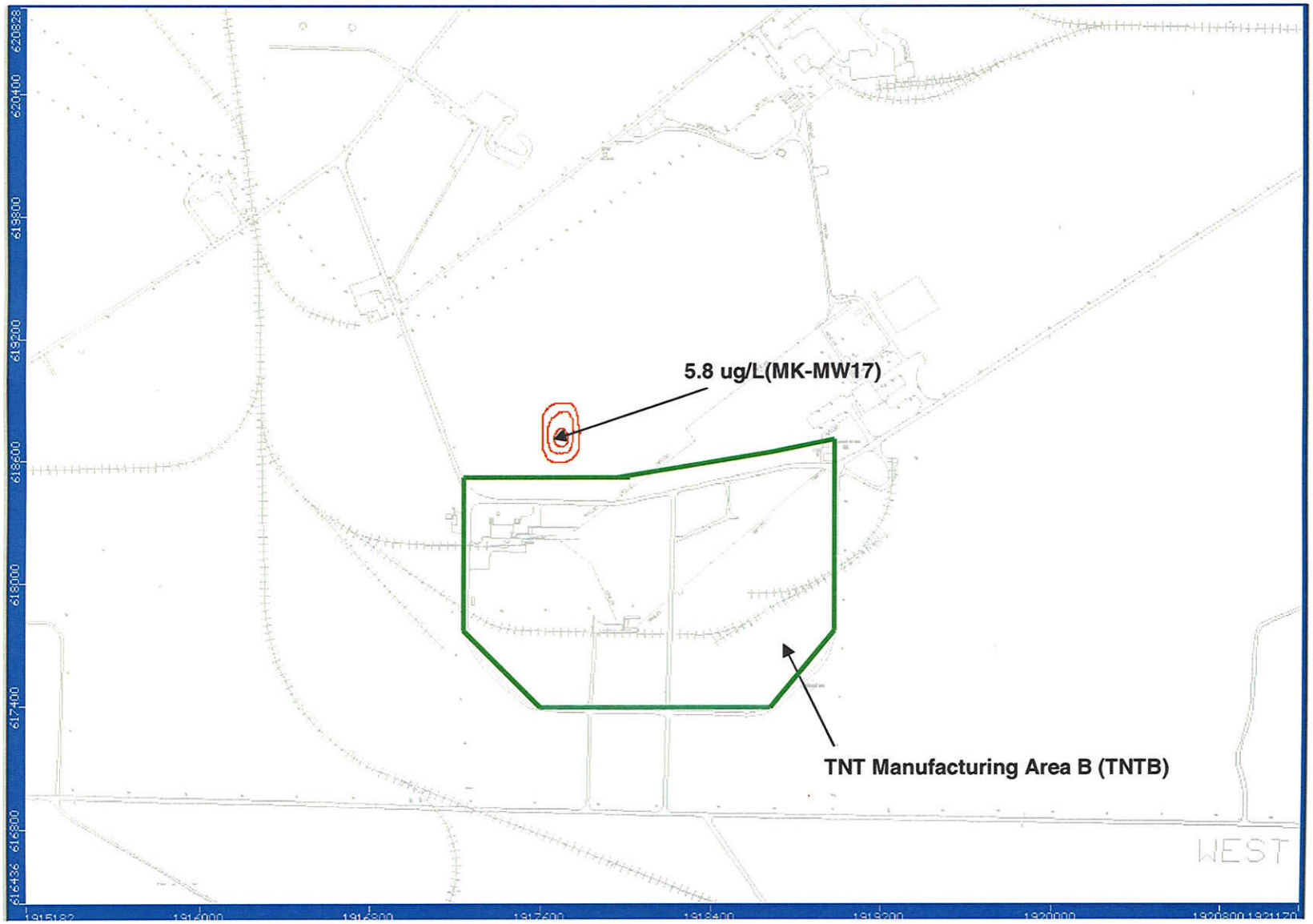


Figure 3- 12
2,4- DNT Plumes in the Overburden/Shale Water Bearing Zone
in the TNT Manufacturing Area C
Plum Brook Ordnance Works, Sandusky, Ohio

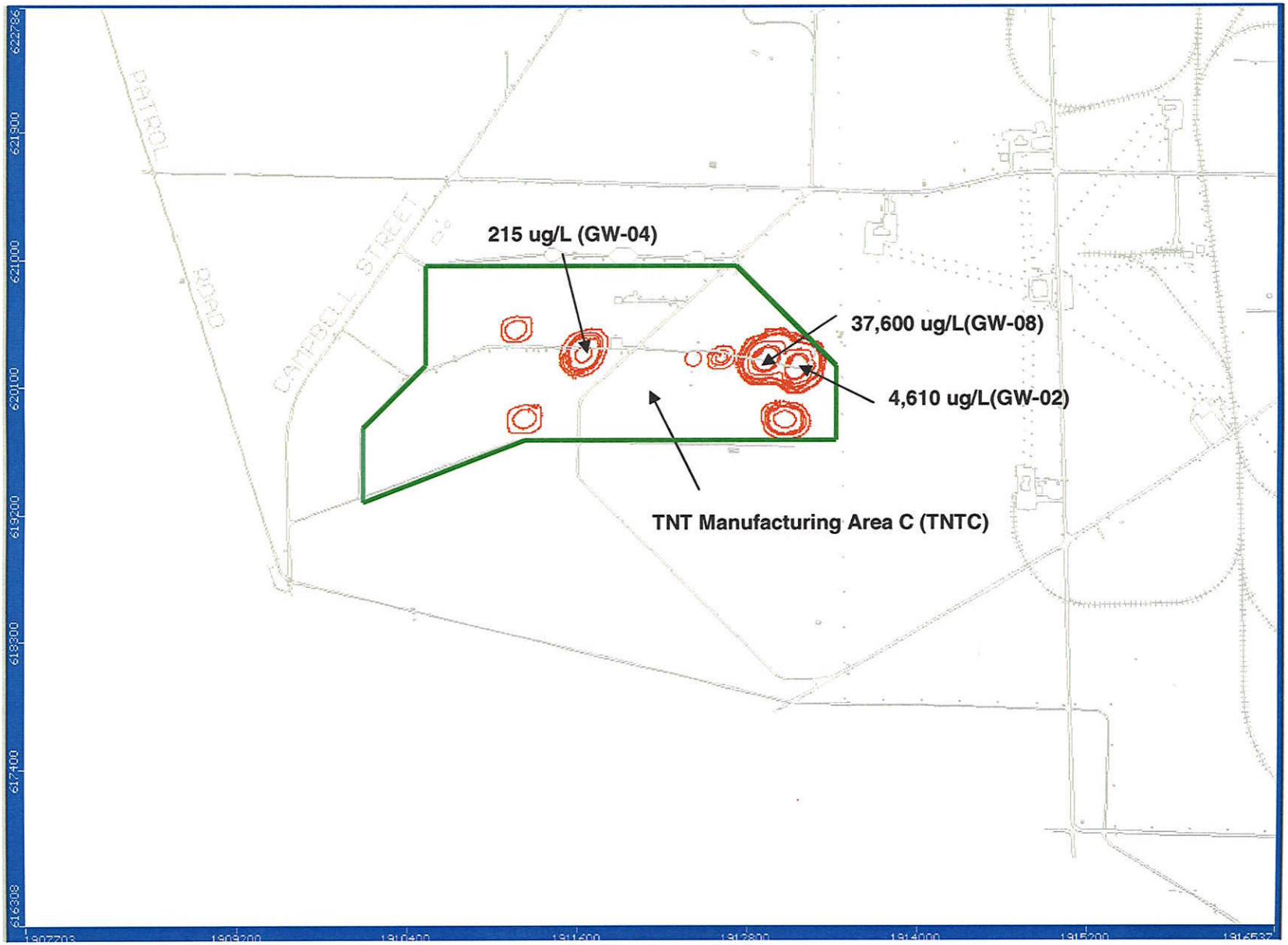


Figure 3- 13
2,4- DNT Plumes in the Overburden/Shale Water Bearing Zone in the Pentolite Road Red Water Ponds Area (PRRWP) Plum Brook Ordnance Works, Sandusky, Ohio

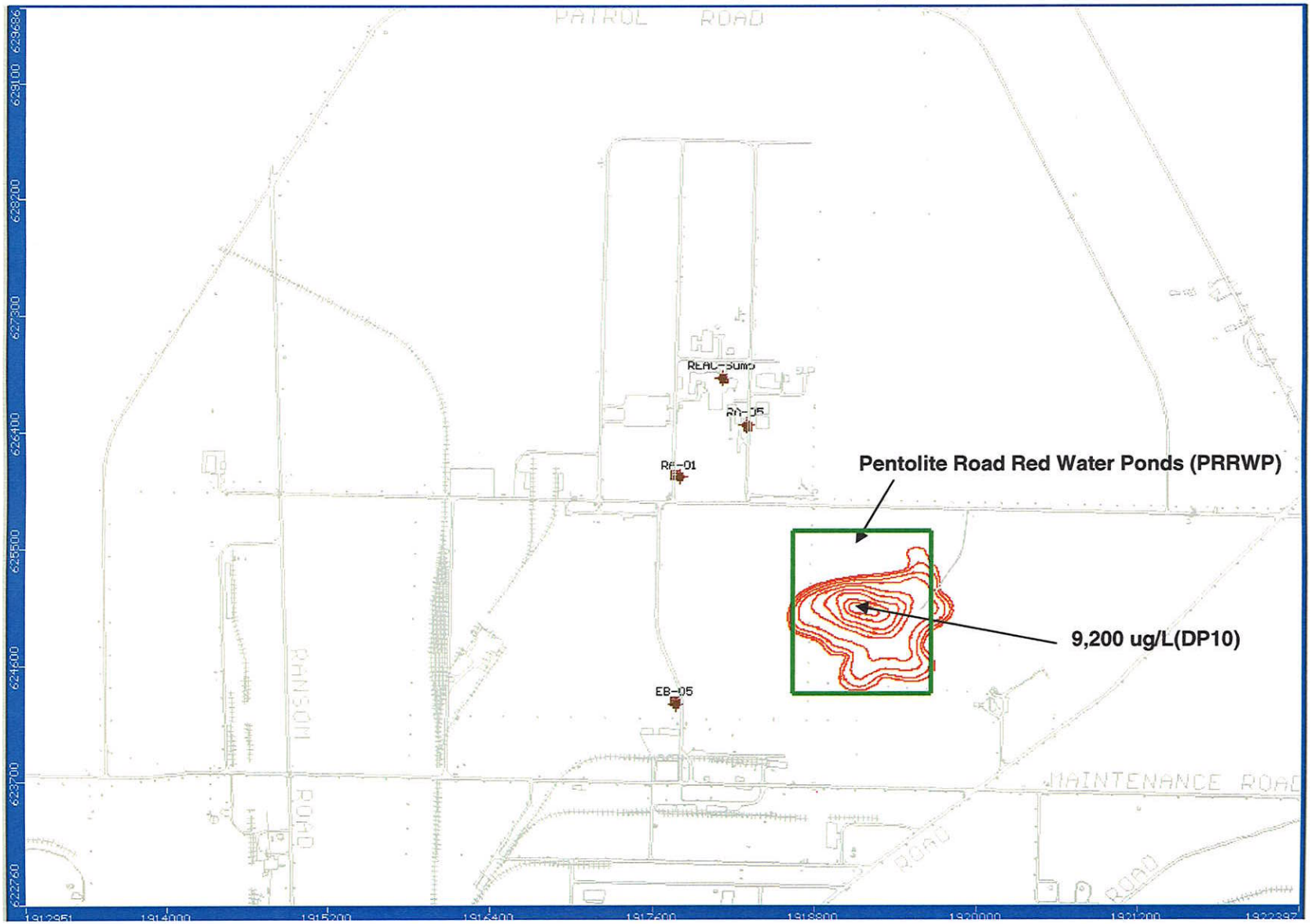


Figure 3- 14
2,4- DNT Plume in the Overburden/Shale Water Bearing Zone
in the West Area Red Water Ponds Area (WARWP)
Plum Brook Ordnance Works, Sandusky, Ohio

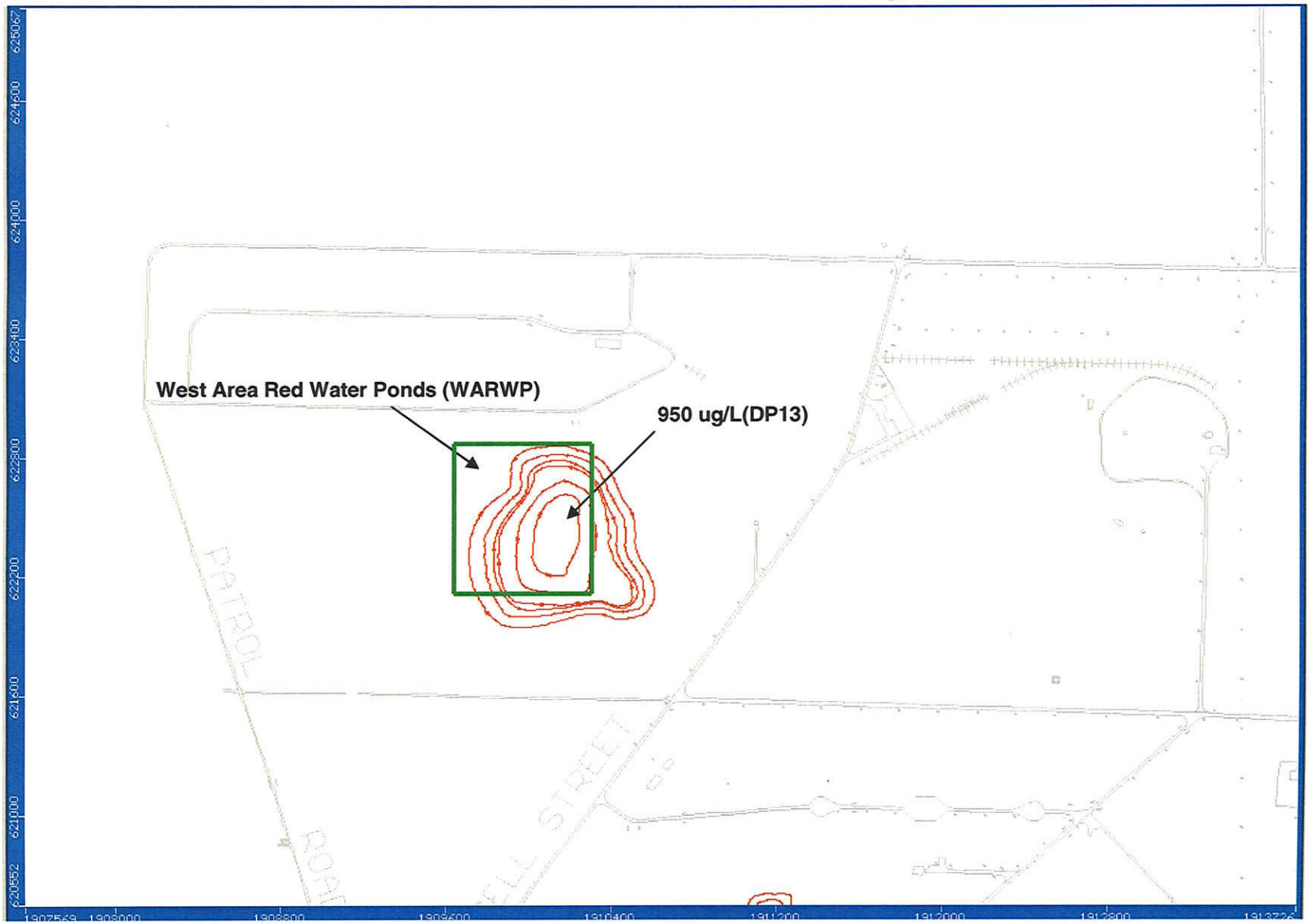


Figure 3- 15
2,4- DNT Plumes in the Delaware Limestone Bedrock Water Bearing Zone in the TNTA Area, Pentolite Road Red Water Ponds Area (PRRWP), and West Area Red Water Ponds Area (WARWP)
Plum Brook Ordnance Works, Sandusky, Ohio

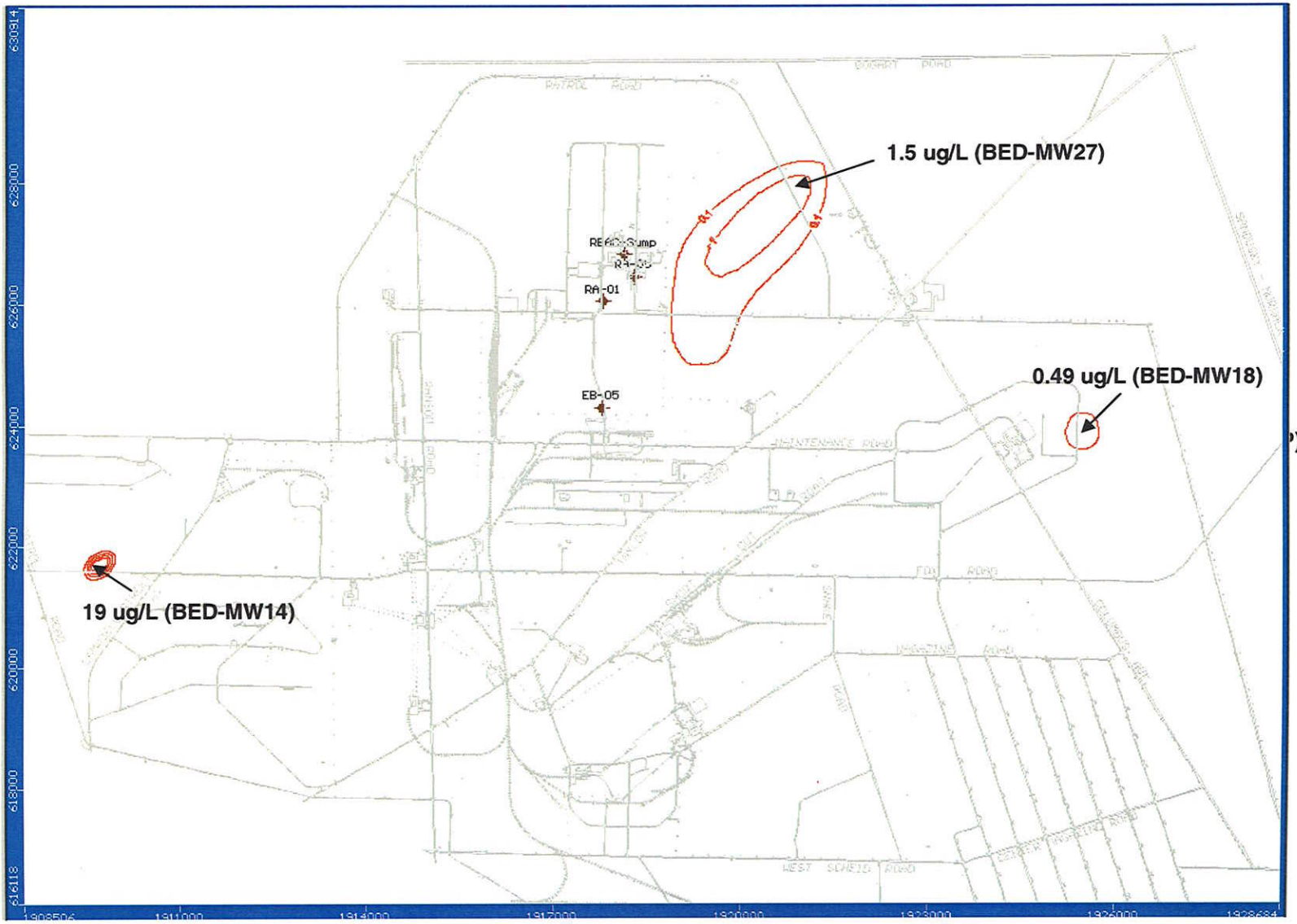


Figure 3- 16
2,6- DNT Plumes in the Overburden/Shale Water Bearing Zone
in the TNT Manufacturing Area A
Plum Brook Ordnance Works, Sandusky, Ohio

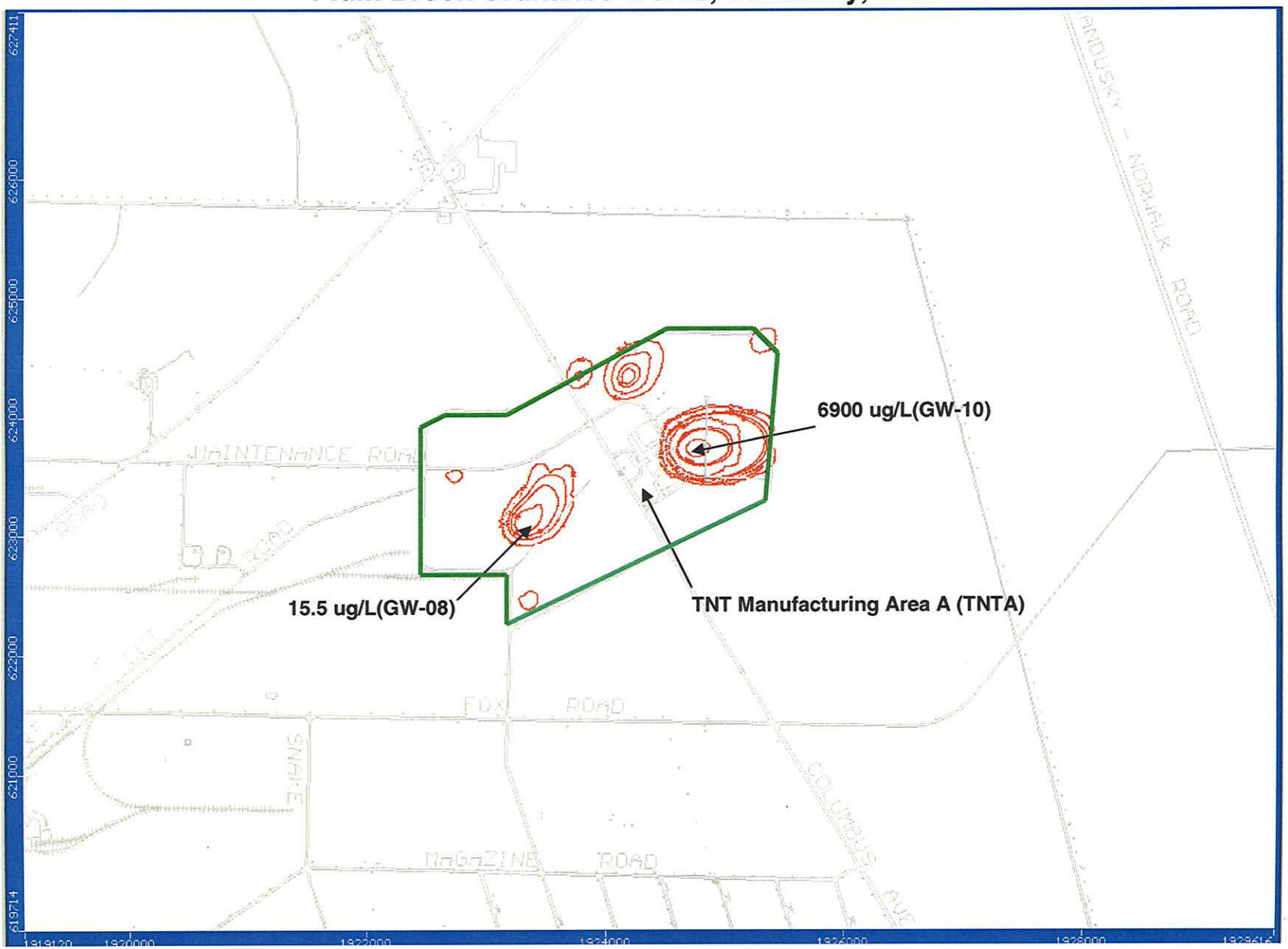


Figure 3- 17
2,6- DNT Plumes in the Overburden/Shale Water Bearing Zone
in the TNT Manufacturing Area B
Plum Brook Ordnance Works, Sandusky, Ohio

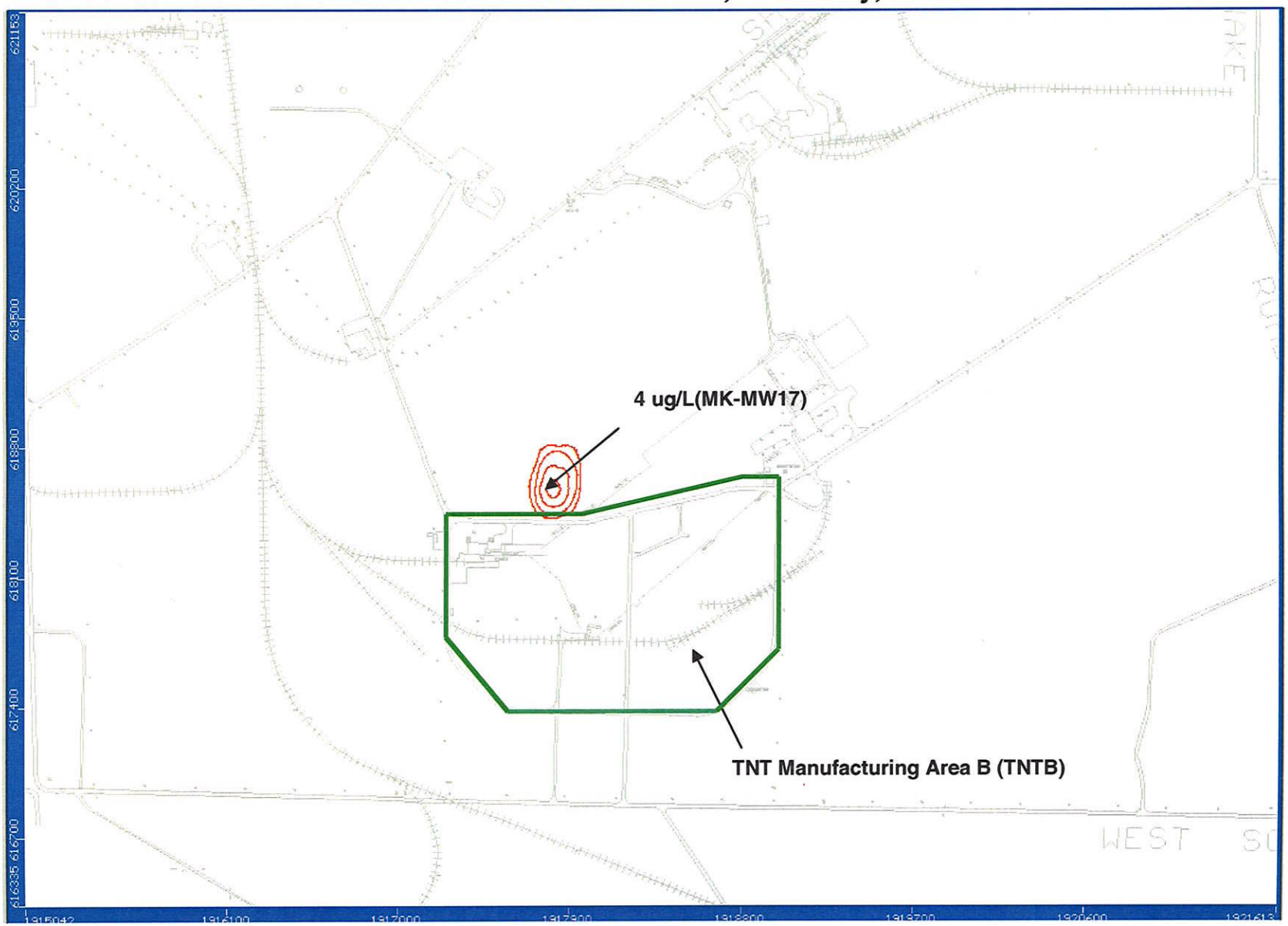


Figure 3- 18
2,6- DNT Plumes in the Overburden/Shale Water Bearing Zone
in the TNT Manufacturing Area C
Plum Brook Ordnance Works, Sandusky, Ohio

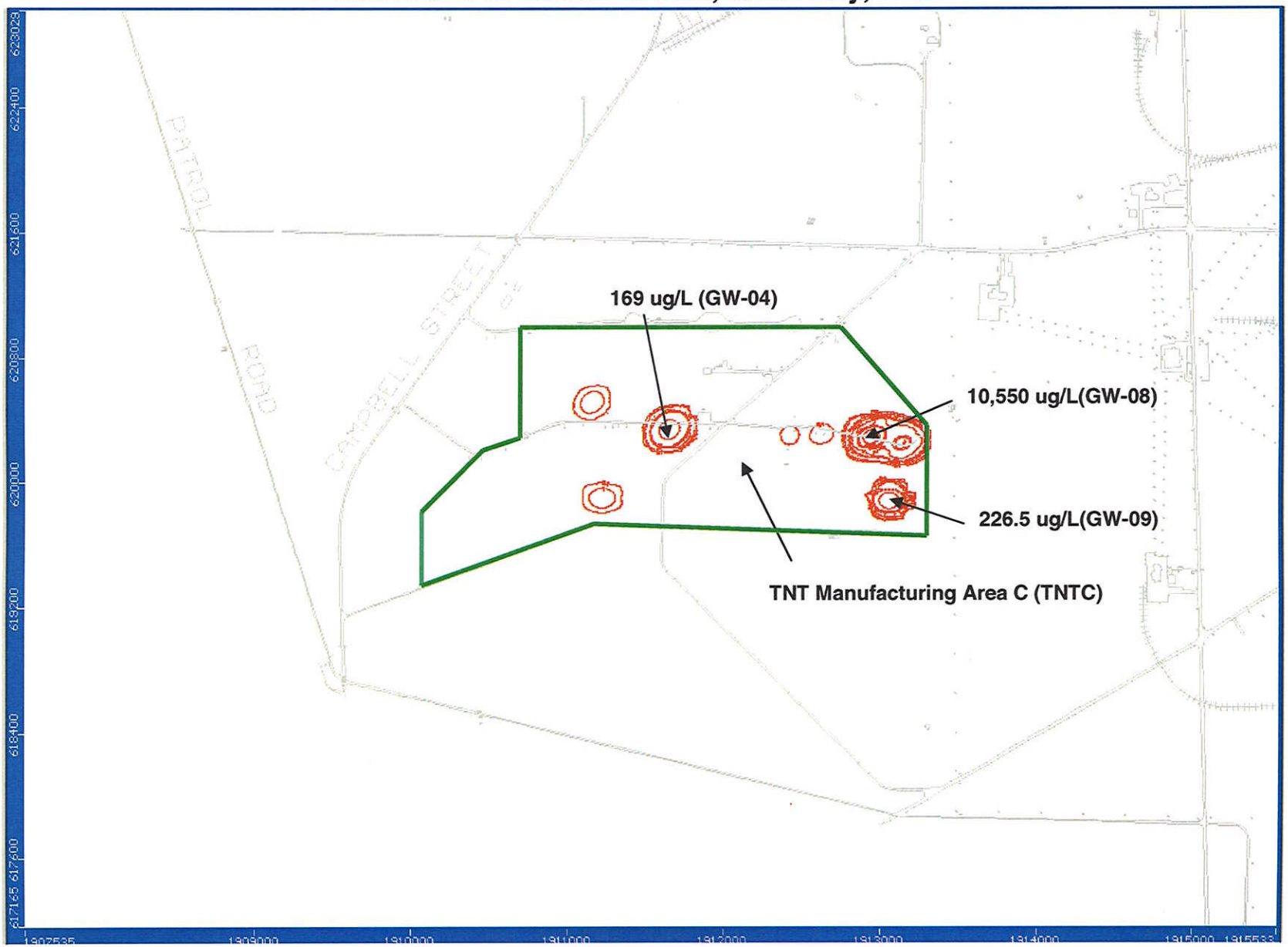


Figure 3- 19
2,6- DNT Plumes in the Overburden/Shale Water Bearing Zone
in the Pentolite Road Red Water Ponds Area (PRRWP)
Plum Brook Ordnance Works, Sandusky, Ohio

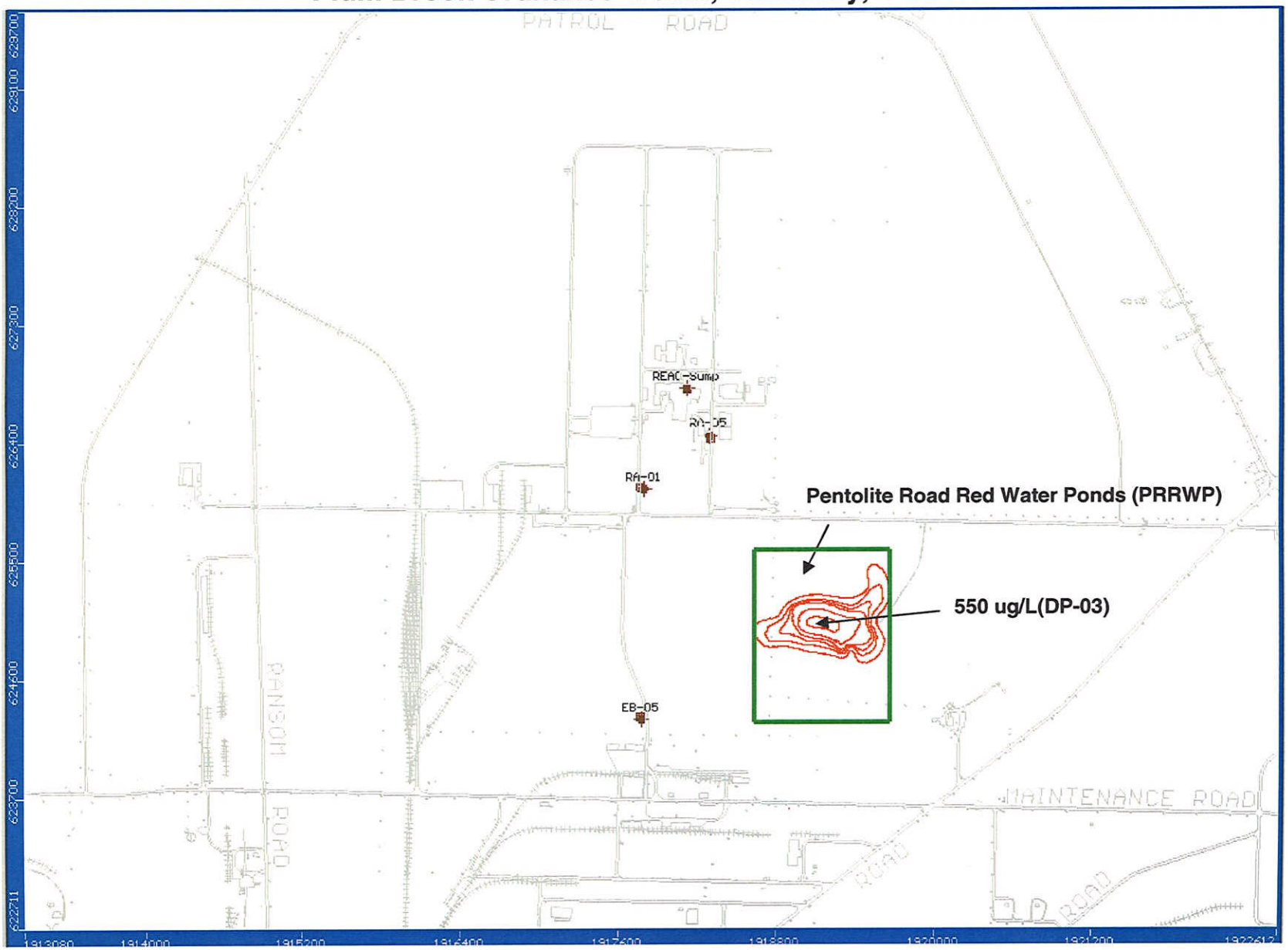


Figure 3- 20
2,6- DNT Plumes in the Overburden/Shale Water Bearing Zone
in the West Area Red Water Ponds Area (WARWP)
Plum Brook Ordnance Works, Sandusky, Ohio

Figure 3- 21
2,6- DNT Plumes in the Delaware Limestone Bedrock Water Bearing Zone in the TNTA Area, Pentolite Road Red Water Ponds Area (PRRWP), and West Area Red Water Ponds Area (WARWP)
Plum Brook Ordnance Works, Sandusky, Ohio

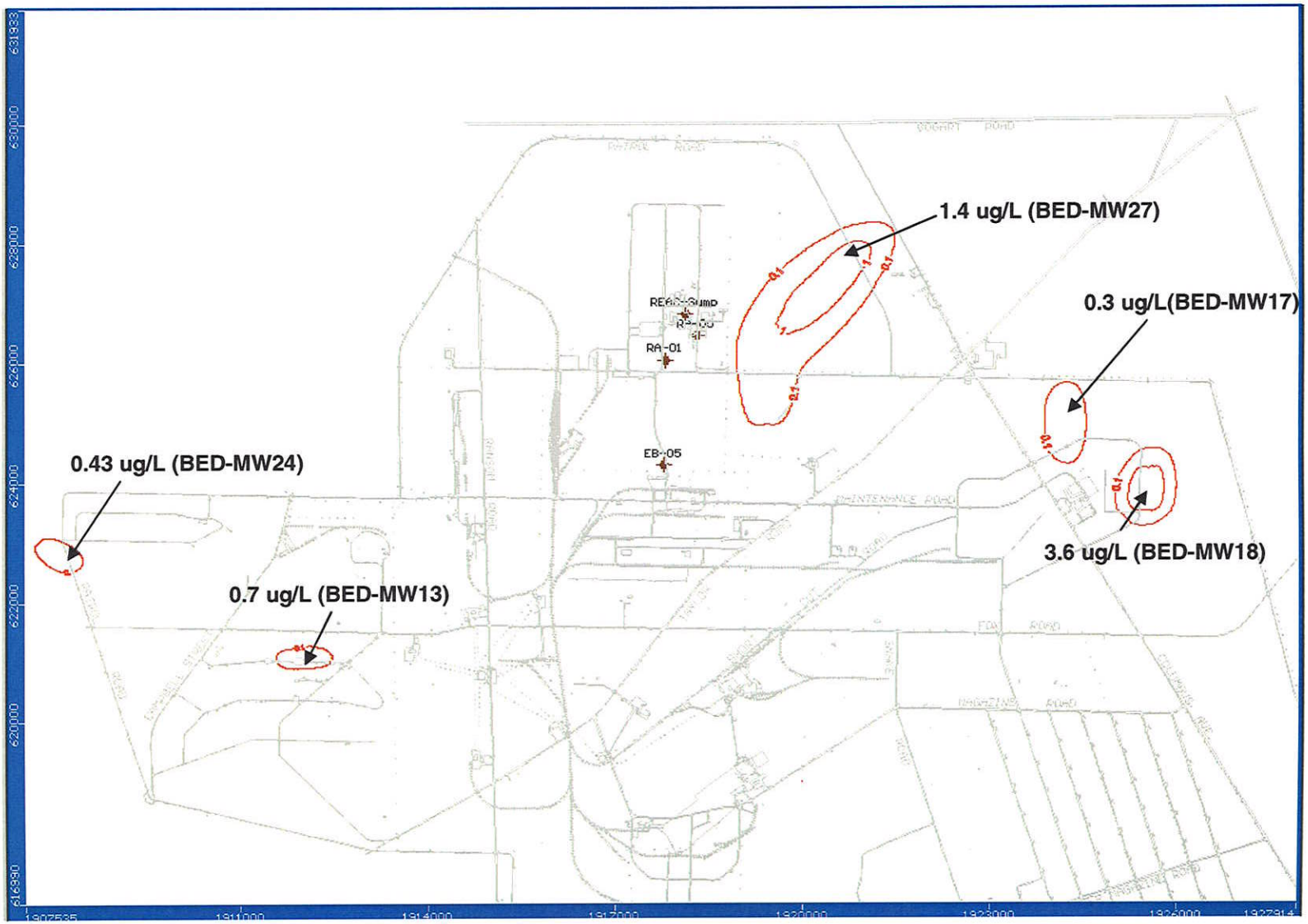
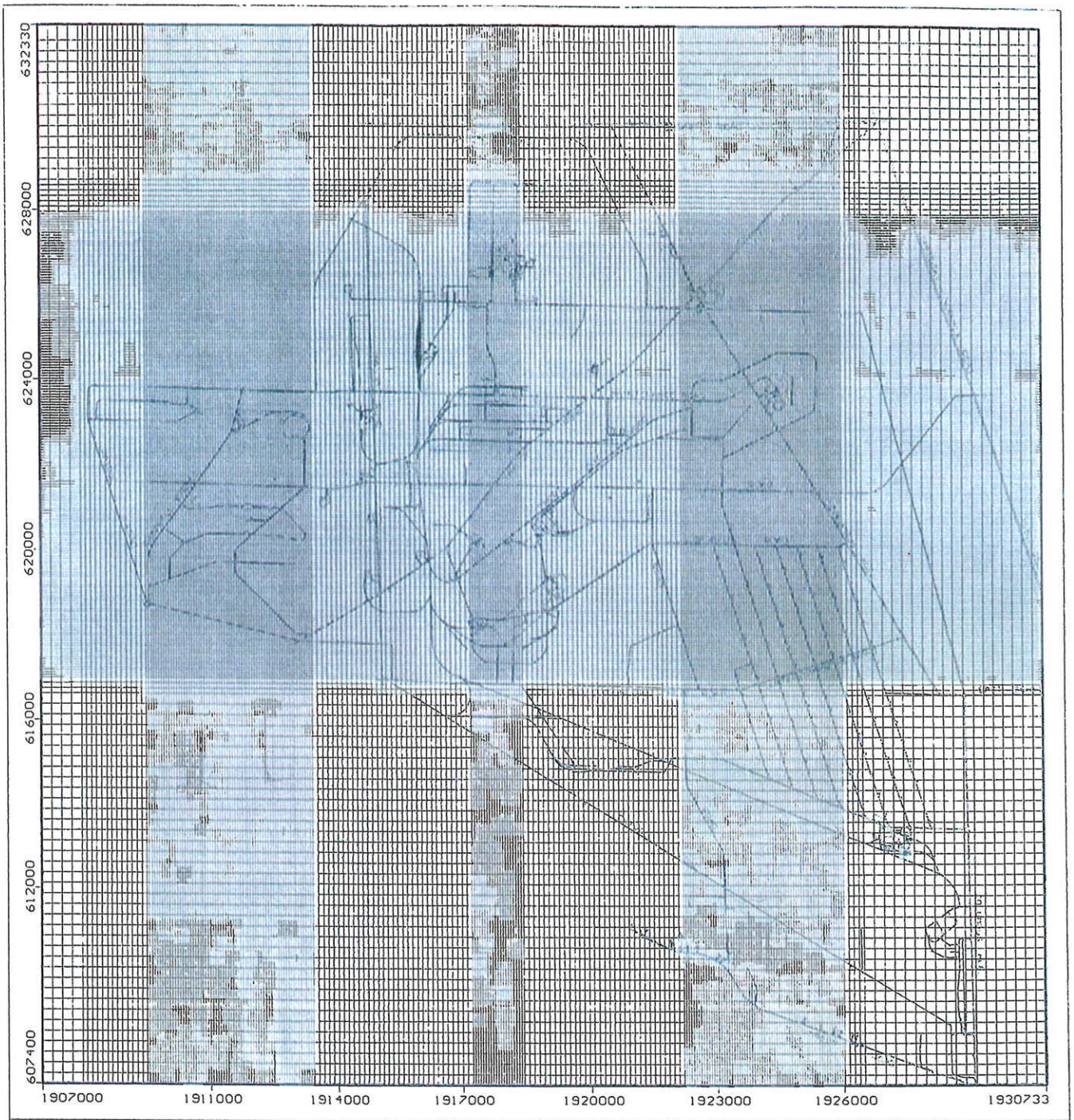


Figure 3-22 Model Grid



Shaw E & I
Project: Plum Brook Ordnance Works
Description: Figure 3-22 Model Grid
Modeller: Song-kai Yan/Jing Li
23 Feb 06

Visual MODFLOW v.3.1.0, (C) 1995-2002
Waterloo Hydrogeologic, Inc.
NC: 253 NR: 236 NL: 4
Current Layer: 1

Figure 3-23
Surface Streams/Ditches Considered in the Model

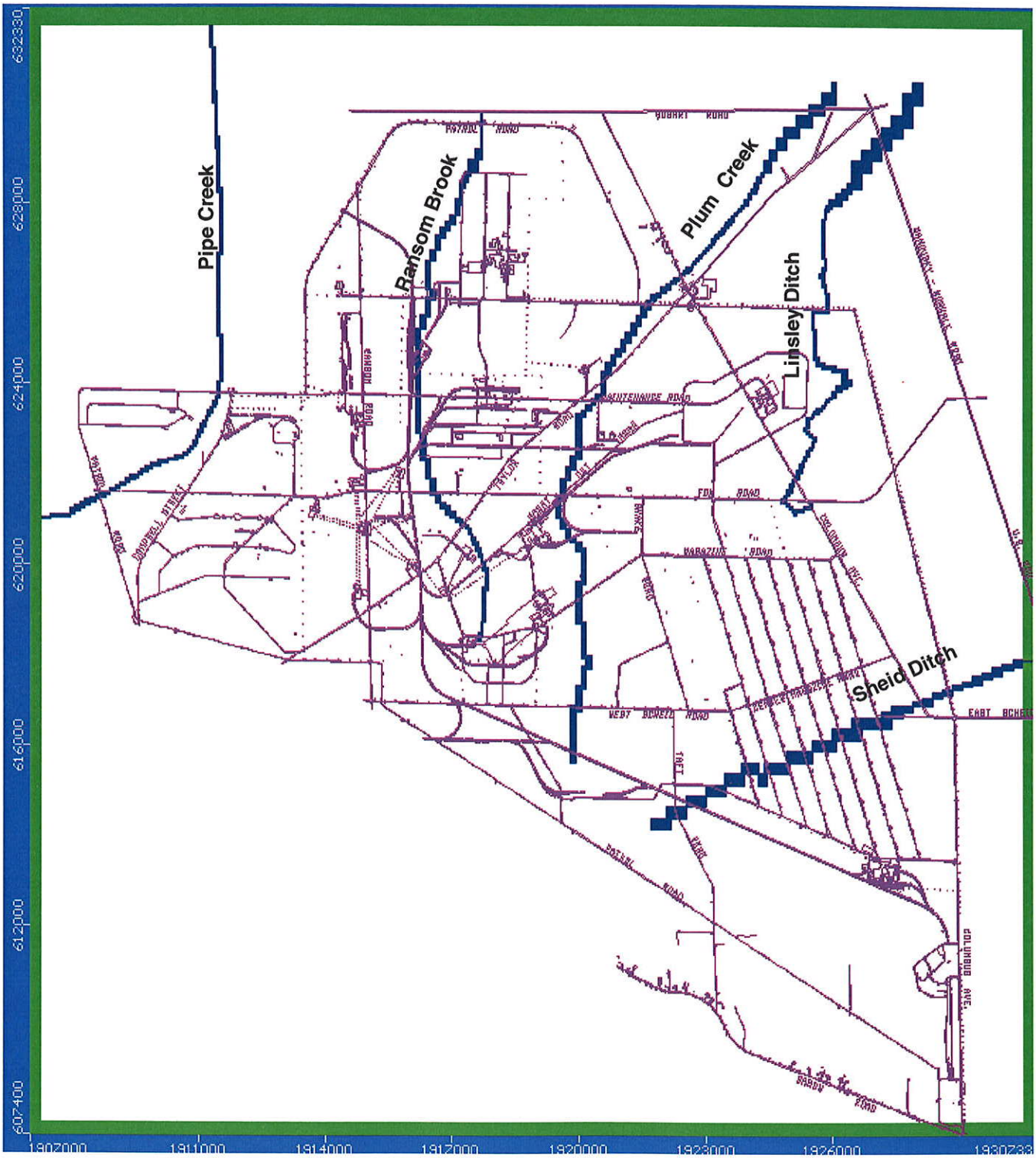


Figure 4-1
TNT Sorbed Concentration Profile in Soil
at TNTA-SO080 in the TNTA Area

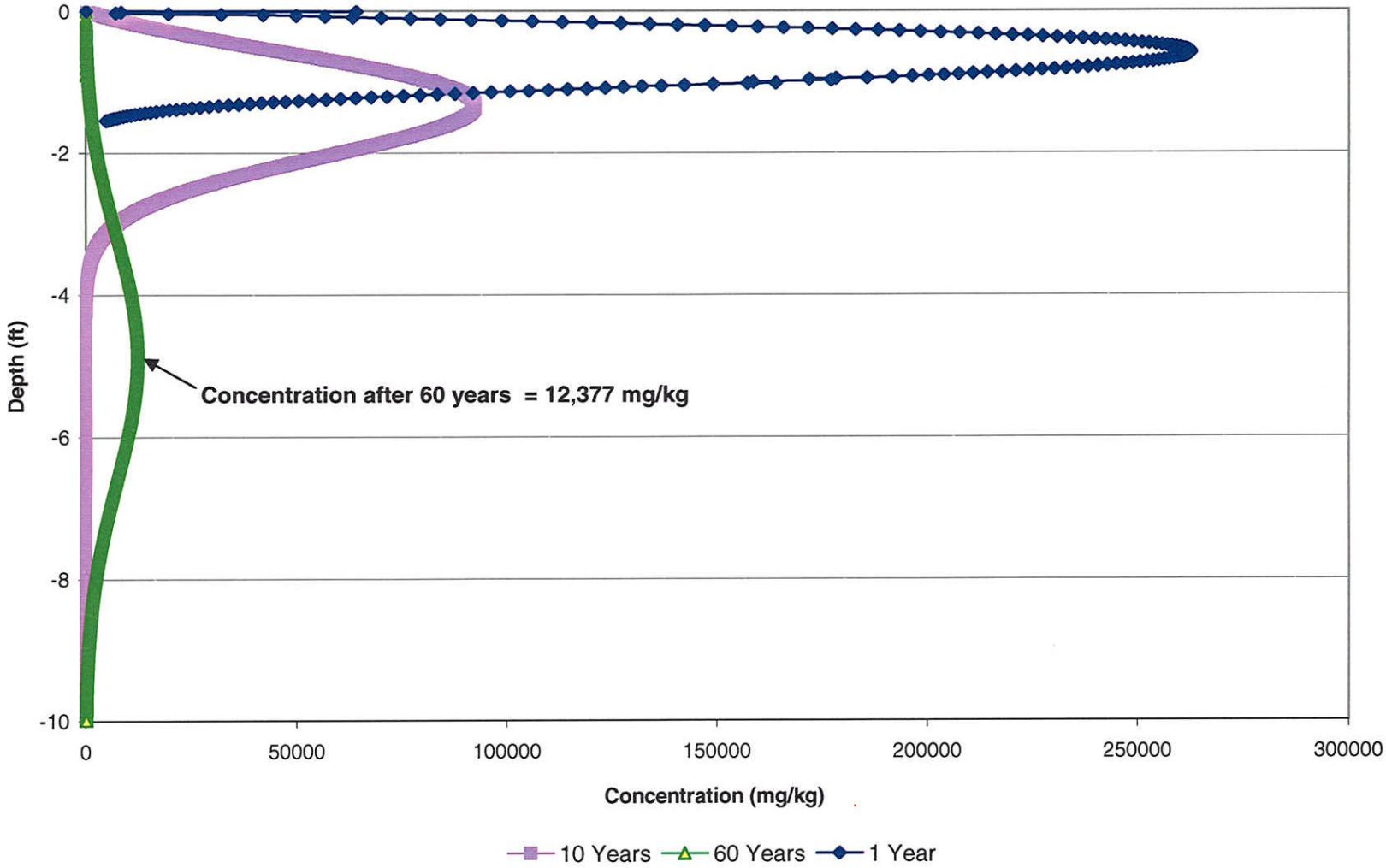


Figure 4-2
TNT Leachate Concentration to Groundwater
at TNTA-SO080 in the TNTA Area
Calibration Run

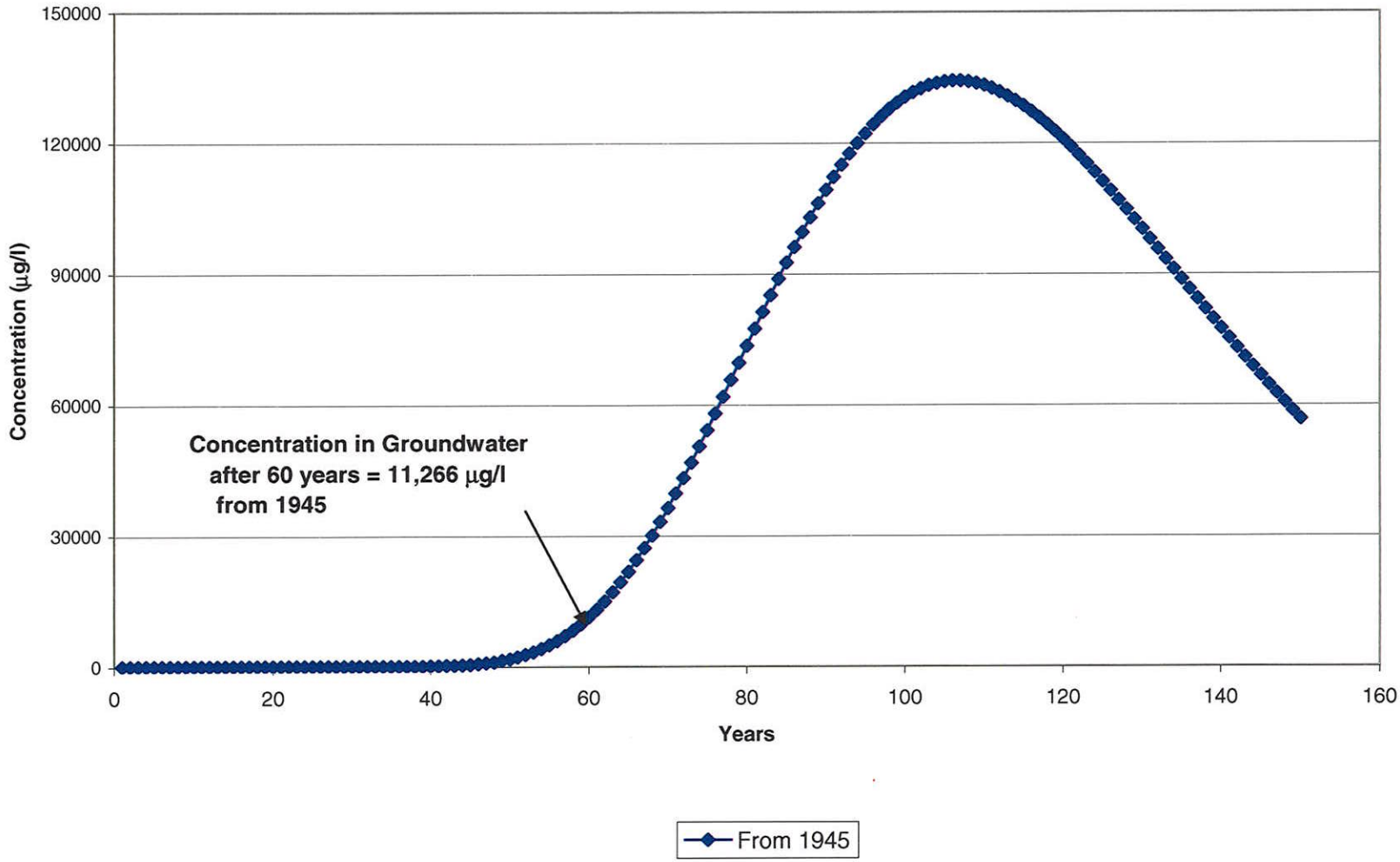


Figure 4-3
TNT Sorbed Concentration Profile in Soil at TNTC-SO165 in the TNTC Area

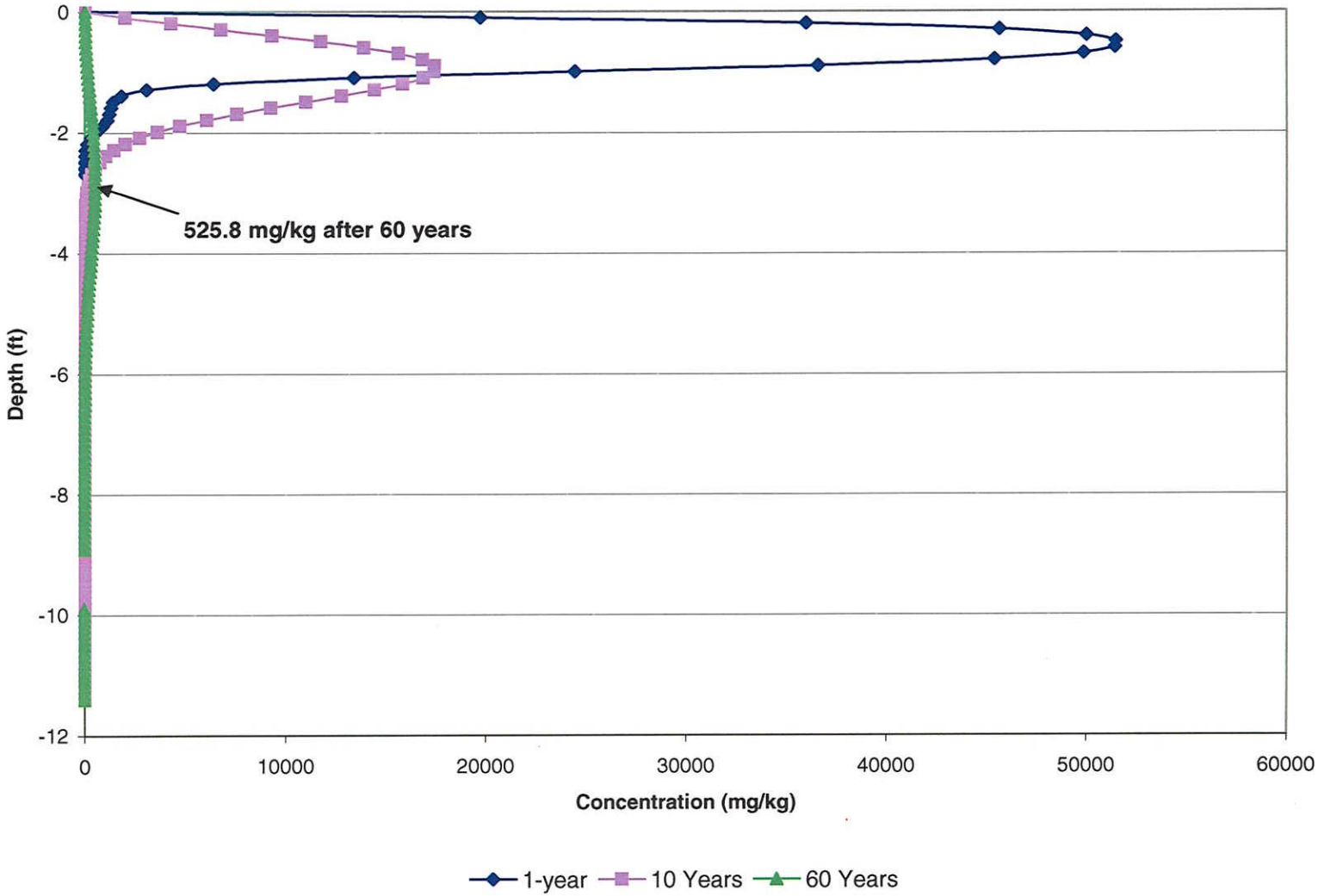


Figure 4-4
TNT Leachate From Soil to Groundwater at TNTC-SO165 in the TNTC Area

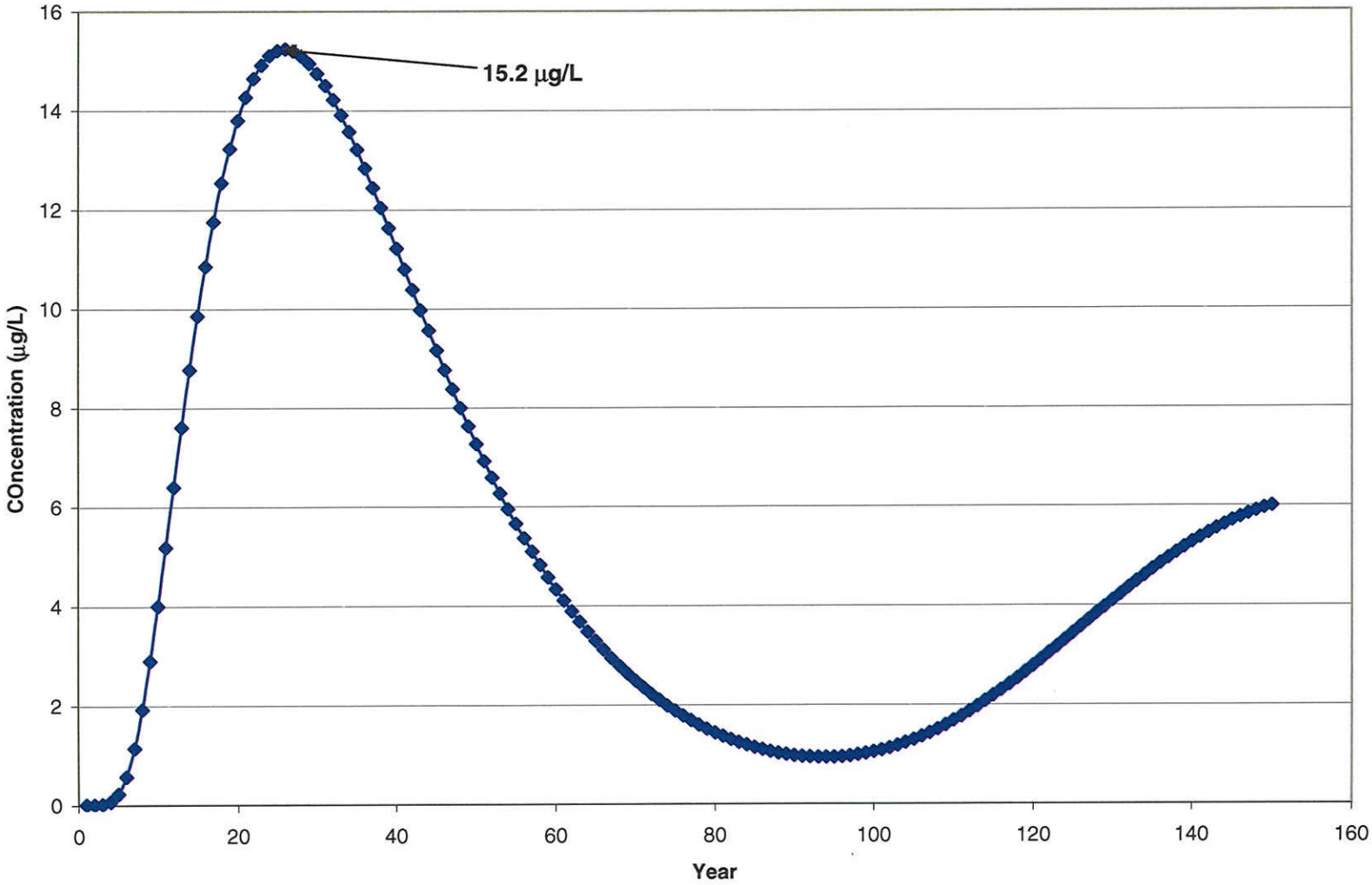


Figure 4-5
2,4-DNT Sorbed Concentration Profile in Soil at TNTA-SO105 in the TNTA Area

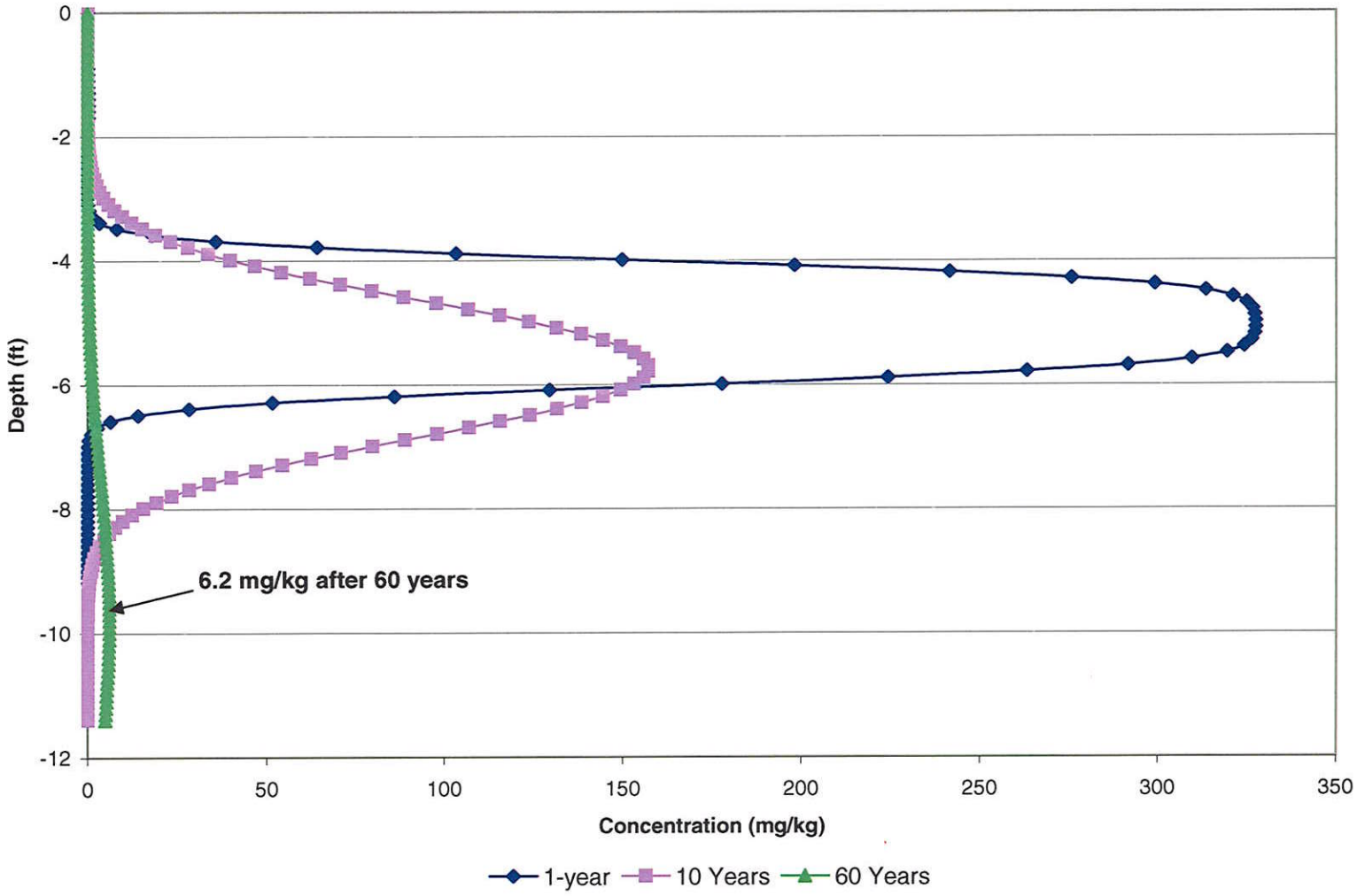


Figure 4-6
2,4-DNT Leachate From Soil to Groundwater at TNTA-SO105 in the TNTA Area

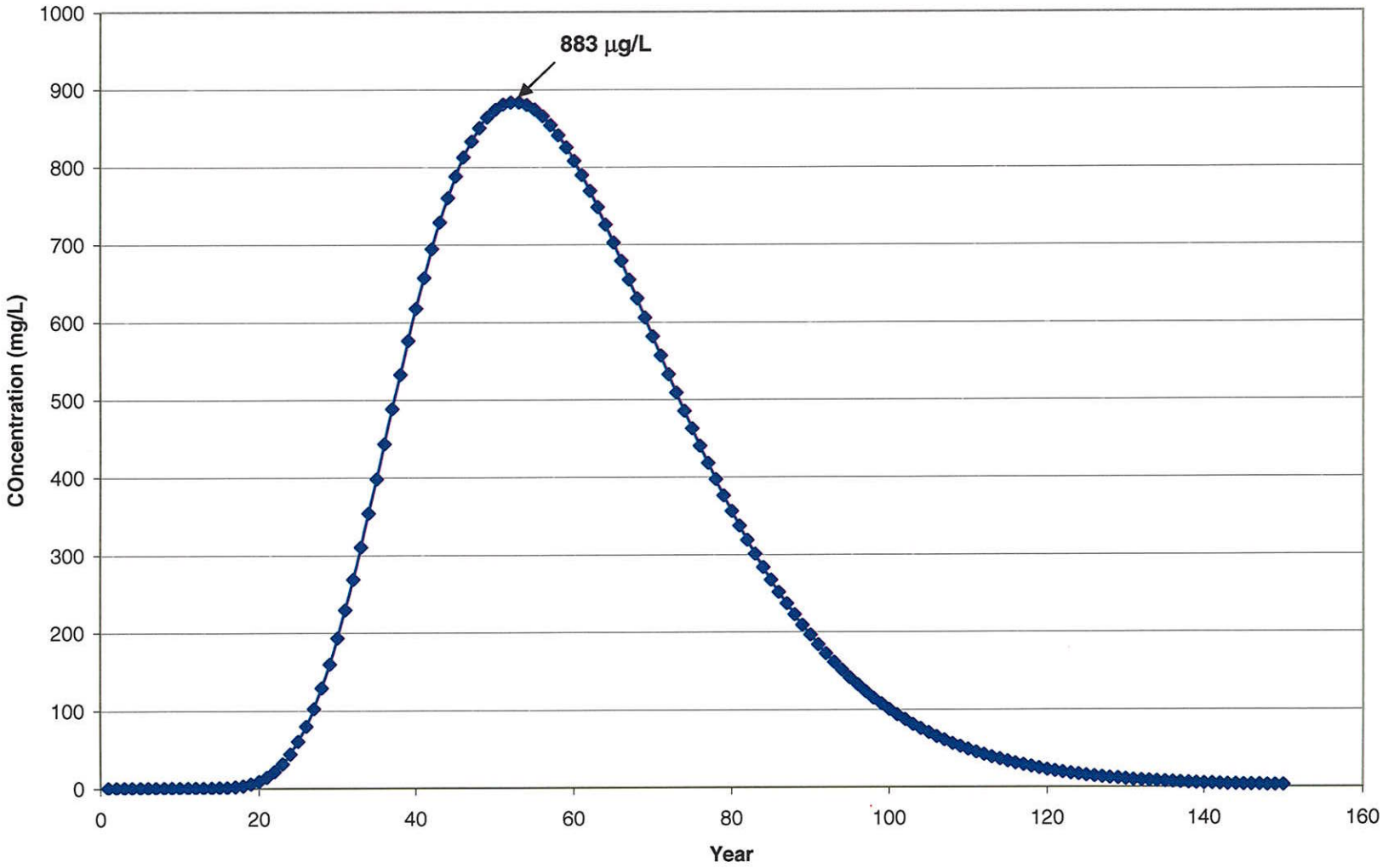


Figure 4-7
2,6-DNT Sorbed Concentration Profile in Soil at TNTA-S25 in the TNTA Area

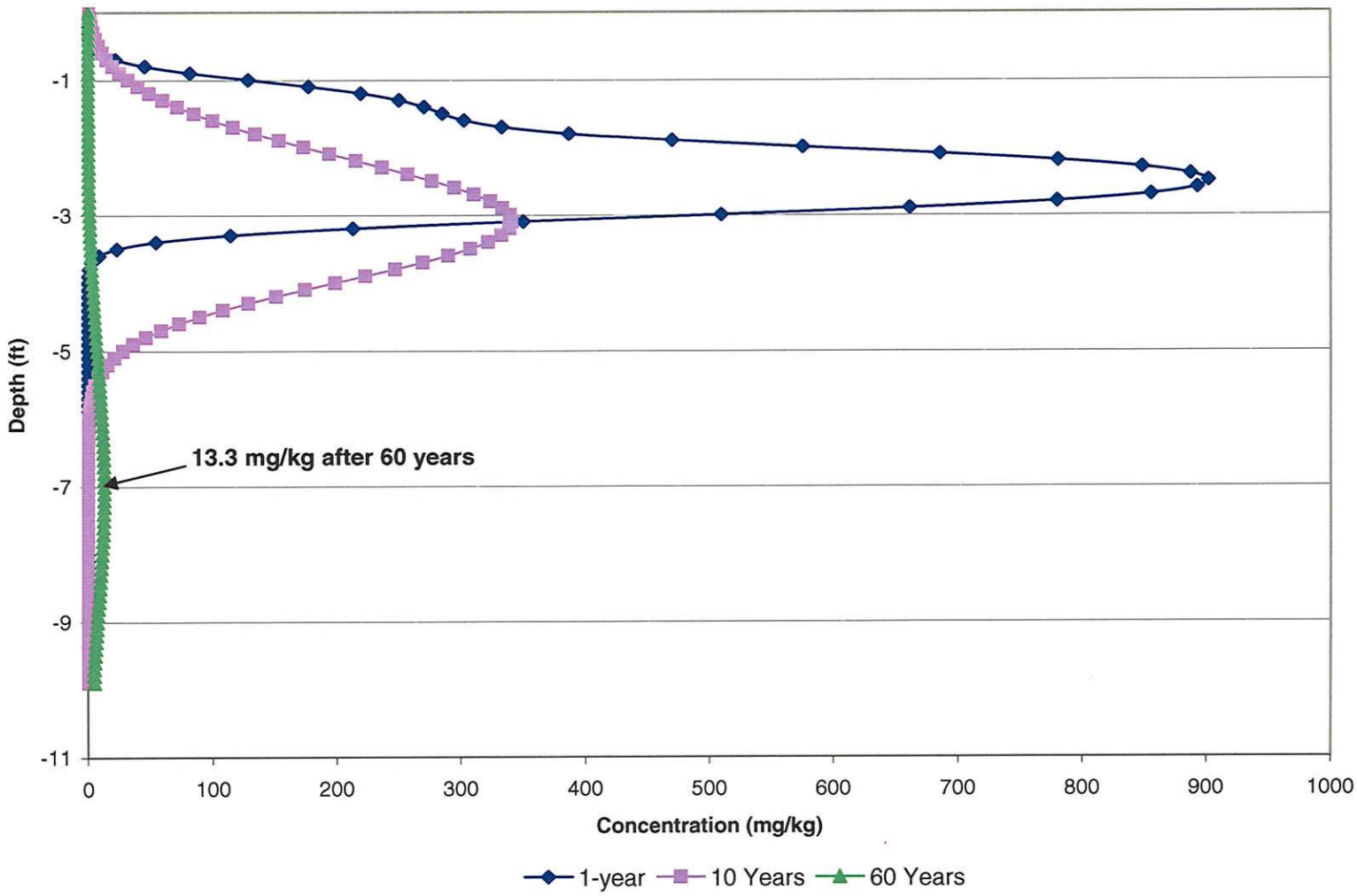


Figure 4-8
2,6-DNT Leachate From Soil to Groundwater at TNTA-S25 in the TNTA Area

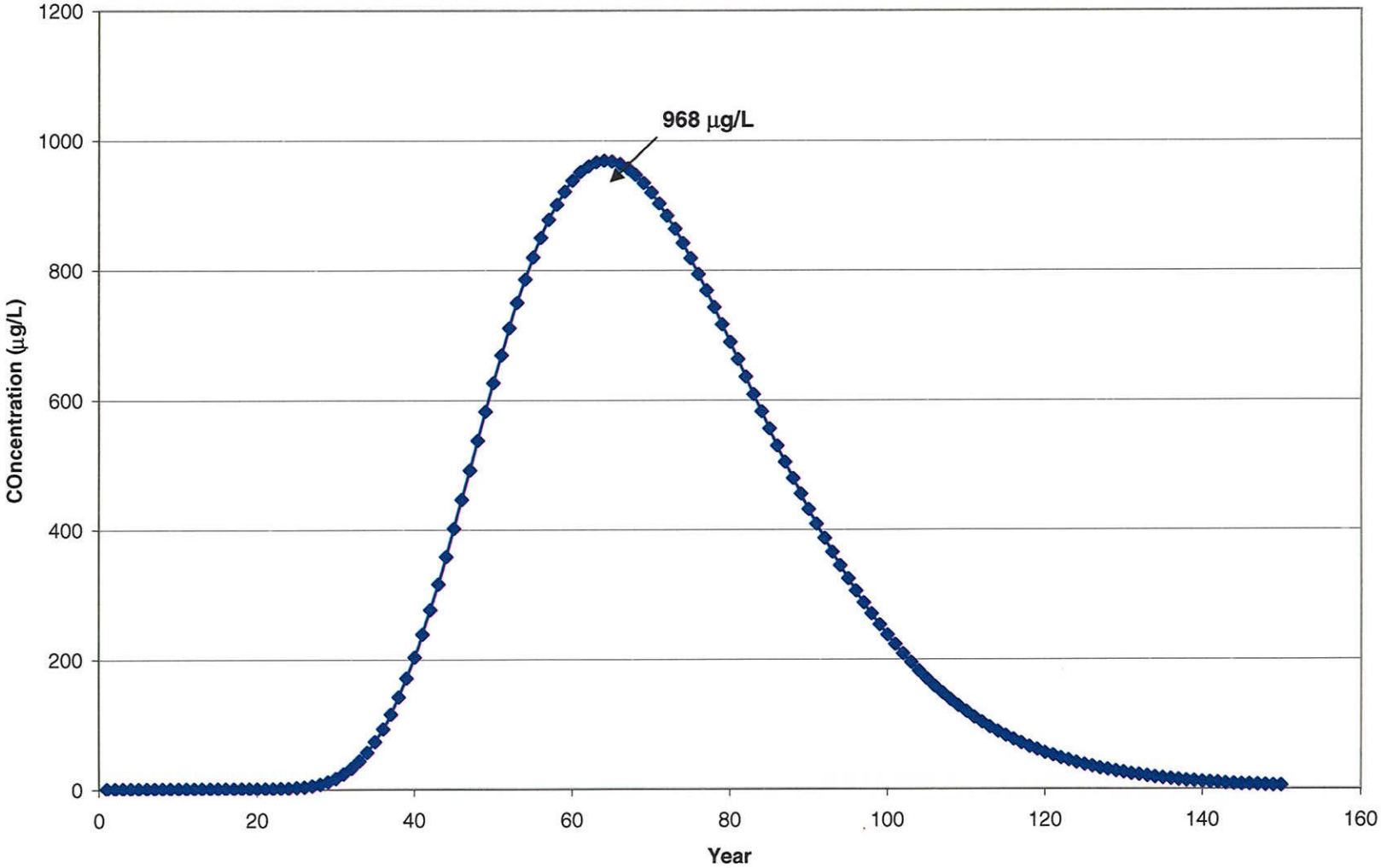
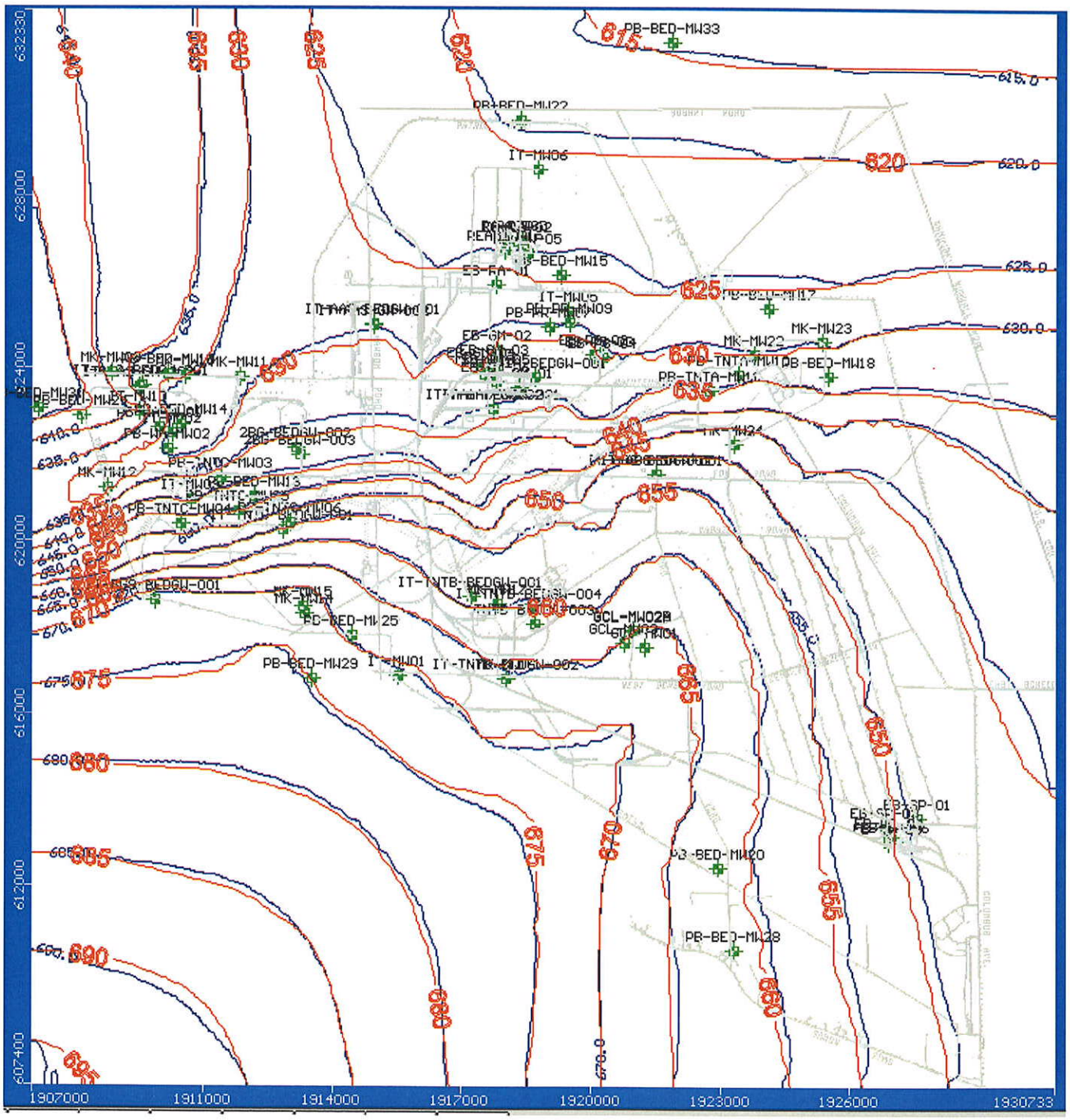


Figure 4-9
Comparison of Simulated and Observed Head Distributions in the Overburden and Weathered Shale Formation

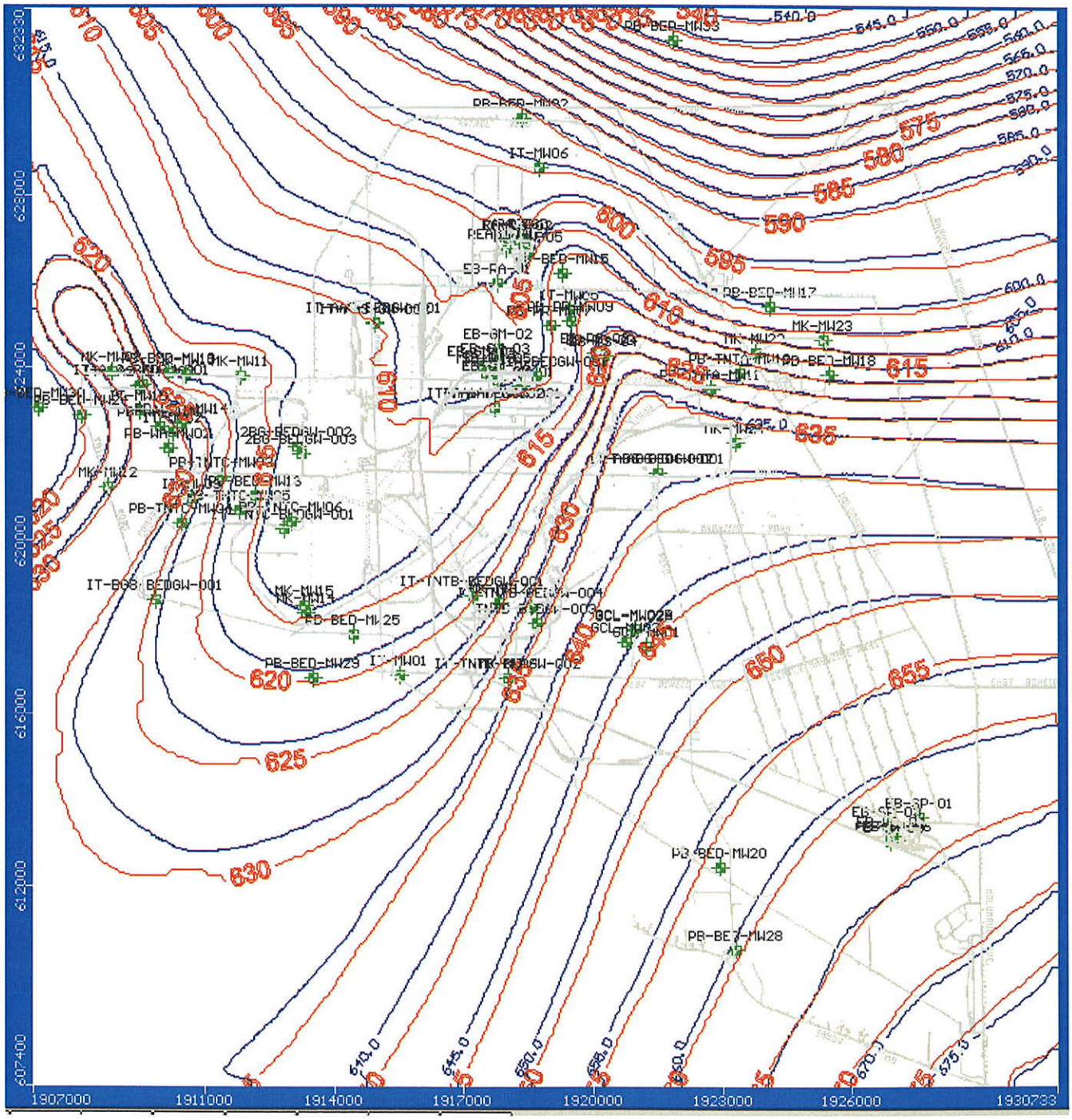


Legends:

Observed Head Contour

Simulated Head Contour

Figure 4-10
Comparison of Simulated and Observed Head Distributions in the Delaware Limestone



Legends: **Observed Head Contour**

Simulated Head Contour

Figure 4-11
Goodness-of-Fit Plot for the Flow Calibration Results
Plum Brook Ordnance Works

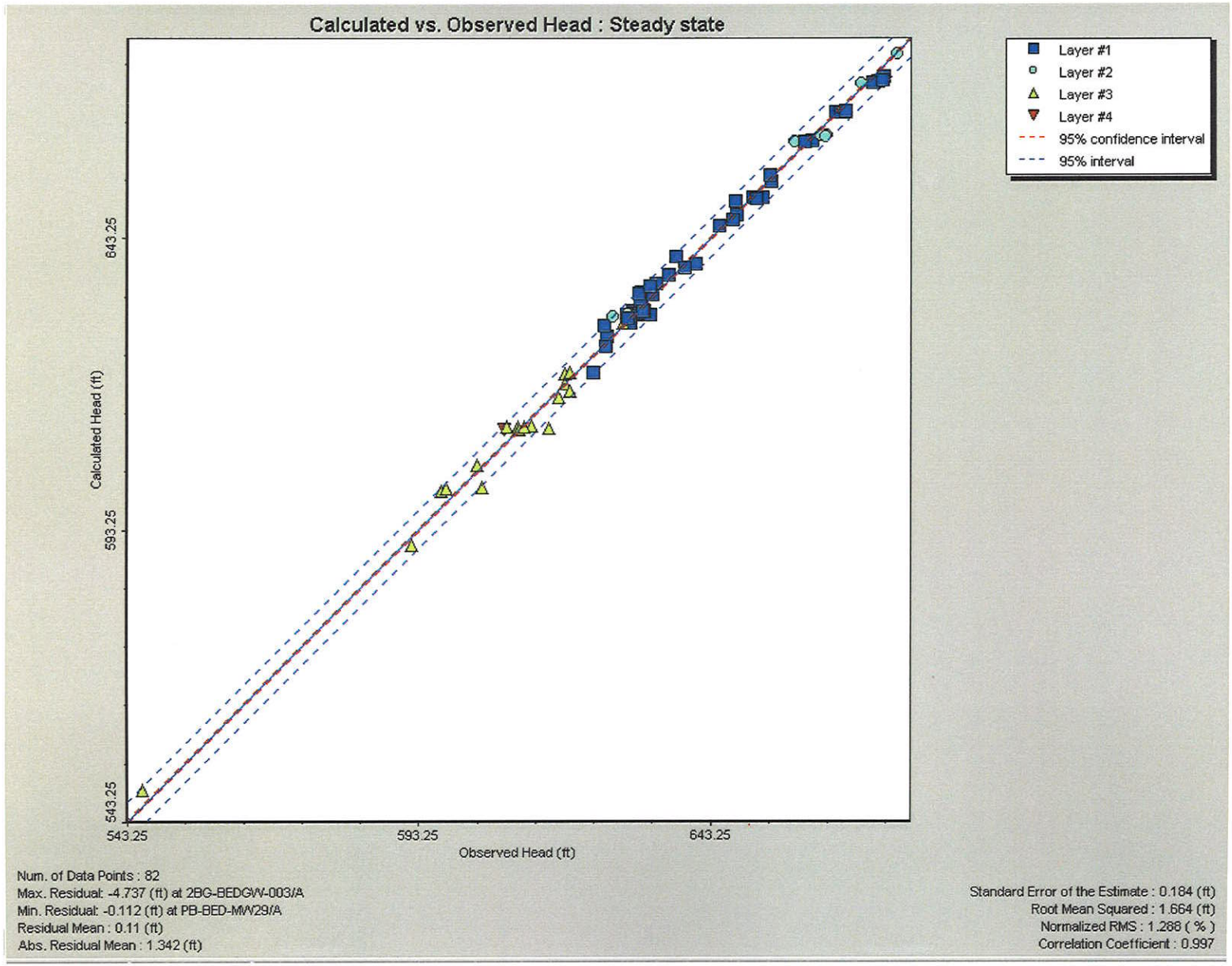
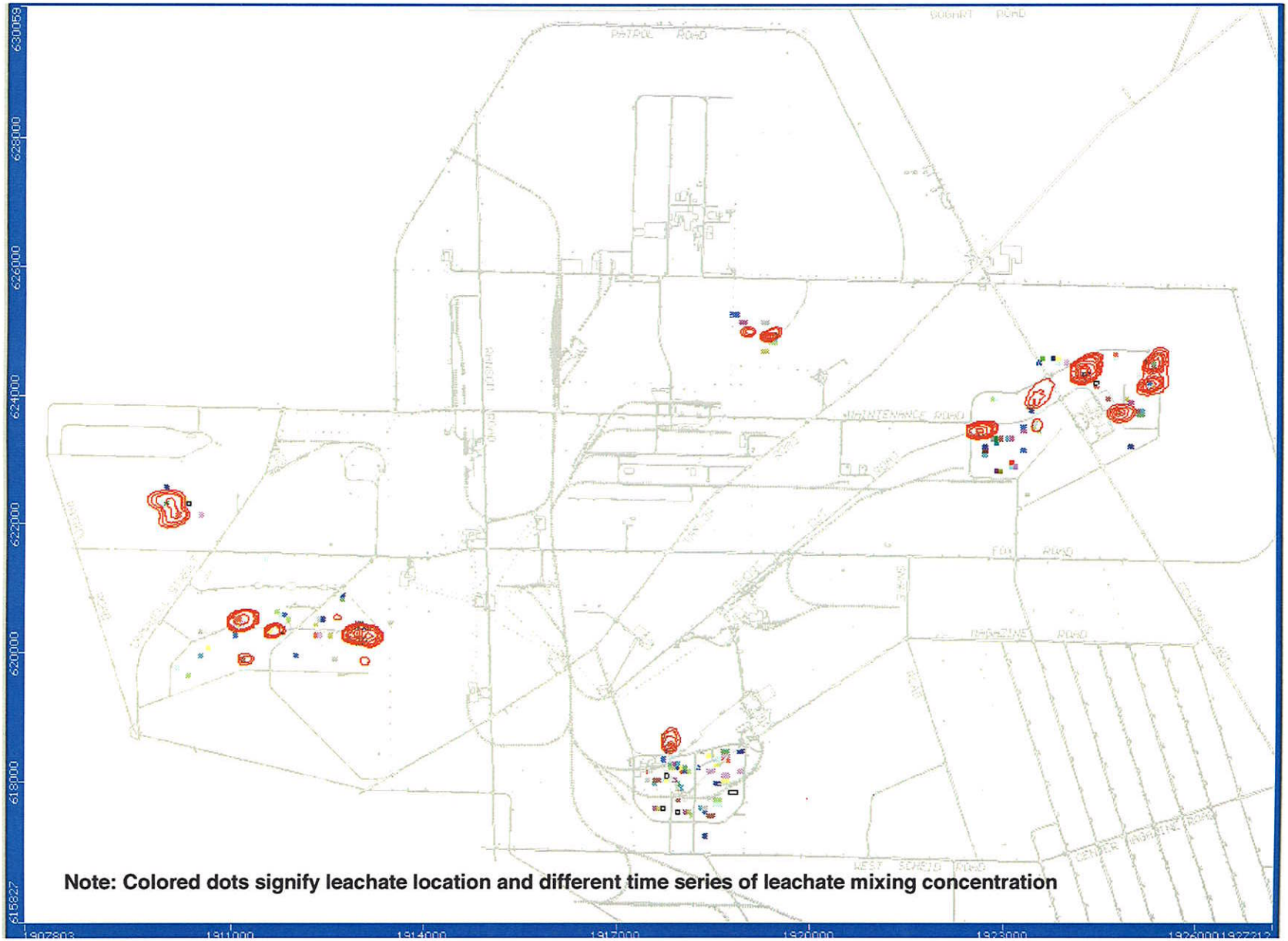
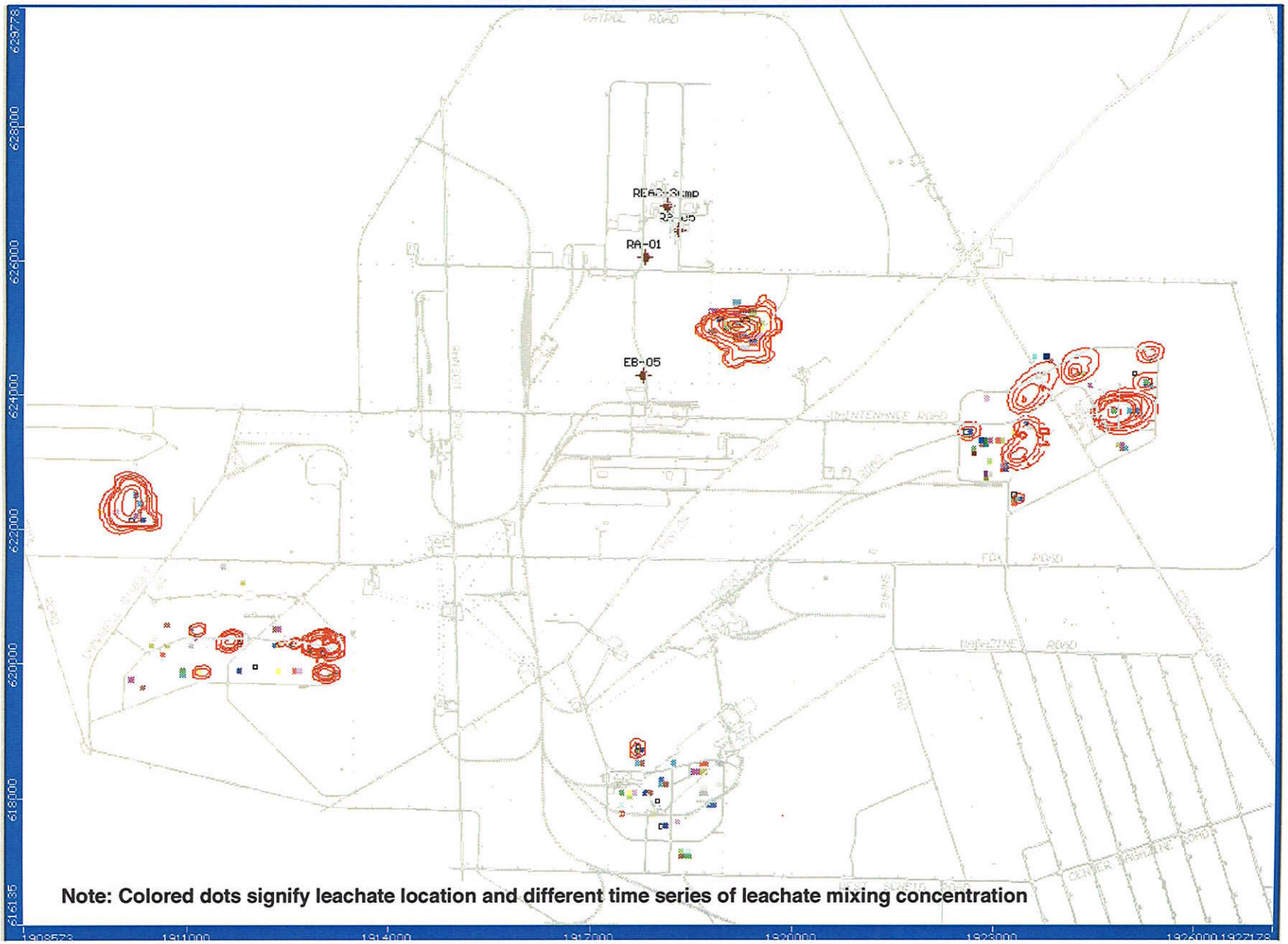


Figure 5-1
Locations of TNT Leachate from Soil with TNT plumes in the Overburden
Plum Brook Ordnance Works



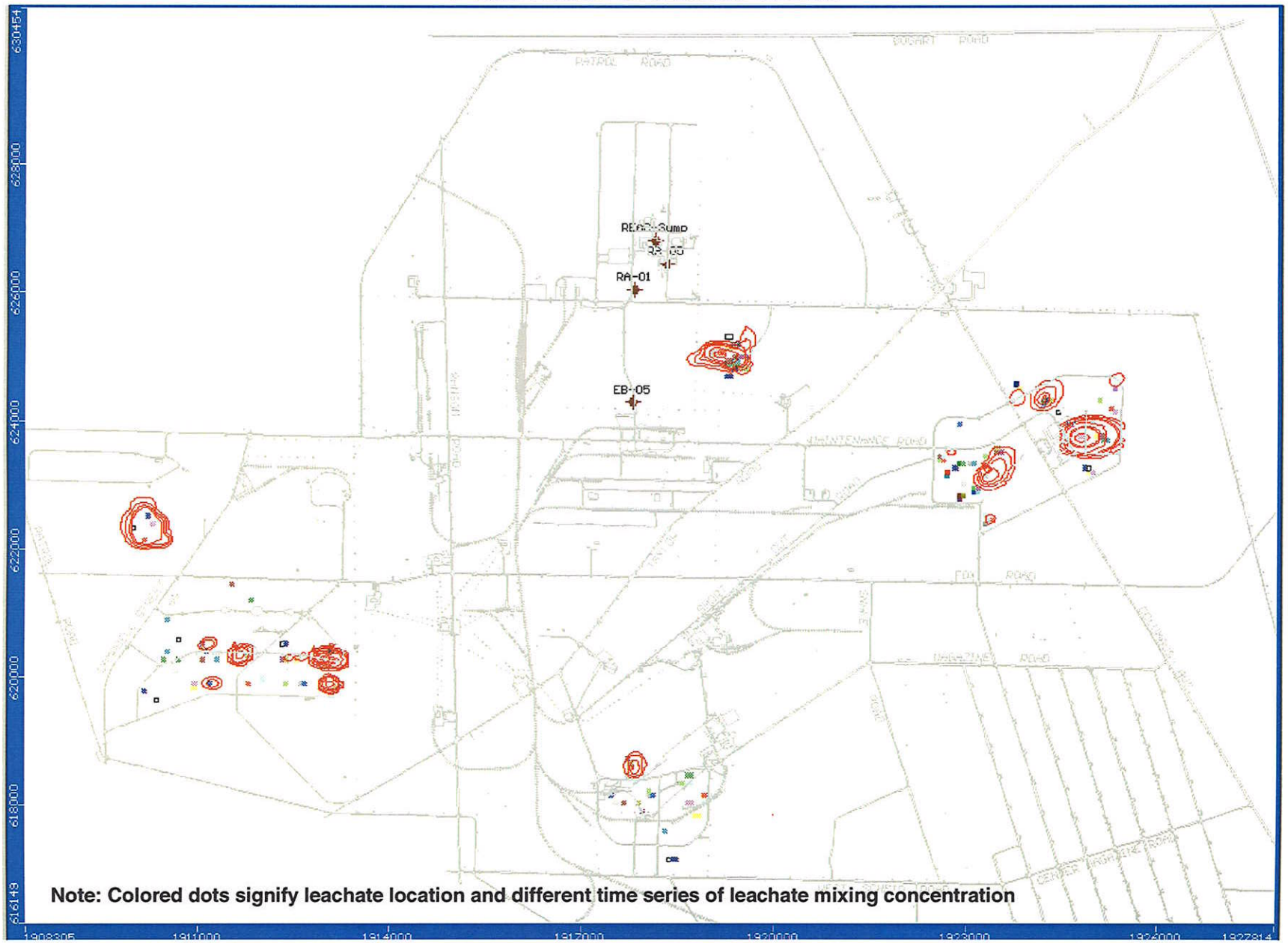
Note: Colored dots signify leachate location and different time series of leachate mixing concentration

Figure 5-2
Locations of 2,4-DNT Leachate from Soil with 2,4-DNT plumes in the Overburden
Plum Brook Ordnance Works



Note: Colored dots signify leachate location and different time series of leachate mixing concentration

Figure 5- 3
Locations of 2,6-DNT Leachate from Soil with 2,6-DNT plumes in the Overburden
Plum Brook Ordnance Works



Note: Colored dots signify leachate location and different time series of leachate mixing concentration

Figure 5-4
Simulated 2,4,6-TNT Plumes in the Five Operable Sites After 10 Years
Overburden
Former Plum Brook Ordnance Works

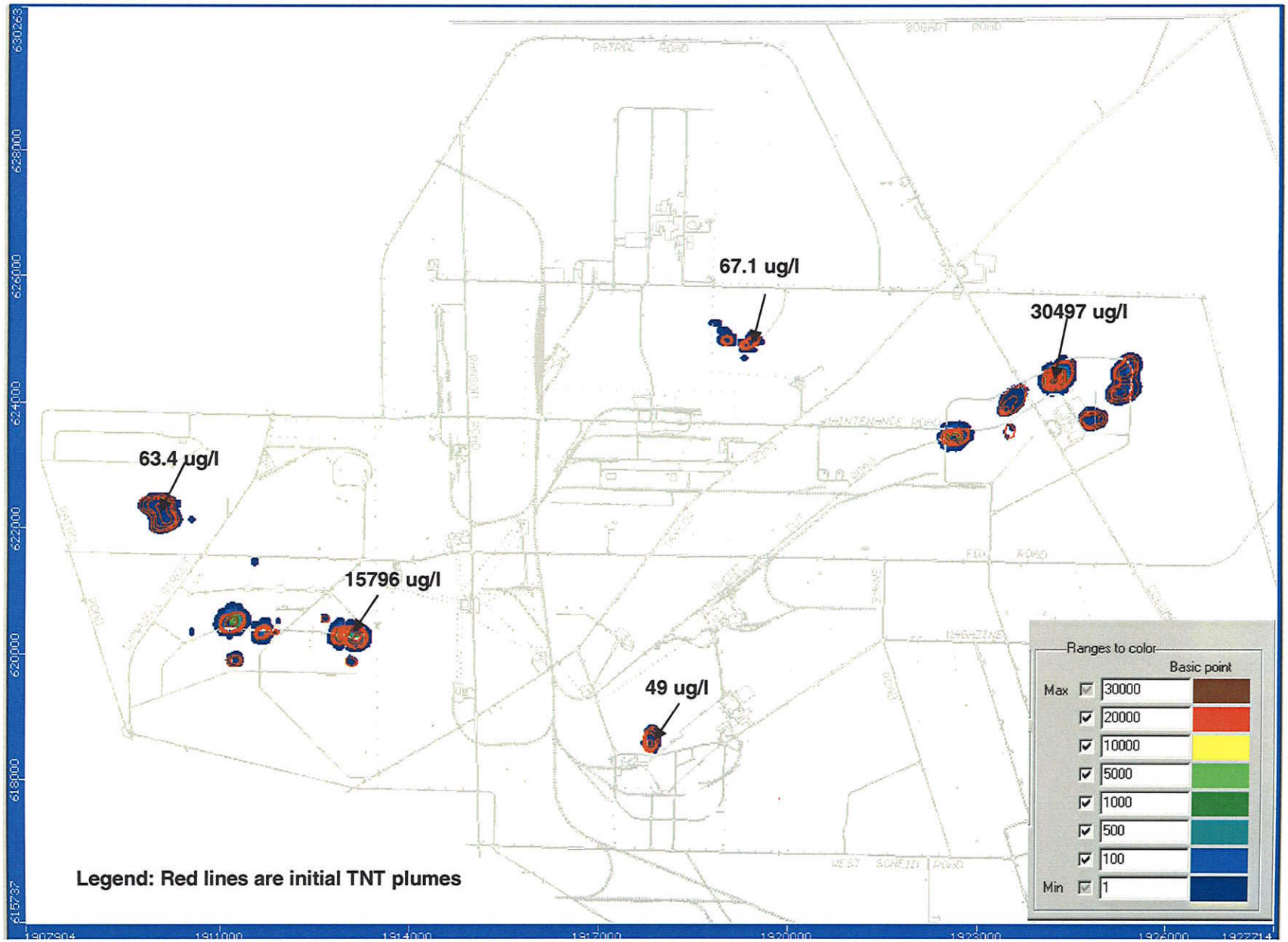


Figure 5-5
Simulated 2,4,6-TNT Plumes in the Five Operable Sites After 50 Years
Overburden
Former Plum Brook Ordnance Works

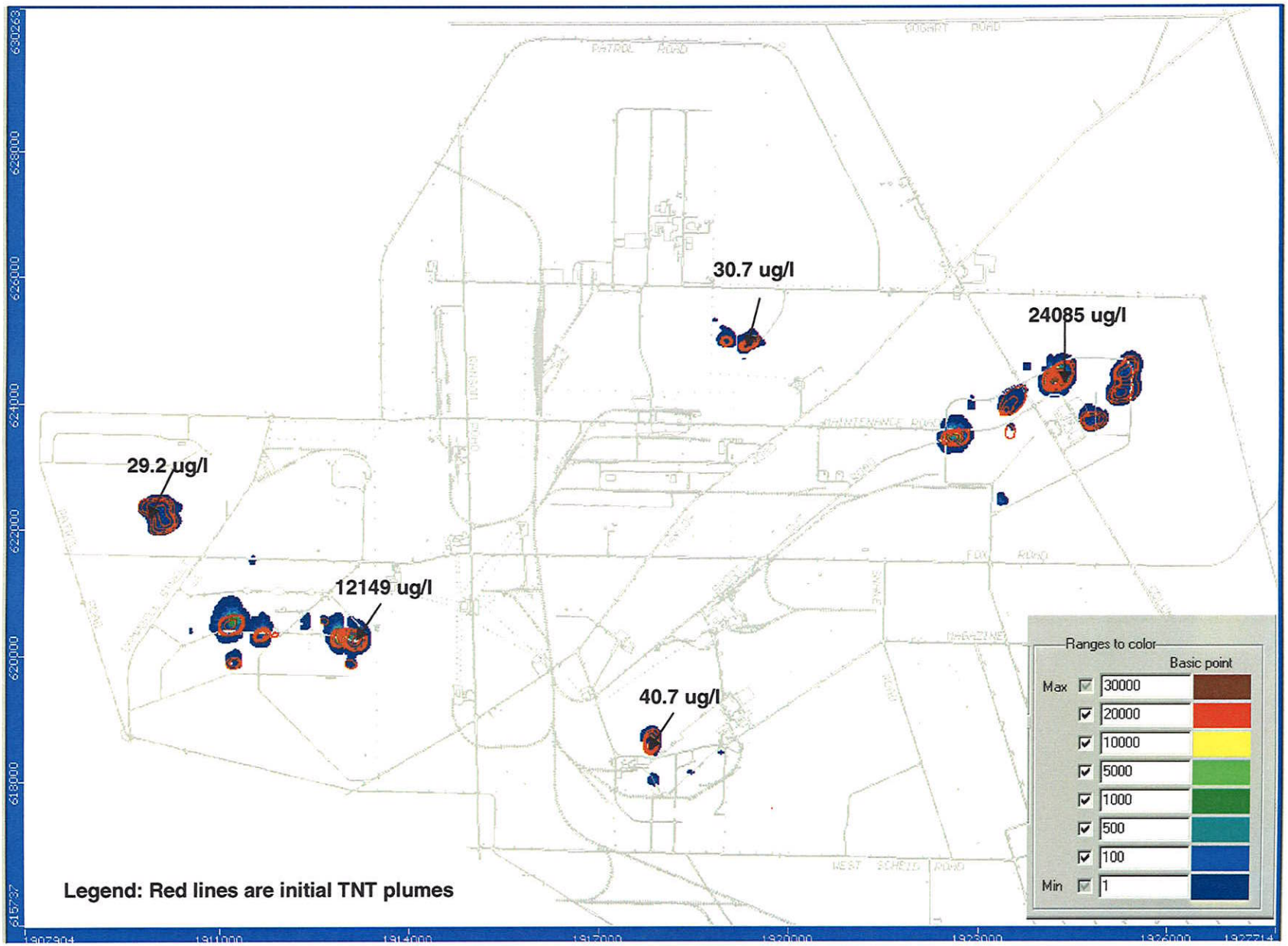


Figure 5-6
Simulated 2,4,6-TNT Plumes in the Five Operable Sites After 100 Years
Overburden
Former Plum Brook Ordnance Works

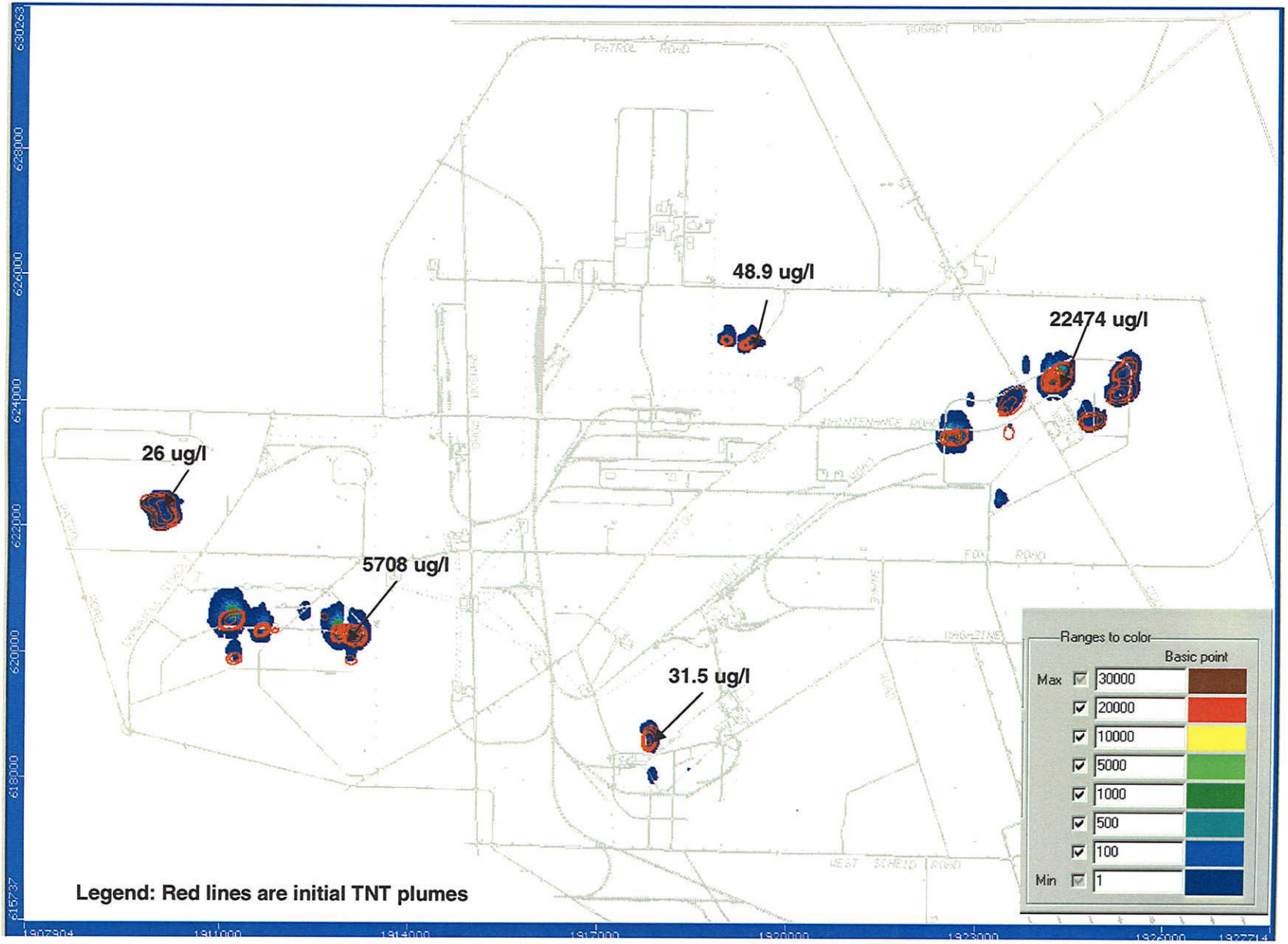


Figure 5-7
Simulated 2,4,6-TNT Plumes in the Five Operable Sites After 150 Years
Overburden
Former Plum Brook Ordnance Works

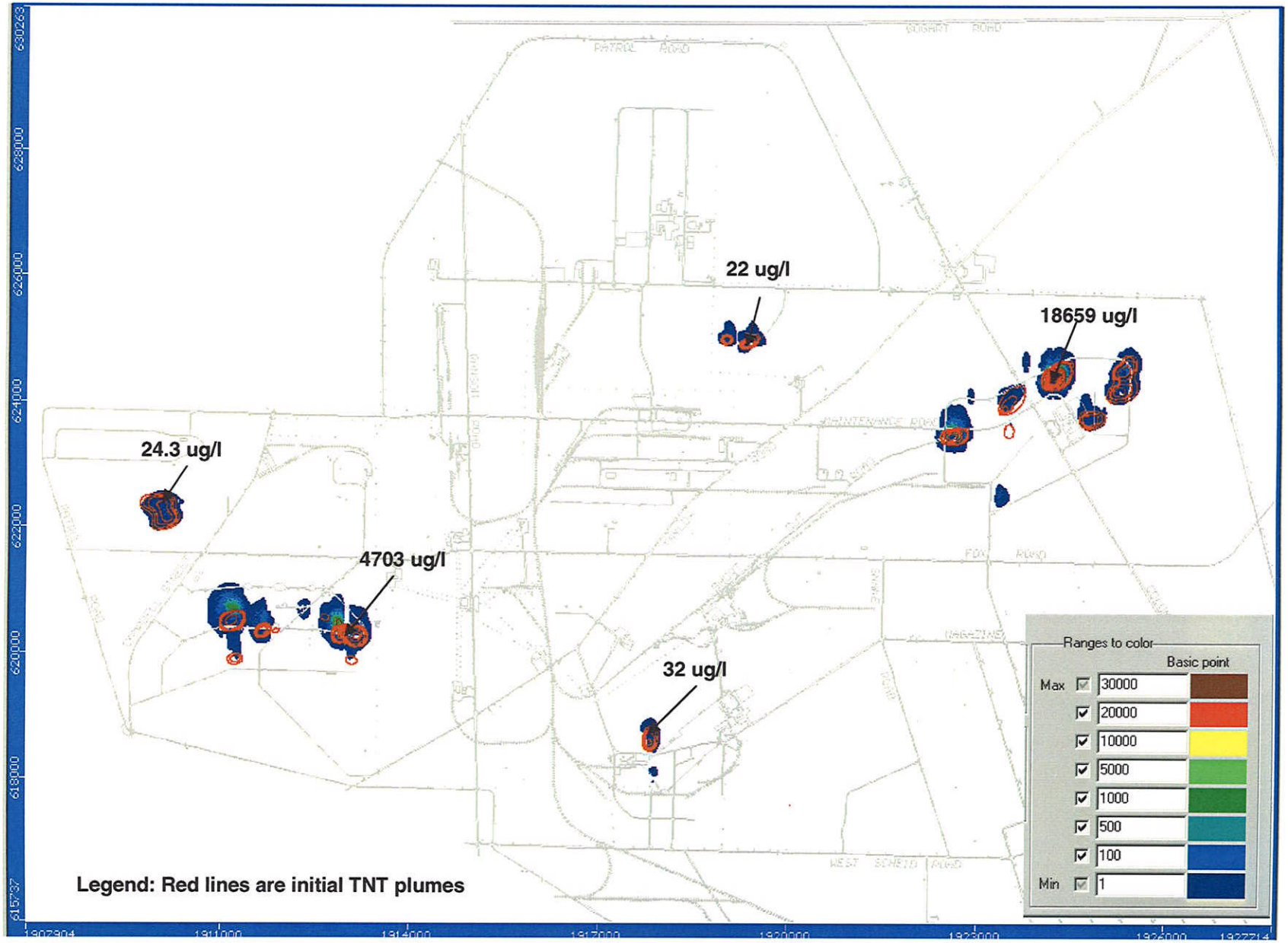


Figure 5-8
Simulated 2,4,6-TNT Plumes in the Five Operable Sites After 100 Years
Bedrock
Former Plum Brook Ordnance Works

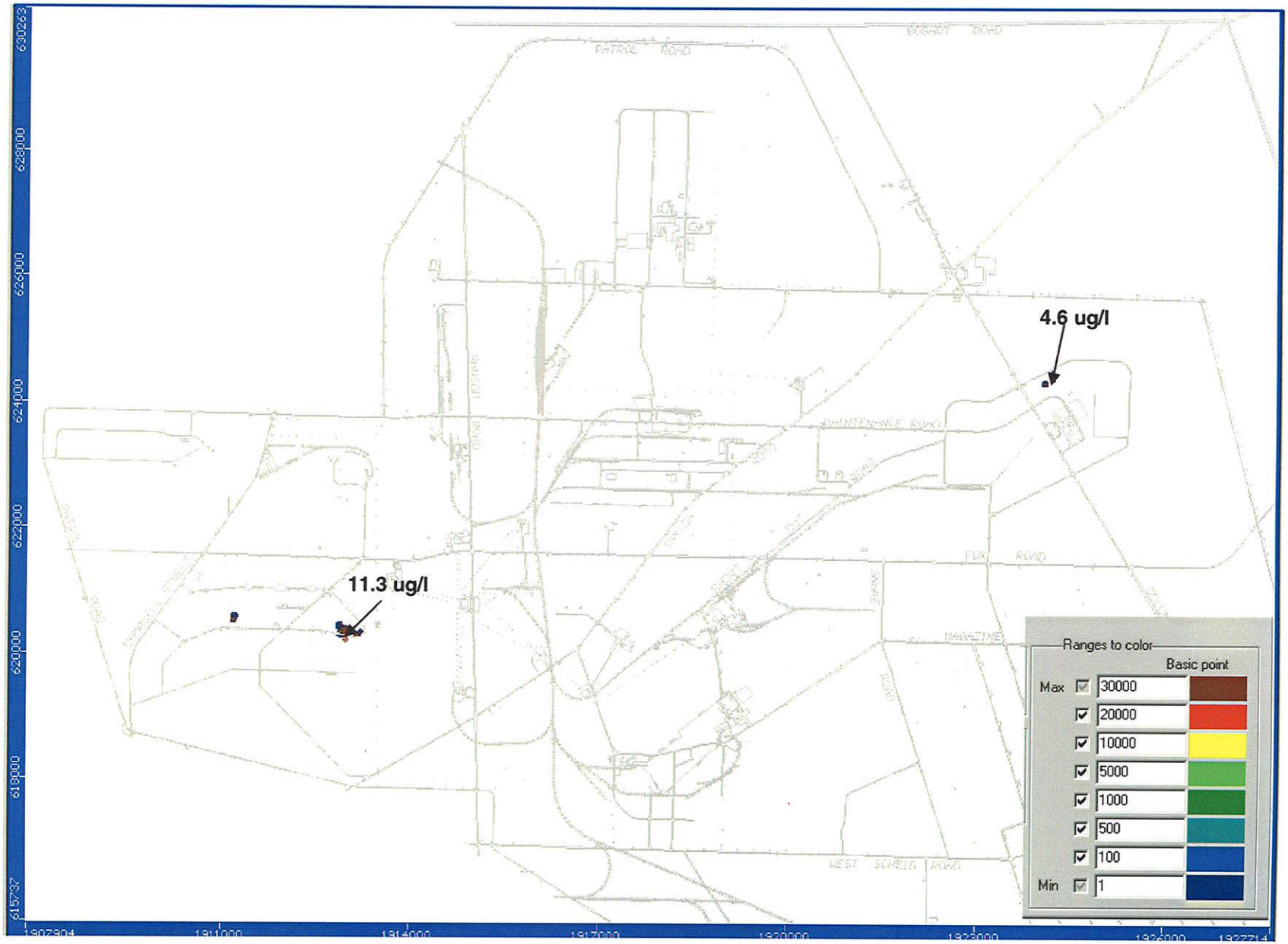


Figure 5-9
Simulated 2,4,6-TNT Plumes in the Five Operable Sites After 150 Years
Bedrock
Former Plum Brook Ordnance Works

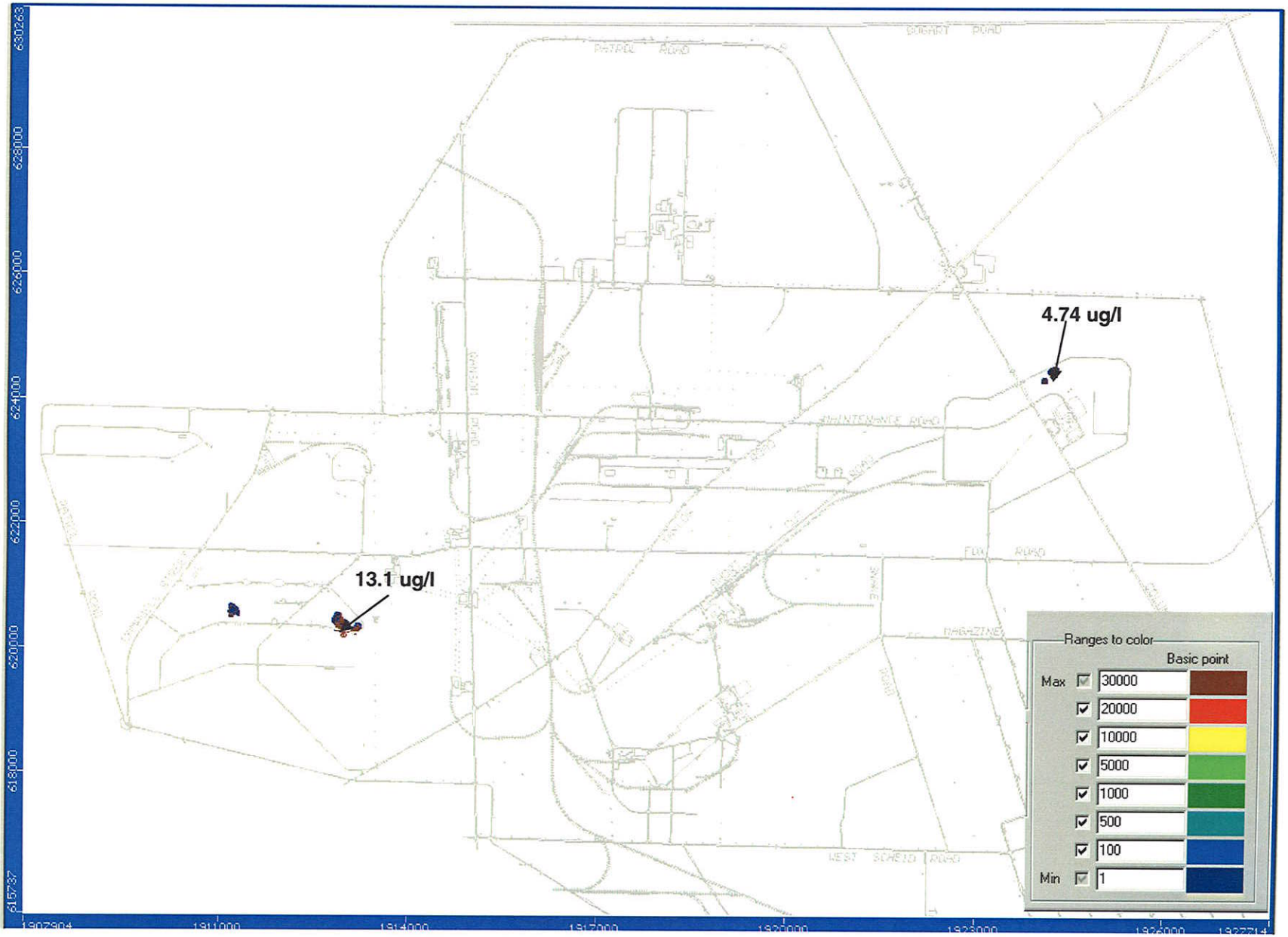


Figure 5-10
Simulated 2,4-DNT Plumes in the Five Operable Sites After 10 Years
Overburden
Former Plum Brook Ordnance Works

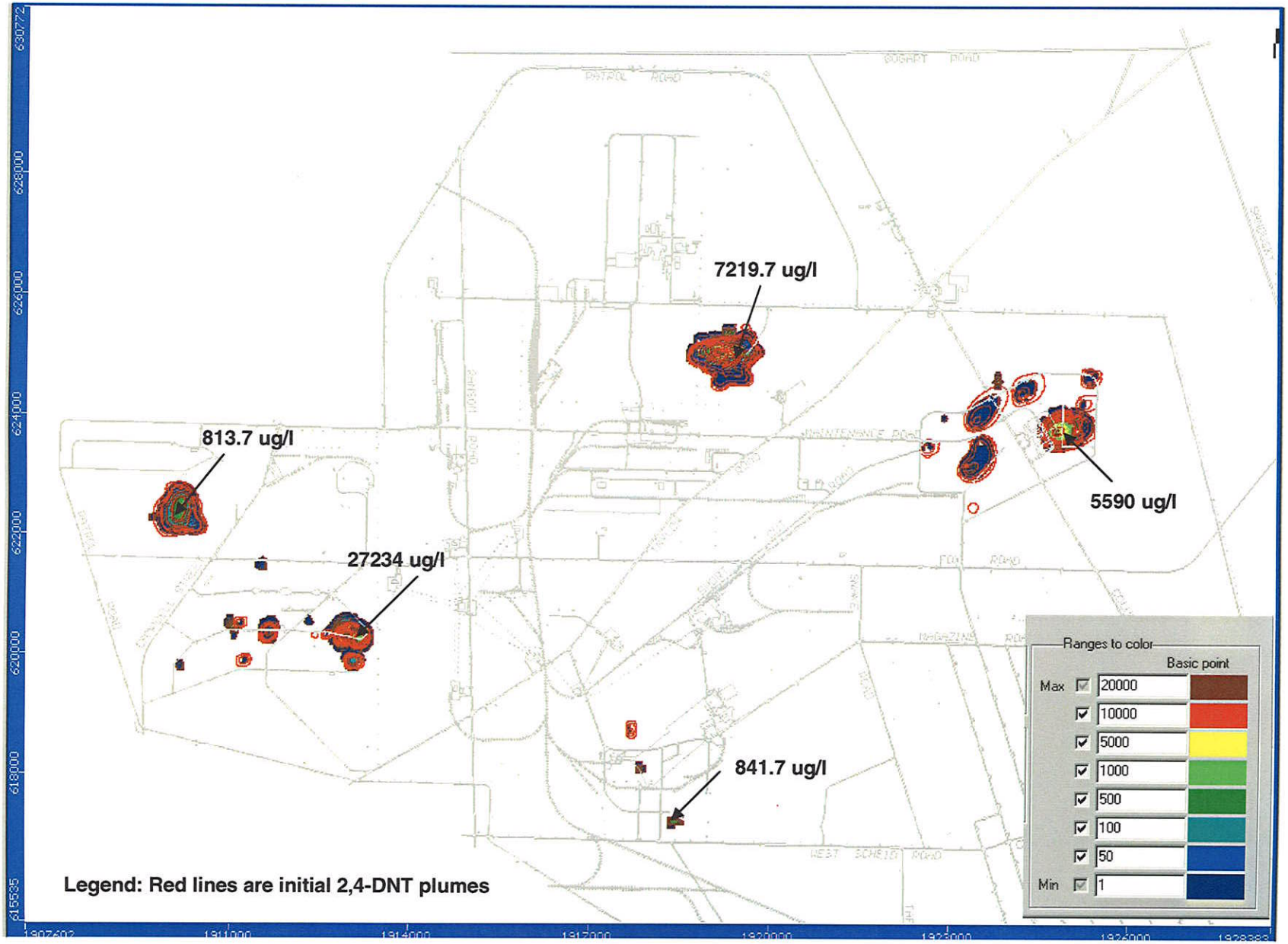


Figure 5-11
Simulated 2,4-DNT Plumes in the Five Operable Sites After 50 Years
Overburden
Former Plum Brook Ordnance Works

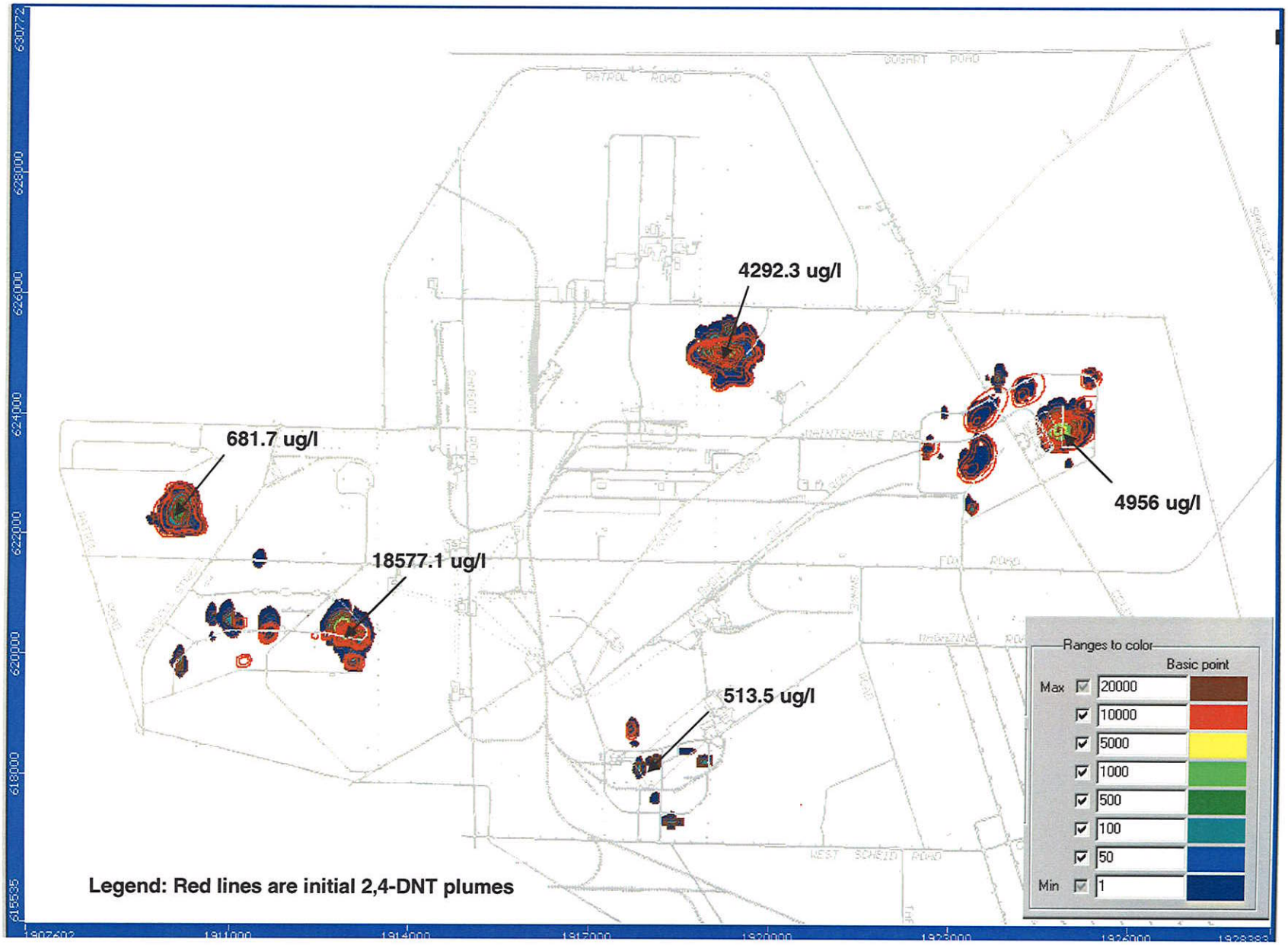


Figure 5-12
Simulated 2,4-DNT Plumes in the Five Operable Sites After 100 Years
Overburden
Former Plum Brook Ordnance Works

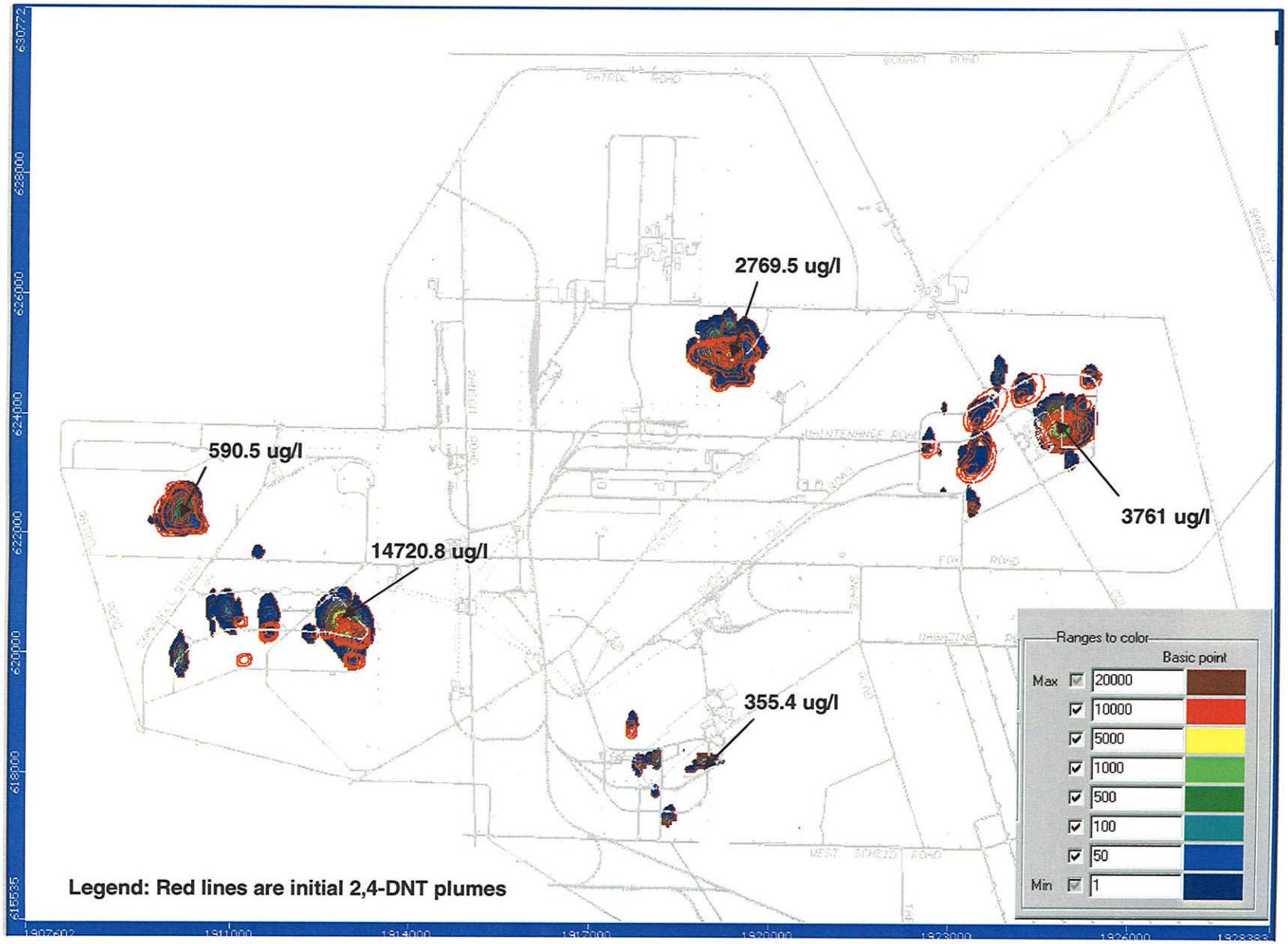


Figure 5-13
Simulated 2,4-DNT Plumes in the Five Operable Sites After 150 Years
Overburden
Former Plum Brook Ordnance Works

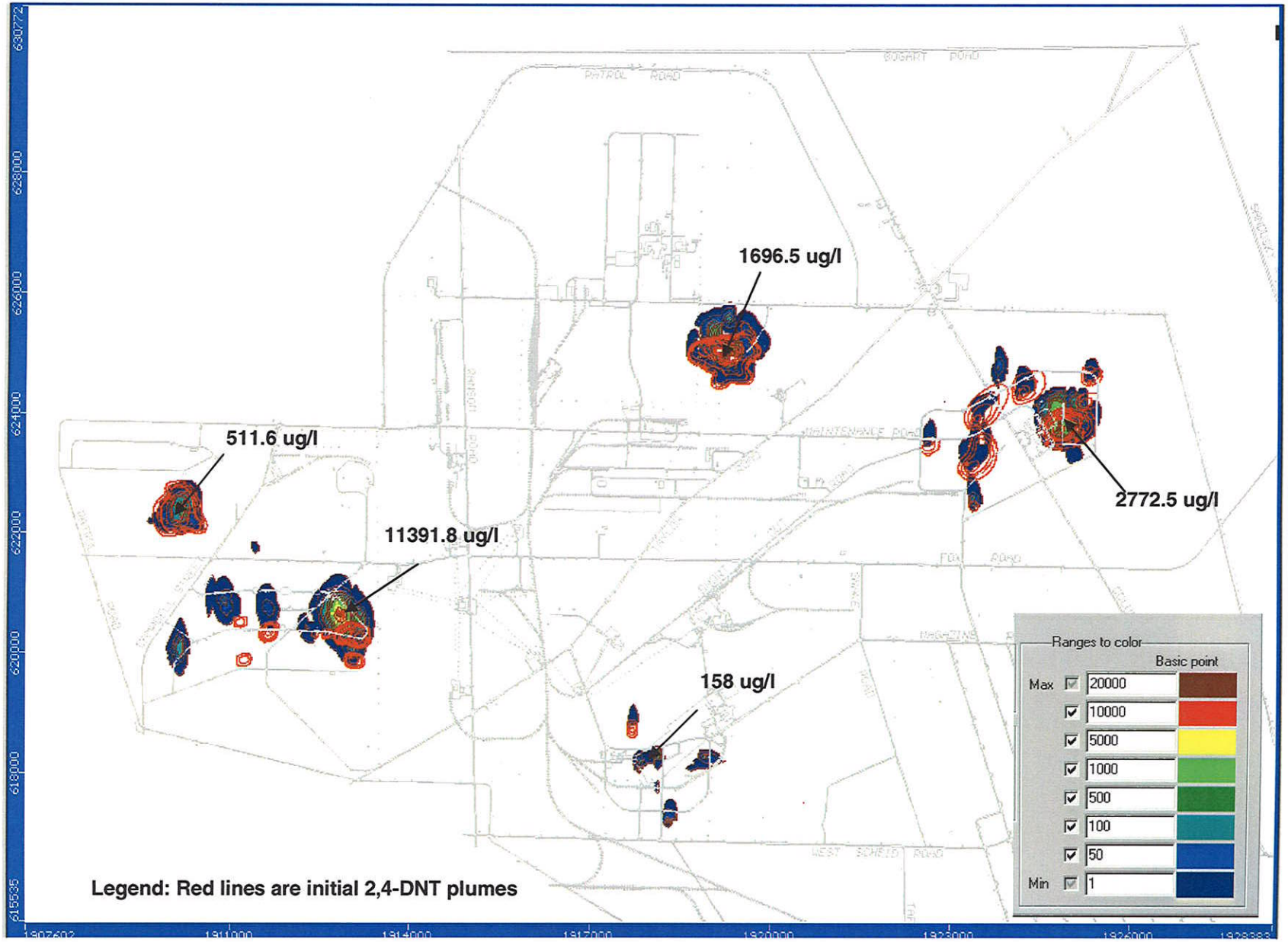


Figure 5-14
Simulated 2,4-DNT Plumes in the Five Operable Sites After 10 Years
Bedrock
Former Plum Brook Ordnance Works

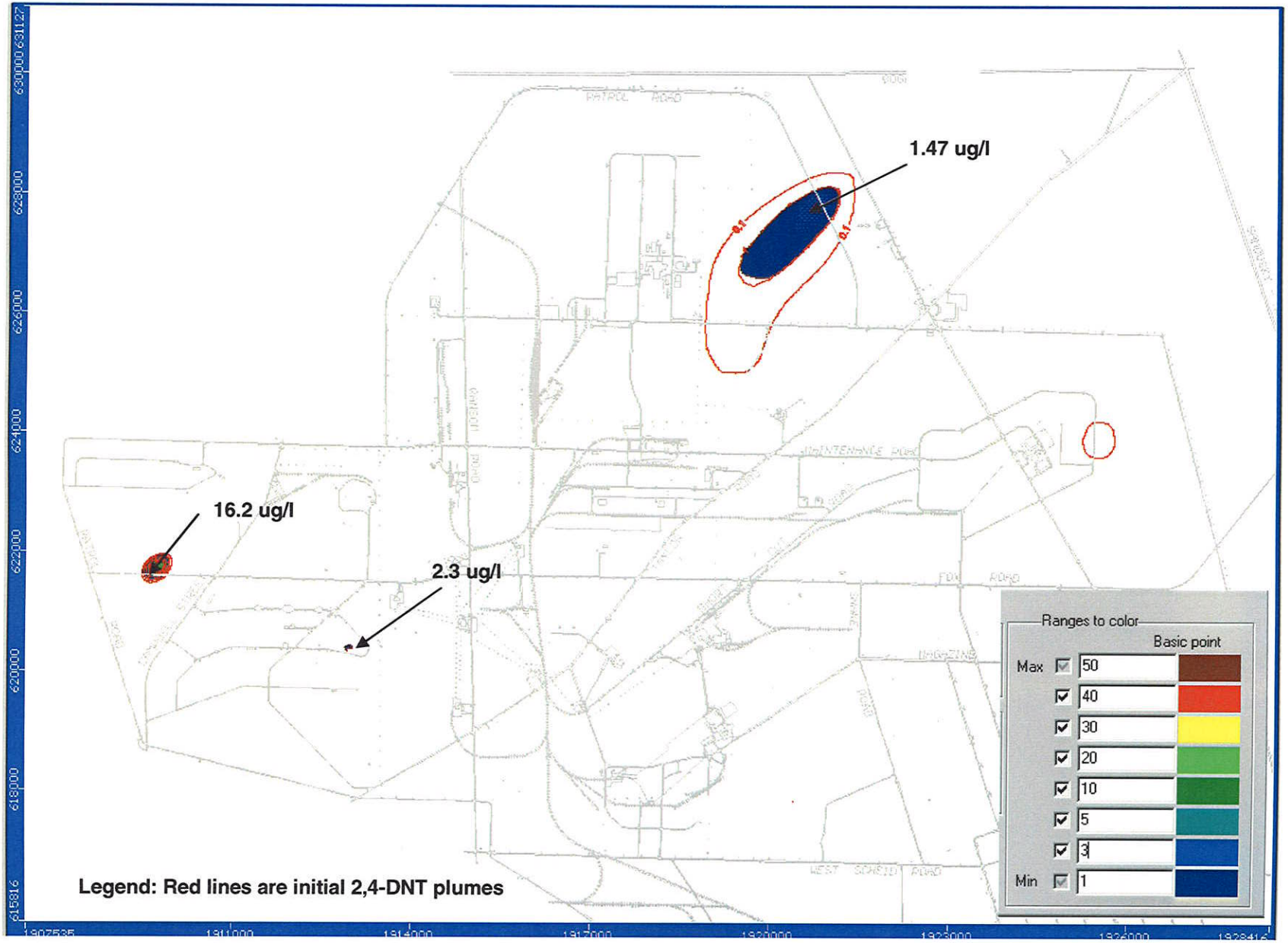


Figure 5-15
Simulated 2,4-DNT Plumes in the Five Operable Sites After 50 Years
Bedrock
Former Plum Brook Ordnance Works

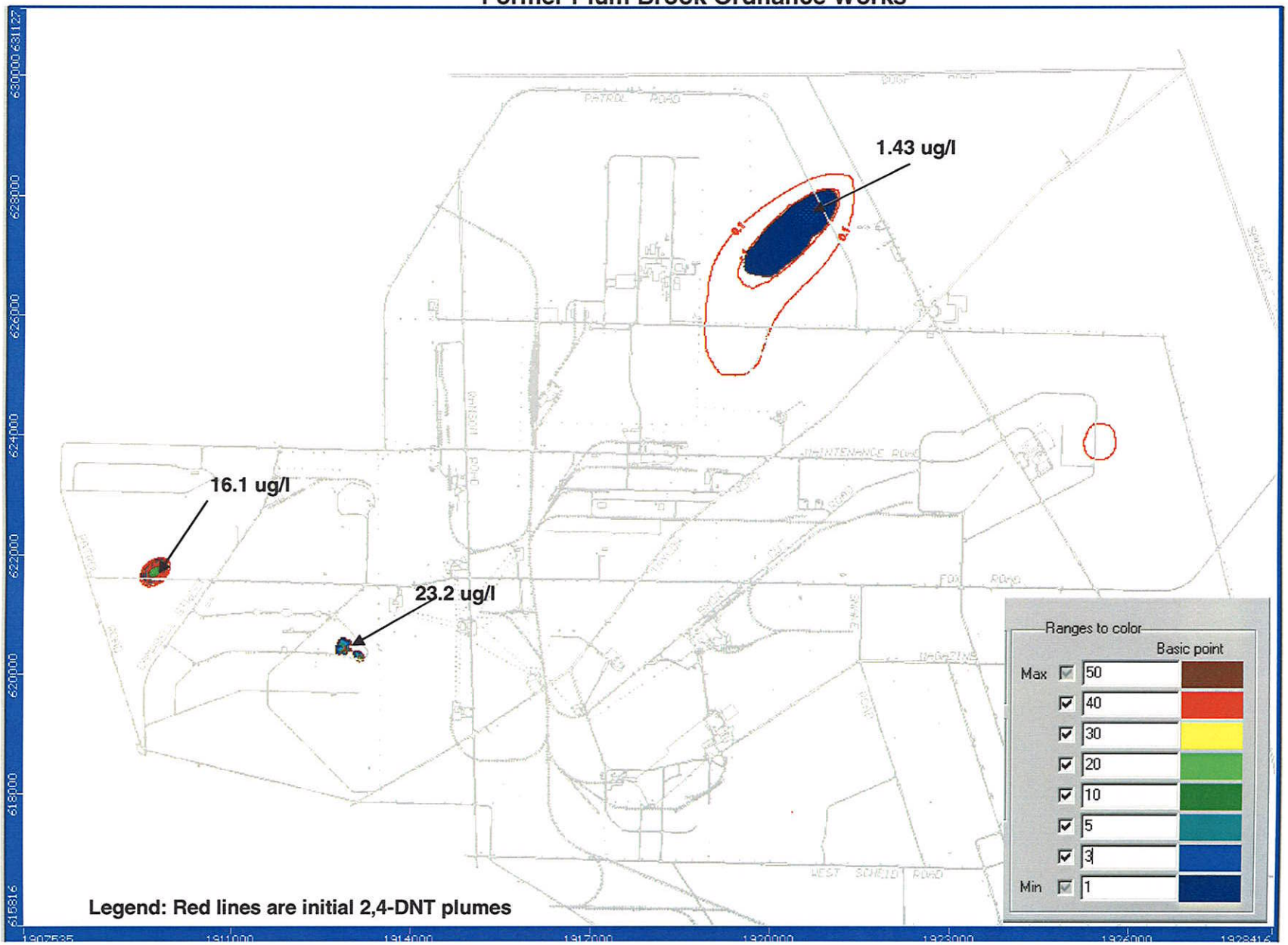


Figure 5-16
Simulated 2,4-DNT Plumes in the Five Operable Sites After 100 Years
Bedrock
Former Plum Brook Ordnance Works

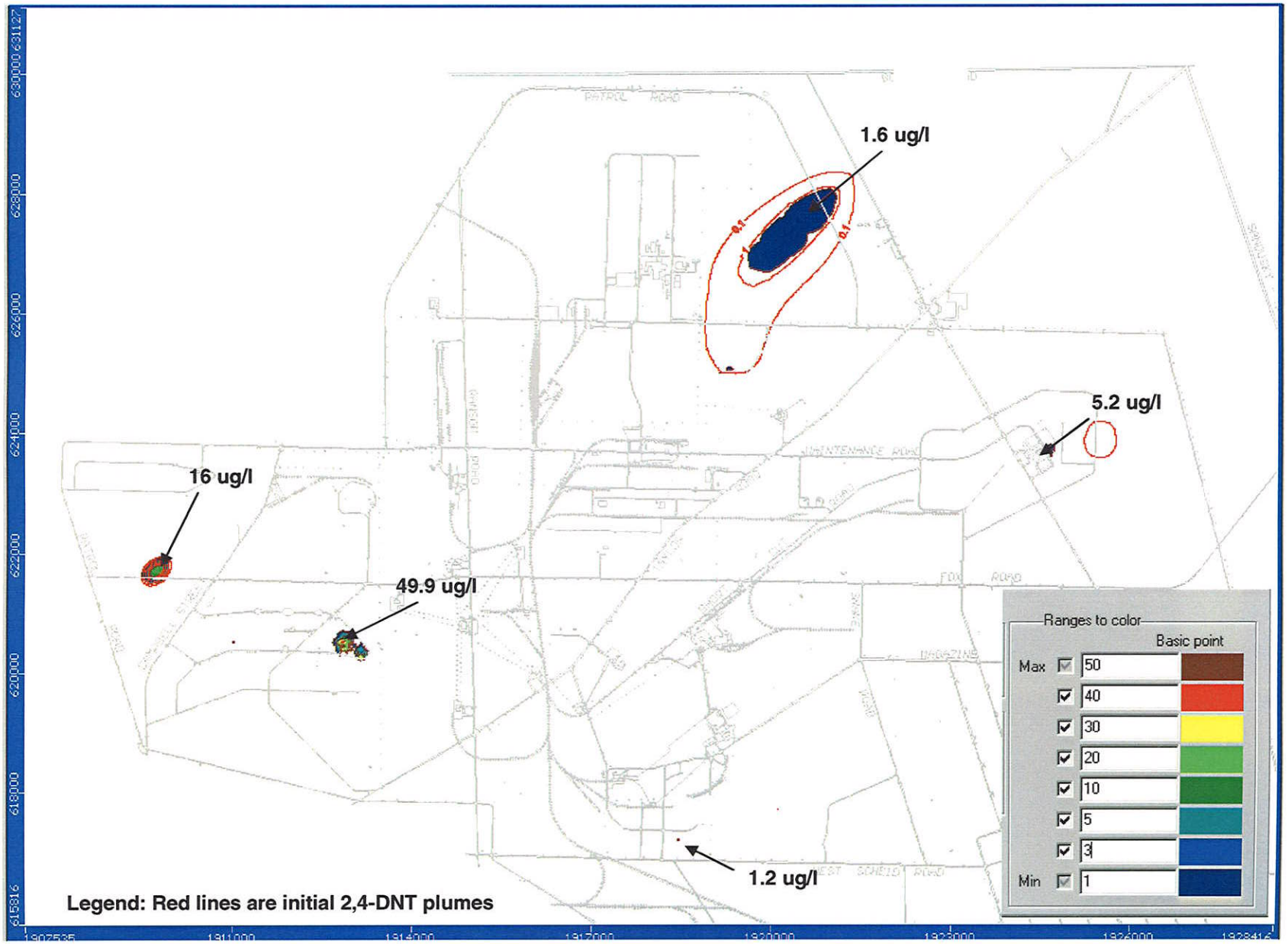


Figure 5-17
Simulated 2,4-DNT Plumes in the Five Operable Sites After 150 Years
Bedrock
Former Plum Brook Ordnance Works

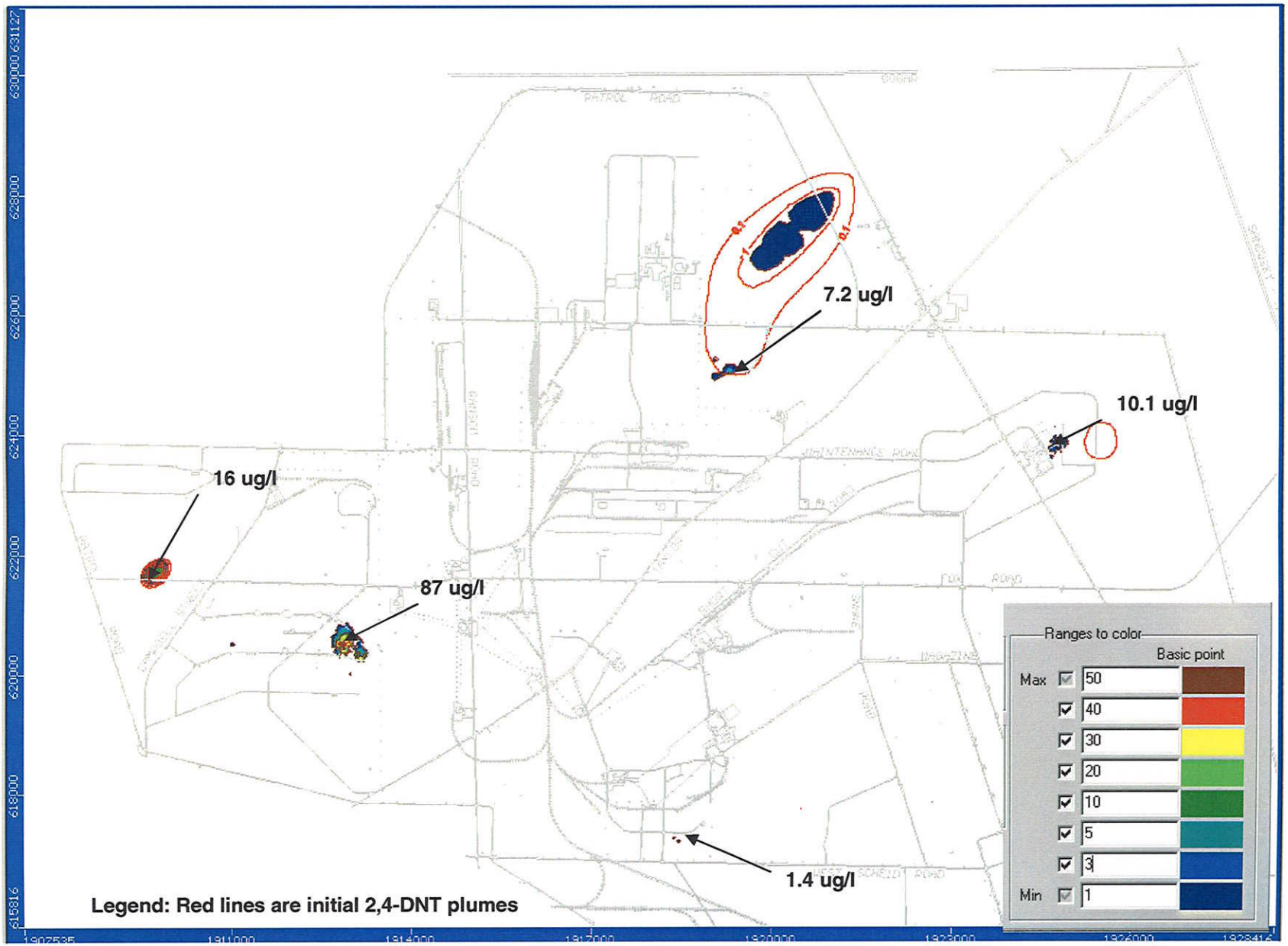


Figure 5-18
Simulated 2,6-DNT Plumes in the Five Operable Sites After 10 Years
Overburden
Former Plum Brook Ordnance Works

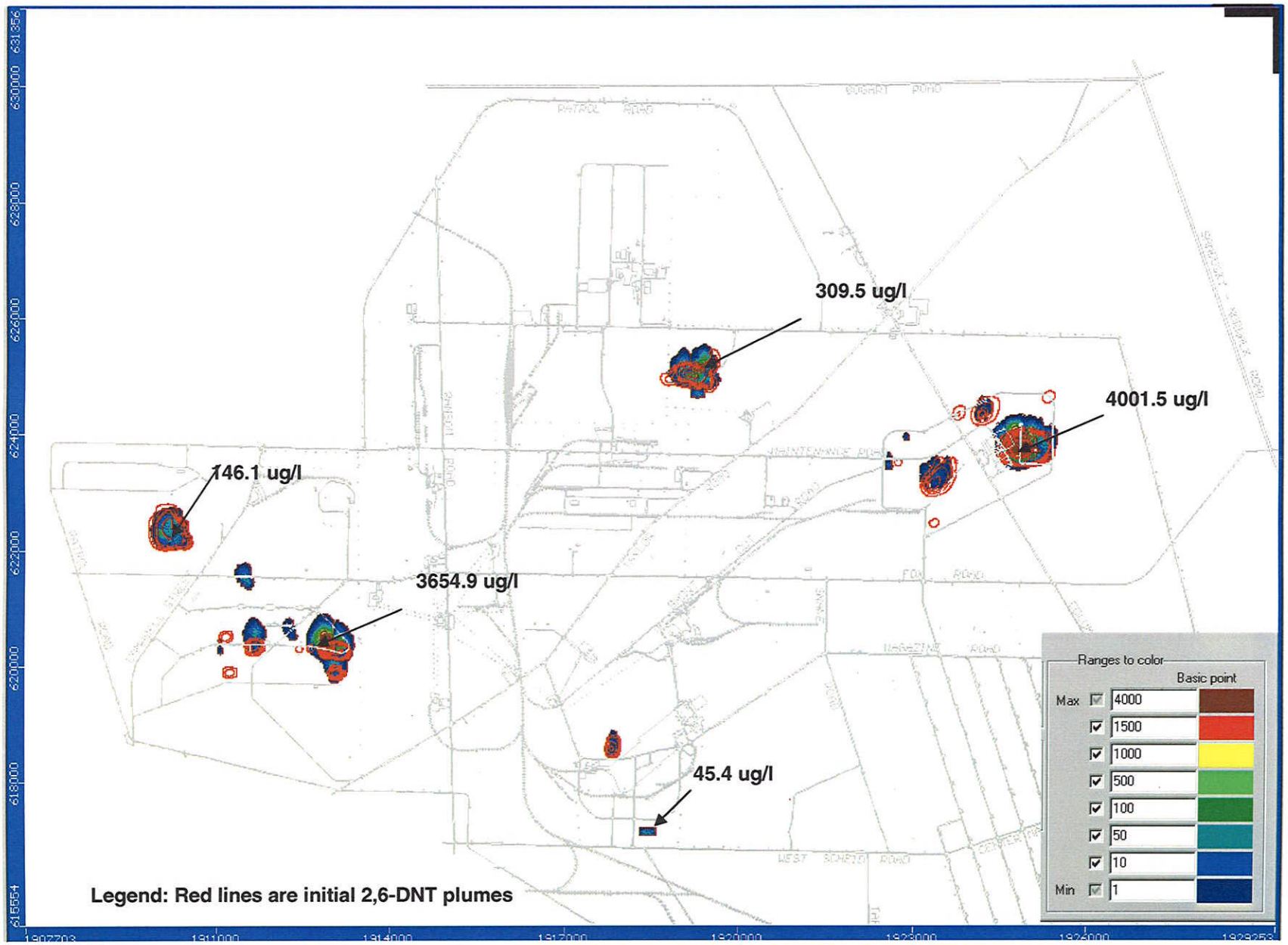


Figure 5-19
Simulated 2,6-DNT Plumes in the Five Operable Sites After 50 Years
Overburden
Former Plum Brook Ordnance Works

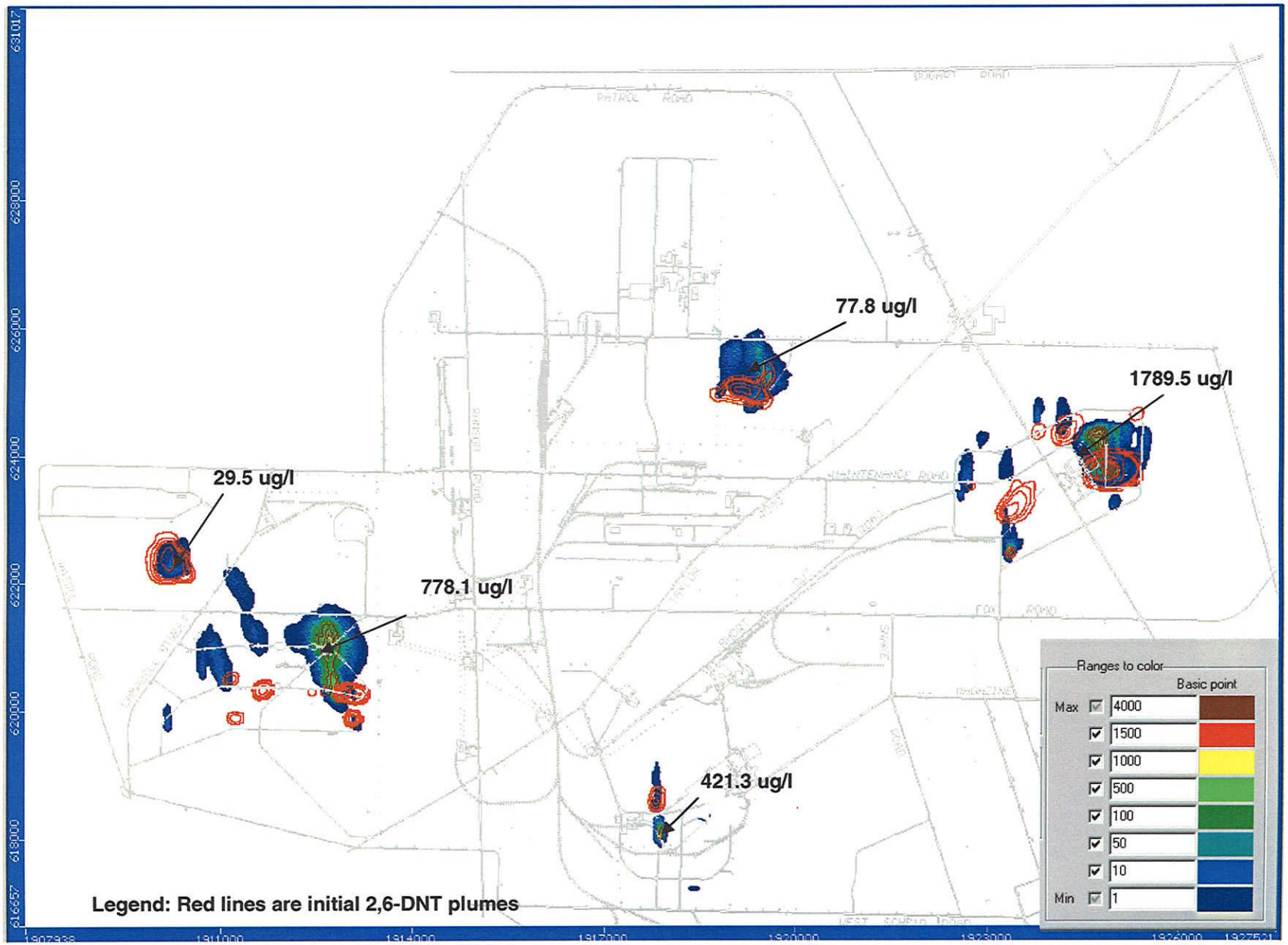


Figure 5-20
Simulated 2,6-DNT Plumes in the Five Operable Sites After 100 Years
Overburden
Former Plum Brook Ordnance Works

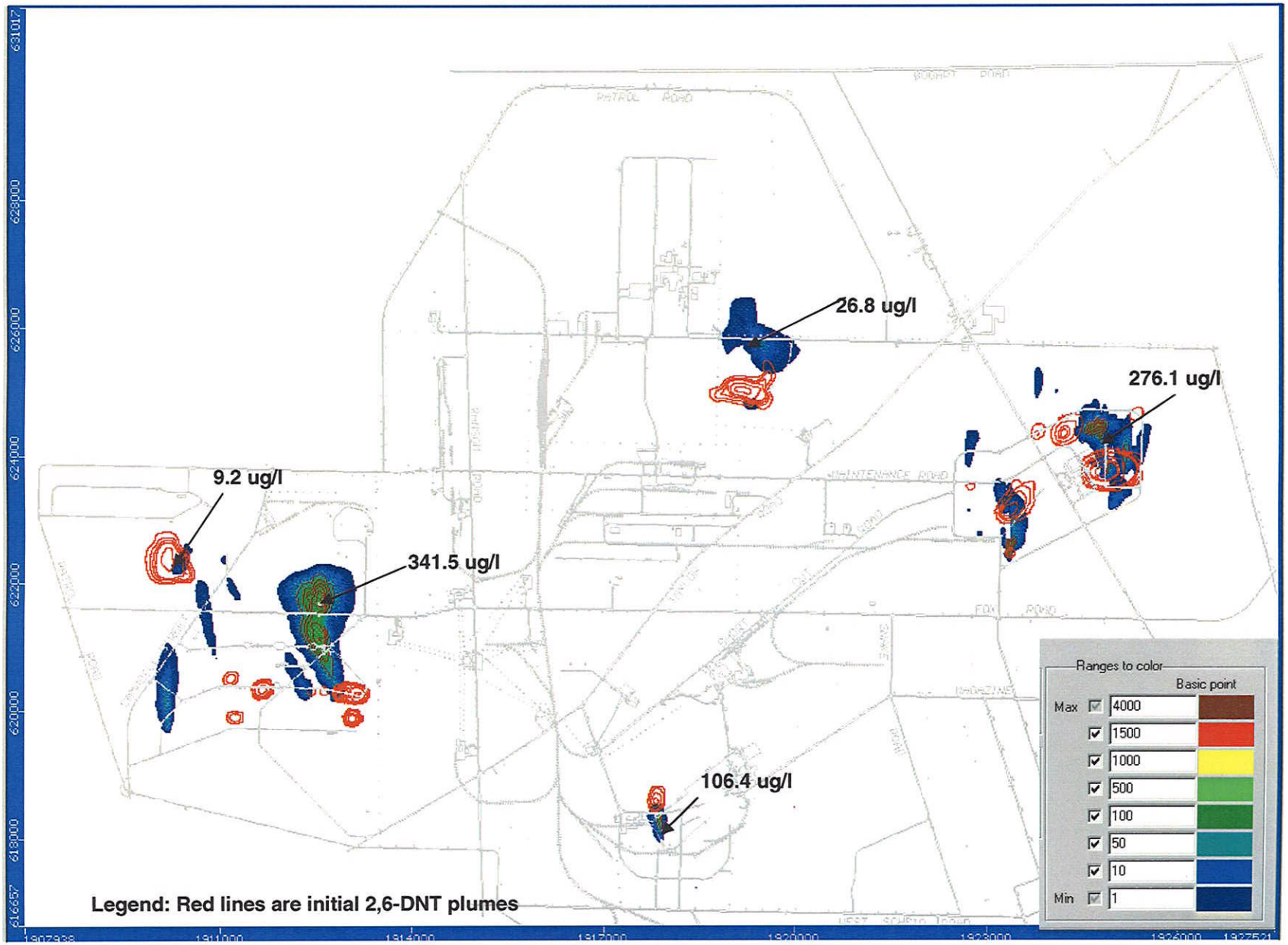


Figure 5-21
Simulated 2,6-DNT Plumes in the Five Operable Sites After 150 Years
Overburden
Former Plum Brook Ordnance Works

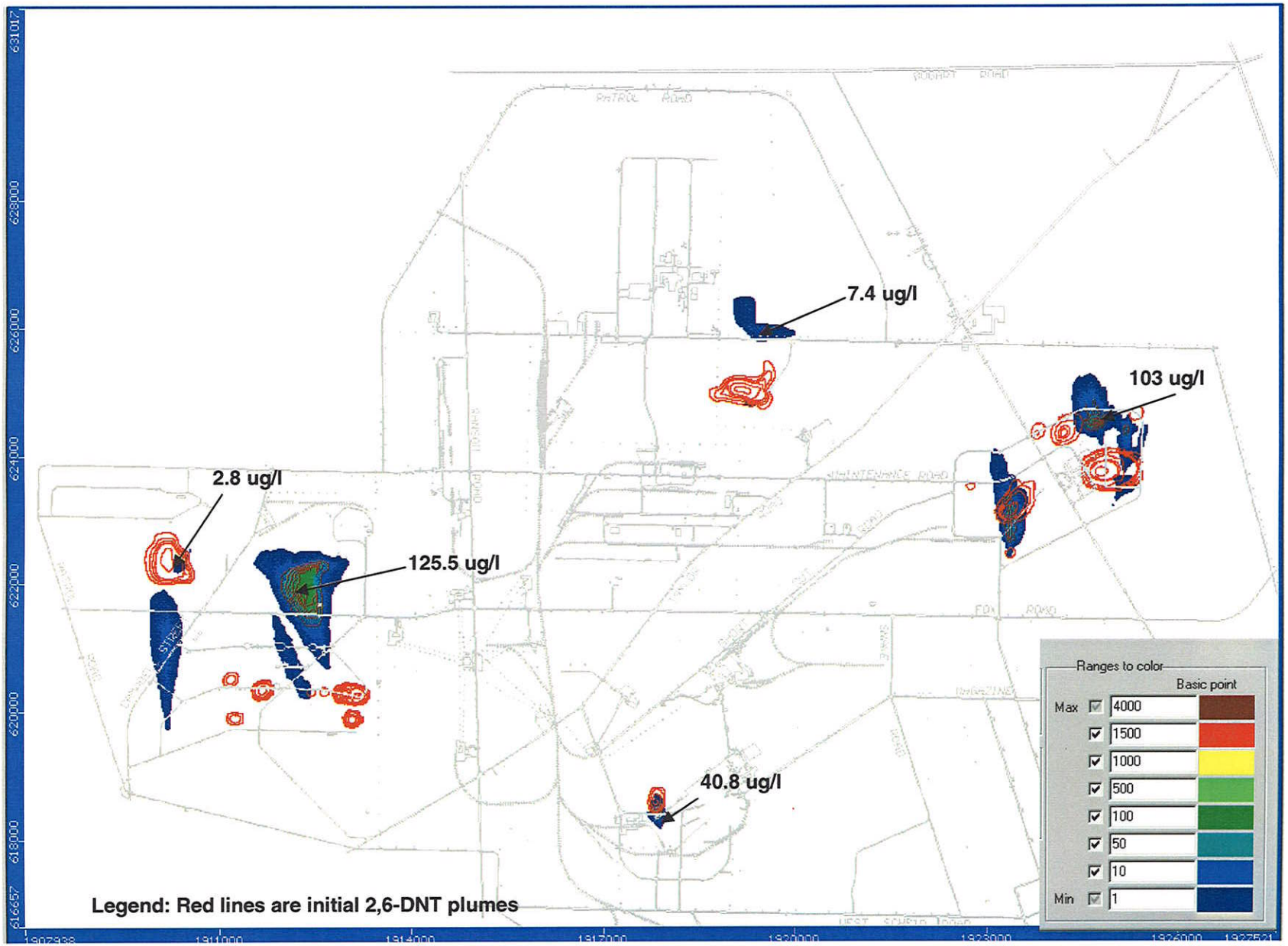


Figure 5-22
Simulated 2,6-DNT Plumes in the Five Operable Sites After 10 Years
Bedrock
Former Plum Brook Ordnance Works

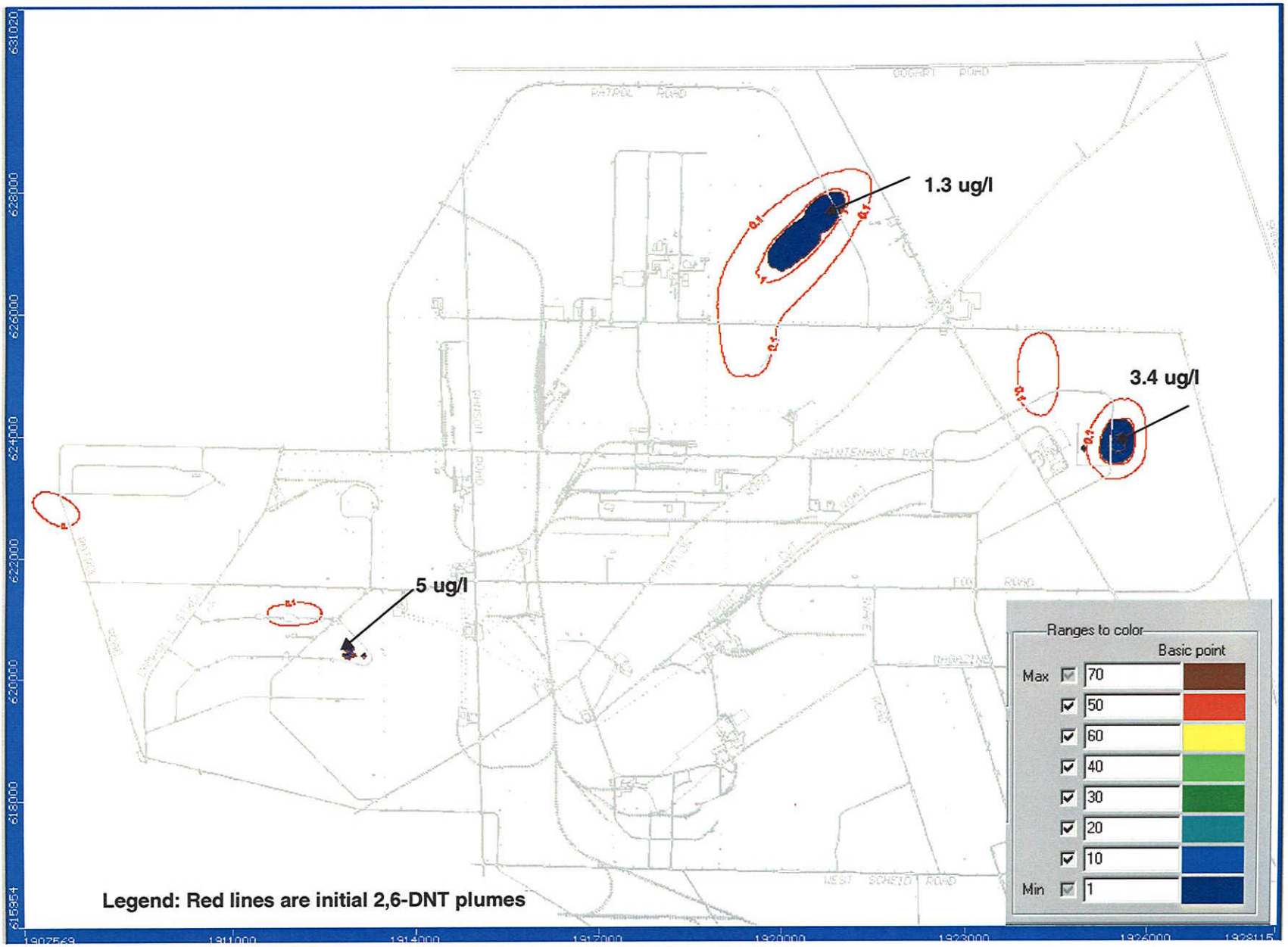


Figure 5-23
Simulated 2,6-DNT Plumes in the Five Operable Sites After 50 Years
Bedrock
Former Plum Brook Ordnance Works

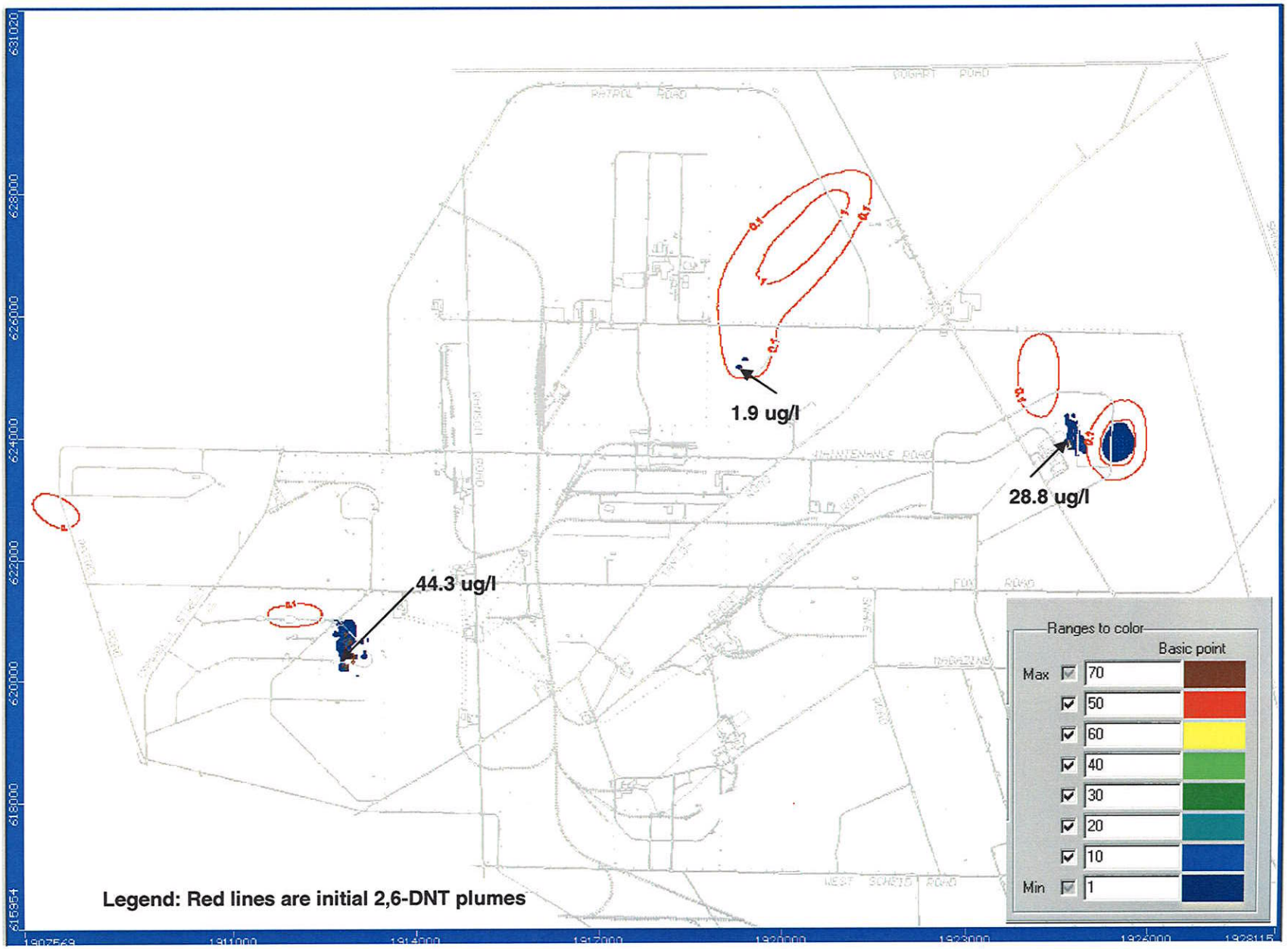


Figure 5-24
Simulated 2,6-DNT Plumes in the Five Operable Sites After 100 Years
Bedrock
Former Plum Brook Ordnance Works

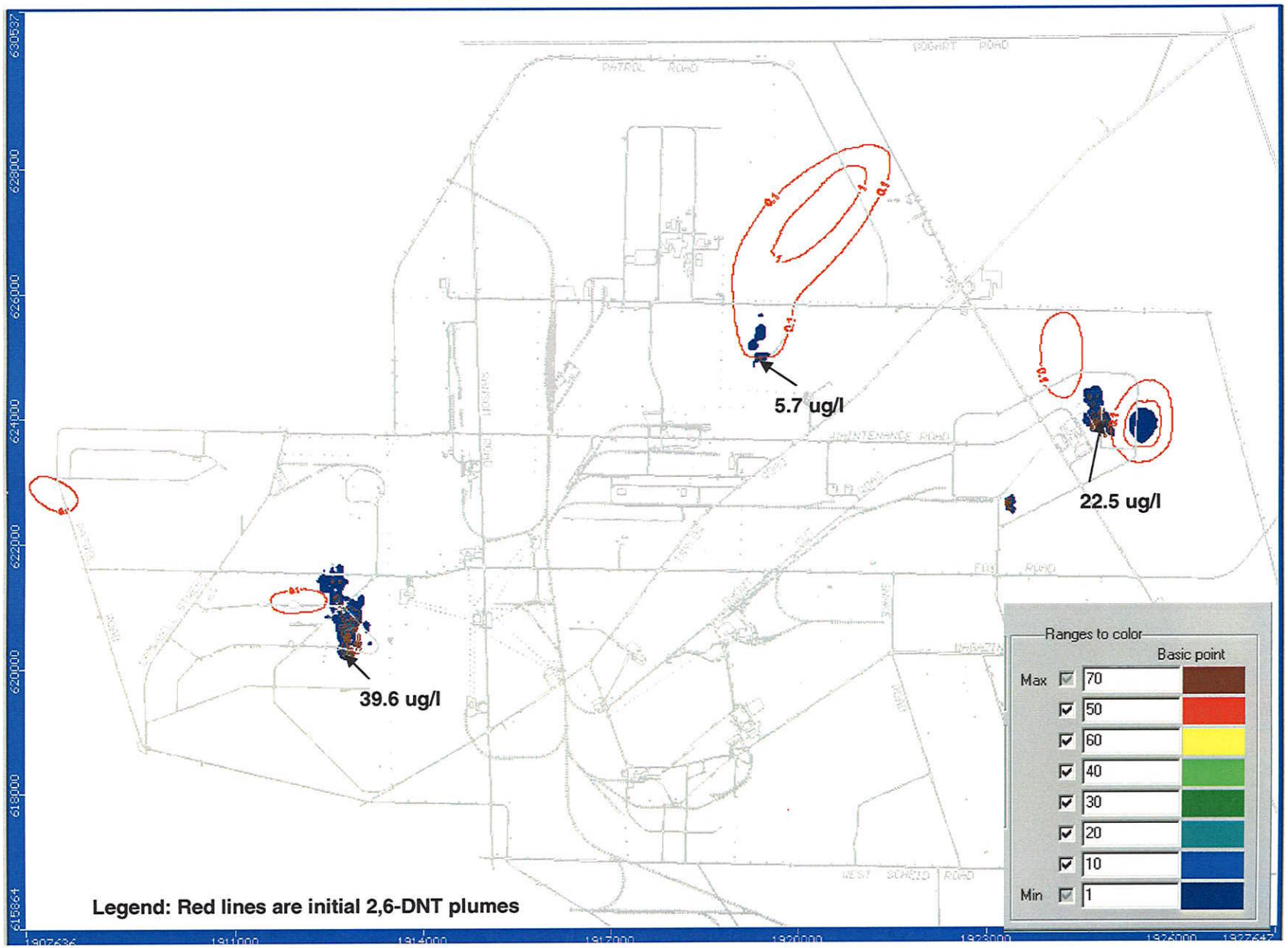
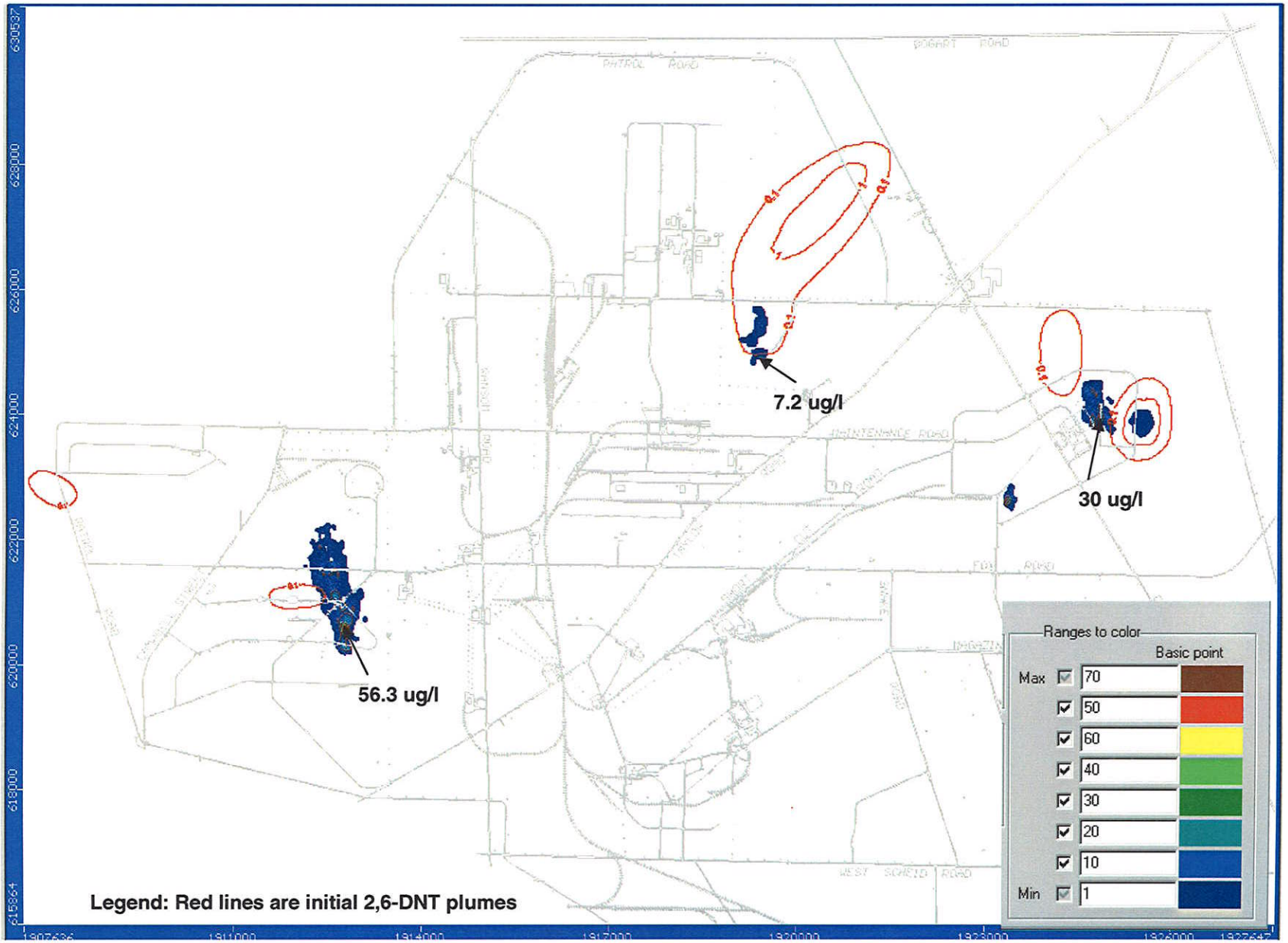


Figure 5-25
Simulated 2,6-DNT Plumes in the Five Operable Sites After 150 Years
Bedrock
Former Plum Brook Ordnance Works



ATTACHMENT A

COMPILED SOIL ANALYTICAL DATA FOR NITROAROMATIC COMPOUNDS (TNT, 2,4-DNT, AND 2,6-DNT)

Table 1
Soil Sample Locations and Analytical Data for Nitroaromatic Compound (2,4,6-TNT)
TNTA Area, Former Plum Brook Ordnance Works, Sandusky, Ohio

Location ID	Northing	Easting	Column #	Row #	Gnd_Elev (ft msl)	GW Elev. (ft msl) Estimated	DTW (ft) Estimated	α (ft)	Sample Depth (ft,blgs) 0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	Comments
TNTA-S1	624547	1923783	194	75	632	629	5.00	0.12	4.9	580									
TNTA-S5	623816	1923318	187	87	636	633	4.00	0.05			0.3								SO334, 395, 396
TNTA-S15	623337	1922879	179	95	650	636	14.00	0.50	53										same location as S16, 19, SO033, 034
TNTA-S17	623260	1922852	179	96	650	637	13.00	0.48	1.1										
TNTA-S20	623121	1922699	176	98	653	637	16.02	0.54	4.3	1.3	31.2		0.088				0.169		same location as S13, S18, S19, S28, SO016, 017, 021, 022, 154, 155, 201, 238, 241, 242, 262, 263, 265, 266, 300, 311, 379, 380
TNTA-S21	622833	1922881	179	103	658	642	16.00	0.54	40.7	17.9									same location as S001, 003, 297, 300, 349, 377
TNTA-S23	622800	1922908	180	103	658	642	16.00	0.54		0.483									same location as S298
TNTA-S25	622475	1923331	187	109	654	646	7.50	0.35			798								same as 061, 068, 069, 160, 161, 275-280, 359, 385
TNTA-S29	623297	1922840	178	95	645	636	9.00	0.39	19										
TNTA-S31	624527	1923495	190	76	649	646	3.00	0.02	0.9										
TNTA-S32	624571	1923587	191	75	634	631	3.00	0.02	3.2										
TNTA-SO012	622906	1923105	183	102	660	630	30.14	0.78			259		229						same as SO066, 248, 249, 387
TNTA-SO013	622924	1923123	183	101	660	640	20.10	0.62		0.285									same location as S250
TNTA-SO014	622915	1923140	184	102	661	640	20.50	0.63		0.483									same as SO014, 015, 245
TNTA-SO018	623184	1922684	176	97	650	637	13.00	0.48	2.48	2.21	0.124								same as SO019, 233, 234, 235
TNTA-SO020	623148	1922694	220	76	638	630	10.00	0.41	8.51								0.47		same as SO403, 404
TNTA-SO024	623103	1922682	176	99	653	638	15.00	0.52	6.67										
TNTA-SO035	623314	1922907	180	95	651	635	16.24	0.55		8.9									same as 327-330, 350
TNTA-SO040	623323	1923086	183	95	654	635	19.48	0.61			7.21		0.317						same as 292, 375, 376
TNTA-SO045	623511	1923266	186	92	650	635	15.00	0.52	0.215			0.13							same location as S319
TNTA-SO047	623485	1923488	189	92	651	635	16.00	0.54			0.249								same as 53, 391
TNTA-SO048	623475	1923528	190	93	651	635	16.00	0.54			0.37								
TNTA-SO051	623510	1923527	190	92	651	635	16.00	0.54			4.08								same as 54,
TNTA-SO052	623547	1923490	189	91	651	635	16.00	0.54	0.507		5.04								same as 320
TNTA-SO053	623519	1923481	189	92	651	635	16.00	0.54			0.204								
TNTA-SO062	623116	1923300	186	98	659	638	21.29	0.64					2.88		15.9		5.35		same as 389, 390
TNTA-SO076	623938	1922842	178	85	636	633	3.20	0.02	0.252										
TNTA-SO077	623958	1922856	179	85	636	633	3.18	0.02	13.2										same location as SO218
TNTA-SO078	623403	1922581	174	94	639	635	4.00	0.05											same location as SO224
TNTA-SO079	623424	1922581	174	93	639	635	4.00	0.05	12000		103		530				260		same location as SO080, 222, 223, 309, 332, 383, 384
TNTA-SO081	623449	1922607	175	93	637	633	5.00	0.12	163		734		0.332						same location as SO081, 087, 225, 226, 310, 353, 38
TNTA-SO082	623401	1922606	175	94	639	635	4.00	0.05			0.647								same location as SO083, 232
TNTA-SO094	623221	1924923	214	97	653	637	16.42	0.55					0.331						same as 397, 398
TNTA-SO103	623727	1925141	217	89	651	635	16.00	0.54		0.483	0.153								same as 284, 315, 416, 484
TNTA-SO105	623763	1925105	217	88	649	635	14.35	0.51					1.56						same as 281, 283, 367, 368
TNTA-SO106	623734	1925074	216	88	650	635	15.00	0.52		2.1	0.36								same as 107, 288, 414
TNTA-SO109	623915	1924922	214	86	653	635	18.28	0.59		0.191			0.483						same as 111, 361
TNTA-SO110	623929	1924935	214	85	653	633	20.00	0.62	0.18		0.377								same as 305, 406
TNTA-SO121	624300	1925060	216	79	650	632	18.00	0.58				10.4	0.298				0.0851		same as 365, 366
TNTA-SO123	624158	1925236	219	82	656	632	23.62	0.68	0.982	284	39.1								same as 124, 125, 254, 323, 407
TNTA-SO126	624168	1925258	219	81	655	632	22.65	0.66	558	1298	0.312	29.9	64.4				8.57		same as 127, 128, 253, 255, 259, 324, 325, 363, 364, 408, 409
TNTA-SO129	624156	1925286	220	82	655	632	23.00	0.67				0.483							same as 130
TNTA-SO145	624575	1924697	210	75	634	629	5.00	0.12	1.12										
TNTA-SO146	624604	1924697	210	74	634	629	5.00	0.12	1.24										
TNTA-SO148	624524	1923827	195	76	632	629	3.00	0.02	0.178										

Table 1
Soil Sample Locations and Analytical Data for Nitroaromatic Compound (2,4,6-TNT)
TNTA Area, Former Plum Brook Ordnance Works, Sandusky, Ohio

Location ID	Northing	Easting	Column #	Row #	Gnd_Elev (ft msl)	GW Elev. (ft msl) Estimated	DTW (ft) Estimated	α (ft)	Sample Depth (ft,blgs) 0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	Comments
TNTA-SO149	624521	1923918	197	76	632	629	3.00	0.02		0.167									
TNTA-SO153	624592	1923811	195	75	632	629	3.00	0.02	0.404										
TNTA-SO162	624173	1924399	205	81	649	633	16.00	0.54	0.158										same as 163
TNTA-SO164	624137	1924431	205	82	650	633	17.00	0.56	0.328										same as 166, 167
TNTA-SO186	623784	1923396	188	88	639	634	5.00	0.12	0.239										same as 338
TNTA-SO191	624487	1925204	218	76	638	630	8.00	0.36		0.435									
TNTA-SO196	624392	1925327	220	78	640	631	8.56	0.38		0.432									
TNTA-SO202	624472	1925333	220	77	638	631	7.00	0.33		0.373									
TNTA-SO203	624336	1924184	201	79	639	631	8.00	0.36	785	170	62.9								same as 205, 261, 267, 268, 269, 418, 419
TNTA-SO207	624286	1924182	201	80	639	631	8.00	0.36		0.333									same as 208, 269
TNTA-SO210	624274	1924261	202	80	640	631	9.00	0.39		0.408									same as 265
TNTA-SO212	624307	1924254	202	79	639	631	10.00	0.41	0.395	0.724	150						1.04		same as 213, 263, 372, 420-422
TNTA-SO221	623953	1922837	178	85	636	633	3.00	0.02		0.126									same as 221
TNTA-SO264	624305	1924286	203	79	639	630	9.00	0.39		1.36									
TNTA-SO270	624296	1924146	200	79	639	631	8.00	0.36	0.195										
TNTA-SO285	623711	1925073	216	89	650	639	11.00	0.43		0.295	0.353								same location as S415, 482
TNTA-SO291	623338	1923074	182	95	651	635	16.00	0.54			0.515								same as 296
TNTA-SO310	623449	1922607	175	93	639	635	4.00	0.05	1.62										
TNTA-SO348	623464	1923275	186	93	651	635	16.00	0.54				18.8							
TNTA-SO399	623734	1924758	211	88	655	635	20.00	0.62									0.483		
TNTA-SO405	623940	1924915	213	85	653	633	20.00	0.62	0.16										

Table 2
Soil Sample Locations and Analytical Data for Nitroaromatic Compound (2,4,-DNT)
TNTA Area, Former Plum Brook Ordnance Works, Sandusky, Ohio

Location ID	Northing	Easting	Column #	Row #	Gnd_Elev (ft msl)	GW Elev. (ft msl) Estimated	DTW (ft) Estimated	α (ft)	Sample Depth (ft,blgs) 0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	Comments
TNTA-S1	624547	1923783	194	75	632	629	5.00	0.12	4.9	4.8									
TNTA-S15	623337	1922879	179	95	650	636	14.00	0.50	1.5										same location as S16, 19, SO033, 034
TNTA-S17	623260	1922852	179	96	650	637	13.00	0.48	0.5										
TNTA-S20	623141	1922676	176	98	653.02	637	16.02	0.54	0.73		2.7		0.0555						same location as SO016, 017, 021, 022, 201, 238, 241, 242, 311, 379
TNTA-S21	622833	1922881	179	103	658	642	16.00	0.54		3.68									same location as S001, 003, 297, 300, 349, 377
TNTA-S22	622793	1922874	179	104	659.1	644.9	14.20	0.50	45										same location as SO299
TNTA-S23	622800	1922908	180	103	658	642	16.00	0.54		0.2									same location as S298
TNTA-S25	622467	1923363	187	109	653.5	646	7.50	0.35	0.6	**299**	**976.5**								same as 061, 068, 069, 160, 161, 275-280, 356, 357, 359, 385
TNTA-S29	623297	1922840	178	95	645	636	9.00	0.39	2.7										
TNTA-S30	622479	1923301	186	109	654	646	8.00	0.36		0.7									same as S24, SO066, 067, 272
TNTA-S32	624571	1923587	191	75	634	631	3.00	0.02	0.3										
TNTA-SO012	622906	1923105	183	102	660.14	630	30.14	0.78	257		**8912**								same as SO066, 248, 249, 387
TNTA-SO013	622924	1923123	183	101	660.1	640	20.10	0.62		0.13									same location as S250
TNTA-SO014	622915	1923140	184	102	660.5	640	20.50	0.63		0.43									same as SO014, 015, 245
TNTA-SO018	623184	1922684	176	97	650	637	13.00	0.48	1.23	0.275									same as SO018, 233, 234, 235
TNTA-SO020	623148	1922694	220	76	638	630	8.00	0.36					0.64						same as SO403, 404
TNTA-SO031	623269	1922822	178	96	646	637	9.00	0.39	0.079										
TNTA-SO035	623314	1922907	180	95	651.24	635	16.24	0.55	0.194	1.08									same as 327-330, 350
TNTA-SO040	623323	1923086	183	95	654.48	635	19.48	0.61			20.4		1.08						same as 292, 375, 376
TNTA-SO047	623485	1923488	189	92	651	635	16.00	0.54			0.11								same as 53, 391
TNTA-SO051	623510	1923527	190	92	651	635	16.00	0.54			0.241								same as 54,
TNTA-SO052	623547	1923490	189	91	651	635	16.00	0.54	0.172		0.189								same as 320
TNTA-SO053	623519	1923481	189	92	651	635	16.00	0.54			0.11								
TNTA-SO059	623015	1922917	180	100	658.6	640	18.60	0.59	0.086	0.341									same location as S321
TNTA-SO062	623116	1923300	186	98	659.29	638	21.29	0.64					3.53		30.9		59		same as 389, 390
TNTA-SO071	622390	1923341	187	110	653.8	647	6.80	0.33	0.217										
TNTA-SO077	623958	1922856	179	85	636.18	633	3.18	0.02	0.344										same location as SO218
TNTA-SO078	623403	1922581	174	94	639	635	4.00	0.05	4.59										same location as SO224
TNTA-SO080	623442	1922582	174	93	636.69	633	3.69	0.04	0.18		2.83						0.147		same location as SO222, 223, 309, 332, 383, 384
TNTA-SO081	623449	1922607	175	93	636.74	633	3.74	0.04			2.825								same location as SO081, 087, 225, 226, 310, 353, 383
TNTA-SO082	623401	1922606	175	94	639	635	4.00	0.05		0.106									same location as SO083, 232
TNTA-SO094	623221	1924923	214	97	653.42	637	16.42	0.55			0.072		51.5		38.1				same as 397, 398
TNTA-SO095	623223	1924901	213	97	653	643	10.00	0.41		0.373									
TNTA-SO097	623237	1924924	214	96	653	643	10.00	0.41			0.147								
TNTA-SO098	623238	1924902	213	96	653	643	10.00	0.41		0.825									
TNTA-SO103	623727	1925141	217	89	651	635	16.00	0.54	2.105	2.895	0.59								same as 284, 315, 416, 484
TNTA-SO104	623726	1925161	218	89	649.2	633	16.20	0.55	0.072		0.192								same as 417
TNTA-SO105	623763	1925105	217	88	649.35	637	12.35	0.47		0.228			344.5						same as 281, 283, 367, 368
TNTA-SO106	623734	1925074	216	88	650	637	13.00	0.48		4.07	1.25								same as 107, 288, 414
TNTA-SO109	623912	1924946	214	86	653.28	635	18.28	0.59		0.62	0.37		6				0.085		same as 111, 361
TNTA-SO110	623929	1924935	214	85	653	633	20.00	0.62	1.325		0.377								same as 305, 406
TNTA-SO114	624017	1924686	210	84	653.2	635	18.20	0.58					0.147						
TNTA-SO116	623947	1924687	210	85	653.2	635	18.20	0.58			13.85		0.54						same as 303
TNTA-SO121	624300	1925060	216	79	650	632	18.00	0.58					0.062				0.087		same as 365, 366
TNTA-SO123	624158	1925236	219	82	655.62	632	23.62	0.68	0.267	0.278	0.07	0.1335							same as 124, 125, 254, 323, 407
TNTA-SO126	624168	1925258	219	81	654.65	632	22.65	0.66	7.78	432.5		2.11	0.275				0.108		same as 127, 128, 253, 255, 259, 324, 325, 363, 364, 408, 409
TNTA-SO129	624156	1925286	220	82	655	632	23.00	0.67		0.0715	0.0625								same as 130

Table 2
Soil Sample Locations and Analytical Data for Nitroaromatic Compound (2,4,-DNT)
TNTA Area, Former Plum Brook Ordnance Works, Sandusky, Ohio

Location ID	Northing	Easting	Column #	Row #	Gnd_Elev (ft msl)	GW Elev. (ft msl) Estimated	DTW (ft) Estimated	α (ft)	Sample Depth (ft,blgs)										Comments
									0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	
TNTA-SO148	624524	1923827	195	76	632	629	3.00	0.02	0.158										
TNTA-SO164	624137	1924431	205	82	650	633	17.00	0.56	0.24										same as 166, 167
TNTA-SO203	624336	1924184	201	79	639	631	8.00	0.36	0.665		0.3825								same as 205, 261, 267, 268, 269, 418, 419
TNTA-SO207	624286	1924182	201	80	639	631	8.00	0.36		0.14									same as 208, 269
TNTA-SO212	624307	1924254	202	79	639	631	8.00	0.36		0.045	0.67								same as 213, 263, 372, 420-422
TNTA-SO218	623949	1922853	179	85	636	633	3.00	0.02		0.052									
TNTA-SO243	622929	1923171	184	101	660	644	16.00	0.54			0.229								
TNTA-SO264	624305	1924286	203	79	639	630	9.00	0.39		0.336									
TNTA-SO285	623711	1925073	216	89	650	639	11.00	0.43		2.67	1.01								same location as S415, 482
TNTA-SO291	623338	1923074	182	95	651	635	16.00	0.54			0.162								same as 296
TNTA-SO304	623959	1924676	209	85	653.3	633	20.30	0.62			0.07								
TNTA-SO348	623464	1923275	186	93	651	635	16.00	0.54				0.469							
TNTA-SO355	622501	1923302	186	108	655	650	5.00	0.12		0.7									same as 271
TNTA-SO358	622469	1923385	188	109	655	650	5.00	0.12		0.235									
TNTA-SO399	623734	1924758	211	88	655	635	20.00	0.62									0.77		
TNTA-SO413	623742	1925036	215	88	650	637	13.00	0.48		0.0765									
TNTA-SO422	624320	1924257	202	79	639	633	6.00	0.24		0.045									

Table 3
Soil Sample Locations and Analytical Data for Nitroaromatic Compound (2,6,-DNT)
TNTA Area, Former Plum Brook Ordnance Works, Sandusky, Ohio

Location ID	Northing	Easting	Column #	Row #	Gnd_Elev (ft msl)	GW Elev. (ft msl) Estimated	DTW (ft) Estimated	α (ft)	Sample Depth (ft,blgs) 0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	Comments
TNTA-S1	624547	1923783	194	75	632	629	5.00	0.12	4.9										
TNTA-S15	623337	1922879	179	95	650	636	14.00	0.50	1.3										same location as S16, 19, SO033, 034
TNTA-S20	623141	1922676	176	98	653.02	637	16.02	0.54	230		2.7		0.0555						same location as S13, S18, S19, S28, SO016, 017, 021, 022, 154, 155, 201, 238, 241, 242, 262, 263, 265, 266, 300, 311, 379, 380
TNTA-S21	622833	1922881	179	103	658	642	16.00	0.54		3.68									same location as S001, 003, 297, 300, 349, 377
TNTA-S22	622793	1922874	179	104	659.1	644.9	14.20	0.50	47										same location as SO299
TNTA-S23	622800	1922908	180	103	658	642	16.00	0.54	0.4										same location as S298
TNTA-S25	622475	1923331	187	109	653.5	646	7.50	0.35		**299**	**976.5**								same as 061, 068, 069, 160, 161, 275-280, 359, 385
TNTA-S30	622479	1923301	187	110	654	646	8.00	0.36		0.7									same as SO066, 067, 271, 272
TNTA-SO012	622906	1923105	183	102	660.14	630	30.14	0.78	5600		**10274**								same as SO066, 248, 249, 387
TNTA-SO013	622924	1923123	183	101	660.1	640	20.10	0.62		0.13									same location as S250
TNTA-SO014	622915	1923140	184	102	660.5	640	20.50	0.63		0.43									same as SO014, 015, 245
TNTA-SO018	623184	1922684	176	97	650	637	13.00	0.48	1.23	0.175									same as SO019, 233, 234, 235
TNTA-SO020	623148	1922694	220	76	638	630	8.00	0.36					0.064						same as SO403, 404
TNTA-SO031	623269	1922822	178	96	646	637	9.00	0.39	0.079										
TNTA-SO035	623314	1922907	180	95	651.24	635	16.24	0.55	0.194	1.08									same as 327-330, 350
TNTA-SO040	623323	1923086	183	95	654.48	635	19.48	0.61			40.8		1.08						same as 292, 375, 376
TNTA-SO047	623485	1923488	189	92	651	635	16.00	0.54			0.11								same as 53, 391
TNTA-SO051	623510	1923527	190	92	651	635	16.00	0.54			0.241								same as 54,
TNTA-SO052	623547	1923490	189	91	651	635	16.00	0.54	0.172		0.189								same as 320
TNTA-SO053	623519	1923481	189	92	651	635	16.00	0.54			0.11								
TNTA-SO059	623015	1922917	180	100	658.6	640	18.60	0.59	0.086	0.341									same location as S321
TNTA-SO062	623116	1923300	186	98	659.29	638	21.29	0.64					3.53		30.9		59		same as 389, 390
TNTA-SO071	622390	1923341	187	110	653.8	647	6.80	0.33	0.217										
TNTA-SO077	623958	1922856	179	85	636.18	633	3.18	0.02	0.344										same location as SO218
TNTA-SO078	623403	1922581	174	94	639	635	4.00	0.05	4.59										same location as SO224
TNTA-SO081	623449	1922607	175	93	636.74	633	3.74	0.04			2.825								same location as SO081, 087, 225, 226, 310, 353, 383
TNTA-SO082	623401	1922606	175	94	639	635	4.00	0.05		0.106									same location as SO083, 232
TNTA-SO094	623221	1924923	214	97	653.42	637	16.42	0.55			0.072		51.5		38.1				same as 397, 398
TNTA-SO095	623223	1924901	213	97	653	643	10.00	0.41		0.373									
TNTA-SO097	623237	1924924	214	96	653	643	10.00	0.41			0.147								
TNTA-SO098	623238	1924902	213	96	653	643	10.00	0.41		0.825									same as 099
TNTA-SO103	623727	1925141	217	89	651	635	16.00	0.54	2.105	2.895	0.59								same as 284, 315, 416, 484
TNTA-SO104	623726	1925161	218	89	649.2	633	16.20	0.55	0.072		0.192								same as 417
TNTA-SO105	623763	1925105	217	88	649.35	637	12.35	0.47		0.228			344.5						same as 281, 283, 367, 368
TNTA-SO106	623734	1925074	216	88	650	637	13.00	0.48		4.07	1.25								same as 107, 288, 414
TNTA-SO109	623912	1924946	214	86	653.28	635	18.28	0.59		0.62	0.37		6				0.085		same as 111, 361
TNTA-SO110	623929	1924935	214	85	653	633	20.00	0.62	1.325		0.377								same as 305, 406
TNTA-SO114	624017	1924686	210	84	653.2	635	18.20	0.58					0.147						

Table 3
Soil Sample Locations and Analytical Data for Nitroaromatic Compound (2,6,-DNT)
TNTA Area, Former Plum Brook Ordnance Works, Sandusky, Ohio

Location ID	Northing	Easting	Column #	Row #	Gnd_Elev (ft msl)	GW Elev. (ft msl) Estimated	DTW (ft) Estimated	α (ft)	Sample Depth (ft,blgs) 0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	Comments
TNTA-SO116	623947	1924687	210	85	653.2	635	18.20	0.58			13.85		0.54						same as 303
TNTA-SO121	624300	1925060	216	79	650	632	18.00	0.58					0.062				0.087		same as 365, 366
TNTA-SO123	624158	1925236	219	82	655.62	632	23.62	0.68	0.267	0.278	0.07	0.1335							same as 124, 125, 254, 323, 407
TNTA-SO126	624168	1925258	219	81	654.65	632	22.65	0.66	7.78	432.5		2.11	0.275				0.108		same as 127, 128, 253, 255, 259, 324, 325, 363, 364, 408, 409
TNTA-SO129	624156	1925286	220	82	655	632	23.00	0.67		0.0715	0.0625								same as 130
TNTA-SO148	624524	1923827	195	76	630.5	629	1.50	0.00	0.158										
TNTA-SO164	624137	1924431	205	82	650	633	17.00	0.56	0.24										same as 166, 167
TNTA-SO203	624336	1924184	201	79	639	631	8.00	0.36	0.665		0.3825								same as 205, 261, 267, 268, 269, 418, 419
TNTA-SO207	624286	1924182	201	80	639	631	8.00	0.36		0.14									same as 208, 269
TNTA-SO212	624307	1924254	202	79	639	631	8.00	0.36		0.045	0.67								same as 213, 263, 372, 420-422
TNTA-SO218	623949	1922853	179	85	635	633	2.00	0.00		0.052									
TNTA-SO222	623443	1922569	174	93	639	635	10.00	0.41	0.18		2.83						0.147		same location as SO080, 223, 309, 332, 383, 384
TNTA-SO243	622929	1923171	184	101	660	644	16.00	0.54			0.229								
TNTA-SO264	624305	1924286	203	79	639	630	9.00	0.39			0.336								
TNTA-SO285	623711	1925073	216	89	650	639	11.00	0.43		2.67	1.01								same location as S415, 482
TNTA-SO291	623338	1923074	182	95	651	635	16.00	0.54			0.324								same as 296
TNTA-SO304	623959	1924676	209	85	653.3	633	20.30	0.62			0.07								
TNTA-SO309	623442	1922582	209	85	653.3	633	20.30	0.62	0.18										
TNTA-SO348	623464	1923275	186	93	651	635	16.00	0.54				0.469							
TNTA-SO355	622501	1923302	186	108	655	650	5.00	0.12		0.7									same as 271
TNTA-SO358	622469	1923385	188	109	655	650	5.00	0.12		0.235									
TNTA-SO399	623734	1924758	211	88	655	635	20.00	0.62									0.77		
TNTA-SO413	623742	1925036	215	88	650	637	13.00	0.48		0.0765									
TNTA-SO422	624320	1924257	202	79	639	633	6.00	0.24		0.045									

Table 4
Soil Sample Locations and Analytical Data for Nitroaromatic Compound (2,4,6-TNT)
TNTB Area, Former Plum Brook Ordnance Works, Sandusky, Ohio

Location ID	Northing	Easting	Column #	Row #	Ground Elev (ft msl)	GW Elev. (ft msl) Estimated	DTW (ft) Estimated	α (ft)	Bldg #	New DTW (ft)	Remaining Conc. From Tom	Sample Depth (ft,blgs)										Comments
												0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	
PB-TNTB-S1	1910377	619640	124	169	661	657	3.90	0.046	**417**	**1.5**	**10.9**	12										same as SS050, 51, and 52
PB-TNTB-S2/S3	618668	1917759	125	170	663	657	5.50	0.169	**417**	**1.5**	**10.9**	1.6	2.7									same as S4, SS054
PB-TNTB-S4	1911507	621486	124	170	663	657	6.00	0.236	**417**	**1.5**	**10.9**	5	8.8									same as SS048, SS048,049, 242, 243and 284
PB-TNTB-S5/S6	618178	1918058	130	178	669	662	6.95	0.333	**466**	**4.5**	**ND**		1.5	51								same as S6, SS003,004, 073, 076, 077, 078, 079 and 376
PB-TNTB-S7	618163	1918117	131	178	669	662	7.09	0.336	**466**	**4.5**	**ND**		1.9	910								same as SS074, and 309
PB-TNTB-S9	618361	1918588	137	175	670	662	8.00	0.361	**456**	**4**	**ND**	6.9	2.3									same as SS031, SS173,182, 213, 216, 219, and 220
PB-TNTB-S10	618323	1918633	138	175	669	662	7.00	0.334	**456**	**4**	**ND**			0.9								same as S11, SO05,SO09, 14, 24, 27, 28, SS174-176, 210, 211, 212, 215, 217, 221, 222, 224-226,
PB-TNTB-S12	618302	1918648	138	176	669	662	7.00	0.334	**456**	**4**	**ND**	3.9										same as S13, SO029, SS223, 292,nd SS327-329
PB-TNTB-S17	618135	1918883	140	178	676	662	14.10	0.503	**453**	**8.5**	**ND**	390				2200						same as SO06, SS268, and 379
PB-TNTB-S18	618043	1918674	138	180	683	663	19.64	0.610	**452**	**10**	**76**	29000										same as S28
PB-TNTB-S23	617836	1918781	139	183	677	663	13.89	0.498				0.3										same as S21, S22, SS139, 270, and SS384
PB-TNTB-S24	617130	1918387	135	194	670	662	8.00	0.361	**412 A**	**6**	**ND**	0.8										same as S25, and SS387
PB-TNTB-SO001	618437	1918703	138	173	667	662	8.00	0.361				0.05										same as SS247 249, 401, and 402
PB-TNTB-SO002	617617	1918323	134	187	676	664	12.00	0.458							0.27							
PB-TNTB-SO007	618014	1917618	122	180	682	663	18.90	0.597	**473**	**10**	**4.44**				5.8							same as SS021, SS022, SO037, SS320, 397
TNTB-B463new	618022	1917878	127	180	676	662	14.00	0.501	**463**	**10**	**80.9**											
PB-TNTB-SO008	617927	1917963	128	182	676	662	14.00	0.501	**462**	**8**	**ND**	0.87						11				same as SS087, 088, 090, 245, 246
PB-TNTB-SO010	618007	1917813	126	180	676	662	14.00	0.501	**463**	**10**	**24**	0.4				1.6				46		same as SO11, SO36, SS061, and 389
PB-TNTB-SO012	617920	1917463	120	180	677	663	14.20	0.505	**472**	**5**	**ND**					27						same as SO40, SS017, SS008, 018, 390, 393-395
PB-TNTB-SO013	618054	1918677	138	180	677	663	14.20	0.505	**452**	**10**	**76**	66				6100				76		same as S18, 19, 20, SS151, 153, 154, 155, 258, 262, 263, 265, 266, 300, 375, and 380
PB-TNTB-SO015	618487	1917728	124	173	665	660	5.00	0.118				4.35										same as SO16, SS057, SS237,238, 239, and 336
PB-TNTB-SO017	618487	1917748	125	173	665	660	5.00	0.118				6.1										same as SS239
PB-TNTB-SO018	618612	1917683	124	171	661	658	4.00	0.050				2.9			0.28							same as SO19, SS047, SS282,and 362
PB-TNTB-SO020	618137	1917408	119	178	669	662	7.00	0.334	**476**	**3**	**ND**	720										SO21, 22, SS038, 235, 236, 310 to 315, 317, 318, 335
PB-TNTB-SO023	618064	1918677	138	179	680	662	18.00	0.580				33										same as SS290, 324, 325
PB-TNTB-SO026	618232	1917988	129	177	669	662	6.50	0.320	**466**	**7.5**	**ND**	23										SS025, 066, 080, 207, 208, 288, 289
PB-TNTB-SO030	617559	1917724	124	187	672	665	7.24	0.341				0.56										
PB-TNTB-SO032	618492	1918874	140	173	668	660	8.17	0.366	**466**	**7.5**	**ND**	7.6										same as SS183, 185, 230, and 231
PB-TNTB-SO035	618192	1918043	130	177	669	661	8.00	0.361	**466**	**7.5**	**ND**	7.6										same as SS069, 071, 232, and 333
PB-TNTB-SO038	617990	1917591	122	181	682	663	18.90	0.597				0.78										
PB-TNTB-SS020	618012	1917643	123	180	680	663	16.50	0.551							5.2							same as SS0021, 388, and 396
PB-TNTB-SS025	617572	1917588	122	187	678	665	13.00	0.479				0.01										
PB-TNTB-SS027	617587	1917658	123	187	672	665	7.00	0.334				0.14										same as SS035
PB-TNTB-SS039	618137	1917448	120	178	669	662	7.00	0.334				0.69										same as SS040
PB-TNTB-SS042	618252	1917735	124	176	670	661	9.00	0.387				0.2										
PB-TNTB-SS044	618313	1917735	124	175	670	661	9.00	0.387				0.06										
PB-TNTB-SS046	618232	1917853	126	177	669	662	7.20	0.340				0.1										same as SS195
PB-TNTB-SS055	618617	1917763	125	171	662	659	3.00	0.017				0.46										

Table 4
Soil Sample Locations and Analytical Data for Nitroaromatic Compound (2,4,6-TNT)
TNTB Area, Former Plum Brook Ordnance Works, Sandusky, Ohio

Location ID	Northing	Easting	Column #	Row #	Ground Elev (ft msl)	GW Elev. (ft msl) Estimated	DTW (ft) Estimated	α (ft)	Bldg #	New DTW (ft)	Remaining Conc. From Tom	Sample Depth (ft,blgs) 0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	Comments
PB-TNTB-SS056	618517	1917663	124	172	662	659	3.00	0.017				0.01										
PB-TNTB-SS058	618517	1917763	125	172	662	659	3.00	0.017				0.76										
PB-TNTB-SS059	618027	1917793	125	180	679	664	15.00	0.521				0.5			0.28							same as SS060, 062, and 398
PB-TNTB-SS063	618062	1917783	125	179	679	664	14.80	0.517				0.43										same as SS064
PB-TNTB-SS065	618227	1917953	128	177	669	662	7.20	0.340				0.2										same as 197
PB-TNTB-SS067	618227	1918038	130	177	669	662	6.50	0.320				0.72										
PB-TNTB-SS081	617942	1917963	128	181	677	663	14.00	0.501	**462**	**8**	**ND**	0.37										same as SS322 and 392
PB-TNTB-SS082	617932	1917981	129	182	676	663	13.00	0.479				0.01										same as SS083-86
PB-TNTB-SS091	617737	1917963	128	185	677	664	13.00	0.479				2.4										same as SS092, to 095, 247 to 250, and 391
PB-TNTB-SS096	617542	1918068	130	188	671	665	6.30	0.284				0.39										same as SS102 and 106
PB-TNTB-SS098	617522	1918098	131	188	671	665	6.30	0.284				0.01										
PB-TNTB-SS105	617722	1918038	130	185	677	664	13.00	0.479				0.01										
PB-TNTB-SS122	617567	1918348	135	187	673	665	7.50	0.348				0.15										
PB-TNTB-SS123	617552	1918338	135	188	672	665	7.00	0.334				0.01										
PB-TNTB-SS127	617712	1918553	137	185	671	664	6.60	0.323				0.09										
PB-TNTB-SS130	617662	1918583	137	186	671	664	6.60	0.323				0.01										
PB-TNTB-SS155	618037	1918653	125	171	663	659	4.00	0.050				0.2										
PB-TNTB-SS161	618022	1918618	137	180	678	664	14.00	0.501				0.32										same as SS162
PB-TNTB-SS171	618387	1918723	138	174	667	661	6.00	0.236				0.12										same as SS296
PB-TNTB-SS177	618297	1918618	137	176	669	662	7.00	0.334	**456**	**4**	**ND**	3.5										same as 178, 180, and 330
PB-TNTB-SS192	617507	1917963	128	188	671	665	6.30	0.284				0.01										
PB-TNTB-SS194	617970	1918616	137	181	677	663	14.00	0.501				0.01										
PB-TNTB-SS196	618252	1917853	126	176	669	661	8.20	0.366				0.68										
PB-TNTB-SS198	618247	1917953	128	176	669	661	8.00	0.361				0.36										
PB-TNTB-SS199	617467	1918448	136	189	672	665	6.80	0.328				0.31										
PB-TNTB-SS204	618247	1917913	127	176	669	661	8.20	0.366				0.3										
PB-TNTB-SS205	618237	1917913	127	177	669	661	8.20	0.366				0.89										same as 206
PB-TNTB-SS241	618697	1917743	125	169	661	658	3.00	0.017				0.08										
PB-TNTB-SS278	618439	1918273	133	173	671	660	11.40	0.444				0.23										
PB-TNTB-SS279	618219	1918263	133	177	669	661	7.50	0.348				0.21										
PB-TNTB-SS281	617467	1918163	132	189	671	665	6.30	0.284				0.36										
PB-TNTB-SS283	618517	1917728	124	172	663	659	3.50	0.030				0.45										
PB-TNTB-SS321	618005	1917712	124	180	679	662	17.00	0.561				0.09										
PB-TNTB-SS334	618137	1917998	129	178	670	663	7.00	0.334				0.78										
PB-TNTB-SS370	618172	1918458	136	178	670	661	9.00	0.387						0.52		25						
PB-TNTB-SS371	618394	1918398	136	174	667	660	6.80	0.328						0.07		0.5						

Table 5
Soil Sample Locations and Analytical Data for Nitroaromatic Compound (2,4,-DNT)
TNTB Area, Former Plum Brook Ordnance Works, Sandusky, Ohio

Location ID 259	Northing	Easting	Column #	Row #	Gnd_Elev (ft msl)	GW Elev. (ft msl) Estimated	DTW (ft) Estimated	α (ft)	Bldg #	New DTW (ft)	remaining Conc.	Sample Depth (ft,blgs) 0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	Comments
PB-TNTB-S1	1910377	619640	124	169	660.9	657	3.90	0.05	**417**	**1.5**	**ND**	12										same as SS050, 51, and 52
PB-TNTB-S2/S3	618668	1917759	125	170	662.5	657	5.50	0.17	**417**	**1.5**	**ND**	1.6	2.7									same as S4, SS054
PB-TNTB-S4	1911507	621486	124	170	663	657	6.00	0.24	**417**	**1.5**	**ND**	5	8.8									same as SS048, SS048,049, 242, 243and 284
PB-TNTB-S5/S6	618178	1918058	130	178	668.95	662	6.95	0.33	**466**	**4.5**	**ND**		1.5	51								same as S6, SS003,004, 073, 076, 077, 078, 079 and 376
PB-TNTB-S7	618163	1918117	131	178	669.09	662	7.09	0.34	**466**	**4.5**	**ND**		1.9	910								same as SS074, and 309
PB-TNTB-S9	618361	1918588	137	175	670	662	8.00	0.36	**456**	**4**	**ND**	6.9	2.3									same as SS031, SS173,182, 213, 216, 219, and 220
PB-TNTB-S10	618323	1918633	138	175	669	662	7.00	0.33	**456**	**4**	**ND**			0.9								same as S11, SO05,SO09, 14, 24, 27, 28, SS174-176, 210, 211, 212, 215, 217, 221,
PB-TNTB-S17	618135	1918883	140	178	676.1	662	14.10	0.50	**453**	**8.5**	**ND**	390				2200						same as SO06, SS268, and 379
PB-TNTB-S18	623121	1922699	176	98	653.02	637	16.02	0.54	**452**	**10**	**ND**	810										same location as S13, S18, S19, S28, SO016, 017, 021, 022, 154, 155, 201,
PB-TNTB-S23	617836	1918781	139	183	676.89	663	13.89	0.50				1.1										same as S21, S22, SS139, 270, and SS384
PB-TNTB-S24	617130	1918387	135	194	670	662	8.00	0.36	**412 A**	**6**	**75**	**11000**										same as S25, and SS387
PB-TNTB-S26	617132	1918408	136	194	670	662	8.00	0.36	**412 A**	**6**	**75**	7700										
PB-TNTB-SO001	618437	1918703	138	173	666.8	662	4.80	0.10				0.05										same as SS247 249, 401, and 402
PB-TNTB-SO002	617617	1918323	134	187	676	664	12.00	0.46							0.27							
PB-TNTB-SO007	618014	1917618	122	180	681.9	663	18.90	0.60	**473**	**10**	**ND**				5.8							same as SS021, SS022, SO037, SS320, 397
PB-TNTB-SO008	617927	1917963	128	182	676	662	14.00	0.50	**462**	**8**	**ND**							3.2				same as SS087, 088, 090, 245, 246
PB-TNTB-SO010	618007	1917813	126	180	676	662	14.00	0.50	**463**	**10**	**240**	0.057								254.5		same as SO11, SO36, SS061, and 389
PB-TNTB-SO012	617920	1917463	120	180	677.2	663	14.20	0.50	**472**	**5**	**ND**	0.26				4.4						same as SO40, SS017, SS008, 018, 390, 393-395
PB-TNTB-SO013	618054	1918677	138	180	677.2	663	14.20	0.50	**452**	**10**	**ND**					2400						same as S18, 19, 20, SS151, 153, 154, 155, 258, 262, 263, 265, 266, 300, 375, and 380
PB-TNTB-SO015	618487	1917728	124	173	665	660	5.00	0.12				0.39										same as SO16, SS057, SS237,238, 239, and 336
PB-TNTB-SO017	618487	1917748	125	173	665	660	5.00	0.12				0.76										same as SS239
PB-TNTB-SO018	618612	1917683	124	171	661.1	659	2.10	0.00				0.059										same as SO19, SS047, SS282,and 362
PB-TNTB-SO020	618137	1917408	119	178	669	662	7.00	0.33	**476**	**3**	**ND**	0.41										SO21, 22, SS038, 235, 236, 310 to 315, 317, 318, 335
PB-TNTB-SO023	618064	1918677	138	179	680	662	18.00	0.58				1.3										same as SS290, 324, 325
PB-TNTB-SO032	618492	1918874	140	173	668.17	660	8.17	0.37	**NE Nail House**	**3.5**	**ND**	0.38										same as SS183, 185, 230, and 231
PB-TNTB-SO035	618192	1918043	130	177	669	661	8.00	0.36	**466**	**7.5**	**ND**	1.6										same as SS069, 071, 232, and 333
PB-TNTB-SO038	617990	1917591	122	181	681.9	663	18.90	0.60				0.34										
PB-TNTB-SS002	617692	1917493	120	183	677	663	14.00	0.50				0.11										
PB-TNTB-SS013	617862	1917498	120	185	678.6	664	14.60	0.51				0.01										
PB-TNTB-SS020	618012	1917643	123	180	679.5	663	16.50	0.55				0.83										same as SS0021, 388, and 396
PB-TNTB-SS091	617737	1917963	128	185	677	664	13.00	0.48				6.2										same as SS092, to 095, 247 to 250, and 391
PB-TNTB-SS096	617542	1918068	130	188	671.3	665	6.30	0.28				2.6										same as SS102 and 106
PB-TNTB-SS098	617522	1918098	131	188	671.3	665	6.30	0.28				4.8										
PB-TNTB-SS111	617107	1918418	136	195	672	666	6.00	0.24	**412 B**	**6**	**ND**	9.7										
PB-TNTB-SS114	617117	1918353	135	195	671	665.5	5.50	0.17	**412 C**	**6**	**9.03**	23										
PB-TNTB-SS278	618439	1918273	133	173	671.4	660	11.40	0.44				7.6										
TNTB-B463new	618022	1917878	127	180	676	662	14.00	0.50	**463**	**10**	**7.4**											

Table 6
Soil Sample Locations and Analytical Data for Nitroaromatic Compound (2,6,-DNT)
TNT B Area, Former Plum Brook Ordnance Works, Sandusky, Ohio

Location ID	Northing	Easting	Column #	Row #	Gnd_Elev (ft msl)	GW Elev. (ft msl) Estimated	DTW (ft) Estimated	α (ft)	Bldg #	New DTW (ft)	Remaining Conc.	Sample Depth (ft,blgs) 0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	Comments
PB-TNTB-S1	1910377	619640	124	169	661	657	5.00	0.12	**417**	**1.5**	**ND**	12	5.6									same as SS050, 51, and 52
PB-TNTB-S2/S3	618668	1917759	125	170	663	657	5.50	0.17	**417**	**1.5**	**ND**	1.6	2.7									same as S4, SS054
PB-TNTB-S4	1911507	621486	124	170	663	657	6.00	0.24	**417**	**1.5**	**ND**	5	8.8									same as SS048, SS048,049, 242, 243and 284
PB-TNTB-S5/S6	618178	1918058	130	178	669	662	6.95	0.33	**466**	**4.5**	**ND**		1.5	51								same as S6, SS003,004, 073, 076, 077, 078, 079 and 376
PB-TNTB-S7	618163	1918117	131	178	669	662	7.09	0.34	**466**	**4.5**	**ND**		1.9	910								same as SS074, and 309
PB-TNTB-S9	618361	1918588	137	175	670	662	8.00	0.36				6.9	2.3									same as SS031, SS173,182, 213, 216, 219, and 220
PB-TNTB-S10	618323	1918633	138	175	669	662	7.00	0.33						0.9								same as S11, SO05,SO09, 14, 24, 27, 28, SS174-176, 210, 211, 212, 215, 217, 221, 222, 224-226,
PB-TNTB-S12	618302	1918648	138	176	669	662	7.00	0.33														same as S13, SO029, SS223, 292,nd SS327-329
PB-TNTB-S17	618135	1918883	140	178	676	662	14.10	0.50	**453**	**8.5**	**ND**	390				2200						same as SO06, SS268, and 379
PB-TNTB-S18	623121	1922699	176	98	653	637	16.02	0.54	**452**	**10**	**ND**	230										same location as S13, S18, S19, S28, SO016, 017, 021, 022, 154, 155, 201, 238, 241, 242, 262, 263, 265, 266,
PB-TNTB-S23	617836	1918781	139	183	677	663	13.89	0.50				2.2										same as S21, S22, SS139, 270, and SS384
PB-TNTB-S24	617130	1918387	135	194	670	662	8.00	0.36	**412 A**	**6**	**0.9**	**12000**										same as S25, and SS387
PB-TNTB-S26	617132	1918408	136	194	670	662	8.00	0.36	**412 A**	**6**	**0.9**	8300										same as SS305
PB-TNTB-SO001	618437	1918703	138	173	667	662	4.80	0.10				0.05										same as SS247 249, 401, and 402
PB-TNTB-SO002	617617	1918323	134	187	676	664	12.00	0.46							0.27							
PB-TNTB-SO007	618014	1917618	122	180	682	663	18.90	0.60	**473**	**10**	**ND**				5.8							same as SS021, SS022, SO037, SS320, 397
PB-TNTB-SO008	617927	1917963	128	182	676	662	14.00	0.50	**462**	**8**	**ND**							1				same as SS087, 088, 090, 245, 246
PB-TNTB-SO010	618007	1917813	126	180	676	662	14.00	0.50	**463**	**7.5**	**180**									180		same as SO11, SO36, SS061, and 389
PB-TNTB-SO013	618054	1918677	138	180	677	663	14.20	0.50	**452**	**10**	**ND**					1500						same as S18, 19, 20, SS151, 153, 154, 155, 258, 262, 263, 265, 266, 300, 375, and 380
PB-TNTB-SO015	618487	1917728	124	173	665	660	5.00	0.12				0.093										same as SO16, SS057, SS237,238, and 336
PB-TNTB-SO020	618137	1917408	119	178	669	662	7.00	0.33	**476**	**3**	**ND**	0.044										SO21, 22, SS038, 235, 236, 310 to 315, 317, 318, 335
PB-TNTB-SO035	618192	1918043	130	177	669	661	8.00	0.36	**466**	**7.5**	**ND**	0.28										same as SS069, 071, 232, and 333
PB-TNTB-SS114	617117	1918353	135	195	671	666	5.50	0.17	**412 C**	**6**	**7.44**	7.44										

Table 7
Soil Sample Locations and Analytical Data for Nitroaromatic Compound (TNT)
TNTC Area, Former Plum Brook Ordnance Works, Sandusky, Ohio

Location ID	Northing	Easting	Column #	Row #	Ground Elev (ft msl)	GW Elev. (ft msl) Estimated	DTW (ft) Estimated	α (ft)	Input File Name	Bldg #	New DTW (ft)	Remaining Conc. From Tom	Sample Depth (ft,blgs)										Comments
													0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	
TNTC-SO001	619782	1913168	79	152	673	662	11.30	0.44	TNT-1C.INP	689	8	ND	4.76				1.96						same as 249, 401, 402
TNTC-SO015	619871	1912606	70	150	676	661	15.50	0.53	TNT-1C.INP					0.197		0.288							same as 277
TNTC-SO026	619955	1912015	60	149	679	657	22.50	0.66	TNT-1C.INP					0.127									same as 030
TNTC-SO051	619640	1910377	32	154	677	655	21.80	0.65	TNT-1C.INP						0.82								same as 054
TNTC-SO065	619784	1910176	29	152	669	655	13.65	0.49	TNT-1C.INP	629	10	ND	0.442										same as 066, 269, 272, 278, 363, 364
TNTC-SO071	620304	1910619	36	143	655	650	5.00	0.12	TNT-4C.INP						0.878								same as 072
TNTC-SO074	620326	1910527	35	143	654	650	6.00	0.24	TNT-4C.INP	626	8	ND		3.87	1.41		0.259						same as 075, 395
TNTC-SO085	620237	1911076	44	144	655	651	4.00	0.05	TNT-4C.INP						5.9								same as 085, 093, 096
TNTC-SO098	620517	1911087	44	140	655	649	6.00	0.24	TNT-5C.INP	616	8	ND		1.07									same as 110, 262-264
TNTC-SO100	620500	1911118	45	140	654	648	5.81	0.21	TNT-2C.INP	616	8	ND			2226								same as 251, 252, 253, 317, 361, 362
TNTC-SO104	620462	1911172	46	141	657	650	7.00	0.33	TNT-2C.INP	616	8	ND			0.194								
TNTC-SO106	620475	1911121	45	141	657	650	7.00	0.33	TNT-2C.INP	616	8	ND		1.13									same as 254, 258
TNTC-SO107	620480	1911094	44	141	657	648	10.00	0.41	TNT-5C.INP	616	8	ND		2.73		39.9		5.44			15.1		same as 108, 123, 261, 379, 380
TNTC-SO120	620303	1911568	53	143	666	652	14.00	0.50	TNT-5C.INP	603	8	ND		1.38									same as 125
TNTC-SO134	620311	1911785	56	143	668	650	18.23	0.58	TNT-2C.INP	602	6	ND	1.03					0.395					same as 135, 331,377
TNTC-SO137	620871	1912711	72	134	647	644	3.40	0.03	TNT-2C.INP				0.677										same as 141
TNTC-SO138	620840	1912712	72	135	648	644	3.50	0.03	TNT-3C.INP				0.25										
TNTC-SO143	620400	1912951	76	142	655	652	3.00	0.02	TNT-3C.INP	686	4	ND		0.139	9.19								same as 144
TNTC-SO145	620398	1913031	77	142	655	652	4.00	0.05	TNT-5C.INP	686	4	ND	5067	2588	0.132								same as 151, 301, 303-305, 325
TNTC-SO146	620389	1913056	78	142	657	654	3.00	0.02	TNT-5C.INP	686	4	ND	159	8.33									same as 147, 149, 150, 306, 307, 330
TNTC-SO148	620402	1913116	79	142	658	654	4.00	0.05	TNT-3C.INP				1.64										
TNTC-SO152	620438	1912984	76	141	658	653	5.00	0.12	TNT-3C.INP	686	4	ND			0.692								
TNTC-SO157	620154	1912987	76	146	671	657	13.90	0.50	TNT-6C.INP	682	4	ND		8.35									same as 309-311, 369
TNTC-SO158	620155	1913006	77	146	671	657	13.90	0.50	TNT-6C.INP	682	4	ND		0.463									
TNTC-SO165	620182	1913008	77	145	669	657	11.55	0.45	TNT-6C.INP	682	8	ND	**54969**	1343			3.43				4.14		same as 280, 312-314, 367, 368
TNTC-SO171	620231	1912827	74	145	666	657	10.00	0.41	TNT-6C.INP	683	9	ND					448				173		same as 399, 400
TNTC-SO173	620256	1912537	69	144	666	655	11.35	0.44	TNT-6C.INP	693	7	ND		0.224							0.33		same as 175, 407, 408
TNTC-SO178	620506	1912291	65	140	655	652	10.00	0.41	TNT-7C.INP	696	12	ND	878		251								same as191, 192, 291-295, 326-328. 333, 374
TNTC-SO179	620480	1912297	65	141	655	652	3.00	0.02	TNT-3C.INP	696	12	ND		1.37									
TNTC-SO184	620493	1912462	67	140	655	652	3.00	0.02	TNT-9C.INP					0.253									same as185
TNTC-SO186	620502	1912395	66	140	655	652	3.00	0.02	TNT-7C.INP	696	12	ND	2.75	13.9									same as187, 189, 190, 288-290, 295
TNTC-SO193	620625	1911754	55	138	650	647	3.00	0.02	TNT-4C.INP					0.29									same as195
TNTC-SO198	620564	1911771	56	139	652	647	5.00	0.12	TNT-4C.INP	606	7	ND		0.884									
TNTC-SO200	620565	1911808	57	139	654	649	5.00	0.12	TNT-7C.INP				0.638	0.289									same as 205
TNTC-SO202	620536	1911868	58	140	655	650	10.00	0.41	TNT-7C.INP				0.569	1.42			0.233				0.213		same as 203, 381, 382
TNTC-SO218	621420	1911523	52	125	644	638	5.70	0.19	TNT-7C.INP				0.56			0.489		0.367					same as 222, 225, 365, 366
TNTC-SO228	620290	1912340	65	144	670	655	15.00	0.52	TNT-8C.INP	692	8	ND		489									same as 229, 243, 244, 279, 284
TNTC-SO231	620253	1912367	66	144	670	655	15.00	0.52	TNT-8C.INP	692	8	ND		1319			0.213						same as 241, 283, 284, 285, 286, 320, 405
TNTC-SO235	620091	1910655	37	147	665	651	14.00	0.50	TNT-8C.INP					2.98									same as 236

Table 7
Soil Sample Locations and Analytical Data for Nitroaromatic Compound (TNT)
TNTC Area, Former Plum Brook Ordnance Works, Sandusky, Ohio

Location ID	Northing	Easting	Column #	Row #	Ground Elev (ft msl)	GW Elev. (ft msl) Estimated	DTW (ft) Estimated	α (ft)	Input File Name	Bldg #	New DTW (ft)	Remaining Conc. From Tom	Sample Depth (ft,blgs)										Comments
													0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	
TNTC-SO281	620224	1913088	78	145	670	665	5.00	0.12	TNT-8C.INP	682	8	ND	47.5										
TNTC-SO302	620426	1913019	77	141	658	654	10.00	0.41	TNT-9C.INP	686	4	ND	902	22.5			0.192				0.555		same as 324, 335, 336, 371, 372
TNTC-SO321	619963	1910507	35	149	670	652	18.00	0.58	TNT-9C.INP					0.172									
TNTC-SO383	619869	1911170	46	150	679	654	24.66	0.70	TNT-9C.INP								0.662						

Table 8
Soil Sample Locations and Analytical Data for Nitroaromatic Compound (2,4,-DNT)
TNTC Area, Former Plum Brook Ordnance Works, Sandusky, Ohio

Location ID	Northing	Easting	Column #	Row #	Gnd_Elev	GW Elev.	DTW	α		Bldg #	New DTW (ft)	remaining Conc.	Sample Depth (ft,blgs)										Comments
													0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	
TNTC-S8	620601	1910719	38	139	650	646	4.00	0.05	3				7.6										
TNTC-S16	620369	1911120	45	142	655	650	5.00	0.12	4				1										
TNTC-S22	620250	1910713	38	144	658	650	8.00	0.36	5				8.7										same as 240 and 274
TNTC-S26	620298	1911325	48	144	665	652	13.00	0.48	6				0.3										
TNTC-SO001	619782	1913168	79	152	673.30	662	11.30	0.44	7	689	8	ND	4.16				1.825						same as 249, 401, 402
TNTC-SO002	619823	1913196	80	151	676.50	662	14.50	0.51	8				0.136										
TNTC-SO005	619823	1913141	79	151	676.50	662	14.50	0.51	9				0.152										
TNTC-SO007	619803	1912939	75	151	676.00	662	14.00	0.50	10								0.448				0.07		same as 397, 398
TNTC-SO015	619871	1912606	70	150	676.00	660.5	15.50	0.53	11					0.184		0.095							same as 277
TNTC-SO016	619897	1912639	71	150	676.00	660.5	15.50	0.53	12					0.064	0.32	0.095	0.079						same as 017, 409
TNTC-SO019	619867	1912352	66	150	681.10	660	21.10	0.64	13				0.153										
TNTC-SO026	619955	1912015	60	149	679.00	656.5	22.50	0.66	14					0.081									same as 030
TNTC-SO036	619927	1911774	56	150	680.00	655	25.00	0.70	15				0.073										
TNTC-SO044	619892	1910947	42	150	675.70	655	20.70	0.63	16					0.082									same as 048
TNTC-SO046	619840	1910943	42	151	675.70	655	20.70	0.63	17					0.061									
TNTC-SO051	619640	1910377	32	154	676.80	655	21.80	0.65	18					0.068	0.18								same as 054
TNTC-SO065	619784	1910176	29	152	668.65	655	13.65	0.49	19	629	10	ND	0.705	0.169	20.4			259.5			22.8		same as 066, 269, 272, 278, 363, 364
TNTC-SO078	620294	1910486	34	144	655.00	650	5.00	0.12	20					0.111									
TNTC-SO084	620376	1910525	35	142	654.06	650	4.06	0.05	21				0.116										
TNTC-SO085	620237	1911076	44	144	655.00	651	4.00	0.05	22					0.096									same as 085, 093, 096
TNTC-SO098	620517	1911087	44	140	655.00	649	6.00	0.24	23	616	8	ND		0.061									same as 110, 262-264
TNTC-SO107	620480	1911094	44	141	657.00	648	10.00	0.41	24	616	8	ND						4.45			28.05		same as 108, 123, 261, 379, 380
TNTC-SO120	620303	1911568	53	143	666.00	652	14.00	0.50	25	603	8	ND		0.151									same as 125
TNTC-SO134	620311	1911785	56	143	668.23	650	18.23	0.58	26	602	6	ND	0.366		0.645			1.695					same as 135, 331,377
TNTC-SO145	620398	1913031	77	142	659.00	654.5	4.50	0.08	27	686	4	ND	0.795	0.074									same as 151, 301, 303-305, 325
TNTC-SO146	620389	1913056	78	142	657.00	654	3.00	0.02	28	686	4	ND	1.135										same as 147, 149, 150, 306, 307, 330
TNTC-SO157	620154	1912987	76	146	670.90	657.00	13.90	0.50	29	682	4	ND	0.137	0.69			0.091						same as 309-311, 369
TNTC-SO158	620155	1913006	77	146	670.90	657.00	13.90	0.50	30	682	4	ND		0.105									
TNTC-SO165	620182	1913008	77	145	668.55	657.00	11.55	0.45	31	682	4	ND	11.05	0.314	0.062						0.097		same as 280, 312-314, 367, 368
TNTC-SO171	620231	1912827	74	145	666.02	657.00	9.02	0.39	32	683	9	ND					118				23.9		same as 399, 400
TNTC-SO173	620256	1912537	69	144	666.35	655	11.35	0.44	33	693	7	ND		0.144			0.072				0.412		same as 175, 407, 408
TNTC-SO178	620506	1912291	65	140	655.00	652	10.00	0.41	34	696	12	ND	1.85		0.353						0.063		same as191, 192, 291-295, 326-328. 333, 374
TNTC-SO186	620502	1912395	66	140	655.00	652	3.00	0.02	35	696	12	ND		0.096									same as187, 189, 190, 288-290, 295
TNTC-SO200	620565	1911808	57	129	654.00	649	5.00	0.12	36				0.078										same as 205
TNTC-SO215	620869	1910525	35	134	648.00	645	3.00	0.02	37				0.066										
TNTC-SO218	621420	1911523	52	125	643.70	638	5.70	0.19	38							0.474							same as 222, 225, 365, 366
TNTC-SO228	620290	1912340	65	144	670.00	655	15.00	0.52	39	692	8	ND		493									same as 229, 243, 244, 279, 284
TNTC-SO231	620253	1912367	66	144	670.00	655	15.00	0.52	40	692	8	ND		320			0.213						same as 241, 283, 284, 285, 286, 320, 405
TNTC-SO235	620091	1910655	37	147	665.00	651	14.00	0.50	41					0.505									same as 236
TNTC-SO238	620132	1910613	37	146	660.00	650	10.00	0.41	42					0.063									
TNTC-SO281	620224	1913088	78	145	670.00	665	5.00	0.12	43				0.433										
TNTC-SO383	619869	1911170	46	150	678.66	654	24.66	0.70	44								1.69						

Table 9
Soil Sample Locations and Analytical Data for Nitroaromatic Compound (2,6,-DNT)
TNTC Area, Former Plum Brook Ordnance Works, Sandusky, Ohio

Location ID	Northing	Easting	Column #	Row #	Gnd_Elev (ft msl)	GW Elev. (ft msl) Estimated	DTW (ft) Estimated	α (ft)	Bldg #	New DTW (ft)	Remaining Conc.	Sample Depth (ft,blgs) 0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	Comments
TNTC-S8	620601	1910719	38	139	650	646	4.00	0.05				1.9										
TNTC-S16	620369	1911120	45	142	655	650	5.00	0.12				1										
TNTC-S22	620250	1910713	38	144	658	650	8.00	0.36				1										same as 240 and 274
TNTC-S26	620298	1911325	48	144	665	652	13.00	0.48				0.5										
TNTC-SO001	619782	1913168	79	152	673.30	662	11.30	0.44	689	8	ND	4.16				1.825						same as 249, 401, 402
TNTC-SO002	619823	1913196	80	151	676.50	662	14.50	0.51				0.136										
TNTC-SO005	619823	1913141	79	151	676.50	662	14.50	0.51				0.152										
TNTC-SO007	619803	1912939	75	151	676.00	662	14.00	0.50								0.448				0.07		same as 397, 398
TNTC-SO015	619871	1912606	70	150	676.00	660.5	15.50	0.53					0.184		0.095							same as 277
TNTC-SO016	619897	1912639	71	150	676.00	660.5	15.50	0.53					0.064	0.32	0.095	0.079						same as 017, 409
TNTC-SO019	619867	1912352	66	150	681.10	660	21.10	0.64				0.153										
TNTC-SO026	619955	1912015	60	149	679.00	656.5	22.50	0.66					0.081									same as 030
TNTC-SO036	619927	1911774	56	150	680.00	655	25.00	0.70				0.073										
TNTC-SO044	619892	1910947	42	150	675.70	655	20.70	0.63					0.082									same as 048
TNTC-SO046	619840	1910943	42	151	675.70	655	20.70	0.63					0.061									
TNTC-SO051	619640	1910377	32	154	676.80	655	21.80	0.65					0.068	0.18								same as 054
TNTC-SO065	619784	1910176	29	152	668.65	655	13.65	0.49	629	10	ND	0.705	0.169	20.4			259.5			22.8		same as 066, 269, 272, 278, 363, 364
TNTC-SO078	620294	1910486	34	144	655.00	650	5.00	0.12					0.111									
TNTC-SO084	620376	1910525	35	142	654	650	4.06	0.05				0.116										
TNTC-SO085	620237	1911076	44	144	655	651	4.00	0.05					0.096									same as 085, 093, 096
TNTC-SO098	620517	1911087	44	140	655	649	6.00	0.24	616	8	ND		0.061									same as 110, 262-264
TNTC-SO107	620480	1911094	44	141	657	648	9.00	0.39	616	8	ND						4.45			28.05		same as 108, 123, 261, 379, 380
TNTC-SO120	620303	1911568	53	143	666	652	14.00	0.50	603	8	ND		0.151									same as 125
TNTC-SO134	620311	1911785	56	143	668	650	18.23	0.58	602	6	ND	0.366		0.645			1.695					same as 135, 331,377
TNTC-SO145	620398	1913031	77	142	655	655	0.50	0.00	686	4	ND	0.795	0.074									same as 151, 301, 303-305, 325
TNTC-SO146	620389	1913056	78	142	657	654	3.00	0.02	686	4	ND	1.135										same as 147, 149, 150, 306, 307, 330
TNTC-SO157	620154	1912987	76	146	671	657	13.90	0.50	682	4	ND	0.137	0.69			0.091						same as 309-311, 369
TNTC-SO158	620155	1913006	77	146	671	657	13.90	0.50	682	4	ND		0.105									
TNTC-SO165	620182	1913008	77	145	669	657	11.55	0.45	682	4	ND	11.05	0.314	0.062						0.097		same as 280, 312-314, 367, 368
TNTC-SO171	620231	1912827	74	145	666	657	10.00	0.41	682	4	ND					118				23.9		same as 399, 400
TNTC-SO173	620256	1912537	69	144	666	655	11.35	0.44	693	7	ND		0.144			0.072				0.412		same as 175, 407, 408
TNTC-SO178	620506	1912291	65	140	655	652	10.00	0.41	696	12	ND	1.85		0.353						0.063		same as191, 192, 291-295, 326-328. 333, 374
TNTC-SO186	620502	1912395	66	140	655	652	3.00	0.02	696	12	ND		0.096									same as187, 189, 190, 288-290, 295
TNTC-SO200	620565	1911808	57	129	654	649	5.00	0.12				0.078										same as 205
TNTC-SO215	620869	1910525	35	134	648	645	3.00	0.02				0.066										
TNTC-SO218	621420	1911523	52	125	644	638	5.70	0.19							0.474							same as 222, 225, 365, 366
TNTC-SO228	620290	1912340	65	144	670	655	15.00	0.52	692	8	ND		493									same as 229, 243, 244, 279, 284
TNTC-SO231	620253	1912367	66	144	670	655	15.00	0.52	ripcity4	8	ND		320			0.213						same as 241, 283, 284, 285, 286, 320, 405
TNTC-SO235	620091	1910655	37	147	665	651	14.00	0.50					0.067									same as 236
TNTC-SO281	620224	1913088	78	145	670	665	5.00	0.12				0.433										
TNTC-SO383	619869	1911170	46	150	679	654	24.66	0.70								1.69						

Table 10
Soil Sample Locations and Analytical Data for Nitroaromatic Compound (2,4,6-TNT)
PRRWP Area, Former Plum Brook Ordnance Works, Sandusky, Ohio

Location ID	Northing	Easting	Column #	Row #	Ground Elev (ft msl)	GW Elev. (ft msl) Estimated	DTW (ft) Estimated	α (ft)	New DTW (ft)	Remaining Conc.	Sample Depth (ft,blgs)												Comments
											0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	
PR-S1	625010	1918890	140	66	634	631	5.00	0.12					0.3										
PR-S13	625063	1919318	143	73	634	631	10.00	0.41								0.5							
PR-S14	624889	1919309	143	70	634	631	10.00	0.41	**4-5**	**1440**				12000		340							
PR-S22	625103	1919222	143	66	632	629	6.00	0.24			0.74												same as SB16
PRRP-DP02	625232	1918802	139	64	634	631	10.00	0.41											0.38				
PRRP-DP11	624841	1919355	144	71	634	630	12.00	0.46					1.4								0.23		
PR-new-1	624880	1919399	144	70	634	631	10.00	0.41	**4-5**	**121**													
PR-new-2	624942	1919278	144	69	634	631	6.00	0.24	**4-5**	**24.8**													same cell as DP23
PR-new-3	624942	1919278	143	69	634	631	6.00	0.24	**4-5**	**19.3**													same cell as ITSB14

Table 11
Soil Sample Locations and Analytical Data for Nitroaromatic Compound (2,4,-DNT)
PRRWP Area, Former Plum Brook Ordnance Works, Sandusky, Ohio

Location ID	Northing	Easting	Column #	Row #	Gnd_Elev	GW Elev.	DTW	α	Bldg #	New	Remaining Conc.	Sample Depth (ft,blgs)											Comments
										DTW (ft)		0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	
PR-S1	625010	1918890	140	66	634.0	631	5.00	0.12						0.4									
PR-S4	624996	1919022	141	68	633.0	630	10.00	0.41					1.1			5.7			2.8					
PR-S6	625099	1919114	142	67	632.0	629	10.00	0.41					2.1			8.7			7.6					
PR-S7	624894	1919109	142	70	633.0	630	10.00	0.41					0.4			3.4			0.3					
PR-S9	625192	1919216	142	65	633.0	630	10.00	0.41					2.4			3.8			2					
PR-S10	624971	1919213	142	68	633.0	630	10.00	0.41				0.3				2.6			2.2					same as S21
PR-S12	625292	1919318	143	63	633.0	629	12.00	0.46								1.2			1.6			26		
PR-S13	625063	1919318	143	73	634.0	631	10.00	0.41								0.4			5.2					
PR-S14	624889	1919309	143	70	634.0	631	10.00	0.41		**4-5**	**3.71**								19					
PR-S15	625151	1919418	144	65	633.0	630	10.00	0.41					0.6			0.3			14					
PR-S16	624908	1919391	144	68	633.0	630	12.00	0.46										8.9			12	15	26	same as DP10
PR-S17	624712	1919403	144	72	633.0	630	3.00	0.02																
PR-S18	625271	1919498	64	145	632.0	629	10.00	0.41										1						same as S19
PR-S20	624911	1919506	145	68	632.0	630	2.00	0.00					19											same as SB18
PR-S22	625103	1919222	143	66	632.0	629	6.00	0.24					3.2				16							same as SB16
PR-S23	625207	1919305	143	64	632.0	629	3.00	0.02				1												
PR-S24	625237	1919405	144	64	632.0	629	3.00	0.02				1.1												
PR-S8	625249	1919060	142	62	634.0	630	4.00	0.05																
PRRP-DP01	624940	1918741	139	69	633.0	630	10.00	0.41									0.96				0.29			
PRRP-DP02	625232	1918802	139	64	633.0	630	10.00	0.41													0.28			
PRRP-DP03	625038	1919103	141	67	633.0	630	12.00	0.46					1.2				25						0.48	
PRRP-DP06	624951	1918911	140	69	633.0	630	10.00	0.41														1.1		
PRRP-DP09	625348	1919218	142	63	633.0	630	6.00	0.24									0.056							
PRRP-DP11	624841	1919355	144	71	633.0	630	12.00	0.46							1.3		1.6				1.2			
PRRP-DP15	625066	1919559	145	67	633.0	630	10.00	0.41													0.19			
ITSB-13	624681	1919244	143	73	634.4	631	3.40	0.03					2.2											
ITSB-14	624942	1919278	143	69	634.7	631	6.00	0.24		**4-5**	**16.3**		20											
ITSB-17	624791	1919171	142	71	634.0	631	3.00	0.02					1.1											
PR-new-1	624880	1919399	144	70	634.00	631	10.00	0.41		**4-5**	**20.2**													
PR-new-2	624942	1919278	144	69	634.00	631	6.00	0.24		**4-5**	**16.4**													same cell as DP23

Table 12
Soil Sample Locations and Analytical Data for Nitroaromatic Compound (2,6,-DNT)
PRRWP Area, Former Plum Brook Ordnance Works, Sandusky, Ohio

Location ID	Northing	Easting	Column #	Row #	Gnd_Elev	GW Elev.	DTW	α	Bldg #	New	Remaining Conc.	Sample Depth (ft,blgs)											Comments
										DTW (ft)		0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	
PR-S4	624996	1919022	141	68	633.00	630	10.00	0.41							0.5								
PR-S6	625099	1919114	142	67	632	629	10.00	0.41					0.4		3.6		0.5						
PR-S7	624894	1919109	142	70	633	630	10.00	0.41							0.4								
PR-S9	625192	1919216	142	65	633	630	3.00	0.02					0.8										
PR-S12	625292	1919318	143	63	633.00	629	12.00	0.46							0.3		0.3						
PR-S13	625063	1919318	143	73	634.00	631	10.00	0.41									0.5						
PR-S14	624889	1919309	143	70	634.00	631	10.00	0.41		**4-5**	**4.88**						2.9						
PR-S15	625151	1919418	144	65	633.00	630.00	10.00	0.41									2						
PR-S16	624908	1919391	144	68	633.00	630.00	12.00	0.46									1						same as DP10
PR-S20	624911	1919506	145	68	633.00	630.00	3.00	0.02					2.7										same as SB18
PR-S22	625103	1919222	143	66	633.00	629	6.00	0.24					0.53				1.5						same as SB16
PRRP-DP01	624940	1918741	139	69	633.00	630.00	10.00	0.41									0.35						
PRRP-DP03	625038	1919103	141	67	633.00	630.00	12.00	0.46									0.58					0.48	
PRRP-DP11	624841	1919355	144	71	633.00	630.00	12.00	0.46							0.57		0.29				0.3	0.25	
PRRP-DP16	624826	1919459	145	71	633.00	630.00	10.00	0.41													0.5		
ITSB-17	624791	1919171	142	71	634.00	631.00	3.00	0.02					0.082										
PR-new-1	624880	1919399	144	70	634.00	631	10.00	0.41		**4-5**	**7.24**												
PR-new-2	624942	1919278	144	69	634.00	631	6.00	0.24		**4-5**	**14.2**												same cell as DP23
PR-new-3	624942	1919278	143	69	634.00	631	6.00	0.24		**4-5**	**ND**												same cell as ITSB14

Table 13
Soil Sample Locations and Analytical Data for Nitroaromatic Compound (2,4,6-TNT)
WARWP Area, Former Plum Brook Ordnance Works, Sandusky, Ohio

Location ID	Northing	Easting	Column #	Row #	Gnd_Elev	GW Elev.	DTW	α	Sample Depth (ft,blgs)										Comments
16					(ft msl)	(ft msl)	(ft)	(ft)	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	
						Estimated	Estimated												
PB-WA-S5	622251	1909944	25	112	633	630	5.00	0.12			0.3								
PB-WA-S10	622125	1910177	29	114	633	630	5.00	0.12				0.4							
PB-WA-S14	622135	1910554	35	114	631	628	5.00	0.12			0.3								
PB-WA-S17	622418	1910299	31	110	633	630	10.00	0.41						3					same as S24
SB12	622306	1910340	32	111	633	630	3.00	0.02	0.68										
DP09	622547	1909995	26	107	639	635	12.00	0.46					1						
DP10	622147	1910023	26	111	635	632	6.00	0.24					0.38						

Table 14
Soil Sample Locations and Analytical Data for Nitroaromatic Compound (2,4,-DNT)
WARWP Area, Former Plum Brook Ordnance Works, Sandusky, Ohio

Location ID	Northing	Easting	Column #	Row #	Gnd_Elev	GW Elev.	DTW	α	Sample Depth (ft,blgs)											Comments
16					(ft msl)	(ft msl)	(ft)	(ft)	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	11-12	
						Estimated	Estimated													same as S21
PB-WA-S5	622251	1909944	25	112	633	630	5.00	0.12	0.3		1.3									
PB-WA-S6	622244	1909722	21	112	635	632	3.00	0.02	3											
PB-WA-S10	622125	1910177	29	114	633	630	5.00	0.12				5.1								
PB-WA-S13	622148	1910331	32	114	633	630	5.00	0.12				0.6								
PB-WA-S14	622135	1910554	35	114	631	628	5.00	0.12	0.4		0.3									
PB-WA-S17	622418	1910299	31	110	633	630	10.00	0.41						3.3						same as S24
PB-WA-S18	622275	1910321	31	112	633	630	10.00	0.41				0.7		0.3						
PB-WA-S20	622177	1910239	30	113	633	630	5.00	0.12	0.4											same as S23
DP09	622547	1909995	26	107	639.02	635	12.00	0.46					0.71				0.49		2.7	
DP10	622147	1910023	26	111	635	632	6.00	0.24					1.4							
DP11	622017	1910000	26	116	633	630	3.00	0.02	0.043											
DP13	622543	1910217	30	108	637.75	634	12.00	0.46					0.29				6.3		6.5	
DP16	622425	1910395	33	109	633	630	4.00	0.05				0.052								
SB07	622213	1909868	24	113	635	632	3.00	0.02	0.23											
SB12	622306	1910340	32	111	633	630	3.00	0.02	0.91											

Table 15
Soil Sample Locations and Analytical Data for Nitroaromatic Compound (2,6,-DNT)
WARWP Area, Former Plum Brook Ordnance Works, Sandusky, Ohio

Location ID	Northing	Easting	Column #	Row #	Gnd_Elev	GW Elev.	DTW	α	Sample Depth (ft,blgs)											Comments
					(ft msl)	(ft msl)	(ft)	(ft)	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	11-12	
						Estimated	Estimated													
PB-WA-S10	622125	1910177	29	114	633	630	5.00	0.12				0.3								
PB-WA-S17	622418	1910299	31	110	633	630	10.00	0.41						0.3						same as S24
DP09	622547	1909995	26	107	639.02	635	12.00	0.46					0.35						0.27	
DP10	622147	1910023	26	111	635	632	6.00	0.24					1.5							
DP13	622543	1910217	30	108	637.75	634	12.00	0.46											0.64	

ATTACHMENT B

GEOTECHNICAL TEST RESULTS

Attachment B
Total Organic Carbon Analytical Results
Groundwater Modeling in the Unsaturated and Saturated Zones
Former Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION_CODE	SAMPLE_NO	SAMPLE_DATE	TYPE	PARAMETER	RESULT	UNITS
PB-PR-S13	PB-PR-S13-3.0-10.0	31-Oct-94	DS	TOTAL ORGANIC CARBON	1990	mg/kg
GCL-MW01	5850	20-Nov-97	GW	TOTAL ORGANIC CARBON	5.4	mg/L
GCL-MW01	5855	17-May-98	GW	TOTAL ORGANIC CARBON	3	mg/L
GCL-MW02A	5860	20-Nov-97	GW	TOTAL ORGANIC CARBON	4.5	mg/L
GCL-MW02A	5865	17-May-98	GW	TOTAL ORGANIC CARBON	3	mg/L
GCL-MW02B	5870	20-Nov-97	GW	TOTAL ORGANIC CARBON	2.7	mg/L
GCL-MW02B	5875	17-May-98	GW	TOTAL ORGANIC CARBON	2	mg/L
GCL-MW03	5880	20-Nov-97	GW	TOTAL ORGANIC CARBON	4.2	mg/L
GCL-MW03	5885	17-May-98	GW	TOTAL ORGANIC CARBON	2	mg/L
IT-AA1-BEDGW-001	5450	16-Nov-97	GW	TOTAL ORGANIC CARBON	16	mg/L
IT-AA1-BEDGW-001	5455	12-May-98	GW	TOTAL ORGANIC CARBON	11	mg/L
IT-AA1-GW-002	5490	20-Nov-97	GW	TOTAL ORGANIC CARBON	6.9	mg/L
IT-AA1-GW-002	5495	13-May-98	GW	TOTAL ORGANIC CARBON	6	mg/L
IT-AA2-BEDGW-001	5460	20-Nov-97	GW	TOTAL ORGANIC CARBON	7.4	mg/L
IT-AA2-BEDGW-001	5465	12-May-98	GW	TOTAL ORGANIC CARBON	6	mg/L
IT-AA2-BEDGW-001	BD3004	8-Oct-01	GW	TOTAL ORGANIC CARBON	3.1	mg/L
IT-AA2-BEDGW-001	CB3030	10-Apr-02	GW	TOTAL ORGANIC CARBON	3.1	mg/L
IT-AA3-BEDGW-001	5470	19-Nov-97	GW	TOTAL ORGANIC CARBON	5.3	mg/L
IT-AA3-BEDGW-001	5475	14-May-98	GW	TOTAL ORGANIC CARBON	2	mg/L
IT-AA3-BEDGW-001	BD3005	27-Sep-01	GW	TOTAL ORGANIC CARBON	0.84	mg/L
IT-AA3-BEDGW-001	CB3033	10-Apr-02	GW	TOTAL ORGANIC CARBON	1	mg/L
IT-AA3-GW-002	5510	19-Nov-97	GW	TOTAL ORGANIC CARBON	4.5	mg/L
IT-AA3-GW-002	5515	14-May-98	GW	TOTAL ORGANIC CARBON	2	mg/L
IT-ABG-BEDGW-01	5480	13-Nov-97	GW	TOTAL ORGANIC CARBON	3.8	mg/L
IT-ABG-BEDGW-01	5485	13-May-98	GW	TOTAL ORGANIC CARBON	3	mg/L
IT-ABG-BEDGW-01	BD3006	28-Sep-01	GW	TOTAL ORGANIC CARBON	7	mg/L
IT-ABG-BEDGW-01	CB3016	5-Apr-02	GW	TOTAL ORGANIC CARBON	3.3	mg/L
IT-ABG-GW-002	5520	19-Nov-97	GW	TOTAL ORGANIC CARBON	13	mg/L
IT-ABG-GW-002	5525	13-May-98	GW	TOTAL ORGANIC CARBON	15	mg/L
IT-BG8-BEDGW-001	5410	17-Nov-97	GW	TOTAL ORGANIC CARBON	5	mg/L
IT-BG8-BEDGW-001	5415	15-May-98	GW	TOTAL ORGANIC CARBON	1	mg/L
IT-BG8-BEDGW-001	BD3007	27-Sep-01	GW	TOTAL ORGANIC CARBON	1	mg/L
IT-BG8-BEDGW-001	CA3006	16-Jan-02	GW	TOTAL ORGANIC CARBON	1	mg/L
IT-BG8-BEDGW-001	CC3001	12-Jul-02	GW	TOTAL ORGANIC CARBON	1.9	mg/L
IT-BG8-BEDGW-001	CD3001	18-Oct-02	GW	TOTAL ORGANIC CARBON	1.3	mg/L
IT-BG8-BEDGW-001	DA3001	10-Apr-03	GW	TOTAL ORGANIC CARBON	1	mg/L
IT-BG8-BEDGW-001	DC3000	18-Sep-03	GW	TOTAL ORGANIC CARBON	1.2	mg/L
IT-BG8-BEDGW-001	DD3001	10-Dec-03	GW	TOTAL ORGANIC CARBON	1.2	mg/L
IT-BG8-BEDGW-001	DE3000	11-Mar-04	GW	TOTAL ORGANIC CARBON	1.1	mg/L
IT-BG8-BEDGW-001	DG3000	16-Jun-04	GW	TOTAL ORGANIC CARBON	1	mg/L
IT-MNTA-BEDGW-001	5440	20-Nov-97	GW	TOTAL ORGANIC CARBON	11	mg/L
IT-MNTA-BEDGW-001	5445	28-May-98	GW	TOTAL ORGANIC CARBON	7	mg/L
IT-MNTA-BEDGW-001	BD3008	3-Oct-01	GW	TOTAL ORGANIC CARBON	3.9	mg/L
IT-MNTA-BEDGW-001	CB3039	12-Apr-02	GW	TOTAL ORGANIC CARBON	5.9	mg/L
IT-MW01	5530	19-Nov-97	GW	TOTAL ORGANIC CARBON	8.6	mg/L
IT-MW01	5535	16-May-98	GW	TOTAL ORGANIC CARBON	7	mg/L
IT-MW01	CC3009	10-Jul-02	GW	TOTAL ORGANIC CARBON	7.1	mg/L
IT-MW01	CD3002	16-Oct-02	GW	TOTAL ORGANIC CARBON	9.9	mg/L
IT-MW01	DA3002	9-Apr-03	GW	TOTAL ORGANIC CARBON	3.8	mg/L
IT-MW02	5540	21-Nov-97	GW	TOTAL ORGANIC CARBON	41	mg/L
IT-MW02	5545	15-May-98	GW	TOTAL ORGANIC CARBON	28	mg/L
IT-MW05	5550	19-Nov-97	GW	TOTAL ORGANIC CARBON	4.7	mg/L
IT-MW05	5555	28-May-98	GW	TOTAL ORGANIC CARBON	6	mg/L
IT-MW06	5560	19-Nov-97	GW	TOTAL ORGANIC CARBON	3.8	mg/L
IT-MW06	5565	28-May-98	GW	TOTAL ORGANIC CARBON	3	mg/L
IT-MW08	5580	19-Nov-97	GW	TOTAL ORGANIC CARBON	4.4	mg/L

Attachment B
Total Organic Carbon Analytical Results
Groundwater Modeling in the Unsaturated and Saturated Zones
Former Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION_CODE	SAMPLE_NO	SAMPLE_DATE	TYPE	PARAMETER	RESULT	UNITS
IT-MW08	5585	13-May-98	GW	TOTAL ORGANIC CARBON	6	mg/L
IT-MW09	5590	23-Nov-97	GW	TOTAL ORGANIC CARBON	2.9	mg/L
IT-MW09	5595	19-May-98	GW	TOTAL ORGANIC CARBON	2	mg/L
IT-MW10	5600	14-Nov-97	GW	TOTAL ORGANIC CARBON	2.7	mg/L
IT-MW10	5605	14-May-98	GW	TOTAL ORGANIC CARBON	3	mg/L
IT-TNTB-BEDGW-001	5420	17-Nov-97	GW	TOTAL ORGANIC CARBON	12	mg/L
IT-TNTB-BEDGW-001	5425	18-May-98	GW	TOTAL ORGANIC CARBON	5	mg/L
IT-TNTB-BEDGW-001	BD3009	28-Sep-01	GW	TOTAL ORGANIC CARBON	4.9	mg/L
IT-TNTB-BEDGW-001	CB3019	5-Apr-02	GW	TOTAL ORGANIC CARBON	3.4	mg/L
IT-TNTB-BEDGW-002	5430	16-Nov-97	GW	TOTAL ORGANIC CARBON	5	mg/L
IT-TNTB-BEDGW-002	5435	18-May-98	GW	TOTAL ORGANIC CARBON	4	mg/L
IT-TNTB-BEDGW-002	BD3010	27-Sep-01	GW	TOTAL ORGANIC CARBON	3.7	mg/L
IT-TNTB-BEDGW-002	CB3018	5-Apr-02	GW	TOTAL ORGANIC CARBON	3	mg/L
MK-MW09	5720	16-Nov-97	GW	TOTAL ORGANIC CARBON	1.5	mg/L
MK-MW09	5725	13-May-98	GW	TOTAL ORGANIC CARBON	1	mg/L
MK-MW10	5730	13-Nov-97	GW	TOTAL ORGANIC CARBON	1.4	mg/L
MK-MW10	5735	12-May-98	GW	TOTAL ORGANIC CARBON	1	mg/L
MK-MW11	5740	18-Nov-97	GW	TOTAL ORGANIC CARBON	3.1	mg/L
MK-MW11	5745	13-May-98	GW	TOTAL ORGANIC CARBON	2	mg/L
MK-MW12	5750	17-Nov-97	GW	TOTAL ORGANIC CARBON	2	mg/L
MK-MW12	5755	14-May-98	GW	TOTAL ORGANIC CARBON	2	mg/L
MK-MW14	5760	16-Nov-97	GW	TOTAL ORGANIC CARBON	6.1	mg/L
MK-MW14	5765	14-May-98	GW	TOTAL ORGANIC CARBON	7	mg/L
MK-MW15	5770	16-Nov-97	GW	TOTAL ORGANIC CARBON	2.6	mg/L
MK-MW15	5775	14-May-98	GW	TOTAL ORGANIC CARBON	1	mg/L
MK-MW16	5780	21-Nov-97	GW	TOTAL ORGANIC CARBON	2.5	mg/L
MK-MW16	5785	18-May-98	GW	TOTAL ORGANIC CARBON	2	mg/L
MK-MW16	CB3017	8-Apr-02	GW	TOTAL ORGANIC CARBON	2	mg/L
MK-MW17	5790	21-Nov-97	GW	TOTAL ORGANIC CARBON	3.4	mg/L
MK-MW17	5795	27-May-98	GW	TOTAL ORGANIC CARBON	3	mg/L
MK-MW17	BD3012	1-Oct-01	GW	TOTAL ORGANIC CARBON	2.7	mg/L
MK-MW17	CB3038	12-Apr-02	GW	TOTAL ORGANIC CARBON	1.6	mg/L
MK-MW19	5800	16-Nov-97	GW	TOTAL ORGANIC CARBON	2.9	mg/L
MK-MW19	5805	1-Jun-98	GW	TOTAL ORGANIC CARBON	3	mg/L
MK-MW20	5810	16-Nov-97	GW	TOTAL ORGANIC CARBON	12	mg/L
MK-MW20	5815	19-May-98	GW	TOTAL ORGANIC CARBON	6	mg/L
MK-MW22	5820	14-Nov-97	GW	TOTAL ORGANIC CARBON	11	mg/L
MK-MW22	5825	18-May-98	GW	TOTAL ORGANIC CARBON	2	mg/L
MK-MW23	5835	29-May-98	GW	TOTAL ORGANIC CARBON	10	mg/L
MK-MW24	5840	13-Nov-97	GW	TOTAL ORGANIC CARBON	21	mg/L
MK-MW24	5845	20-May-98	GW	TOTAL ORGANIC CARBON	9	mg/L
PB-BED-MW13	5890	13-Nov-97	GW	TOTAL ORGANIC CARBON	9.6	mg/L
PB-BED-MW13	5895	29-May-98	GW	TOTAL ORGANIC CARBON	2	mg/L
PB-BED-MW13	BD3017	3-Oct-01	GW	TOTAL ORGANIC CARBON	6.6	mg/L
PB-BED-MW13	CB3025	10-Apr-02	GW	TOTAL ORGANIC CARBON	7.4	mg/L
PB-BED-MW14	5900	18-Nov-97	GW	TOTAL ORGANIC CARBON	190	mg/L
PB-BED-MW14	5905	16-May-98	GW	TOTAL ORGANIC CARBON	160	mg/L
PB-BED-MW14	BD3018	28-Sep-01	GW	TOTAL ORGANIC CARBON	617	mg/L
PB-BED-MW14	CB3022	8-Apr-02	GW	TOTAL ORGANIC CARBON	937	mg/L
PB-BED-MW15	5910	18-Nov-97	GW	TOTAL ORGANIC CARBON	11	mg/L
PB-BED-MW15	5915	28-May-98	GW	TOTAL ORGANIC CARBON	13	mg/L
PB-BED-MW15	BD3019	9-Oct-01	GW	TOTAL ORGANIC CARBON	8.4	mg/L
PB-BED-MW15	CB3041	15-Apr-02	GW	TOTAL ORGANIC CARBON	6.5	mg/L
PB-BED-MW16	5920	24-Nov-97	GW	TOTAL ORGANIC CARBON	8.4	mg/L
PB-BED-MW16	5925	1-Jun-98	GW	TOTAL ORGANIC CARBON	14	mg/L
PB-BED-MW16	BD3020	10-Oct-01	GW	TOTAL ORGANIC CARBON	6.8	mg/L

Attachment B
Total Organic Carbon Analytical Results
Groundwater Modeling in the Unsaturated and Saturated Zones
Former Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION_CODE	SAMPLE_NO	SAMPLE_DATE	TYPE	PARAMETER	RESULT	UNITS
PB-BED-MW16	CB3037	11-Apr-02	GW	TOTAL ORGANIC CARBON	5.5	mg/L
PB-BED-MW17	5930	20-Nov-97	GW	TOTAL ORGANIC CARBON	1.2	mg/L
PB-BED-MW17	5935	29-May-98	GW	TOTAL ORGANIC CARBON	3	mg/L
PB-BED-MW17	BD3021	3-Oct-01	GW	TOTAL ORGANIC CARBON	5.7	mg/L
PB-BED-MW17	CB3014	11-Apr-02	GW	TOTAL ORGANIC CARBON	5.3	mg/L
PB-BED-MW17	DF3000	6-May-04	GW	TOTAL ORGANIC CARBON	6.4	mg/L
PB-BED-MW17	DH3000	26-Aug-04	GW	TOTAL ORGANIC CARBON	1	mg/L
PB-BED-MW18	5940	19-Nov-97	GW	TOTAL ORGANIC CARBON	6.5	mg/L
PB-BED-MW18	5945	19-May-98	GW	TOTAL ORGANIC CARBON	3	mg/L
PB-BED-MW18	BD3024	2-Oct-01	GW	TOTAL ORGANIC CARBON	2.5	mg/L
PB-BED-MW18	CB3015	5-Apr-02	GW	TOTAL ORGANIC CARBON	1.4	mg/L
PB-BED-MW19	5950	14-Nov-97	GW	TOTAL ORGANIC CARBON	16	mg/L
PB-BED-MW19	5955	16-May-98	GW	TOTAL ORGANIC CARBON	9	mg/L
PB-BED-MW19	BD3025	4-Oct-01	GW	TOTAL ORGANIC CARBON	8.6	mg/L
PB-BED-MW19	CB3013	4-Apr-02	GW	TOTAL ORGANIC CARBON	5.9	mg/L
PB-BED-MW19	DF3001	5-May-04	GW	TOTAL ORGANIC CARBON	5.6	mg/L
PB-BED-MW19	DH3001	25-Aug-04	GW	TOTAL ORGANIC CARBON	5.6	mg/L
PB-BED-MW20	5960	17-Nov-97	GW	TOTAL ORGANIC CARBON	1	mg/L
PB-BED-MW20	5965	28-May-98	GW	TOTAL ORGANIC CARBON	1	mg/L
PB-BED-MW20	BD3026	26-Sep-01	GW	TOTAL ORGANIC CARBON	0.5	mg/L
PB-BED-MW20	CA3005	15-Jan-02	GW	TOTAL ORGANIC CARBON	1.1	mg/L
PB-BED-MW20	CB3001	4-Apr-02	GW	TOTAL ORGANIC CARBON	0.74	mg/L
PB-BED-MW20	CC3003	10-Jul-02	GW	TOTAL ORGANIC CARBON	1	mg/L
PB-BED-MW20	CD3003	17-Oct-02	GW	TOTAL ORGANIC CARBON	1	mg/L
PB-BED-MW20	DA3003	11-Apr-03	GW	TOTAL ORGANIC CARBON	1	mg/L
PB-BED-MW20	DC3001	18-Sep-03	GW	TOTAL ORGANIC CARBON	1	mg/L
PB-BED-MW20	DD3002	9-Dec-03	GW	TOTAL ORGANIC CARBON	1	mg/L
PB-BED-MW20	DE3001	10-Mar-04	GW	TOTAL ORGANIC CARBON	1	mg/L
PB-BED-MW20	DG3001	17-Jun-04	GW	TOTAL ORGANIC CARBON	2.1	mg/L
PB-BED-MW22	BD3027	8-Oct-01	GW	TOTAL ORGANIC CARBON	1.7	mg/L
PB-BED-MW22	CB3009	4-Apr-02	GW	TOTAL ORGANIC CARBON	2.2	mg/L
PB-BED-MW22	DF3002	5-May-04	GW	TOTAL ORGANIC CARBON	2	mg/L
PB-BED-MW22	DH3002	26-Aug-04	GW	TOTAL ORGANIC CARBON	1.8	mg/L
PB-BED-MW23	BD3028	9-Oct-01	GW	TOTAL ORGANIC CARBON	6.2	mg/L
PB-BED-MW23	CB3040	11-Apr-02	GW	TOTAL ORGANIC CARBON	6.4	mg/L
PB-BED-MW24	BD3029	9-Oct-01	GW	TOTAL ORGANIC CARBON	3	mg/L
PB-BED-MW24	CA3001	17-Jan-02	GW	TOTAL ORGANIC CARBON	1.8	mg/L
PB-BED-MW24	CB3008	3-Apr-02	GW	TOTAL ORGANIC CARBON	2.4	mg/L
PB-BED-MW24	CC3004	12-Jul-02	GW	TOTAL ORGANIC CARBON	3.7	mg/L
PB-BED-MW24	CD3004	19-Oct-02	GW	TOTAL ORGANIC CARBON	3.7	mg/L
PB-BED-MW24	DA3004	9-Apr-03	GW	TOTAL ORGANIC CARBON	2.4	mg/L
PB-BED-MW24	DC3002	17-Sep-03	GW	TOTAL ORGANIC CARBON	1.9	mg/L
PB-BED-MW24	DD3003	11-Dec-03	GW	TOTAL ORGANIC CARBON	1.6	mg/L
PB-BED-MW24	DE3002	10-Mar-04	GW	TOTAL ORGANIC CARBON	1.5	mg/L
PB-BED-MW24	DG3002	16-Jun-04	GW	TOTAL ORGANIC CARBON	1	mg/L
PB-BED-MW25	BD3030	5-Oct-01	GW	TOTAL ORGANIC CARBON	4	mg/L
PB-BED-MW25	CA3002	16-Jan-02	GW	TOTAL ORGANIC CARBON	2	mg/L
PB-BED-MW25	CB3004	3-Apr-02	GW	TOTAL ORGANIC CARBON	3	mg/L
PB-BED-MW25	CC3005	11-Jul-02	GW	TOTAL ORGANIC CARBON	2.7	mg/L
PB-BED-MW25	CD3005	17-Oct-02	GW	TOTAL ORGANIC CARBON	2.7	mg/L
PB-BED-MW25	DA3005	10-Apr-03	GW	TOTAL ORGANIC CARBON	2	mg/L
PB-BED-MW25	DC3003	18-Sep-03	GW	TOTAL ORGANIC CARBON	2.8	mg/L
PB-BED-MW25	DD3004	11-Dec-03	GW	TOTAL ORGANIC CARBON	2.4	mg/L
PB-BED-MW25	DE3003	11-Mar-04	GW	TOTAL ORGANIC CARBON	2.3	mg/L
PB-BED-MW25	DG3003	17-Jun-04	GW	TOTAL ORGANIC CARBON	1.9	mg/L
PB-BED-MW27	BD3032	9-Oct-01	GW	TOTAL ORGANIC CARBON	3.7	mg/L

Attachment B
Total Organic Carbon Analytical Results
Groundwater Modeling in the Unsaturated and Saturated Zones
Former Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION_CODE	SAMPLE_NO	SAMPLE_DATE	TYPE	PARAMETER	RESULT	UNITS
PB-BED-MW27	CB3012	9-Apr-02	GW	TOTAL ORGANIC CARBON	3.5	mg/L
PB-BED-MW27	CD3009	18-Oct-02	GW	TOTAL ORGANIC CARBON	2.6	mg/L
PB-BED-MW28	DC3004	17-Sep-03	GW	TOTAL ORGANIC CARBON	5.9	mg/L
PB-BED-MW28	DD3007	9-Dec-03	GW	TOTAL ORGANIC CARBON	5.3	mg/L
PB-BED-MW28	DE3004	9-Mar-04	GW	TOTAL ORGANIC CARBON	5.2	mg/L
PB-BED-MW28	DG3004	15-Jun-04	GW	TOTAL ORGANIC CARBON	4.7	mg/L
PB-BED-MW29	DC3005	16-Sep-03	GW	TOTAL ORGANIC CARBON	2.6	mg/L
PB-BED-MW29	DD3008	9-Dec-03	GW	TOTAL ORGANIC CARBON	3.9	mg/L
PB-BED-MW29	DE3005	10-Mar-04	GW	TOTAL ORGANIC CARBON	2.2	mg/L
PB-BED-MW29	DG3005	16-Jun-04	GW	TOTAL ORGANIC CARBON	4.5	mg/L
PB-BED-MW30	DF3003	7-May-04	GW	TOTAL ORGANIC CARBON	10.5	mg/L
PB-BED-MW30	DH3003	25-Aug-04	GW	TOTAL ORGANIC CARBON	8.9	mg/L
PB-PR-MW7	5690	17-Nov-97	GW	TOTAL ORGANIC CARBON	2700	mg/L
PB-PR-MW7	5695	20-May-98	GW	TOTAL ORGANIC CARBON	2900	mg/L
PB-PR-MW8	5700	17-Nov-97	GW	TOTAL ORGANIC CARBON	14000	mg/L
PB-PR-MW8	5705	20-May-98	GW	TOTAL ORGANIC CARBON	11000	mg/L
PB-PR-MW9	5710	17-Nov-97	GW	TOTAL ORGANIC CARBON	1300	mg/L
PB-PR-MW9	5715	20-May-98	GW	TOTAL ORGANIC CARBON	930	mg/L
PB-TNTA-MW10	5610	18-Nov-97	GW	TOTAL ORGANIC CARBON	4.2	mg/L
PB-TNTA-MW10	5615	29-May-98	GW	TOTAL ORGANIC CARBON	2	mg/L
PB-TNTA-MW10	CB3042	15-Apr-02	GW	TOTAL ORGANIC CARBON	4	mg/L
PB-TNTA-MW11	5620	18-Nov-97	GW	TOTAL ORGANIC CARBON	4.5	mg/L
PB-TNTA-MW11	5625	29-May-98	GW	TOTAL ORGANIC CARBON	3	mg/L
PB-TNTA-MW11	BD3034	3-Oct-01	GW	TOTAL ORGANIC CARBON	4.3	mg/L
PB-TNTA-MW11	CB3043	15-Apr-02	GW	TOTAL ORGANIC CARBON	9	mg/L
PB-TNTC-MW3	5630	21-Nov-97	GW	TOTAL ORGANIC CARBON	2.4	mg/L
PB-TNTC-MW3	5635	18-May-98	GW	TOTAL ORGANIC CARBON	3	mg/L
PB-TNTC-MW3	CB3027	10-Apr-02	GW	TOTAL ORGANIC CARBON	2	mg/L
PB-TNTC-MW4	5640	24-Nov-97	GW	TOTAL ORGANIC CARBON	2.6	mg/L
PB-TNTC-MW4	5645	18-May-98	GW	TOTAL ORGANIC CARBON	3	mg/L
PB-TNTC-MW4	BD3043	4-Oct-01	GW	TOTAL ORGANIC CARBON	5.7	mg/L
PB-TNTC-MW4	CB3028	10-Apr-02	GW	TOTAL ORGANIC CARBON	1.1	mg/L
PB-TNTC-MW5	5650	21-Nov-97	GW	TOTAL ORGANIC CARBON	3	mg/L
PB-TNTC-MW5	5655	18-May-98	GW	TOTAL ORGANIC CARBON	3	mg/L
PB-TNTC-MW5	BD3035	3-Oct-01	GW	TOTAL ORGANIC CARBON	2.1	mg/L
PB-TNTC-MW5	CB3029	8-Apr-02	GW	TOTAL ORGANIC CARBON	2.9	mg/L
PB-TNTC-MW6	5660	20-Nov-97	GW	TOTAL ORGANIC CARBON	10	mg/L
PB-TNTC-MW6	5665	16-May-98	GW	TOTAL ORGANIC CARBON	9	mg/L
PB-WA-MW1	5670	21-Nov-97	GW	TOTAL ORGANIC CARBON	2.1	mg/L
PB-WA-MW1	5675	18-May-98	GW	TOTAL ORGANIC CARBON	3	mg/L
PB-WA-MW2	5680	23-Nov-97	GW	TOTAL ORGANIC CARBON	970	mg/L
PB-WA-MW2	5685	15-May-98	GW	TOTAL ORGANIC CARBON	780	mg/L
PRRP-DP02	7270	14-Jun-98	GW	TOTAL ORGANIC CARBON	19.3	mg/L
PRRP-DP03	7310	8-Jun-98	GW	TOTAL ORGANIC CARBON	6600	mg/L
PRRP-DP04	7350	9-Jun-98	GW	TOTAL ORGANIC CARBON	10	mg/L
PRRP-DP09	7550	14-Jun-98	GW	TOTAL ORGANIC CARBON	671	mg/L
PRRP-DP11	7630	14-Jun-98	GW	TOTAL ORGANIC CARBON	3060	mg/L
PRRP-DP20	7990	14-Jun-98	GW	TOTAL ORGANIC CARBON	1.8	mg/L
PT-5912	DH3007	27-Aug-04	GW	TOTAL ORGANIC CARBON	2.9	mg/L
REACTOR1	5970	21-Nov-97	GW	TOTAL ORGANIC CARBON	2500	ug/L
REACTOR1	5975	1-Jun-98	GW	TOTAL ORGANIC CARBON	5	mg/L
TNTA-BEDGW-001	BD3037	9-Oct-01	GW	TOTAL ORGANIC CARBON	12.3	mg/L
TNTA-BEDGW-001	CB3044	15-Apr-02	GW	TOTAL ORGANIC CARBON	10.7	mg/L
TNTB-BEDGW-003	BD3038	8-Oct-01	GW	TOTAL ORGANIC CARBON	12.1	mg/L
TNTB-BEDGW-003	CB3024	10-Apr-02	GW	TOTAL ORGANIC CARBON	4.6	mg/L
TNTB-BEDGW-004	BD3041	5-Oct-01	GW	TOTAL ORGANIC CARBON	3.6	mg/L

Attachment B
Total Organic Carbon Analytical Results
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Former Plum Brook Ordnance Works, Sandusky, Ohio

LOCATION_CODE	SAMPLE_NO	SAMPLE_DATE	TYPE	PARAMETER	RESULT	UNITS
TNTB-BEDGW-004	CB3023	8-Apr-02	GW	TOTAL ORGANIC CARBON	2.9	mg/L
TNTC-BEDGW-001	BD3042	4-Oct-01	GW	TOTAL ORGANIC CARBON	2.5	mg/L
TNTC-BEDGW-001	CB3026	9-Apr-02	GW	TOTAL ORGANIC CARBON	1.4	mg/L
WARP-DP09	8450	16-Jun-98	GW	TOTAL ORGANIC CARBON	32	mg/L
WARP-DP13	8610	15-Jun-98	GW	TOTAL ORGANIC CARBON	36.6	mg/L
PB-WA-SED1	PB-WA-SED1-0.2-1.7	27-Oct-94	SD	TOTAL ORGANIC CARBON	46	mg/kg
PB-WA-SED7	PB-WA-SED8-0.2-1.7	27-Oct-94	SD	TOTAL ORGANIC CARBON	44	mg/kg
PRRP-SD01	11160	5-Nov-98	SD	TOTAL ORGANIC CARBON	33000	mg/kg
PRRP-SD02	11170	5-Nov-98	SD	TOTAL ORGANIC CARBON	5450	mg/kg
PRRP-SD03	11180	5-Nov-98	SD	TOTAL ORGANIC CARBON	17000	mg/kg
PRRP-SD04	11190	5-Nov-98	SD	TOTAL ORGANIC CARBON	12000	mg/kg
PRRP-SD04	11191	5-Nov-98	SD	TOTAL ORGANIC CARBON	7120	mg/kg
PRRP-SD04	11192	5-Nov-98	SD	TOTAL ORGANIC CARBON	46000	mg/kg
PRWP-SD001	AC1001	15-Sep-00	SD	TOTAL ORGANIC CARBON	24800	mg/kg
PRWP-SD002	AC1002	15-Sep-00	SD	TOTAL ORGANIC CARBON	25900	mg/kg
PRWP-SD003	AC1003	15-Sep-00	SD	TOTAL ORGANIC CARBON	9040	mg/kg
PRWP-SD004	AC1004	15-Sep-00	SD	TOTAL ORGANIC CARBON	5190	mg/kg
PRWP-SD005	AC1005	15-Sep-00	SD	TOTAL ORGANIC CARBON	10400	mg/kg
WARP-SD01	11100	5-Nov-98	SD	TOTAL ORGANIC CARBON	5430	mg/kg
WARP-SD02	11110	5-Nov-98	SD	TOTAL ORGANIC CARBON	3960	mg/kg
WARP-SD03	11120	5-Nov-98	SD	TOTAL ORGANIC CARBON	9650	mg/kg
WARP-SD04	11130	5-Nov-98	SD	TOTAL ORGANIC CARBON	5520	mg/kg
WARP-SD05	11140	5-Nov-98	SD	TOTAL ORGANIC CARBON	40200	mg/kg
WARP-SD06	11150	5-Nov-98	SD	TOTAL ORGANIC CARBON	93400	mg/kg
WRWP-SD001	AD1001	14-Sep-00	SD	TOTAL ORGANIC CARBON	17300	mg/kg
WRWP-SD002	AD1002	14-Sep-00	SD	TOTAL ORGANIC CARBON	17300	mg/kg
WRWP-SD003	AD1003	14-Sep-00	SD	TOTAL ORGANIC CARBON	17100	mg/kg
WRWP-SD004	AD1004	14-Sep-00	SD	TOTAL ORGANIC CARBON	36600	mg/kg
WRWP-SD005	AD1005	14-Sep-00	SD	TOTAL ORGANIC CARBON	38000	mg/kg

Sample type: DS - subsurface soil; GW - groundwater; SD - sediment
Units: mg/L - milligrams per liter; mg/kg - milligrams per - milligrams per kilogram

APPENDIX F

TOXICOLOGICAL PROFILES

Introduction to the Toxicity Profiles

1.0 Purpose and Use of the Toxicity Profiles

Human health toxicity profiles are presented for each chemical of potential concern (COPC), each chemical for which documentation of chemical-specific values is required or about which there are chemical-specific issues that require resolution. The toxicological profiles provide documentation of the chemical-specific physical properties and toxicity values used in the risk assessment (RA). They also discuss the identity, classification and uses of the chemical, the common sources of release to the environment and the fate of the chemical in the environment, including the relevance of aquatic and terrestrial food-chain pathways to human health. A brief review of toxicokinetics discusses absorption, distribution, metabolism or biotransformation, excretion of the parent compound and metabolites, and mechanism of toxicity including identifying the ultimate toxicant – i.e., the moiety (parent chemical or metabolite) identified as most likely responsible for the adverse effects associated with the chemical. This information may be helpful to determine whether laboratory animals may serve as appropriate models for toxicity to humans, and to clarify the nature of toxicological interactions with other chemicals. A discussion of dermal exposure provides perspective on the significance of dermal uptake, and documents the development of dermal toxicity values and the extent or rate of dermal uptake from soil or water according to the latest USEPA (2004a) guidance.

The noncancer effects evaluation and carcinogenicity evaluation provide an overall perspective on the nature of the adverse effects associated with the chemical, as well as documentation of the toxicity values. Chemical-specific issues or controversies that may influence the interpretation or application of the results of the RA are also discussed herein. The toxicity values used in the RA are summarized in a table.

EPA (2004b) Region IX has developed preliminary remediation goals (PRG) that many states and other EPA regions use for environmental screening. The PRGs are reviewed and recalculated, if necessary, to reflect newer toxicity evaluations.

The overall purpose of the toxicity profiles is to provide perspective on characteristics of each of the chemicals included in the RA so that the numerical risk estimates can be interpreted and applied wisely in the management of the site.

2.0 Chemical Identity

The identity of the chemical or chemical class is given in the title of each profile; additional information or clarification is provided in the *Introduction and Physical Properties* Section as required. The hyphenated number in parentheses following the chemical name is its unique Chemical Abstract Service (CAS) registration number. The CAS number may be located in the profile title, text, or in the case of multiple isomers or members of a chemical class, in the table that provides the physical properties.

3.0 Physical Properties

The toxicity profiles also provide documentation for the physical properties or constants that are important for chemical transport modeling, such as molecular weight (MW) in grams per mole (g/mole), the log of the octanol/water partition coefficient (log K_{ow}), Henry's Law constant (H) in atmosphere-cubic meters per mole (atm-m^3/mole), the soil/water partition coefficient (K_d) in

liters per kilogram (L/kg) for metals, the log of the soil/organic carbon partition coefficient (log K_{oc}) (unitless) for organic chemicals, diffusivity in air (D_a) in square centimeters per second (cm^2/s), diffusivity in water (D_w) in cm^2/s, vapor pressure (VP) in atmospheres (atm), solubility in water (S) in milligrams per liter (mg/L), and, for volatile organic compounds (VOC), boiling point of pure compound (T_b) in degrees Kelvin (°K), critical temperature (T_c) in °K, and enthalpy of vaporization at the boiling point ($\Delta H_{v,b}$) in calories per mole (cal/mol). Organic chemicals are designated as VOCs or semivolatile organic compounds (SVOC) based on their propensity to volatilize from environmental media. Chemicals designated as VOCs generally have an H greater than 1E-5 atm-m^3/mole (EPA, 2002).

The physical constants generally are taken from the most reliable source (i.e., the source that provides the highest level of documentation). Values for interrelated properties are usually taken from the same source (e.g., H is often estimated from VP and S; therefore, the same source is generally used for all three property values). When one source provides several values for a given property, professional judgment is used to select the most appropriate. Obvious outliers may be dropped from consideration. The average or the midpoint of a range of values may be selected. K_d values for metals and K_{oc} values for ionizing organic compound are based on a default pH of 6.8 (EPA, 2002) if the data are available. VP, S and H values are limited to those provided for normal ambient temperatures (0 to 30 °C) and the reference temperature is provided.

When values for H are not located, they are calculated as follows, provided the requisite information is available (EPA, 1998):

$$H = \frac{VP \bullet MW}{S}$$

where:

H = Henry's law constant (atm-m^3/mole, calculated)
VP = vapor pressure (atm)
MW = molecular weight (g/mole)
S = solubility in water (mg/L).

When values for K_{oc} are not located, they are calculated as follows for phthalates and polyaromatic aromatic hydrocarbons (PAH) provided log K_{ow} is available (EPA, 1998):

$$\log K_{oc} = 0.97 \log K_{ow} - 0.094$$

where:

K_{oc} = soil/organic carbon partition coefficient (unitless, calculated)
K_{ow} = octanol/water partition coefficient (unitless).

K_{oc} for other organic chemicals is calculated as follows provided log K_{ow} is available (EPA, 1998):

$$\log K_{oc} = 0.78 \log K_{ow} + 0.151$$

where:

K_{oc} = soil/organic carbon partition coefficient (unitless, calculated)
K_{ow} = octanol/water partition coefficient (unitless).

When values for D_a are not located, they are calculated as follows (EPA, 1998):

$$D_a = \frac{1.9}{MW^{2/3}}$$

where:

D_a = diffusivity in air (cm^2/s, calculated)
MW = molecular weight (g/mole).

When values for D_w are not located, they are calculated as follows (EPA, 1998):

$$D_w = \frac{22E{-}5}{MW^{2/3}}$$

where:

D_w = diffusivity in water (cm^2/s, calculated)
MW = molecular weight (g/mole).

Values for T_b, T_c and $\Delta H_{v,b}$ for VOCs are preferentially taken from EPA (2003a), unless there is evidence that values provided by other sources (HSDB, 2005; NIST, 2005) are more reliable. If values are not located for these variables, they may be estimated by the most appropriate technique for the specific chemical or class to which it belongs as recommended by Lyman et al. (1990). The estimation method used is identified by footnote in the table of physical properties.

4.0 Environmental Release, Fate and Transport

The toxicity profiles also present the predominant sources of release to the environment as well as a qualitative or semi-quantitative description of the fate and transport of the chemical in air, water, sediment, and soil. No attempt is made to present detailed quantitative data because environmental fate is usually highly dependent on climatic conditions and the characteristics of the medium of interest, both of which may differ from location to location and change from time to time. The source and fate information may provide perspective regarding the likelihood that the chemical's presence is related to site activities, that the chemical will migrate across media, or that the chemical will persist at toxicologically significant levels.

Biotransfer factors are provided for chemicals for which food-chain pathways may be significant, which includes a few inorganic chemicals and those organic chemicals that are highly lipophilic, persist in the environment, and are resistant to metabolism by lower trophic

organisms in the food chain. High lipophilicity is indicated by a log K_{ow} greater than 3 (Lyman et al., 1990). Lipophilicity enhances partitioning to biomedia and passage across biological membranes. Persistence in the environment is evidence that the chemical might resist biotransformation and, therefore, remain in edible tissues at toxicologically significant concentrations. Toxicokinetic data, when available, clarify the potential for biotransfer. Biotransformation products may be more toxic than the parent compound, but they tend to be short-lived or more quickly removed from the body, reducing the likelihood of significant bioaccumulation. Similarly, VOCs tend to be mobile and labile (i.e., subject to rapid and extensive biotransformation and excretion), and generally do not participate significantly in food-chain pathways. Therefore, biotransfer factors are not estimated for VOCs, with few exceptions. Some SVOCs, however, are highly lipophilic and may persist. Biotransfer factors generally are not estimated unless empirical data suggest that participation in food-chain pathways is likely to be significant.

The biotransfer factors of interest are water-to-fish bioconcentration factors (BCF) or bioaccumulation factors (BAF), or biota-sediment accumulation factors (BSAF), soil-to-plant biotransfer factors (Bp), cattle ingestion-to-beef factors (Bb) and cattle ingestion-to-milk factors (Bm). Separate soil-to-plant biotransfer factors are available for the reproductive parts of plants (e.g., fruits, seeds) and the vegetative parts of plants (e.g., stems, leaves) for inorganic and some organic chemicals. Soil-to-plant factors for the reproductive parts of plants are designated Bpr; soil-to-plant factors for the vegetative parts of plants are designated Bpv.

Most chemicals in surface water bodies remain predominantly in the dissolved phase in the water column or partition to sediment, which generally settles to the bottom. The difference in concentration between surface water and sediment is usually upwards of an order of magnitude. Theoretically it is appropriate to evaluate biotransfer from both media, using BCF to quantify uptake from water and BSAF to quantify uptake from sediment. Quantification of biotransfer, however, is accompanied by considerable uncertainty and variability because field conditions cannot be readily duplicated in the laboratory where BCF values are generally measured. Therefore, the biotransfer models for either medium are intentionally designed to be very conservative to ensure protection of human health. Consequently, evaluating biotransfer from both water and sediment captures the conservatism of both models and is likely to grossly overestimate total biotransfer. Therefore, most chemicals with the potential to participate significantly in aquatic food chain pathways are evaluated for bioconcentration from surface water *or* bioaccumulation from sediment, depending on which pathway is expected to predominate, but not both.

BCF values are adopted from empirical data when the data are clearly the best choice (i.e., similar results in multiple species of fin fish). When the empirical data are few or inconsistent, BCFs for inorganic chemicals are taken from various sources. BCF values for organic chemicals are generally estimated from the Bintein and Devillers model (Devillers et al., 1996):

$$\log BCF = 0.910 \log K_{ow} - 1.975 \log(6.8E{-}7K_{ow} + 1) - 0.786$$

where:

BCF = bioconcentration factor (L/kg, calculated)
K_{ow} = octanol/water partition coefficient (unitless).

The Bintein and Devillers model is selected over simpler models adopted by the EPA largely because the Bintein and Devillers approach has undergone scrutiny since first published (Bintein and Devillers, 1993), and considerable effort was expended to validate the model; i.e., to compare modeled and empirical results. The Bintein and Devillers model is probably more realistic than simpler models, particularly for chemicals with higher log K_{ow} values. BSAF values are chosen instead of BCFs for those very highly lipophilic chemicals such as the polychlorinated biphenyls (PCB), polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/PCDF) and selected organochlorine pesticides expected to partition almost entirely to benthic sediment.

Soil-to-plant biotransfer factors (Bp) for SVOCs are estimated by a simple model by Travis and Arms (1988), which is based only on log K_{ow}:

$$\log Bp = 1.588 - 0.578 \log K_{ow}$$

where:

Bp = soil-to-plant biotransfer factor (unitless, calculated)
K_{ow} = octanol/water partition coefficient (unitless).

Separate biotransfer factors are not estimated for the reproductive parts of plants (Bpr) and the vegetative parts of plants (Bpv) by the Travis and Arms model.

Cattle ingestion-to-beef factors (Bb) for SVOCs are estimated by a simple model by Travis and Arms (1988), which is based only on log K_{ow}:

$$\log Bb = -7.6 + \log K_{ow}$$

where:

Bb = cattle ingestion-to-beef biotransfer factor (days/kg, calculated)
K_{ow} = octanol/water partition coefficient (unitless).

Cattle ingestion-to-milk factors (Bm) for SVOCs are estimated by a simple model by Travis and Arms (1988), which is based only on log K_{ow}:

$$\log Bm = -8.10 + \log K_{ow}$$

where:

Bm = cattle ingestion-to-milk biotransfer factor (days/kg, calculated)
K_{ow} = octanol/water partition coefficient (unitless).

It should be understood that the biotransfer models described above depend only on one or two physical property values that are related largely to the propensity for transfer across biological membranes. Many compounds have relatively large log K_{ow} values, indicating ready passage across membranes; however, they are sufficiently volatile, or are otherwise mobile or labile so they are unable to persist in biological tissues. For example, many constituents with high log K_{ow} values are efficiently metabolized by lower trophic organisms in the food chain so that significant human exposure does not occur. Such is the case for practically all VOCs and most SVOCs; relatively few compounds participate significantly in food-chain pathways. Therefore, biotransfer is evaluated as a potential pathway only for those chemicals with empirical data that indicate food-chain exposure could be significant.

5.0 Toxicokinetics

A toxicokinetics section was added to the toxicity profiles in early 2004. Toxicokinetics describes the uptake or absorption of the chemical from contact media, the distribution of the chemical (or its metabolites) within the body following absorption, the metabolism or biotransformation of the chemical, and the mechanisms of excretion of the parent compound and its biotransformation products from the body. The toxicokinetics section documents the gastrointestinal (GI) absorption factor (GAF) required to develop toxicity factors for dermal exposure, because dermal risk characterization depends on an absorbed dose rather than an exposure dose. The toxicokinetics section also identifies the compounds that are rapidly metabolized or eliminated, which justifies excluding their evaluation in food-chain pathways even though they may have a large K_{ow} that indicates ready passage across cell membranes. This section also tries to identify the ultimate toxicant and elucidate the most important mechanism(s) of toxicity.

6.0 Dermal Exposure

The toxicity profiles provide the documentation for the GAF, which is used to develop the dermal toxicity values. The toxicity profiles also provide documentation for the dermal absorption factor (ABS), which describes the extent of dermal uptake from soil, and the time for dermal uptake to reach steady state (t^*), the permeability coefficient (K_p), the lag time for chemical to cross the stratum corneum (τ), the fraction absorbed (FA), and the ratio of the permeability coefficient for passage across the stratum corneum to the permeability coefficient for passage across the viable epidermis (B), all which are used to estimate the rate of dermal uptake from water. These values are taken from EPA (2004a) if available. Otherwise, they are estimated by the EPA (2004a) methods.

6.0 Toxicity Evaluation

The toxicity profile contains a brief description of the nature of the adverse effects associated with the chemical. It is important to note that a discussion of adverse effects without a discussion of dose is incomplete and potentially misleading, because virtually any chemical may be toxic at some dose, and many chemicals (e.g., nutritionally required minerals, vitamins, amino acids, etc.) enhance human health at some low dose. An ever growing and compelling body of evidence suggests that many environmental contaminants also enhance health at low doses (Hart and Frame, 1996).

6.1 Noncancer Evaluation

The toxicity values for noncancer effects include a reference dose (RfD) expressed in milligrams per kilogram per day (mg/kg-day) for chronic or subchronic oral exposure, and a reference concentration (RfC), in milligrams per cubic meter (mg/m^3), for chronic or subchronic inhalation exposure. The inhalation RfC in units of mg/m^3 may be converted to an equivalent inhalation RfD by assuming continuous chronic exposure of humans with a body weight of 70 kg and an inhalation rate of 20 m^3/day (EPA, 1989, 1991). In other words, the RfC expressed as mg/m^3 is multiplied by the inhalation rate of 20 m^3/day, and the result is divided by the assumed adult body weight of 70 kg to yield an inhalation RfD expressed as mg/kg-day.

RfD and RfC values are usually derived from empirical benchmark doses (BMD) or concentrations called no-observed-effect levels (NOEL) or no-observed-adverse-effect levels (NOAEL) from animal toxicity or human epidemiology studies. If the data do not permit identifying a NOEL or NOAEL, a lowest-observed-adverse-effect level (LOAEL) or lowest-effect level (LEL) may be used. A frank-effect level (FEL), e.g., mortality, shortened life span or serious physiologic, neurologic or behavioral disturbances, is generally considered an inappropriate benchmark from which to develop an RfD or RfC. Some RfD and RfC derivations employ a BMD that is a statistically estimated dose for humans at which some low proportion of the population may experience some minimally adverse effect. A BMD at which 10 percent of the population may be expected to experience such an effect is expressed as BMD_{10}. The RfD or RfC is derived by dividing the benchmark level (e.g., NOAEL or BMD_{10}) by a series of uncertainty and modifying factors, which collectively are designated the uncertainty factor (UF).

RfD and RfC values are not currently available for acute toxicity and acute exposure is not evaluated in the RA. Nonetheless, the levels associated with acute lethality and data regarding the effects of acute exposure to levels higher than ordinarily observed in chronic environmental exposure provide additional perspective regarding the toxicity of the chemical. Therefore, information regarding acute toxicity, when available, is included in the profiles. Lethality data for laboratory animals are generally expressed as the oral dose associated with lethality of 50 percent of an exposed population (LD_{50}) or the concentration in air associated with lethality of 50 percent of an exposed population (LC_{50}). Occasionally the dose associated with lethality in a low percentage of an exposed population (LD_{LO}) is presented.

RfD and RfC values are derived for both chronic and subchronic exposure. For purposes of the RA, chronic exposure is defined as equal to or greater than 7 years, i.e., at least 10 percent of expected life span; subchronic exposure is defined as 2 weeks to 7 years.

Under the assumption of monotonicity (i.e., incidence, intensity, or severity of effects can increase, but cannot decrease, with increasing magnitude or duration of exposure), a chronic RfD may be considered sufficiently protective for subchronic exposure, but a subchronic RfD may not be protective for chronic exposure. Currently, verified subchronic RfD values are unavailable. Provisional subchronic RfDs exist for few chemicals and are compiled in the Health Effects Assessment Summary Tables (HEAST) (EPA, 1997) and some National Center for Environmental Assessment (NCEA) or Provisional Peer Reviewed Toxicity Value (PPRTV) derivations. Although once updated semi-annually, the HEAST is no longer updated, because the EPA (2005) Integrated Risk Information System (IRIS) is generally considered the source of the highest quality toxicity values. For some chemicals the PPRTV derivations are more recent

and it is known that summaries on IRIS will be replaced with the PPRTV derivations. In these cases the PPRTV values will be selected preferentially to those on IRIS. Subchronic RfD and RfC values are generally obtained from EPA (1997) or more recent NCEA or PPRTV evaluations, or they may be derived *de novo* from the toxicological data set or from chronic RfD values as follows:

- If the UF applied in the derivation of the chronic RfD does not provide for expansion from subchronic to chronic exposure (e.g., if the chronic RfD was derived from a chronic study), the chronic RfD is adopted as being sufficiently protective for subchronic exposure.

- If the UF applied in the derivation of the chronic RfD contains a component to expand from subchronic to chronic exposure, the subchronic RfD is derived by multiplying the chronic RfD by the component of the UF used to expand from subchronic to chronic exposure (e.g., if a factor of 10 was used to expand from subchronic to chronic exposure, the subchronic RfD will be 10 times larger than the chronic RfD).

6.2 Carcinogenicity Evaluation

The evaluation of the potential carcinogenicity of a chemical includes both a qualitative and a quantitative aspect (EPA, 1986, 2003b). The qualitative aspect is a weight-of-evidence evaluation of the likelihood that a chemical might induce cancer in humans. EPA (1986) recognizes six weight-of-evidence group classifications for carcinogenicity:

Group A - Human Carcinogen. Human data are sufficient to identify the chemical as a human carcinogen.

Group B1 - Probable Human Carcinogen. Human data indicate that a causal association is credible, but alternative explanations cannot be dismissed.

Group B2 - Probable Human Carcinogen. Human data are insufficient to support a causal association, but test data in animals support a causal association.

Group C - Possible Human Carcinogen. Human data are inadequate or lacking, but animal data suggest a causal association, although the studies have deficiencies that limit interpretation.

Group D - Not Classifiable as to Human Carcinogenicity. Human and animal data are lacking or inadequate.

Group E - Evidence of Noncarcinogenicity to Humans. Human data are negative or lacking, and adequate animal data indicate no association with cancer.

More recently, EPA (2003b) proposed a less formal and more narrative description of cancer weight of evidence. The newer weight-of-evidence descriptions are beginning to appear in the EPA (2005) and the PPRTV toxicity documentation. However, the older weight-of-evidence classifications still predominate in most EPA toxicity documentation.

Toxicity values for cancer risk include a slope factor (SF) for oral exposure, expressed as the risk per mg/kg-day ingested dose, and a unit risk factor (URF) for inhalation exposure, expressed as the risk per microgram per cubic meter ($\mu g/m^3$) in ambient air. These quantitative estimates are generally provided for chemicals in EPA weight-of-evidence Groups A, B and C if the data are adequate. The SF or URF is usually estimated as an upper bound on the slope of the dose- or concentration-response curve from animal toxicity or human epidemiology studies. The inhalation URF in units of risk per $\mu g/m^3$ may be converted to an equivalent inhalation SF in units of risk per mg/kg-day by assuming continuous lifetime exposure of humans with a body weight to 70 kg and an inhalation rate of 20 m^3/day. In other words, the URF expressed as risk per $\mu g/m^3$ is divided by the inhalation rate of 20 m^3/day, and multiplied by the assumed body weight of 70 kg and a conversion factor of 1000 $\mu g/mg$.

EPA (1986, 2003b) generally assumes that there are no thresholds for carcinogenic expression; therefore, any exposure represents some quantifiable risk. A few potential carcinogens are understood to require a threshold for carcinogenic expression. Such chemicals are more appropriately evaluated with an RfD developed as described above.

6.3 Hierarchy for Selecting Toxicity Data

Toxicity values generally are chosen using the following hierarchy:

- The EPA's (2005) on-line IRIS database containing toxicity values that have undergone the most rigorous Agency review.
- PPRTV derivations for the Superfund Technical Support Center (STSC); there may be individual chemicals for which the PPRTV derivations supercede those on IRIS.
- Older NCEA derivations for the STSC, HEAST (EPA, 1997), or other EPA documents or memoranda.

When EPA-derived toxicity values are not located in any of the above sources, Minimal Risk Levels (MRL) from the Agency for Toxic Substances Disease Registry (ATSDR) toxicity profiles may be adopted or adapted for use in the RA. MRLs are derived by a methodology similar to the EPA methodology for RfD derivation. ATSDR toxicity profiles generally identify levels significant to human health with particular emphasis on target organ and mechanism of toxicity. Also, the U.S. Army Center for Health Promotion and Preventive Medicine (CHPPM) has derived toxicity values for certain chemicals (and their degradation products) associated with military use. Finally, the primary literature may be surveyed to determine whether sufficient data exist to derive a toxicity value using the EPA methodology. The use of surrogate chemicals is also considered if the chemical structure, adverse effects, and toxic potency of the surrogate and chemical of interest are judged to be sufficiently similar.

GAFs, used to derive dermal RfD values and SFs from the corresponding oral toxicity values, are obtained from the following hierarchy:

- EPA (2004a)
- Empirical data
- PPRTV summaries or NCEA position papers
- Federal agency reviews of the empirical data, such as ATSDR toxicity profiles and various EPA criteria documents
- Other published reviews of the empirical data.

7.0 Preliminary Remediation Goals

EPA (2004b) Region IX has developed preliminary remediation goals (PRG) for nearly 600 frequently encountered environmental contaminants for soil for residential use, for soil for industrial use, for ambient air, and for tap water. The PRGs are based on standard default exposure assumptions, and are often adapted for the risk-based screening step for selecting chemicals of potential concern for human health RAs. EPA (2004b) provides the methodology and standard exposure default assumptions with which to estimate PRGs. Generally, PRGs are developed for both cancer risk, based on a risk of 1E-6, and noncancer hazard, based on a hazard index of 1. The smaller of the two sets of estimates is presented in the published PRG tables, but the larger is usually available in the "InterCalc" tables accessible at the EPA Region IX website. New or updated PRGs are calculated in the toxicity profiles for chemicals not included in the tables and for chemicals with updated toxicity values.

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METALS

ALUMINUM (7429-90-5)

1.0 Introduction and Physical Properties

Aluminum is a naturally occurring **metal** (ATSDR, 1999). It is the third most abundant element in nature, constituting approximately 8 percent of the minerals in the earth's crust. Aluminum is highly reactive; thus, is always found in combination with other substances such as oxygen, fluoride or silica. Aluminum is used in a wide variety of metallurgical applications, including packaging (particularly food items), kitchen utensils, auto bodies and components, airplanes, building components, electrical transmission, and to adsorb occluded gases in making steel (ATSDR, 1999; Elinder and Sjogren, 1986; HSDB, 2005). Aluminum compounds are used in testing for gold, arsenic and mercury, in metal alloys, in protective coatings, paints and printer inks, in cosmetics, food additives and some pharmaceuticals, as coagulating agents in the treatment of drinking water, and in photography flash bulbs and fireworks. Relevant physical properties are compiled below:

MW	log K_{ow}	H	K_d	D_a	D_w	VP	S
26.98[a] (Element)	NA	NA	1500[b]	NA	NA	NA	Note 1[c]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; K_d = soil/water partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; NA = not applicable.

[a]Hazardous Substance Data Bank (HSDB), 2005, National Library of Medicine, on line, accessed 29 November.

[b]Baes, C.F., R.D. Sharp, A.L. Sjoreen, R.W. Shor, 1984, ***A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture***, Health and Safety Division, Oak Ridge National Laboratory, ORNL-5786, September.

[c]Solubility of aluminum compounds varies from essentially insoluble in hot or cold water to highly soluble to highly reactive (e.g., aluminum chloride reacts explosively with water liberating heat and hydrogen chloride gas). Agency for Toxic Substances and Disease Registry (ATSDR), 1999, ***Update Toxicological Profile for Aluminum***, U.S. Department of Health and Human Services, Atlanta, Georgia, July, on line.

2.0 Environmental Fate and Transport

Aluminum is one of the few elements for which natural release far outweighs anthropogenic release (ATSDR, 1999; HSDB, 2005). The predominant natural process is the weathering and release of dust from soil and rocks into the air. Major anthropogenic sources include aluminum mining and smelting, coal combustion, and other mining or industrial activities that process crustal materials and release aluminum to the atmosphere. Aluminum exists in the air as particulates that presumably are subject to wet and dry deposition. Large particulates predominate, which suggests that deposition occurs not far from the point of release.

Aluminum is deposited on soil from the atmosphere (ATSDR, 1999). Other anthropogenic sources to soil include wastes from mines, smelters and coal combustion. Aluminum in soil exists in several soluble and insoluble forms, depending on pH and the nature of the minerals and organic material present in the soil. Generally, increasing acidity (decreasing pH) mobilizes aluminum and facilitates leaching.

Aluminum exists naturally in water in several hydrated and complexed forms (ATSDR, 1999). Sources include solution from surrounding soil, precipitation, and runoff and erosion from soil. The

extent to which aluminum in water settles out is highly variable and depends on pH and the other constituents present in the water with which aluminum may form compounds and complexes. Generally an equilibrium is established between soluble and insoluble forms.

Bioconcentration in fish is largely a function of water quality (e.g., pH and total organic carbon). Highest concentrations of aluminum are generally found in the gills and lowest concentrations are found in edible muscle tissue. Concentrations decrease as the fish pass through the larval and juvenile stages. Therefore, the bioconcentration of aluminum in edible fish tissues is not expected to represent a toxicologically significant source to humans (EPA, 1995).

Acid conditions in soil mobilize aluminum for uptake by plants, but the extent of uptake and the distribution between the roots and the aerial parts is highly dependent on the species of plant (ATSDR, 1999). Teas and some herbs may bioconcentrate aluminum; however, these items are unlikely to contribute significantly to the diet. Aluminum does not accumulate significantly in cow's milk or beef, and is not expected to undergo biomagnification in terrestrial food chains. For these reasons biotransfer is not expected to contribute significantly to human exposure and biotransfer factors are not compiled or estimated.

3.0 Toxicokinetics

Aluminum is poorly absorbed following inhalation exposure (ATSDR, 1999). Evidence suggests that the epithelium of the upper and lower respiratory tract can absorb aluminum, and that absorption is somewhat more efficient for aluminum fumes (occupational exposure) rather than dust. Aluminum can be retained in the lungs for long periods. Also, it has been shown that aluminum absorbed by the olfactory epithelium can reach the brain directly via axonal transfer.

Dietary aluminum is absorbed from the GI tract in the range of 0.1 to 0.3 or perhaps 0.5 percent (ATSDR, 1999). Unusually bioavailable forms such as carboxylic acid complexes may be absorbed at 1 percent of the administered dose. Ingestion of large amounts of aluminum in antacid preparations can increase total absorption, but factors other than the amount ingested appear to reduce the proportion of the total dose that is absorption.

ATSDR (1999) concluded that aluminum is "essentially not absorbed dermally," although the data are confusing and one study in mice verifies that dermal uptake occurs. Quantitative data were not located.

Normal humans have a body burden of aluminum in the 30 to 50 mg range, with approximately one-half located in the skeleton and one-fourth in the lungs (ATSDR, 1999). Body burden generally increases with age. The amount in the lungs probably reflects accumulation from inhalation of aluminum in dust. Levels in brain tissue range from 0.25 to 0.75 mg/kg wet weight in the white matter and approximately twice that in the gray matter.

Aluminum following inhalation exposure is associated largely with the lungs and thoracic lymph nodes (ATSDR, 1999). In humans, increased levels are seen also in the liver and spleen. Increased levels in these tissues have not been seen in animals exposed via inhalation. Some inhaled particulates are cleared from the respiratory tract by mucocilliary elevation and are swallowed, thereby becoming available for GI absorption.

Animal studies with ingested aluminum suggest that distribution is preferentially to various regions of the brain (ATSDR, 1999). Prolonged studies with rats indicate that distribution also occurs to bone, muscle and kidneys, but that tissue levels return to normal shortly after exposure ceases. Limited evidence in animals suggests that transplacental distribution and excretion via lactation also occur. Vitamin D and related compounds may increase uptake and tissue retention. Distribution studies following administration by various parenteral routes yielded quite variable results, suggesting that the target tissues may be specific to the form of aluminum administered. The brain was clearly not reported as the most predictable target tissue for all forms of aluminum administered to all species by parenteral routes.

Aluminum in the body may occur in the form of free ions (Al^{+3}), low-molecular-weight complexes (particularly stable chelates), macromolecular complexes, or covalently bound macromolecular complexes (ATSDR, 1999). All forms may be metabolically active. Essentially irreversible complexes may be formed in the nucleus and chromatin material of the cell.

The kidney is the primary organ for excretion of absorbed aluminum (ATSDR, 1999). Urinary excretion patterns after inhalation exposure (i.e., prolongation of elevated urinary levels of aluminum) indicate that body burden and excretion half-life both increase with prolonged exposure. Excretion is lower in premature infants than full-term infants, probably because glomerular filtration is underdeveloped before birth. This suggests that the unborn and premature may be unusually sensitive to the effects of aluminum.

4.0 Dermal Exposure

As noted above, ATSDR (1999) concluded that aluminum is essentially not absorbed dermally. Therefore, the likelihood of systemic toxic effects arising from dermal exposure to aluminum is very small, and no attempt is made to quantify dermal uptake or risk.

5.0 Noncancer Effects Evaluation

Aluminum is relatively nontoxic via ingestion to physiologically normal humans, but recently concern has arisen regarding neurological effects, including Alzheimer's disease and similar forms of dementia (EPA, 2001a). Much of this concern stems from studies with large oral doses of soluble aluminum salts (e.g., aluminum hydroxide) and from medical procedures that bypass the GI absorption barrier (i.e., parenteral administration). A review of several animal studies with many different forms of aluminum suggests that the developing infant is potentially the most sensitive member of the human population. A provisional chronic oral RfD of 1E+0 mg/kg-day was derived from a LOAEL of 100 mg/kg-day for minimal and equivocal neurological effects in the offspring of mice. The mice were fed diets fortified with aluminum lactate throughout gestation and lactation. An uncertainty factor of 100 (factor of 10 for interspecies extrapolation, and factors of 3 each for a minimal LOAEL and for intraspecies variation) was used. Confidence in the oral RfD is low. The nervous system is the target organ for oral exposure to aluminum. (The nervous system rather than the CNS is chosen as the target organ because it cannot be stated unequivocally that some of the neurologic effects observed do not involve the peripheral nerves.)

EPA (1997) provides no subchronic oral RfD for aluminum, and one cannot be derived from the key study for the chronic oral RfD. Therefore, the chronic oral RfD of 1E+0 mg/kg-day is adopted as sufficiently protective for subchronic oral exposure.

Occupational exposure to aluminum metal dust and aluminum oxide is associated with pulmonary fibrosis and related respiratory effects such as cough, emphysema, pneumonia and decreased pulmonary function (ACGIH, 1991). The toxicity of occupational exposure to dusts of aluminum pyro powders is somewhat higher, and occupational exposure to salts such as the sulfate and chloride may yield hydrolysis to the corresponding acids, which are irritants in their own right. Pulmonary effects were also observed in animals exposed to powders and dusts of metallic aluminum and various aluminum compounds.

Results of testing Canadian gold and uranium miners prophylactically treated with aluminum oxide powders to prevent silicosis associated aluminum exposure with impaired cognitive performance (EPA, 2001b). The likelihood of cognitive impairment was directly related to the duration of exposure. Neurological performance was also impaired in aluminum foundry workers exposed to fumes and aluminum dust (4.6 to 11.5 mg aluminum/m^3) for a mean of 12 years. Other studies also implicate aluminum as a cause of neurological impairment and neurophysical effects in exposed smelter workers and aluminum welders. A provisional inhalation RfC is based on the LOAEL of 4.6 mg aluminum/m^3 in the study of foundry workers described above. The lower end of the exposure concentration adjusted for intermittent exposure is 1.64 mg/m^3. Application of an uncertainty factor of 300 (factors of 10 each to estimate a NOAEL from a LOAEL and for interspecies extrapolation, and a factor of 3 to address deficiencies in the inhalation toxicity data base) yields an RfC of 5E-3 mg/m^3, which is equivalent to a chronic inhalation RfD of 1.4E-3 mg/kg-day. Confidence in the inhalation RfC is medium. The nervous system is the target organ for inhalation exposure to aluminum.

EPA (1997) provides no subchronic inhalation RfC for aluminum, nor can one be estimated from the key study used for the chronic RfC. Therefore, the chronic inhalation RfC of 5E-3 mg/m^3 (1.4E-3 mg/kg-day) is adopted as sufficiently protective for subchronic oral exposure.

6.0 Carcinogenicity Evaluation

EPA (2001a) reviewed the human and laboratory animal data regarding the potential carcinogenicity of aluminum and concluded that the carcinogenicity cannot be determined, which places aluminum and its compounds in EPA (1986) cancer weight-of-evidence Group D. The human data are insufficient for drawing conclusions and the animal data are largely negative. Potency factors are not derived.

7.0 Toxicity Summary

Toxicity values for aluminum are summarized as follows:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure[a]		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
1E+0	1E+0	NS	5E-3/ 1.4E-3	5E-3/ 1.4E-3	NS	D	ND	D	ND	ND

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data.

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure[a]		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
Target organ or critical effect abbreviations: NS = nervous system. [a]Dermal exposure is not evaluated.										

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ARSENIC (7440-38-2)

1.0 Introduction and Physical Properties

Arsenic is a natural **metalloid**, the 20th most abundant element in the earth's crust, that occurs in both inorganic and organic forms (ATSDR, 2000; HSDB, 2004). Elemental arsenic is a steel-grey material that may occur naturally. However, arsenic is usually found in the environment combined with other elements such as oxygen, chlorine, and sulfur. Most inorganic and organic arsenic compounds are non-volatile, odorless and tasteless white or colorless powders. Inorganic arsenic occurs naturally in soil and in many kinds of rock, especially in minerals and ores that contain copper or lead. Inorganic arsenic is more toxic than organic forms. Major uses of arsenic in the U.S. include its incorporation into wood preservatives and other agricultural chemicals. It is also used as a metal in various electrical devices and is alloyed with lead and copper in the manufacture of lead bullets or shot (Lewis, 1997). Arsenic is also a component of the chemical warfare agent Lewisite (Opresko et al., 1998). Lewisite is manufactured by the condensation of arsenic trichloride with acetylene in the presence of aluminum, copper or mercuric chloride (Lewis, 1997). Relevant physical properties are compiled below:

MW	log K_{ow}	H	K_d	D_a	D_w	VP	S
74.92[a]	NA	NA	2.9E+1[b]	NA	NA	Note 1[c]	Note 2[c]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; K_d = soil/water partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; NA = not applicable.
Note 1: Variable: inorganic arsenic compounds are not likely to volatilize; some organic arsenic compounds are low-boiling liquids or gases at normal temperatures.
Note 2: Variable: inorganic arsenic compounds range from practically insoluble to freely miscible in water; most organic arsenic compounds are not readily soluble, most arsenic acid compounds are soluble to freely miscible.
[a] Hazardous Substance Data Bank (HSDB), 2004, National Library of Medicine, on line, accessed 21 April.
[b]U.S. Environmental Protection Agency (EPA), 2001, ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites***, Peer Review Draft, Office of Solid Waste and Emergency Response, OSWER 9355.4-24, March.
[c]Agency for Toxic Substances and Disease Registry, (ATSDR), 2000, ***Update Toxicological Profile for Arsenic***, U.S. Public Health Service, Atlanta, Georgia, September, on line.

2.0 Environmental Fate and Transport

The production of arsenic and its use in nonferrous alloys and in the manufacture of semiconductors may result in its release to the environment through various waste streams HSDB, 2004). Other important anthropogenic releases are metal smelting, coal burning, and other industrial activities. Arsenic may be present at military sites as a result of training with or demilitarization or disposal of Lewisite. Most (approximately 80 percent) of anthropogenic releases are initially to soil (ATSDR, 2000).

Arsenic occurs in the air as a combination of trivalent and pentavalent forms almost entirely adsorbed to small particles that permit dispersion over long distances (ATSDR, 2000). Residence time in the atmosphere averages approximately nine days. Removal is largely by wet and dry deposition. Arsenic in surface water can undergo a variety of reactions and exist as several different soluble compounds. Sorption to sediment is often an important removal process, but biotransformation in sediment may return soluble forms to the water. Arsenic in soil generally exists as insoluble forms sorbed to clay or organic matter or complexed with calcium or iron. Mobility is low and leaching is not generally significant, except that increasing soil pH can dramatically increase solubility and mobility.

Arsenic has been shown to bioconcentrate in aquatic organisms, mainly at the water-algae interface (ATSDR, 2000). There is no evidence for biomagnification through the various trophic levels, nor do there appear to be significant differences between bottom-feeders and predatory fish. Arsenic is among the metals listed as being of no concern for bioaccumulation in fish (EPA, 1995). Empirical data suggest that bioconcentration through terrestrial food chain pathways is unlikely to be significant (ATSDR, 2000). Therefore, biotransfer factors are not developed for arsenic.

3.0 Toxicokinetics

All forms of inorganic arsenic are readily absorbed by the lungs and GI tract; the extent of absorption is greater for more soluble compounds than for more insoluble compounds (ATSDR, 2000). Dermal absorption has not been well characterized but is significantly less than inhalation or oral absorption. GI and dermal absorption of arsenic from soil is much lower than from aqueous solution. Distribution is generally widespread throughout the body following absorption.

Metabolism of inorganic arsenic involves reduction of As^{+5} to As^{+3}, and oxidation of As^{+3} to As^{+5} so that arsenic is present systemically as a mixture of arsenate and arsenite (ATSDR, 2000). Arsenite is readily oxidized and methylated primarily in the liver to form the organic compounds monomethyl arsonic acid and dimethyl arsinic acid, which are rapidly excreted in the urine.

4.0 Dermal Exposure

EPA (2003) concluded that a GAF should not be estimated for the purpose of adjusting oral toxicity values for dermal exposure. Therefore, the oral toxicity values described below are used directly without adjustment for evaluating dermal exposure.

EPA (2003) cites empirical data indicating that dermal uptake of arsenic from soil approximates 3 percent. The ABS of 0.03 recommended by EPA (2003) is used herein. Empirical data regarding the uptake of soluble forms of arsenic from water were not located. The EPA (2003) default K_p for inorganic chemicals of 1E-3 cm/hour is selected for arsenic.

5.0 Noncancer Effects Evaluation

Inorganic arsenic may be an essential nutrient, at least for food-producing domestic animals, exerting beneficial effects on growth, health and feed conversion efficiency (Underwood, 1977). A lethal dose of arsenic trioxide in humans is 70-180 mg, approximately 50 to 140 mg arsenic (Ishinishi et al., 1986). Acute oral exposure of humans to high doses of arsenic produces liver swelling, skin lesions, disturbed heart function and neurological effects. The only noncancer effects in humans clearly attributable to chronic oral exposure to arsenic are dermal hyper pigmentation and keratosis, as revealed by studies of several hundred Chinese exposed to naturally occurring arsenic in well water (EPA, 2004). Similar effects were observed in persons exposed to high levels of arsenic in water in Utah and the northern part of Mexico. EPA (2004) verified an RfD of 3E-4 mg/kg-day for chronic oral exposure, based on a NOAEL of 8E-4 mg/kg-day for hyper pigmentation and kertatosis of the skin from the Chinese data. An uncertainty factor of 3 was applied. An increased incidence of Blackfoot disease was also observed, which may not be related to arsenic alone. Goyer (1991) describes black-foot disease as a peripheral vascular disorder manifested as acrocyanosis and Raynaud's disease, which may progress to gangrene. EPA (2004) notes that the skin is the more sensitive target organ. Nonetheless, in keeping with EPA (1989) guidance

regarding selection of target organ, both the skin and peripheral vascular system are selected as target organs for prolonged oral exposure to arsenic. Confidence in the RfD is medium.

The available data do not suggest a significant difference between chronic and subchronic exposure regarding the threshold for noncancer effects. Therefore, EPA (1997) adopted the chronic oral RfD as the provisional subchronic oral RfD for arsenic.

Occupational (predominantly inhalation) exposure is also associated with neurological deficits, anemia, and vascular effects (Ishinishi et al., 1986). However, concomitant exposure to other chemicals cannot be ruled out in the occupational studies. Therefore, the data are not sufficient for estimation of an inhalation RfC.

6.0 Carcinogenicity Evaluation

Inorganic arsenic is clearly a carcinogen in humans. Inhalation exposure is associated with increased risk of lung cancer in persons employed as smelter workers, in arsenical pesticide applicators, and in a population residing near a pesticide manufacturing plant (EPA, 2004). Oral exposure to high levels in well water is associated with increased risk of skin cancer and several forms of internal cancer, although the role of other chemicals in the internal cancers is unclear. Extensive animal testing with various forms of arsenic given by many routes of exposure to several species, however, has not demonstrated the carcinogenicity of arsenic, indicating that the common laboratory animals are not good models for carcinogenicity to humans. EPA (2004) classified inorganic arsenic in cancer weight-of-evidence Group A (human carcinogen), and recommended an oral SF of 1.5E+0 per mg/kg-day, based on the incidence of skin cancer in the Chinese study. EPA (2004) noted that arsenic probably functions via several different mechanisms of toxicity not including direct interaction with DNA. These appear to obey thresholds or to generate a non-linear slope that approaches 0 in the low-dose range. The SF probably exaggerates cancer risk in the low dose range associated with most environmental exposures, although the extent is unclear.

An inhalation URF of 4.3E-3 per $\mu g/m^3$, equivalent to an inhalation SF of 1.5E+1 per mg/kg-day, was derived for inorganic arsenic from the incidence of lung cancer in occupationally exposed men (EPA, 2004).

7.0 Toxicity Summary

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure[a]		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
3E-4	3E-4	S, PVS	ND	ND	NA	A	1.5E+0	A	4.3E-3	1.5E+1

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data; NA = not applicable.
Target organ or critical effect abbreviations: S = skin; PVS = peripheral vascular system.
[a]sRfDo, cRfDo and SFo should be used for dermal exposure without adjustment for GI absorption.

8.0 Preliminary Remediation Goals

EPA (2002) Region IX presents PRGs for arsenic for all relevant media based on cancer risk in the published PRG table. The PRG table presents noncancer PRGs for soil, but not for air or tap water. This reason for this is unclear, since arsenic in soil may enter the air via dust emissions, and arsenic is routinely detected in groundwater. Therefore, noncancer PRGs for all relevant media are estimated and presented in the following table:

Chemical	Oral RfD (mg/kg-day)	Inhalation RfD (mg/kg-day)	PEF (m^3/kg)	Preliminary Remediation Goal			
				Residential Soil (mg/kg)	Industrial Soil (mg/kg)	Ambient Air (µg/m^3)	Tap Water (µg/L)
Arsenic	8.8E-8	8.8E-8	1.316E+9	2.2E+1	2.6E+2	1.1E+0	1.1E+1
RfD = reference dose; PEF = particulate emission factor.							

The PRGs are based on a hazard index of 1.

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CHROMIUM (7440-47-3)

1.0 Introduction and Physical Properties

Chromium is a naturally occurring **metal** (ATSDR, 2000). It occurs in several valence states; chromium (III) (16065-83-1) and chromium (VI) (18540-29-9) are the forms most commonly encountered in environmental media. Chromium is used largely in the metallurgical, refractory and chemical industries. The largest amount is used in the metallurgical industry in various steels and nonferrous alloys. The second largest use is by the chemical industry in pigments, metal finishing, leather tanning and wood treatment. Relevant physical properties are compiled below:

MW	log K_{ow}	H	K_d	D_a	D_w	VP	S
52.00[a] (element)	NA	NA	1.8E+6 (CrIII) 1.9E+1 (CrVI)[b]	NA	NA	ND	Note 1[a]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; K_d = soil/water partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; NA = not applicable; ND = no data.

Note 1: Chromium compounds vary from insoluble to highly soluble.

[a]Agency for Toxic Substances and Disease Registry, (ATSDR), 2000, ***Toxicological Profile for Chromium***, U.S. Public Health Service, Atlanta, Georgia, September, on line.

[b]U.S. Environmental Protection Agency (EPA), 2001, ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites***, Peer Review Draft, Office of Solid Waste and Emergency Response, OSWER 9355.4-24, March.

2.0 Environmental Fate and Transport

Chromium is released into the atmosphere from natural gas, oil and coal combustion, and from use by the industries mentioned above (ATSDR, 2000). Other sources include wind transport from road dust, cement producing plants, the wearing down of asbestos brake linings from automobiles, incineration of municipal refuse and sewage sludge, exhaust emission from automotive catalytic converters, and emissions from cooling towers that use chromium compounds as rust inhibitors. Significant quantities of chromium are released to surface water from industrial use. Land disposal of chromium-containing commercial products, solid waste and slag from chromate manufacture, and coal ash, primarily from electric utilities and other operations that burn coal, are the major releases to soil.

Chromium releases from combustion processes and ore processing are generally in the form of chromium (III) oxide; however, chromium (VI) has been identified in fly ash from coal combustion at chromate manufacturing and user sites (ATSDR, 2000). Airborne chromium exists in particulate form that may travel great distances from the point of emissions; wet and dry deposition account for the majority of removal from air.

Most chromium released to surface water eventually adsorbs to particles and becomes deposited in bottom sediment, but small quantities may remain in the water in both soluble and insoluble forms (ATSDR, 2000). The soluble forms are usually chromium (VI) salts and soluble chromium (III) compounds. Chromium (VI) may be found in water, but eventually organic matter and other reducing agents will reduce chromium (VI) to chromium (III). Chromium in soil is present mainly as insoluble chromium (III) carbonates and oxides that are unlikely to be mobile to any significant extent. However, soluble forms may also be present, depending on the form of the chemical

released, that may be quite mobile in soil. Also, lower pH facilitates complexation with organic matter and increases mobility.

Empirical evidence suggests that chromium is unlikely to participate significantly in food chain pathways (ATSDR, 2000; EPA, 1995); therefore, biotransfer factors are not compiled.

3.0 Toxicokinetics

Identification of chromium in urine, serum and tissues of occupationally exposed humans confirms that soluble chromium (III) and chromium (VI) compounds are absorbed from the lung (ATSDR, 2000). The rate of absorption, however, depends largely on the physical and chemical characteristics of the chromium compound involved, as shown in numerous animal inhalation studies. Chromium (VI) compounds are more readily absorbed because the chromate anion participates in facilitated diffusion mechanisms not available to chromium (III).

Absorption of dietary sources of chromium from the GI tract in humans ranges from approximately 0.5 to 2 percent, as inferred from urinary excretion data (ATSDR, 2000). The extent of absorption appears to be inversely related to dietary chromium content. A review of several studies suggests that 0.4 to 14.5 percent of orally administered chromium not related to dietary sources is absorbed by the GI tract of humans, but valence and chemical form and nutritional status (fed vs. fasting) appear to influence efficiency of absorption (ATSDR, 2000). Chromium (VI) sources are more efficiently absorbed than chromium (III) sources as described above for inhalation exposure. Experiments with laboratory animals showed that the stomach has the ability to reduce chromium (VI) to chromium (III), reducing the extent of absorption when chromium (VI) compounds were administered *per os* compared with injection directly into the jejunum.

Both chromium (III) and chromium (VI) can penetrate intact human skin, and dermal uptake is increased if the skin is damaged (ATSDR, 2000). In some cases, dermal uptake was sufficient to result in signs of toxicity. The form and the vehicle greatly influence the rate of dermal uptake.

Inhaled particles of chromium compounds can remain in the lungs for years (ATSDR, 2000). Chromium absorbed into the blood is distributed throughout the body with highest levels frequently located in the kidneys. Chromium has been shown to cross the placenta and to be excreted via lactation. Autopsy studies in the US show that highest concentrations in newborns occur in the kidney, liver, aorta, heart, pancreas and spleen, and that tissue levels decline with age.

The main feature of the metabolism of chromium involves reduction of chromium (VI) to chromium (III) via the formation of chromium (V) and chromium (IV) intermediates (ATSDR, 2000). Reduction of chromium (VI) to chromium (III) occurs in the acid milieu of the stomach, primarily by reaction with ascorbate. Ascorbate, glutathione and other substrates effectively reduce absorbed chromium (VI) to chromium (III). Chromium (III) is considered a nutritionally essential element required for the proper metabolism of glucose, proteins and lipids. It acts as part of a complex known as GTF, which facilitates the action of insulin. Although chromium (III) complexes are generally thought to be inert, there is recent evidence that chromium (III) may be reduced to chromium (II), which could catalyze the Haber-Weiss reaction resulting in the production of genotoxic hydroxyl radicals.

Absorbed chromium is excreted primarily in the urine (ATSDR, 2000).

4.0 Dermal Exposure

EPA (2004a) recommends GAFs of 0.013 for chromium (III) and 0.025 for chromium (VI), generally consistent with the toxicokinetic data reviewed above, which are used in this evaluation. The GAF of 0.013 for chromium (III) should be used for total chromium, which is assumed to consist of 6 parts of chromium (III) to 1 part of chromium (VI) (EPA, 2004b, 2004c).

Data were not located regarding the extent of dermal uptake of chromium from soil, and EPA (2004a) provides no estimate of the extent of dermal absorption (ABS). EPA (2004a) recommends that dermal uptake from soil should not be quantified for chemicals without ABS recommendations, but that these chemicals should be discussed qualitatively as a source of uncertainty. EPA (2004a) compiled *in vivo* and *in vitro* data from human experiments of dermal uptake of chromium from water. Average K_p values of 1E-4 cm/hour and 1E-3 cm/hour are estimated for chromium (III) and chromium (VI), respectively. The K_p of 1E-4 cm/hour for chromium (III) should be used for total chromium as explained above.

5.0 Noncancer Effects Evaluation

As mentioned above, chromium (III) is an essential nutrient involved in maintenance of normal metabolism (ATSDR, 2000). EPA (2004b) verified an RfD of 1.5E+0 mg/kg-day for chronic oral exposure to chromium (III) by applying an uncertainty factor of 1000 to a NOEL of 1800 g/kg (1.468 mg/kg body weight/day) as an average total ingested dose in a dietary study in which rats were given 600 feedings of chromic oxide baked into bread. No other dose levels were tested. Confidence in the RfD is low. No target organ or critical effect was identified for the toxicity of oral exposure to chromium (III).

The available data do not suggest a significant difference between chronic and subchronic exposure regarding the threshold for the noncancer effects of chromium (III). Therefore, EPA (1997) adopted the verified chronic oral RfD, which at the time was listed on IRIS as 1E+0 mg/kg-day, as the provisional subchronic oral RfD for chromium (III). Subsequently, EPA (2004b) recalculated the average daily dose, which led to revising the chronic oral RfD from 1E+0 to 1.5E+0 mg/kg-day. Since the only change between the earlier and the present verified oral RfD reflects a recalculation, it is recommended that the current verified chronic oral RfD of 1.5E+0 mg/kg-day should also be used for subchronic exposure.

EPA (2004b) verified an RfD for chronic oral exposure to chromium (VI) of 3E-3 mg/kg-day based on a NOAEL of 25 mg/L (2.5 mg/kg-day) in the drinking water of rats exposed for one year. An overall uncertainty factor of 900 was applied. The uncertainty factor consists of factors of 10 each for inter- and intra-species variation, a factor of 3 to expand from subchronic to chronic exposure, and a modifying factor of 3 to address concerns that relatively low levels may induce GI effects and possibly some forms of cancer in humans. Inclusion of the modifying factor of 3 was a relatively recent (1998) revision to a previously verified derivation. Nonetheless, EPA (2004b) notes that confidence in the chronic oral RfD is low.

EPA (1997) presented a provisional subchronic oral RfD of 2E-2 mg/kg-day for chromium (VI) based on the same drinking water study and an uncertainty factor of 200 (not otherwise explained). Presumably, this derivation reflects the earlier IRIS evaluation before inclusion of the modifying factor of 3. However, the concern for GI effects that gave rise to the modifying factor could apply to

subchronic as well as chronic exposure. Therefore, it is recommended that a new preliminary subchronic oral RfD should be calculated for chromium (VI). This is done by applying an overall uncertainty factor of 300 to the NOAEL of 2.5 mg/kg-day from the drinking water study. The uncertainty factor of 300 reflects the overall uncertainty factor of 900 used for the chronic RfD without the factor of 3 to expand from subchronic to chronic exposure. The preliminary subchronic oral RfD for chromium (VI) so calculated is 8E-3 mg/kg-day.

The data summarized by EPA (2004b) are insufficient to identify a mechanism of toxicity or target organ(s) for chronic oral exposure to chromium (VI). Data from other sources, however, are sufficient to identify potential target organs. Goyer (1991) reported that renal tubular necrosis is the major effect in humans from ingestion of chromium compounds. The context, however, suggests that this effect is associated with acute exposure to high doses (e.g., accidental or attempted suicide ingestion); therefore, the kidney may not be an acceptable candidate as a target organ for chronic oral exposure. Furthermore, a review of human and animal studies by EPA (1998a) did not implicate the kidney as a target organ for chronic oral exposure. EPA (1998a), however, reported GI effects in a cohort of 155 Chinese villagers who consumed water from a well located adjacent to a chromium alloy plant. Symptoms included oral ulcers, diarrhea, abdominal pain, indigestion, and leukocytosis with a left shift. The dose rate of chromium (VI) was estimated at 0.57 mg/kg-day, nearly 200 times the oral RfD. It is likely that the GI symptoms reflect the irritant nature of chromium (VI).

EPA (1998a) also reviewed several reproductive studies. An early and inadequately conducted study reported no effects in rats fed a diet containing 0.125 percent K_2CrO_4. A diet containing 0.25 percent resulted in "subnormal condition" (including rough coat) and "subnormal" offspring; a diet containing 0.5 percent resulted in diarrhea and sterility. Assuming rats consume food equivalent to 5 percent of their body weight each day (EPA, 1980), dietary levels of 0.125, 0.25 and 0.5 percent correspond to chromium (VI) dose rates of 17, 33, and 67 mg/kg-day, respectively. Drinking water studies consistently report developmental effects and impaired reproduction in rats and mice ingesting approximately 20 mg chromium (VI)/kg-day. A well controlled study reported slightly decreased erythrocyte size and hemoglobin content in rats and mice of either sex fed diets containing 400 ppm potassium chromate. The effects were interpreted as "suggestive of a potential bone marrow/erythroid response." The 400 ppm diet is equivalent to chromium (VI) dose rates of 6.4 mg/kg-day in rats (EPA, 1998a) and approximately 11 mg/kg-day in mice, assuming that mice consume food equivalent to 10 percent of their body weight/day (EPA, 1980). In addition, cytoplasmic vacuolization of hepatocytes was observed in mice fed diets containing 50, 100 or 400 ppm potassium chromate, but it is not clear if either the incidence or intensity occurred in a dose-related manner. The 50 ppm diet, the lowest associated with hepatocellular vacuolization, is equivalent to a chromium (VI) intake rate of approximately 1.3 mg/kg-day. A subsequent study reported decreased erythrocyte hemoglobin content in female mice fed a diet containing 100 ppm potassium chromate, equivalent to a chromium (VI) dose rate of 6.0 mg/kg-day.

The GI signs reported in humans are clearly an indication of adverse effects; therefore, the GI tract is selected as a target organ. The mechanism of toxicity is assumed to be the irritation induced by tissue contact with chromium (VI). The slight hematologic changes observed in rats and mice and the hepatocellular vacuolization observed in mice do not appear to be sufficiently threatening to be considered adverse. Therefore, target organs selected for chronic oral exposure to chromium (VI) include the GI tract, unborn child (fetus), and reproductive system.

Inhalation (occupational) exposure to chromium may induce respiratory symptoms, changes in lung function and irritation, erosion or perforation of the nasal septum, depending in part on the exposure level (EPA, 2004b). No adverse effects were observed in workers exposed to 1E-3 mg/m^3 for 0.2 to 23.6 years (average 2.5 years). EPA (1998b, 2004b) reviewed several human and animal studies, and determined that effects observed from inhalation exposure to chromium (VI) are not relevant to exposure to chromium (III). EPA (1998c) concluded that chromium (VI) is the only form of chromium of concern for inhalation exposure.

EPA (2004b) developed separate chronic inhalation RfC values for human exposure to chromic acid mists and dissolved chromium (VI) aerosols, and for exposure to chromium (VI) particulates. A verified chronic inhalation RfC of 8E-6 mg/m^3 for chromic acid mists and dissolved chromium (VI) aerosols is based on an adjusted LOAEL of 7.14E-4 mg/m^3 associated with atrophy of the nasal septum in subchronically occupationally exposed humans. An overall uncertainty factor of 90 was used, consisting of factors of 10 for intraspecies variation, 3 to estimate a NOAEL from a LOAEL, and 3 to expand from subchronic to chronic exposure. Confidence in the inhalation RfC is low. The upper respiratory tract is considered the target organ for inhalation exposure to chromic acid mists and dissolved chromium (VI) aerosols. The chronic inhalation RfC is equivalent to a chronic inhalation RfD of 2.3E-6 mg/kg-day.

Inhalation exposure to chromium (VI) particulates is associated with pneumocyte toxicity; i.e., with effects on the lungs themselves. EPA (2004b) derived an RfC of 1E-4 mg/m^3 for chronic inhalation exposure to chromium (VI) particulates from an adjusted benchmark concentration of 3.4E-2 mg/m^3 associated with altered enzyme activity in bronchioalveolar lavage fluid from rats exposed to sodium dichromate dust intermittently for up to 90 days. An uncertainty factor of 300 was used, consisting of a factor of 10 to provide additional protection to unusually sensitive individuals, and factors of 3 each to cover for physiologic differences between rats and humans, and to expand from subchronic to chronic exposure. Confidence in the RfC is medium. The RfC is equivalent to a chronic inhalation RfD of 2.9E-5 mg/kg-day. The lung is considered to be the target organ for chronic inhalation exposure to chromium (VI) particulates.

No current EPA-derived subchronic inhalation evaluation exists for chromic acid mists and dissolved chromium (VI) aerosols. However, a preliminary subchronic inhalation RfC can be derived by excluding the uncertainty factor of 3 for expanding from subchronic to chronic exposure. Application of the remaining overall uncertainty factor of 30 to the adjusted LOAEL of 7.14E-4 mg/m^3 yields a preliminary subchronic inhalation RfC of 2E-5 mg/m^3 for chromic acid mists and dissolved chromium (VI) aerosols. The preliminary subchronic inhalation RfC is equivalent to a subchronic inhalation RfD of 6.8E-6 mg/kg-day.

No current EPA-derived subchronic inhalation evaluation exists for chromium (VI) particulates. However, a preliminary subchronic inhalation RfC can be derived by excluding the uncertainty factor of 3 for expanding from subchronic to chronic exposure. Application of the remaining overall uncertainty factor of 100 to the adjusted LOAEL benchmark concentration of 3.4E-2 mg/m^3 yields a preliminary subchronic inhalation RfC of 3E-4 mg/m^3 for chromium (VI) particulates. The preliminary subchronic inhalation RfC is equivalent to a subchronic inhalation RfD of 9.7E-5 mg/kg-day.

EPA (1998c) noted that exposure to chromic acid mists and dissolved chromium (VI) aerosols is likely to be restricted to occupational settings and that most environmental exposures would involve exposure to chromium (VI) particulates. Therefore, the chronic and subchronic inhalation RfCs and RfDs for chromium particulates will be used in this evaluation.

6.0 Carcinogenicity Evaluation

EPA (2004b) classified chromium (III) in cancer weight-of-evidence group D – not classified as to carcinogenicity to humans – because of inadequate data. Chromium (VI) is classified in cancer weight-of-evidence group A – known human carcinogen – based on the consistent finding of lung cancer in epidemiologic studies of occupationally exposed workers in chromate production and the chrome pigment industry (EPA, 2004b). Conclusions regarding the human data are corroborated by data from animal experiments. There is no evidence that oral exposure to chromium (VI) induces cancer, and EPA (2004b) assigned chromium (VI) to Group D for oral exposure.

An inhalation URF of 1.2E-2 per ug/m^3, equivalent to an inhalation SF of 4.2E+1 per mg/kg-day, was based on increased risk of lung cancer deaths in chromate production workers (EPA, 2004b). It should be noted that the quantitative assessment is based on the concentration of total chromium to which the workers were exposed, including insoluble (trivalent) and soluble (hexavalent) forms. It was assumed that chromium (VI) constituted not less than one-seventh of the total chromium; i.e., a ratio of 1 part of chromium (VI) to 6 parts of chromium (III). However, the forms of chromium in the air were not identified, and chromium (VI) may have constituted a significantly much greater portion of total airborne chromium. EPA (2004b) presented the URF of 1.2E-2 per ug/m^3 as a verified potency estimate for chromium (VI), but noted that this estimate may underestimate the potency of exposure to pure chromium (VI) by as much as seven-fold.

EPA (2004c) Region IX adjusted the inhalation SF for chromium (VI) to 2.9E+2 per mg/kg-day to cover for the potential seven-fold uncertainty described above, largely to be consistent with State of California policy. This position, however, is a worst-case interpretation of the EPA (2004b) verification that is inconsistent with EPA (2003) Region IV policy to use verified toxicity values whenever possible, and is not adopted herein.

7.0 Toxicity Summary

Toxicity values for chromium (III) and chromium (VI) are summarized below. Theoretical toxicity values are calculated for total chromium assuming a chromium (III)/chromium (VI) ratio of 6 to 1.

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
Chromium (III)										
1.5E+0	1.5E+0	ND	ND	ND	NA	D	ND	D	ND	ND
Chromium (VI)[b]										
8E-3	3E-3	GI, F, Re	3E-4/ 9.7E-5	1E-4/ 2.9E-5	Lu	D	ND	A	1.2E-2	4.2E+1
Total Chromium[c]										
1.3E+0	1.3E+0	GI, F, Re	2.1E-3/ 6.0E-4	7E-4/ 2.0E-4	Lu	D	ND	A	1.7E-3	6.0E+0

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data; NA = not applicable. Target organ or critical effect abbreviations: GI = gastrointestinal tract, F = unborn child (fetus), Re = reproductive system, Lu = lung. [a]sRfDo and cRfDo should be adjusted by the appropriate GAF values described above when used for dermal exposure. [b]Inhalation RfC/RfD values listed are those for chromium (VI) particulates. Values for chromic acid mists and dissolved chromium (VI) aerosols are not relevant to environmental exposures. [c]Based on the assumption that total chromium consists of 1 part of chromium (VI) and 6 parts of chromium (III).										

8.0 Preliminary Remediation Goals

EPA (2004c) Region IX has developed preliminary remediation goals (PRG) that are useful for screening chemical concentrations in environmental media. The Region IX PRGs are based on standard default exposure assumptions, and are often adapted for the risk-based screening step for selecting chemicals of potential concern for human health risk assessments.

EPA (2004c) provides PRGs for chromium (III), chromium (VI), and total chromium, which is assumed to consist of chromium (VI) and chromium (III) in a 1:6 ratio. The PRGs for chromium (III) are appropriately based on the verified chronic oral RfD of 1.5E+0 mg/kg-day. It is noted that no PRG is provided for chromium (III) in ambient air. However, this is appropriate because the data (EPA, 1998c) suggest that inhalation exposure to chromium (III) at levels anticipated in the environment would not lead to adverse health effects.

The noncancer PRGs for chromium (VI), however, are based on the inhalation RfD for chromic acid mists and dissolved chromium (VI) aerosols, which is probably not appropriate. Also, the cancer-based PRGs are based on the adjusted inhalation SF described above, which also is inappropriate for this evaluation. Therefore, PRGs for chromium (VI) are re-calculated below, using the toxicity values summarized in the table above. Similarly, PRGs are calculated for total chromium using the toxicity values presented in the table above.

Inhalation SF $(mg/kg\text{-}day)^{-1}$	Oral RfD (mg/kg-day)	Inhalation RfD (mg/kg-day)	PEF (m^3/kg)	Preliminary Remediation Goal			
				Residential Soil (mg/kg)	Industrial Soil (mg/kg)	Ambient Air ($\mu g/m^3$)	Tap Water ($\mu g/L$)
Chromium (VI)							
4.2E+1	3E-3	2.9E-5	1.316E+9	2.3E+2nc 2.1E+2ca	3.0E+3nc 4.5E+2ca	1.1E-1nc 1.6E-4ca	1.1E+2nc NA
Total Chromium							
6.0E+0	1.3E+0	2.0E-4	1.316E+9	8.2E+4nc 1.5E+3ca	6.7E+5nc 3.1E+3ca	7.3E-1nc 1.1E-3ca	4.8E+4nc NA
SF = cancer slope factor; RfD = reference dose; PEF = particulate emission factor; nc = based on noncancer effects; ca = based on cancer risk; NA = not applicable.							

The cancer risk-based PRGs correspond to a cancer risk of 1E-6, the noncancer-based PRGs correspond to an HI of 1.

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COBALT 7440-48-4)

1.0 Introduction and Physical Properties

Cobalt is a relatively scarce **metal**, constituting about 0.001 percent of the earth's crust (Elinder and Friberg, 1986). It often occurs in association with nickel, silver, lead, copper and iron ores. Cobalt is used in forming special metal alloys with unusual and useful properties (ATSDR, 2001; HSDB, 2004). It is also used in cutting materials, lacquers, varnishes, paint driers, enamels, inks, glazes, glass manufacture, as a catalyst in petroleum refining, and as a supplement in animal and human nutrition. Relevant physical properties are compiled below:

MW	log K_{ow}	H	K_d	D_a	D_w	VP	S
58.93[a]	NA	NA	75[b]	NA	NA	ND	Note 1[c]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; K_d = soil/water partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; NA = not applicable; ND = no data.

Note 1: Cobaltous chloride as a typical cobalt salt: soluble.

[a]Hazardous Substance Data Bank (HSDB), 2004, National Library of Medicine, on line, accessed 12 August.

[b]Risk Assessment Information System (RAIS), 2004, "Chemical-Specific Factors," Oak Ridge National Laboratory, on line, accessed 12 August.

[c]Budavari, S, Ed., 1989, ***The Merck Index, An Encyclopedia of Chemicals, Drugs, and Biologicals***, Eleventh Edition, Merck & Co., Rahway, NJ.

2.0 Environmental Fate and Transport

Cobalt is released to the environment, particularly to the air, largely from industrial processes that involve grinding or polishing hard metal devices that contain cobalt (HSDB, 2004). Other anthropogenic sources include fossil fuel burning, vehicular and aircraft exhaust, production and use of cobalt-containing alloys and chemicals, copper and nickel smelting and refining, disposal of sewage sludge, and application of fertilizers derived from phosphate rock (ATSDR, 2001). Natural sources include soil and soil dust, seawater spray, and volcanic eruptions. Natural releases to the atmosphere slightly exceed anthropogenic releases.

Ionic cobalt compounds exist in the particulate phase in air and these compounds may be removed from the air by wet and dry deposition (HSDB, 2004).

HSDB (2004) reports that K_d values for cobalt range from 0.2 to 3,800 L/kg. The value of 75 L/kg presented above appears to be a reasonable intermediate point. Soils with higher pH and content of clay, natural organics, and hydrous manganese and iron oxides, bind cobalt to a greater degree; as these factors decrease, the mobility of cobalt increases. Microbial activity may increase the solubility of cobalt in soil. Chelating agents increase the solubility of cobalt and enhance its mobility in soil. Cobalt compounds do not volatilize from moist or dry soil surfaces due to their ionic character.

The transport and speciation of cobalt in natural waters and sediments is complicated by many factors (HSDB, 2004). The presence of sewage-derived organics appears to enhance the solubility of cobalt in freshwater by forming soluble complexes. Cobalt exists in the +2 or +3 oxidation state for the majority of its compounds and complexes. Volatilization from water surfaces is not expected, due to the ionic nature of dissolved cobalt compounds.

A few plant species are known to accumulate cobalt; however, translocation to aerial parts is generally insignificant (ATSDR, 2001; HSDB, 2004). Cobalt is bioaccumulated by aquatic organisms, particularly at the lower trophic levels. Biomagnification, however, does not occur and cobalt localizes in the viscera and on the skin, rather than in edible tissues. Therefore, cobalt is not expected to impact human health through the food-chain pathways and biotransfer factors are not provided.

3.0 Toxicokinetics

Inhaled cobalt particles deposit in the upper or lower respiratory tract, depending largely on particulate size (ATSDR, 2001). Uptake may occur by dissolution or phagocytosis; larger particles are removed by ciliary clearance. The extent of pulmonary uptake depends largely on particle size distribution.

GI absorption of ingested cobalt in humans ranges from 18 to 97 percent, depending on the form and dose, and on the nutritional status of the subjects (ATSDR, 2001). Cobalt is absorbed more efficiently in cases of iron deficiency. Animal studies show that soluble forms such as cobalt chloride are absorbed to a much greater extent (13 to 34 percent) than insoluble cobalt oxide (1 to 3 percent).

Experiments with humans indicate that cobalt in hard metal dust can be absorbed through the skin, although the rate or extent of uptake were not quantified (ATSDR, 2001). Experiments in animals indicate that cobalt is absorbed much more efficiently through abraded than intact skin.

Distribution of cobalt within body tissues depends in large measure on the route of exposure (ATSDR, 2001). Cobalt as a component of cyanocobalamin (vitamin B12) is generally distributed among the body tissues. Highest levels following inhalation exposure are found in the tissues and lymph nodes of the respiratory tract. Lesser but elevated levels are found in liver, spleen and kidney. Highest levels are found in the liver following ingestion exposure.

Elimination also depends on route of exposure (ATSDR, 2001). Inhaled particulates are cleared by mucociliary elevation, phagocytosis and dissolution. Elevated particles are swallowed and subjected to GI absorption or throughput in the feces. Absorbed cobalt is excreted primarily through the urine.

4.0 Dermal Exposure

The provisional chronic oral RfD for cobalt was derived from a study in which humans were treated orally with cobalt chloride (EPA, 2002a). The toxicokinetic data indicate that absorption of soluble forms of cobalt ranges from 13 to 34 percent (ATSDR, 2001). The midpoint, 0.2 (rounded to one significant figure) is selected as the GAF for cobalt.

Data were not located regarding the extent of dermal uptake of cobalt from soil, and EPA (2003) provides no estimate of the extent of dermal absorption (ABS). EPA (2003) recommends that dermal uptake from soil should not be quantified for chemicals without ABS recommendations, but that these chemicals should be discussed qualitatively as a source of uncertainty. Data regarding the uptake of soluble forms of cobalt from water were not located. The EPA (2003) default K_p for inorganic chemicals of 1E-3 cm/hour is selected for cobalt.

5.0 Noncancer Effects Evaluation

Acute high oral or parenteral doses of cobalt in humans or animals induce myocardial degeneration often leading to mortality, enhanced erythropoiesis, enlarged thyroid, and, in animals, renal tubular degeneration (Elinder and Friberg, 1986). Chronic ingestion from the consumption of beer containing high concentrations of cobalt is associated with "beer-cobalt cardiomyopathy", which includes polycythemia and goiter, as well as marked myocardial degeneration and mortality.

Cobalt is nutritionally essential as a cofactor in cyanocobalamin (EPA, 2002a). The element is ubiquitous and universally present in the diet. Data from a dietary survey performed in the 1980s indicate that daily U.S. dietary intakes of cobalt are in the range of 3E-3 to 1.1E-2 mg/day (4E-5 to 2E-4 mg/kg-day, assuming an average body weight of 70 kg).

The most consistent and thoroughly characterized effect of exogenously administered cobalt in humans is the erythropoietic effect of stimulating erythrocyte production resulting in increased blood hemoglobin concentration (EPA, 2002a). Cobalt chloride has been used therapeutically at dose rates of 1.6E-1 to 3.2E-1 mg cobalt/kg-day in anemic, anephric dialysis patients for 12 to 32 weeks to induce a significant, but reversible, rise in blood hemoglobin concentration. The best clinical study demonstrating this effect identified an effect level of 1.8E-1 mg/kg-day, which EPA (2002a) designated a LOAEL. An uncertainty factor of 10 was applied to the LOAEL to derive a provisional chronic oral RfD of 2E-2 per mg/kg-day. The uncertainty factor of 10 consists of factors of 3 each to account for the use of a LOAEL instead of a NOAEL, and to account for deficiencies in the data base, primarily the lack of a truly chronic study. Confidence in the provisional oral RfD was judged to be low-to-medium. Increased erythropoiesis (increased erythrocyte production resulting in increased blood hemoglobin concentration) is the critical effect of prolonged oral exposure to cobalt.

The provisional chronic oral RfD is adopted as sufficiently protective for subchronic as well as chronic exposure. The uncertainty factor used for the chronic RfD calculation was not modified for subchronic exposure because the second factor of 3 appears to address other deficiencies in the data base (e.g., limited data regarding developmental toxicity) in addition to the lack of a truly chronic study.

Another effect of exposure to cobalt appears to be an allergic response in sensitized individuals (EPA, 2002a). The dose-response relationships of this effect, however, are not well elucidated. Also, it appears that interrelationships may exist between cobalt and nickel sensitization. EPA (2002a) concluded that data regarding the allergic response were insufficient for RfD derivation, and cautioned that the provisional oral RfD may not be sufficiently protective for sensitized individuals.

Occupational (inhalation and dermal) exposure is associated with allergic dermatitis, chronic interstitial pneumonitis, reversibly impaired lung function, occupational asthma, and myocardial effects (ACGIH, 1991). Cobalt was determined to be the etiologic factor in hard metal disease, the syndrome of respiratory symptoms and pneumoconiosis associated with inhalation exposure to dusts containing tungsten carbide with cobalt powder as a binder (Elinder and Friberg, 1986). It should be noted that the workers experiencing hard metal disease were also exposed to tungsten and sometimes to titanium, tantalum and niobium (Elinder and Friberg, 1986).

Recently, it has been shown that titanium potentiates the effects of cobalt, and exposure to cobalt in hard metal disease is not considered an appropriate basis for development of an inhalation RfC

(EPA, 2002b). The available epidemiological and animal exposure studies with cobalt free from titanium are sufficient to identify respiratory signs and impaired lung function as the most sensitive endpoint of inhalation exposure. A provisional chronic RfC of 2E-5 mg/m^3 was based on a NOAEL of 5.3 μg/m^3 in an occupational study of diamond polishers from 10 different work shops. The NOAEL is equivalent to a continuous exposure concentration of 1.9 μg/m^3. An uncertainty factor of 100 (10 to provide additional protection for unusually sensitive individuals, and 3 each to address the likelihood that exposure may have been subchronic for some workers, and to account for lack of developmental and reproductive data) was applied to calculate the provisional chronic inhalation RfC. The RfC is equivalent to a chronic inhalation RfD of 5.7E-6 mg/kg-day. The LOAEL, 15.1 μg/m^3, was associated with symptoms including chronic cough and irritation of eyes, nose and throat, and spirometric evidence of impaired lung function. The entire respiratory tract is considered to be the target organ for prolonged inhalation exposure to cobalt. Confidence in the inhalation RfC is medium-to-low.

EPA (2002b) did not present a provisional subchronic inhalation RfC for cobalt. A preliminary subchronic RfC can be estimated, however, by applying an uncertainty factor of 30 to the adjusted NOAEL of 1.9 μg/m^3 described above. The subchronic uncertainty factor of 30 is equivalent to the chronic uncertainty factor of 100 without the factor of 3 to account for subchronic exposure. The preliminary subchronic inhalation RfC so derived is 6E-5 mg/ m^3 (rounded to one significant figure) which is equivalent to a preliminary subchronic inhalation RfD of 1.8E-5 mg/kg-day.

6.0 Carcinogenicity Evaluation

Cobalt may be assigned to EPA cancer weight-of-evidence Group B1 (probable human carcinogen) or "likely to be carcinogenic to humans" based on limited evidence of carcinogenicity in humans (occupational studies) and sufficient evidence of carcinogenicity in animals (EPA, 2002c). Rats and mice exposed via inhalation to cobalt sulfate heptahydrate for 2 years developed alveolar and bronchial lung tumors. Cobalt has been shown to be genotoxic in mammalian systems, although not generally in microbial systems. EPA (2002c) derived a provisional inhalation URF of 2.8E-3 per μg cobalt/m^3 based on the increased incidence of lung tumors in male mice in the 2-year inhalation study mentioned above. The URF is equivalent to an inhalation SF of 9.8E+0 per mg cobalt/kg-day.

Data regarding the potential carcinogenicity of oral exposure to cobalt were not located. The Group B1 cancer weight-of-evidence classification is appropriately applied only to inhalation exposure.

7.0 Toxicity Summary

Toxicity values for cobalt are summarized as follows:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
2E-2	2E-2	E	6E-5/ 1.8E-5	2E-5/ 5.7E-6	RT	ND	ND	B1	2.8E-3	9.8E+0

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data; NA = not applicable.

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
Target organ or critical effect abbreviations: E = erythropoietic effect; RT = respiratory tract. [a]sRfDo and cRfDo should be adjusted by the GAF of 0.2 when used for dermal exposure.										

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IRON (7439-89-6)

1.0 Introduction and Physical Properties

Iron is a very abundant, ubiquitous, naturally occurring **metal** that constitutes approximately 5 percent of the earth's crust (Spivey Fox and Rader, 1988). It is the second most prevalent metal in the earth's crust following aluminum (HSDB, 2004). Its primary use is in making steels and other metals that have a wide range of application. Less than one percent of iron is used to make iron compounds that have application in dyes and pigments, water treatment, organic chemical synthesis, and medicinal preparations. Relevant physical properties are compiled below:

MW	log K_{ow}	H	K_d	D_a	D_w	VP	S
55.85[a] (Element)	NA	NA	ND	NA	NA	ND	Note 1[a]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; K_d = soil/water partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; NA = not applicable; ND = no data.
Note 1: Ferrous sulfate as a typical iron salt: soluble.
[a]Hazardous Substance Data Bank (HSDB), 2004, National Library of Medicine, on line, accessed 7 July.

2.0 Environmental Fate and Transport

There is little information available regarding the anthropogenic release of iron and its fate in the environmental, probably because of its prevalence in nature. Clearly, however, mining and handling of iron ores releases dust containing iron oxides (HSDB, 2004). Presumably the manufacture and use of iron compounds may result in release to the environment, but data were not located.

Insoluble iron compounds are most likely to occur in air as particulates, and are expected to deposit to soil and surface water (HSDB, 2004). Although data are unavailable, soluble compounds are expected to leach to groundwater, and to remain in solution in both groundwater and surface water. The extent of partitioning to sediment is expected to depend on water pH, organic matter and reduction-oxidation potential of the water system.

Biouptake of iron is known to occur, because the element is a nutritionally required trace element that is a structural component of heme proteins and some enzymes, which are common to mammals and several other orders of living organisms (Spivey Fox and Rader, 1988). However, there is no evidence that iron bioconcentrates in either aquatic or terrestrial food chain pathways. Therefore, biotransfer factors for iron are not presented.

3.0 Toxicokinetics

The GI absorption of iron is regulated by homeostatic mechanisms sited largely in the intestinal mucosa (Goyer, 1991; EPA, 1996). Approximately 2 to 15 percent of dietary iron is ordinarily absorbed; however, several dietary factors may increase or decrease absorption (HSDB, 2004). Dietary iron from animal sources is absorbed more readily (10 to 25 percent) than iron from vegetables and grains (1 to 10 percent) (Elinder, 1986). Absorption is greatly increased at times of unusual need (rapid growth of childhood, pregnancy, blood loss). Divalent (ferrous) iron is absorbed

into the intestinal mucosal cells and released to the blood plasma where it is oxidized to the trivalent (ferric) form, which binds with a specific protein, transferrin, for transport to storage sites.

Approximately 67 percent of iron in the body is associated with hemoglobin in the erythrocytes, 10 percent is associated with myoglobin and various iron-containing enzymes, and the remainder is bound to ferritin or hemosiderin, which are intracellular storage forms (Goyer, 1991). Ferritin and hemosiderin bind iron in a manner that renders it inactive for beneficial use (e.g., hemoglobin synthesis) and inactive as a toxicant. Some of the iron taken up by the cells of the reticuloendothelial system remains stored and some enters a labile pool that is available for erythropoiesis.

Excess iron is generally excreted, in part in shed intestinal epithelial cells, or in the bile or urine (Goyer, 1991). In cases of very high iron intake, excretion may be unable to remove iron as quickly as it is absorbed. Iron overload results, which stimulates increased synthesis of ferritin and increased iron storage, particularly in the liver, pancreas, spleen, various endocrine organs and the heart.

4.0 Dermal Exposure

As noted above, the GI absorption of iron appears to be under homeostatic control in normal humans (EPA, 1996), which suggests that GI absorption could vary widely between individuals depending on nutritional status. Given the uncertainty about the GI absorption of iron, a default GAF of 1 (EPA, 2003) is chosen for this evaluation.

Data were not located regarding the extent of dermal uptake of iron from soil, and EPA (2003) provides no estimate of the extent of dermal absorption (ABS). EPA (2003) recommends that dermal uptake from soil should not be quantified for chemicals without ABS recommendations, but that these chemicals should be discussed qualitatively as a source of uncertainty. Empirical data regarding the uptake of soluble forms of iron from water were not located. The EPA (2003) default K_p for inorganic chemicals of 1E-3 cm/hour is selected for iron.

5.0 Noncancer Effects Evaluation

Iron is a nutritionally required trace element that forms an integral part of hemoglobin, myoglobin and several enzymes (Spivey Fox and Rader, 1988). The NAS (1989) Recommended Daily Allowance (RDA) for iron is 10 mg/day (0.13 mg/kg-day) for adult males; 15 mg/day (0.24 to 0.33 mg/kg-day) for females aged 11 to 50 years; 30 mg/day (0.443 mg/kg-day) for pregnant females; and 10 mg/day (0.36 to 1.11 mg/kg-day) for children aged 6 months to 10 years.

Both acute and chronic toxicity syndromes are associated with ingestion exposure to iron. Acute toxicity generally involves children (Goyer, 1991). Acute ingestion of large quantities (e.g., children may ingest several ferrous sulfate tablets with candy-like coating) results in severe GI irritation and, in some cases, liver damage. Liver cirrhosis and blood coagulation defects (indicative of reduced circulating levels of blood clotting factors produced by the liver) are observed as sequellae to severe acute toxicity.

Three chronic toxicity syndromes that result in iron overload have been observed in humans (Goyer et al., 1991). The first chronic syndrome is idiopathic hemochromotosis, which arises from a genetic

derangement of the homeostatic mechanisms that control iron absorption. This syndrome involves greatly increased GI absorption of iron, regardless of the level of iron in the diet, which results in massive iron overload.

The second chronic syndrome is iron overload resulting from high dietary intake (Goyer, 1991). Although high dietary intake seldom results in iron overload in humans with normal homeostatic control of iron absorption, rare exceptions occur (EPA, 1996). One such exception is the occurrence of iron overload in Bantus who regularly consumed Kaffir beer, an acid beer brewed in iron vessels. This syndrome is not entirely understood; however, the iron in Kaffir beer appears to have exceptionally high bioavailability – equivalent to that of nutritional iron supplements especially formulated for bioavailability – which may account for the increased absorption and iron overload. Other exceptions include persons who take large amounts of tonics or nutritional supplements containing iron.

The third chronic syndrome involves persons requiring multiple blood transfusions over a period of time (Goyer, 1991). This results in the parenteral administration of large quantities of iron that are released as the transfused erythrocytes expire and are removed from the circulation by the reticuloendothelial system. As noted above, excretion cannot keep up with unusually high circulating levels of iron, such as results from multiple blood transfusions. Clearly, the third syndrome has no relevance to environmental exposure.

Regardless of the chronic syndrome that produces it, the effects of iron overload involve the same pathogenesis (Goyer, 1991). Iron stores in the body increase from the normal level of 3 to 5 g, to levels of 20 to 40 g. The cells are induced to increase production of ferritin, which binds the iron cation inactivating its toxicity. Increasingly larger proportions of iron are located in hemosiderin than in ferritin. Hemosiderin is a larger storage protein, probably formed primarily from ferritin. The iron in hemosiderin is essentially completely unavailable and nontoxic. Hemosiderosis is the term given to large accumulations of hemosiderin that do not result in adverse effects because the iron is unavailable. Extremely large accumulations of hemosiderin that result in impaired cellular function is termed hemochromotosis. Hemochromotosis of the liver, endocrine glands and heart is associated with reduced liver function, eventually liver cirrhosis, pancreatic fibrosis, diabetes mellitus, other endocrine disruption and cardiovascular effects.

Goyer (1991) and EPA (1996) reviewed the available data regarding the toxicity of iron. Neither source located any data clearly associating *environmental* exposure with toxicity. EPA (1996) reviewed a study associating high circulating ferritin levels and high dietary iron intakes with myocardial infarction in Finnish men, but association with other factors (e.g., high levels of red meat consumption) confounds interpretation of this study. Furthermore, attempts to produce an animal model of chronic iron toxicity have failed, presumably because of the efficacy of the homeostatic mechanisms that regulate iron absorption from the GI tract. The lack of human environmental exposure data and the lack of a suitable animal model caused the EPA (1996) to turn to other data from which to derive an oral RfD.

EPA (1996) reasoned that a NOEL for chronic iron overload could be inferred from the estimates of dietary intake and iron status (circulating ferritin levels) established by the second National Health and Nutrition Examination Survey (NHANES II) data base. The NHANES II study determined that average dietary iron intakes, which ranged from 0.15 to 0.27 mg/kg-day, were associated with

normal iron status. EPA (1996) derived a provisional chronic oral RfD of 3E-1 mg/kg-day by applying an uncertainty factor of 1 to the NOEL of 0.27 mg/kg-day, the upper end of the NHANES II average intake range. Confidence in the RfD is medium. The chronic oral RfD of 3E-1 mg/kg-day is adopted as sufficiently conservative for subchronic oral exposure as well.

The appropriateness of the oral RfD for iron is controversial. The oral RfD derivation reflects estimates of iron intake based on a nutritional survey, but identifies neither a NOAEL nor LOAEL for iron ingestion based on any toxicological endpoints. In other words, it is likely that a much higher level of dietary iron intake would be innocuous, although this probability is not incorporated into the oral RfD derivation. For example, EPA (1996) reviewed a study that showed that Ethiopians have the highest per capita iron intakes, ranging from 98 to 1418 mg/day (equivalent to 1.4 to 20.3 mg/kg-day) with an average of 471 mg/day (6.7 mg/kg-day). Increased tissue stores of iron and adverse effects were not observed. The lack of effects was attributed to unusually low bioavailability of iron in the Ethiopian diet. Furthermore, it should be noted that the oral RfD of 3E-1 mg/kg-day is below the upper range of the RDA for 11- to 50-year-old females (0.24 to 0.33 mg/kg-day), for pregnant females (0.443 mg/kg-day), and for 6-month- to 10-year-old children (0.36 to 1.11 mg/kg-day). Therefore, it is likely that the oral RfD for iron exaggerates noncancer human hazards beyond the conservative assumptions typically associated with EPA toxicity values.

The mechanism of toxicity of iron is unique; it produces iron overload (EPA, 1996), and no other chemicals are known to do so. Some chemicals, e.g., nitrate, nitrite and certain nitroaromatics, may also result in elevated circulating levels of iron, but the mechanism of toxicity involves hemolysis of erythrocytes, which differs from iron overload and is more likely to affect the spleen, at least initially (EPA, 2004). Therefore, HQ or HI values calculated for iron should not be summed with values from other chemicals.

Inhalation (occupational) exposure to iron oxide fumes may lead to radiographic densities in the lungs without demonstrable clinical effects (ACGIH, 1991). Inhalation of dusts or mists of ferric salts may irritate the respiratory tract. Inhalation data are insufficient for derivation of an inhalation RfC or RfD.

6.0 Carcinogenicity Evaluation

Data regarding the potential carcinogenicity of iron were not located. Neither a cancer weight-of-evidence classification nor cancer potency factors are available.

7.0 Toxicity Summary

Toxicity values for iron are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
3E-1	3E-1	Ir	ND	ND	NA	ND	ND	ND	ND	ND

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo =

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data; NA = not applicable. Target organ or critical effect abbreviations: Ir = iron overload. [a]sRfDo and cRfDo should be used for dermal exposure without adjustment for GI absorption.										

In most cases, it is inappropriate to apply the toxicity values summarized above to environmental exposure.

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LEAD (7439-92-1)

1.0 Introduction and Physical Properties

Lead is a naturally occurring **metal** that constitutes approximately 0.002 percent of the earth's crust (HSDB, 2005). It is the fifth most prevalent commercially produced metal and is used in the manufacture of batteries, ammunition, and other metal products (ATSDR, 2005; HSDB, 2005). Relevant physical properties are compiled below:

MW	log K_{ow}	H	K_d	D_a	D_w	VP	S
207.20[a] (element)	NA	NA	3373[b,c]	NA	NA	ND	Note 1[a]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; K_d = soil/water partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; NA = not applicable.
Note 1: Lead chloride (typical soluble salt): 9.9E+3 mg/L (20° C).
[a]Agency for Toxic Substances and Disease Registry, (ATSDR), 2005, ***Update Toxicological Profile for Lead***, Draft for Public Comment, U.S. Public Health Service, Atlanta, Georgia, September, on line.
[b]Hazardous Substance Data Bank (HSDB), 2005, National Library of Medicine, on line, accessed 29 November January.
[c]Mean of 11 soils (range 172 to 4.32E+7 L/kg).

2.0 Environmental Fate and Transport

Lead may enter the environment during mining, ore processing, smelting, refining, use, recycling or disposal (ATSDR, 2005; HSDB, 2005). Emission in automobile exhaust was at one time the largest source of atmospheric lead. Natural sources are minor compared with anthropogenic sources. Generally the form of lead that enters the atmosphere is not known. However, metallic lead may be released from smelting and refining plants. Lead in air exists attached to small particles that may travel great distances before removal by wet or dry deposition. Lead deposited on or released to soil generally remains in the top 2 to 5 cm and is relatively immobile, although a small percentage may be present in soluble forms that are subject to leaching. Acid conditions increase the potential for leaching. Lead released to surface water tends to form salts that are only sparingly soluble. Deposition in bed sediment is the primary removal mechanism, although biomethylation may mobilize lead and return it to the water column. Soil and sediment act as sinks for anthropogenic releases of lead.

Another significant source of lead contamination to soil or surface water is the release of bullets and shot on shooting ranges (EPA, 2001, 2003a; Cao et al., 2003). Lead bullets or shot may remain intact or may fragment, particularly at the point of impact at target lines or berms. In addition, lead dust from the muzzle may accumulate at the firing line. Lead fragments in soil or water are subject to oxidation, carbonation and hydration reactions; the range of products formed depends on soil/water characteristics such as pH, moisture level and temperature. Acidic conditions favor the formation of more soluble compounds and generally increase mobility. High levels of organic matter tend to sequester these lead compounds and reduce mobility, although dissolved carbon sources may carry lead, thereby increasing mobility. High cation exchange capacity and anions such as phosphate, carbonate and sulfide in high levels tend to form stable reaction products that may coat the lead fragments retarding further reaction and decreasing subsequent mobility.

Lead from bullets, shot or fragments may be transformed and released to soil at the rate of approximately 1 percent per year so that lead concentrations in most affected soils exceed 400 mg/kg

(Cao et al., 2003). Mobility and uptake by plants may be greatly increased; levels in plants growing in shot-fall zones of 1500 to 10,000 mg/kg have been measured. Levels in associated surface water have been measured in the range of 60 to 2900 µg/L. Increased tissue levels have been reported in terrestrial invertebrates, birds and mammals (EPA, 2000).

Lead, however, does not biomagnify through the aquatic or terrestrial food chains (ATSDR, 2005; EPA, 1995). Furthermore, lead in fish is localized in the mucus on the epidermis, the dermis, and scales so that the edible portions generally do not pose a hazard to human health (HSDB, 2005); therefore, biotransfer factors are not developed for lead.

3.0 Toxicokinetics

Inhaled lead is efficiently absorbed by the respiratory tract (ATSDR, 2005). Approximately 20 to 40 percent of inhaled lead is retained in the respiratory tract; the remainder is removed during exhalation. Submicron size particles that are retained by the respiratory tract are nearly completely absorbed; larger particles are probably removed from the respiratory tract by mucociliary clearance and swallowed, thereby becoming available for GI absorption. Organic lead forms (e.g., tetraethyl or tetramethyl lead) retained in the respiratory tract are approximately 40 to 80 percent absorbed.

GI absorption is variable, depending on species, age, form of lead, and several other factors (ATSDR, 2005). Adult humans generally absorb 3 to 10 percent of a single oral dose of lead in a water-soluble form; children absorb 40 to 50 percent. Animal studies and other human studies confirm the greater efficiency of absorption by the young, which probably contributes to their greater sensitivity of children to toxic effects. Fasting, iron deficiency, and reduced lead particle size increase the efficiency of lead absorption. Lead in soil is absorbed less efficiently than lead in the soluble forms used in most toxicokinetic studies.

Dermal absorption of inorganic forms of lead is much less efficient than respiratory or GI absorption, and appears to depend in part on the particular compound applied to the skin (ATSDR, 2005). The available data suggest that dermal uptake accounts for not more than 0.1 percent of the applied dose. Organic lead forms are efficiently absorbed through intact skin.

The distribution of absorbed lead appears to be independent of the route of exposure and uptake (ATSDR, 2005). Approximately 94 percent of the body burden in adult humans is in the skeleton, compared with approximately 73 percent in children. Most of the remaining body burden is found in the blood, where approximately 99 percent is bound to macromolecules within the erythrocytes. Lead appears to have greater affinity for fetal hemoglobin than adult hemoglobin, although the extent is unclear. This may contribute to the greater sensitivity of children to lead-induced anemia. Plasma lead is approximately 40 to 75 percent bound to plasma protein, particularly albumin. The half-life of blood lead in adult humans is approximately 30 days. Pregnancy, lactation and osteoporosis – conditions that result in net bone dissolution – result in increased blood lead levels. Lead is transferred across the placenta and to the neonate during lactation. Fetal cord blood concentrations at delivery approximate 1.1 times maternal levels.

Metabolism of inorganic lead is limited to the formation of various complexes (ATSDR, 2005). The predominant intracellular ligand in erythrocytes is delta-aminolevulinate hydratase (ALAD). The predominant extra cellular ligands are albumin and various sulfhydryl-containing non-protein

macromolecules. Organic lead is efficiently dealkylated by oxidative mechanisms. Products of tetraethyl lead metabolism include diethyl and monoethyl lead as well as inorganic lead.

Absorbed lead is removed from the blood and excreted primarily in the urine and feces; sweat, saliva, hair and nails, and lactation represent minor excretory routes (ATSDR, 2005). Fecal/urinary excretion ratios are approximately 0.5 regardless of the route of exposure.

4.0 Dermal Exposure

As noted above, dermal uptake of inorganic lead from environmental media is generally considered to be insignificant, especially when compared with ingestion and inhalation exposure (EPA, 2003b, 1996). From the only adequate *in vivo* study available, EPA (2004a) estimated a K_p of 5.0E-6 cm/hour, which is vanishingly small, for an organic form of lead. Since environmental exposure is likely to involve inorganic rather than organic lead forms, dermal uptake is not evaluated quantitatively.

5.0 Noncancer Effects Evaluation

The noncancer toxicity of lead to humans has been well characterized through decades of medical observation and scientific research (EPA, 2005). The principal effects of acute oral exposure are gastrointestinal colic with diffuse paroxysmal abdominal pain (probably due to vagal irritation), anemia, and, in severe cases, acute encephalopathy, particularly in children (Tsuchiya, 1986). The primary effects of long-term exposure are neurological and hematological. Limited occupational data indicate that long-term exposure to lead may induce kidney damage. The principal target organs of lead toxicity are the nervous system and the erythrocyte. Some of the effects on the blood, particularly changes in levels of certain blood enzymes, and subtle neurobehavioral changes in children, appear to occur at levels so low as to be considered non-threshold effects. In part for this reason the EPA (1990, 2005) considered the derivation of an RfD for chronic oral exposure to be inappropriate.

The Integrated Exposure, Uptake Biokinetic Model (IEUBK) Version 0.99D (EPA, 2003b) is generally used to evaluate lead in children, the most sensitive receptor under a residential exposure scenario. The IEUBK model integrates lead uptake from inhalation, drinking water, diet, soil and dust ingestion, and ingestion of incidental sources such as chips of lead-based paint, and estimates blood lead concentrations over the first seven years of a child's life. Generally, it is considered that childhood blood lead levels below 10 μg/dL reflect minimal likelihood of adverse effects from exposure to lead. Since it is plausible that children could be present under most residential site-use scenarios, it is appropriate to use the IEUBK to establish target levels for lead in soil for residential use. EPA (1994) used the IEUBK to estimate a lead concentration of 400 mg/kg in bare soil to which children might be regularly exposed as the level below which further evaluation and exposure-reduction action is not necessary. EPA (1998) confirmed the 400 mg/kg concentration as a screening level. It should be applied as the *average* concentration of lead in a reasonably sized exposure unit for a child.

The IEUBK, however, does not address lead concentrations in media to which adults may be exposed in a non-residential site-use scenario. EPA (1996) adopted a model similar to the IEUBK to estimate blood lead concentrations in adult women in an occupational exposure scenario. The pregnant woman is assumed to be the member of the adult population most sensitive to exposure to lead because of the potential for developmental effects on her unborn baby. The EPA (1996) adult

blood lead model estimates a lead concentration in soil of approximately 800 mg/kg (EPA, 2004b) as the level below which the 95th percentile fetal blood lead concentration would not exceed 10 μg/dL. Like the IEUBK, the 800 mg/kg concentration should be applied as the *average* for a reasonably sized exposure unit for a working adult.

6.0 Carcinogenicity Evaluation

EPA (2005) classified lead in cancer weight-of-evidence Group B2 (probable human carcinogen), based on inadequate evidence in humans and sufficient animal evidence. The human data consist of several epidemiologic occupational studies that yield confusing results. All the studies lacked quantitative exposure date and failed to control for smoking and concomitant exposure to other possibly carcinogenic metals. Rat and mouse bioassays showed statistically significant increases in renal tumors following dietary and subcutaneous exposure to several soluble lead salts. Various lead compounds were observed to induce chromosomal alterations in vivo and in vitro, sister chromatid exchange in exposed workers and cell transformation in Syrian hamster embryo cells, to enhance simian adenovirus induction, and to alter molecular processes that regulate gene expression. EPA (2005) declined to estimate risk for oral exposure to lead because many factors (e.g., age, general health, nutritional status, existing body burden and duration of exposure) influence the bioavailability of ingested lead, introducing a great deal of uncertainty into any estimate of risk.

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INORGANIC MANGANESE (7439-96-5)

1.0 Introduction and Physical Properties

Manganese is a naturally occurring **metal** found in the earth's crust in the form of numerous minerals such as pyrolusite, romanechite, manganite and hausmannite (ATSDR, 2000; HSDB, 2005; Keen and Leach, 1988). It occurs ubiquitously in the environment, constituting approximately 0.085 percent of the earth's crust, commonly in valence states of +2, +4 and +7; valences of +1, +3, +5 and +6 are rare. Manganese is used in the manufacture of steel, and in other metallurgical processes, batteries, and various manganese-containing chemicals including matches, glass and porcelain, fireworks, varnishes, ceramics, diagnostic contrast media and fungicides. Relevant physical properties are compiled below:

MW	log K_{ow}	H	K_d	D_a	D_w	VP	S
54.938[a] (Elemental)	NA	NA	65[b]	NA	NA	NA	Note 1[c]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; K_d = soil/water partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; NA = not applicable.
Note 1: Metallic manganese decomposes in the presence of water. Manganous chloride as a typical manganese salt: 7.23E+5 mg/L (25° C).
[a]Hazardous Substance Data Bank (HSDB), 2005, National Library of Medicine, on line, accessed 1 December.
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[c]Agency for Toxic Substances and Disease Registry, (ATSDR), 2000, ***Update Toxicological Profile for Manganese***, U.S. Public Health Service, Atlanta, Georgia, September, on line.

2.0 Environmental Fate and Transport

Inorganic manganese compounds enter the atmosphere and other environmental compartments from the weathering of rocks and windblown soil (HSDB, 2005). Anthropogenic sources of atmospheric manganese include metal processing, disposal and use of manganese-containing materials (antiseptics, catalysts, dietary supplements, dry cells, feed additives, fertilizers, pesticides and pigments), resuspension of manganese-containing soil dust, and fly ash emissions from incinerators (ATSDR, 2000; HSDB, 2005). Another source of atmospheric manganese is the combustion of gasoline containing organic manganese anti-knock ingredients such as methylcyclopentadienyl manganese tricarbonyl (MMT). It is unclear whether manganese from this source remains as an organic form or is converted to an inorganic form. The use of MMT in gasoline has been discontinued because of deleterious effects on catalytic converters. Manganese may be released to water by discharge from industrial facilities or in leachate from landfills and soil. Landfill disposal of manganese-containing wastes is the predominant source of manganese release to soil.

Manganese exists in the air bound to particles; dry deposition is the primary removal mechanism, although wet deposition may also be significant (ATSDR, 2000). Manganese in fly ash exists as chlorides and oxides that are relatively soluble and mobile in the environment.

Manganese in water exists as any of several sparingly soluble salts that attach to suspended sediment (ATSDR, 2000). Sedimentation is the primary removal process. Soluble forms also exist, depending on pH of the water, and may be released from sediment. The extent of absorption to constituents of soil is highly variable. Low concentrations may occur in an irreversibly "fixed" form to clay, but higher concentrations often manifest considerable mobility.

Manganese may accumulate in various kinds of plants such as legumes, nuts, heather, and tea, and in the lower aquatic trophic levels, but not significantly in the higher aquatic trophic levels or most terrestrial animals (ATSDR, 2000; HSDB, 2005). This indicates that food-chain pathways are unlikely to be significant for human health; therefore, biotransfer factors are not compiled or estimated.

3.0 Toxicokinetics

Manganese is nutritionally essential for humans (ATSDR, 2000). Stable tissue levels are maintained by homeostatic regulation of GI absorption and biliary excretion.

Manganese is absorbed by the respiratory tract (ATSDR, 2000), although data quantifying the extent of absorption were not located. Smaller particles are probably retained in the lung eventually to be absorbed; larger particles are probably removed by mucocilliary elevation and swallowed so that they become available for GI absorption. The more soluble compounds are more readily absorbed by the respiratory tract. Studies in rats given radiolabeled manganese by intranasal administration suggest that olfactory uptake and direct transmission to the brain may occur.

GI absorption of manganese in humans averages 3 to 5 percent, but homeostatic mechanisms reduce the extent of absorption at higher doses (ATSDR, 2000). The more soluble compounds are more readily absorbed. Iron deficiency enhances manganese uptake. Absorption appears to be more efficient and resulting tissue levels appear to be higher in infants than adults.

Quantitative data regarding dermal uptake of manganese were not located.

Normal tissue levels of manganese in humans range from 0.1 to 1 mg/kg wet weight with highest levels in liver, pancreas and kidney, and lowest levels in bone and fat (ATSDR, 2000). Animal studies (inhalation, intranasal, intratracheal and oral administration) confirm that many tissues including the brain, and in some instances specific regions of the brain, show significant increases in manganese levels after treatment. Tissue levels recede toward normal after treatment ceases.

Metabolism of manganese appears to be limited to oxidation-reduction changes in valence state (ATSDR, 2000). The evidence suggests that manganese (+2) is oxidized to manganese (+3), which alters its tissue distribution and slows excretion. Manganese is removed from the blood in the liver and is excreted principally through the bile. Urine, sweat and milk represent minor excretory routes. Animal studies show that the young are less efficient than adults in excreting manganese, although the young do not appear to be more sensitive to its effects.

4.0 Dermal Exposure

Data were not located regarding the extent of dermal uptake of manganese from soil, and EPA (2004) provides no estimate of the extent of dermal absorption (ABS). EPA (2004) recommends that dermal uptake from soil should not be quantified for chemicals without ABS recommendations, but that these chemicals should be discussed qualitatively as a source of uncertainty. Empirical data regarding the uptake of soluble forms of manganese from water were not located. ATSDR (2000), however, notes that the uptake of manganese across intact skin is "extremely limited," suggesting that uptake of toxicologically significant amounts is unlikely. EPA (2004) provides no estimate of K_p for manganese; therefore, dermal uptake of manganese from water is not quantified.

5.0 Noncancer Effects Evaluation

Manganese is nutritionally required by humans for normal growth and health (EPA, 2005). Humans exposed to approximately 0.8 mg manganese/kg-day in drinking water (28 mg/L) exhibited lethargy, increased muscle tonus, tremor and mental disturbances. The elderly appeared to be more sensitive than children. Oral treatment of laboratory rodents induces biochemical changes in the brain, but rodents do not exhibit the neurological signs exhibited by humans.

EPA (2005) verified a chronic oral RfD for manganese of 1.4E-1 mg/kg-day from a NOAEL of 1.4E-1 mg/kg-day for neurologic effects from human dietary studies and an uncertainty factor of 1. Confidence in the RfD is medium. The oral RfD of 1.4E-1 mg/kg-day will be used for dietary items other than drinking water. EPA (2005) recommends that the contribution of background diet should be subtracted and that a modifying factor of 3 should be used to adjust for use when oral exposure involves drinking water and non-dietary ingestion. The oral RfD resulting from these manipulations is 2.4E-2 mg/kg-day, which will be used for drinking water and incidental ingestion of non-dietary items. The CNS is the target organ for chronic oral exposure to manganese.

The NOAEL described above is associated with a dose rate of approximately 10 mg/day for an adult. However, EPA (2002) notes that normal intake levels may well exceed 10 mg/day, especially with diets containing substantial amounts of whole-grain cereals, nuts, green leafy vegetables, and tea. Adverse effects have not been reported at dietary levels of 10 mg/day. It is likely that larger dose rates are innocuous as well.

EPA (1997) effectually adopts the chronic oral RfD as sufficiently protective for subchronic oral exposure.

Occupational exposure to high concentrations in air induces a generally typical spectrum of neurological effects, and increased incidence of pneumonia (ACGIH, 1991). EPA (2005) presents a verified chronic inhalation RfC of 5E-5 mg/m^3 (equivalent to an inhalation RfD of 1.4E-5 mg/kg-day) based on a LOAEL for neurological effects in occupationally exposed humans and an uncertainty factor of 1000. The uncertainty factor consists of three factors of 10 each to provide additional protection for unusually sensitive individuals, to extrapolate a NOAEL from a LOAEL, and to address database limitations including the less-than-chronic periods of exposure, the lack of developmental toxicity data, and uncertainty regarding potential but unquantified differences in the toxicity of different forms of manganese. Confidence in the RfC is medium. The CNS is the target organ for inhalation exposure to manganese. The chronic inhalation RfC is adopted as sufficiently protective for subchronic inhalation exposure.

6.0 Carcinogenicity Evaluation

EPA (2005) classified manganese in cancer weight-of-evidence Group D (not classifiable as to carcinogenicity to humans). Quantitative cancer risk estimates are not derived for Group D chemicals.

7.0 Toxicity Summary

Noncancer Effects						Carcinogenicity				
Oral Exposure			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
1.4E-1[a]/ 2.4E-2[b]	1.4E-1[a]/ 2.4E-2[b]	CNS	5E-5/ 1.4E-4	5E-5/ 1.4E-5	CNS	D	ND	D	ND	ND

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data.

Target organ or critical effect abbreviations: CNS = central nervous system.

[a]Dietary items other than drinking water.

[b]Ingestion of environmental media and drinking water.

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NICKEL 7440-02-0)

1.0 Introduction and Physical Properties

Nickel is a naturally occurring **metal** whose concentration ranks 24th in the crust of the earth (ATSDR, 2003), averaging approximately 180 mg/kg (HSDB, 2004). Its primary use is in metal alloys, to which it imparts many desirable characteristics. Nickel compounds are used for nickel plating, to color ceramics, to make some batteries, and as catalysts that increase the rate of various chemical reactions (ATSDR, 2003). Relevant physical properties are compiled below:

MW	log K_{ow}	H	K_d	D_a	D_w	VP	S
58.69[a] (element)	NA	NA	6.5E+1[b]	NA	NA	ND	Note1[c]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; K_d = soil/water partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; NA = not applicable.
Note 1: Nickel chloride as a typical nickel salt: 6.42E+5 at 20°C.

[a]Hazardous Substance Data Bank (HSDB), 2004, National Library of Medicine, on line, accessed 14 December.

[b]U.S. Environmental Protection Agency (EPA), 2001, ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites***, Peer Review Draft, Office of Solid Waste and Emergency Response, OSWER 9355.4-24, March.

[c]Agency for Toxic Substances and Disease Registry, (ATSDR), 2003, ***Update Toxicological Profile for Nickel***, Draft for Public Comment, U.S. Public Health Service, Atlanta, Georgia, September, on line.

2.0 Environmental Fate and Transport

Natural sources of airborne particles that contain nickel include soil, sea, volcanoes, forest fires, and vegetation (ATSDR, 2003; HSDB, 2004). Meteorites that enter the atmosphere contribute free nickel to the air. Anthropogenic releases of nickel, approximately 1.4 to 5 times as great as natural releases, include combustion of fuel oils (including diesel engine emissions) and coal, nickel refining, municipal waste incineration, and steel and nickel alloy production. Nickel exists in the atmosphere as free metal and as various compounds, all in the form of particulates. Small particles may remain suspended in the air for long periods (half-life up to 30 days) and travel great distances. Removal mechanisms are limited to gravitational settling and wet and dry deposition.

Nickel is deposited on soil from the atmosphere (ATSDR, 2003; HSDB, 2004). Other contributions to soil include direct disposal of nickel-containing waste. Nickel in soil is subject to adsorption, precipitation, coprecipitation and complexation, which tend to immobilize it and reduce leaching. Several soil properties, such as calcium and magnesium content and pH, control the extent to which nickel remains immobile or available for leaching because several nickel salts are quite soluble.

Nickel gains access to surface water bodies by direct deposition from the atmosphere, in waste streams from industries that process or use nickel, from domestic waste water treatment plants, and by erosion and runoff from soil (ATSDR, 2003; HSDB, 2004). Nickel in water is subject to the same processes that occur in soil. These processes transfer nickel to particles that are subject to settling; however, large proportions may remain in solution (e.g., 75 percent in one polluted lake).

Empirical data with voles and rabbits living in sludge-amended land, as well as with aquatic invertebrates and vertebrates, suggest that nickel is not biomagnified in either aquatic or terrestrial food chain pathways (ATSDR, 2003). Nickel was identified by the EPA (1995) as a metal of no

concern to human health from bioconcentration in fish. Therefore, biotransfer factors are not presented for nickel.

3.0 Toxicokinetics

Absorption of inhaled nickel that reaches the lungs (i.e., particles less than 1 micrometer in diameter) approximates 20 to 35 percent, depending on the specific compound involved (ATSDR, 2003). Uptake from the GI tract depends greatly on the specific compound and the mode of administration. In one study with humans uptake of nickel sulfate given in drinking water was much higher (approximately 27 percent) than when given in food (approximately 0.7 percent). Other studies show that the nature of the food items and their time of consumption relative to the time of administration of nickel have a great effect on the extent of uptake. EPA (2004a) cited a 1972 study to support the GAF of 4 percent in humans for nickel in food and water.

Nickel has been shown to penetrate the skin. Studies in humans with radioactive nickel sulfate applied to occluded skin indicate that 55 to 77 percent of the dose is absorbed within 24 hours (ATSDR, 2003). A study in guinea pigs indicated that systemic absorption accounts for 0.005 percent to 0.51 percent of the dermally applied dose of radioactive nickel chloride. The extent to which nickel is sequestered in the dermis and the extent to which it passes to the bloodstream is unclear.

Highest levels of nickel are found in the lungs in occupationally exposed humans and animals exposed by the inhalation route (ATSDR, 2003). Highest levels in animals treated *per os* were found in the kidneys and blood. Significant levels were also found in liver, heart, lung and fat. Highest levels in animals following dermal treatment were found in the skin, blood, kidneys and liver.

Nickel metabolism is limited to ligand exchange reactions by which the cation binds to albumin and other serum proteins (ATSDR, 2003). Dogs lack some of the binding sites present in the serum of other species; therefore, more nickel in dog serum remains free and unbound. Some serum nickel binds to nickeloplasmin, which appears to represent a non-exchangeable pool.

Absorbed nickel is excreted in the urine regardless of the route of exposure (ATSDR, 2003). An excretion half-time of approximately 28 hours has been estimated for humans.

4.0 Dermal Exposure

As noted above, EPA (2004a) estimated a GAF for nickel of 4 percent.

Data were not located regarding dermal uptake of nickel in soil and EPA (2004a) provides no estimate of the extent of dermal absorption (ABS). EPA (2004a) recommends that dermal uptake from soil should not be quantified for chemicals without ABS recommendations, but that these chemicals should be discussed qualitatively as a source of uncertainty. EPA (2004a) compiled *in vitro* data from human experiments of dermal uptake of soluble salts of nickel from water. An average K_p value of 6.4E-5 cm/hour is estimated for nickel from 5 studies reviewed by EPA (2004a) and is used in this evaluation.

5.0 Noncancer Effects Evaluation

In a subchronic gavage study with nickel chloride in water, clinical signs of toxicity in rats included lethargy, ataxia, irregular breathing, reduced body temperature, salivation and discolored extremities (EPA, 2004b). EPA (2004b) presented a verified RfD of 2E-2 mg/kg-day for chronic oral exposure to nickel, based on a NOAEL for decreased organ and body weights in a two-year dietary study with nickel sulfate in rats and an uncertainty factor of 300. Confidence in the oral RfD is medium. The critical effect of prolonged oral exposure to low levels of nickel appears to be reduced body and organ weights without histopathological lesions. EPA (1997) adopted the verified chronic oral RfD of 2E-2 mg/kg-day as the provisional subchronic oral RfD. These oral RfDs are appropriate for oral exposure to soluble salts of nickel or unspeciated nickel compounds.

Inhalation exposure is associated with asthma and pulmonary fibrosis in welders using nickel alloys (ACGIH, 1991). Lung effects were observed in laboratory animals exposed by inhalation. Although the lung is clearly the target organ for inhalation exposure, the data are inadequate for derivation of an inhalation RfC or RfD.

6.0 Carcinogenicity Evaluation

Occupational exposure to nickel is associated with increased risk of nasal, laryngeal and lung cancer (ACGIH, 1991; ATSDR, 2003). Inhalation exposure of rats to nickel subsulfide increased the incidence of lung tumors. EPA (2004b) presented a cancer weight-of-evidence Group A classification (human carcinogen) for nickel, and an inhalation URF of 2.4E-4 per $\mu g/m^3$ for nickel refinery dust. The URF is equivalent to 8.4E-1 per mg/kg-day. The quantitative estimate was derived from human occupational studies. EPA (2004b) also presented a URF of 4.8E-4 per $\mu g/m^3$, which is equivalent to 1.7E+0 per mg/kg-day, for nickel subsulfide, one of the most predominant constituents in nickel refinery dust. The evaluation for nickel refinery dust is ordinarily chosen when the form of nickel in air is unknown. The Group A classification should apply only to inhalation exposure.

7.0 Toxicity Summary

Toxicity values for nickel are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
Nickel, Soluble Salts or Unspeciated										
2E-2	2E-2	BW	ND	ND	NA	Please see below.				
Nickel Refinery Dust										
Please see above						NA	NA	A	2.4E-4	8.4E-1
Nickel Subsulfide										
Please see above.						NA	NA	A	4.8E-4	1.7E+0

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data; NA = not applicable.

Target organ or critical effect abbreviations: BW = reduced body weight.

[a]sRfDo and cRfDo should be adjusted by the GAF of 0.04 when applied to dermal exposure.

8.0 Preliminary Remediation Goals

EPA Region IX has developed preliminary remediation goals (PRG) that are useful for screening chemical concentrations in environmental media (EPA, 2004c). The Region IX PRGs are based on standard default exposure assumptions, and are often adapted for the risk-based screening step for selecting chemicals of potential concern for human health risk assessments.

PRGs are available for nearly 600 chemicals for soil for residential use, for soil for industrial use, for ambient air, and for tap water (EPA, 2004c). Exposure routes addressed by PRGs for soil include incidental ingestion, dermal contact, and inhalation of volatiles or dust; exposure routes addressed by PRGs for tap water include drinking water consumption and inhalation of volatiles. EPA (2004c) provides the methodology and standard exposure default assumptions with which to estimate PRGs for chemicals not included in the tables. Generally, PRGs are developed for both cancer risk and noncancer hazard, and the smaller of the two estimates is chosen. PRGs are currently available for nickel soluble salts for all media except ambient air, presumably because nickel will not volatilize to become airborne. Particulates, however, are emitted to air as described above, and nickel in soil may become airborne through dust emissions. For these reasons it was deemed prudent to develop a PRG for nickel compounds in ambient air as follows:

Chemical	Oral RfD (mg/kg-day)	Inhalation RfD (mg/kg-day)[a]	PEF (m^3/kg)	Preliminary Remediation Goal			
				Residential Soil (mg/kg)	Industrial Soil (mg/kg)	Ambient Air (µg/m^3)	Tap Water (µg/L)
Nickel Soluble Salts	2E-2	2E-2	1.316E+9	NA[b]	NA[b]	7.3E+1	NA[b]

RfD = reference dose; PEF = particulate emission factor; VF_s = soil-to-air volatilization factor; NA = not applicable.
[a]The oral RfD is adopted for inhalation exposure in accordance with EPA Region IX PRG methodology.
[b]See EPA Region IX PRG tables.

The PRG is based on an HI of 1.

9.0 References

Agency for Toxic Substances and Disease Registry, (ATSDR), 2003, ***Update Toxicological Profile for Nickel***, Draft for Public Comment, U.S. Public Health Service, Atlanta, Georgia, September, on line.

American Conference of Governmental Industrial Hygienists (ACGIH), 1991, ***Documentation of the Threshold Limit Values and Biological Exposure Indices***, Sixth Edition, ACGIH, Cincinnati, OH, pp. 1070-1075.

Hazardous Substance Data Bank (HSDB), 2004, National Library of Medicine, on line, accessed 14 December.

U.S. Environmental Protection Agency (EPA), 1995, "Final Water Quality Guidance for the Great Lakes System; Final Rule," (40 CFR 9, 122, 123, 131, and 132), ***Federal Register***, 60(56): 15365-15425.

U.S. Environmental Protection Agency (EPA), 1997, ***Health Effects Assessment Summary Tables, FY 1997 Update***, Office of Solid Waste and Emergency Response, Washington, DC, 9200.6-303(97-1), EPA 540/R-97-036, PB97-921199.

U.S. Environmental Protection Agency (EPA), 2004a, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final***, Office of Superfund Remediation and Technology Innovation, Washington, DC, EPA/540/R/99/005, OSWER 9285.7-02EP July.

U.S. Environmental Protection Agency (EPA), 2004b, ***Integrated Risk Information System (IRIS)***, National Center for Environmental Assessment, Cincinnati, OH, on line, accessed 14 December.

U.S. Environmental Protection Agency (EPA), 2004c, ***Region 9 PRG Table,*** EPA Region IX, San Francisco, CA, October.

THALLIUM (7440-28-0)

1.0 Introduction and Physical Properties

Thallium is a naturally occurring **metal** with an abundance of about 0.3-0.6 ppm in the earth's crust (HSDB, 2005). Thallium compounds are used in a variety of applications, including pharmaceuticals, semiconductors, photoelectric cells, optical systems, ore separation, glass production, and as oxidizing agents in organic synthesis (ATSDR, 1992; HSDB, 2005). An important former use of thallium and its compounds (before 1972) was in pesticide formulations for the control of insects and rodents. Relevant physical properties are compiled below:

MW	log K_{ow}	H	K_d	D_a	D_w	VP	S
204.38[a] (Elemental)	NA	NA	7.1E+1[b,c]	NA	NA	NA	Note 1[a]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; K_d = soil/water partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; NA = not applicable.
Note 1: Thallium sulfate as a typical thallium salt: 4.87E+4 mg/L (20° C).
[a]Agency for Toxic Substances and Disease Registry, (ATSDR), 1992, ***Toxicological Profile for Thallium***, U.S. Public Health Service, Atlanta, Georgia, July, on line.
[b]U.S. Environmental Protection Agency (EPA), 2002, ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites***, Office of Solid Waste and Emergency Response, OSWER 9355.4-24, December.
[c]pH = 6.8.

2.0 Environmental Fate and Transport

Thallium is released to the atmosphere largely from coal-burning power plants, cement factories, and ferrous and nonferrous smelting operations (ATSDR, 1992; HSDB, 2005). Facilities that produce or use thallium or its compounds account for a much smaller part of the total release.

Thallium in air exists as oxide, hydroxide, sulfate or sulfide particles (ATSDR, 1992; HSDB, 2005). The hydroxide and sulfate are water soluble and may partition to water vapor for eventual removal in precipitation. The less soluble particulate forms are probably removed by dry deposition.

Thallium released to surface water usually occurs as the monovalent ion that forms soluble salts with several anions (ATSDR, 1992; HSDB, 2005). Adsorption to suspended particulates may also occur, but the soluble forms remain in the water column.

Although empirical data are sparse, the high solubility of several thallium salts suggests that mobility in soil could be high and the potential for leaching could be significant (ATSDR, 1992).

Terrestrial plants have been shown to absorb thallium from soil, but there is no evidence that biomagnification occurs. EPA (1995) identifies thallium as a chemical unlikely to be of concern for bioaccumulation in aquatic food chains. For these reasons it is concluded that thallium is unlikely to participate significantly in food-chain pathways and biotransfer factors are not estimated or compiled.

3.0 Toxicokinetics

Data regarding absorption from the respiratory tract following inhalation exposure were not located; however, small particles are probably absorbed to some extent and larger particles are probably

removed by mucocilliary clearance and swallowed, where they become available for GI absorption. Thallium compounds appear to be completely absorbed from the GI tract in humans and laboratory animals (ATSDR, 1992). Quantitative data regarding dermal uptake of thallium were not located, although HSDB (2005) states that absorption through the skin occurs readily.

Tissue levels in acutely poisoned humans appear to be highest in the brain in regions dense with neurons, such as the gray matter (HSDB, 2005). Tissue distribution testing in a single human volunteer cancer patient treated orally with a small dose of radiolabeled thallium indicated that highest concentrations were located in scalp hair followed by kidney, heart, bone, spleen and brain (ATSDR, 1992). Distribution in orally treat laboratory animals is rapid and widespread, with higher levels generally associated with the kidney. The rank of levels in other tissues is more variable (ATSDR, 1992), but high levels are ordinarily found in the testis (HSDB, 2005).

The biological half-life in rats in one study was 3.3 days, indicating that excretion is efficient (ATSDR, 1992). Excretion in humans may be somewhat slower. Excretion appears to be primarily through the urine in humans, and through the urine and feces. However, the data are somewhat confusing because animal studies indicate that the ratio of fecal to urinary excretion increases with time. This suggests that biliary excretion and enterohepatic recirculation may be operative, which could result in underestimation of fecal excretion in the human study.

4.0 Dermal Exposure

As noted above, GI absorption of thallium is essentially complete. EPA (2004) concluded that a GAF should not be estimated for thallium for the purpose of adjusting oral toxicity values for dermal exposure. Therefore, the oral toxicity values described below are used directly without adjustment for evaluating dermal exposure.

Thallium may be readily absorbed by the skin (HSDB, 2005); however, data were not located regarding the extent of dermal uptake of thallium from soil, and EPA (2004) provides no estimate of the extent of dermal absorption (ABS). EPA (2004) recommends that dermal uptake from soil should not be quantified for chemicals without ABS recommendations, but that these chemicals should be discussed qualitatively as a source of uncertainty. Empirical data regarding the uptake of soluble forms of thallium from water were not located. The EPA (2004) default K_p for inorganic chemicals of 1E-3 cm/hour is selected for thallium.

5.0 Noncancer Effects Evaluation

Thallium is highly toxic. Acute oral exposure to thallium and its compounds may cause death preceded by neurological disturbances and effects on the lungs, heart and liver (ATSDR, 1992). Formerly, thallium was used medicinally to induce alopecia to facilitate treatment of ringworm of the scalp, sometimes with disastrous results. The critical effect of chronic oral exposure to low levels of thallium compounds in animals and humans is alopecia (ACGIH, 1992; EPA, 2005). EPA (2005) verified chronic oral RfDs for several thallium salts (thallium acetate, thallium carbonate, thallium chloride, thallium nitrate and thallium sulfate) based on a study with thallium sulfate. The oral RfD for thallium sulfate of 8E-5 mg/kg-day was based on a NOAEL of 0.25 mg/kg-day in rats treated by gavage with thallium sulfate for 90 days. No adverse effects were seen in this study. An uncertainty factor of 3000 was used, consisting of factors of 10 each to extrapolate from subchronic to chronic data, for intraspecies extrapolation and to account for interspecies variability, and a factor of 3 to account for lack of reproductive and chronic toxicity data. Confidence in the chronic RfD is

low. The skin (alopecia) and liver (altered blood biochemistry) are considered the target organs for oral exposure to thallium, based on other data reviewed by EPA (2005). Effects on the testis and kidney were observed in rats exposed to higher dose rates. The chronic oral RfD for thallium sulfate of 8E-5, when adjusted for differences in molecular weight, is equivalent to a chronic oral RfD for thallium of 6.5E-5 mg/kg-day. This adjustment is based on the assumption that the toxicity of thallium sulfate is due entirely to thallium, rather than to the sulfate moiety. The oral RfD for thallium of 6.5E-5 mg/kg-day will be used in this evaluation.

EPA (1997) provides a provisional subchronic oral RfD for thallium sulfate of 8E-4 mg/kg-day, equivalent to a subchronic oral RfD for thallium of 6.5E-4 mg/kg-day, based on the study discussed above and an uncertainty factor of 300, eliminating the factor of 10 to expand from subchronic to chronic exposure. EPA (1997) provides provisional subchronic chronic oral RfDs for several thallium salts (thallium acetate, thallium carbonate, thallium chloride, thallium nitrate and thallium sulfate) based on the same study with thallium sulfate.

Inhalation exposure data are very limited. An occupational study suggests that neurological effects may develop following prolonged inhalation exposure (ATSDR, 1992). The nervous system appears to be more sensitive than the skin as a target organ for inhalation exposure. The data are inadequate for estimation of an inhalation RfC or RfD.

6.0 Carcinogenicity Evaluation

Several thallium compounds (thallium oxide, thallium acetate, thallium carbonate, thallium chloride, thallium nitrate, thallium sulfate) are classified as cancer weight-of-evidence Group D substances (not classifiable as to carcinogenicity to humans) (EPA, 2005). No weight-of-evidence classification was located for thallium alone, but the Group D classification can be applied to thallium. Quantitative cancer risk estimates are not derived for Group D chemicals.

7.0 Toxicity Summary

Toxicity values for thallium are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
6.5E-4	6.5E-5	S, L	ND	ND	NA	D	NA	D	NA	NA

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data; NA = not applicable.
Target organ or critical effect abbreviations: L = liver; S = skin.
[a]sRfDo and cRfDo should be used for dermal exposure without adjustment for GI absorption.

8.0 References

Agency for Toxic Substances and Disease Registry, (ATSDR), 1992, ***Toxicological Profile for Thallium***, U.S. Public Health Service, Atlanta, Georgia, July, on line.

Hazardous Substance Data Bank (HSDB), 2005, National Library of Medicine, on line, accessed 1 December.

U.S. Environmental Protection Agency (EPA), 1995, "40 CFR 9, 122, 123, 131, and 132 Final Water Quality Guidance for the Great Lakes System; Final Rule," ***Federal Register***, 60(56); 15366-15425.

U.S. Environmental Protection Agency (EPA), 2004, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final***, Office of Superfund Remediation and Technology Innovation, Washington, DC, EPA/540/R/99/005, OSWER 9285.7-02EP July.

U.S. Environmental Protection Agency (EPA), 2005, ***Integrated Risk Information System (IRIS)***, National Center for Environmental Assessment, Cincinnati, OH, on line, accessed 1 December.

VANADIUM (7440-62-2)

1.0 Introduction and Physical Properties

Vanadium is a widespread **metal**, comprising about 0.014 percent of the earth's crust (Wennig and Kirsch, 1988) with an average concentration of approximately 150 mg/kg (ATSDR, 1992). It may exist in six oxidation states (-1, 0, +2, +3, +4 and +5); +3, +4 and +5 are most important in environmental and biological media. Vanadium is always found combined in nature, generally with oxygen, and occurs in upwards of 50 different mineral ores. It is also associated with fossil fuels. Vanadium is used predominantly in the production of special steels and alloys, some of which have unique application in nuclear power technology (Lagerkvist et al., 1986; HSDB, 2005). Relevant physical properties are compiled below:

MW	log K_{ow}	H	K_d	D_a	D_w	VP	S
50.942[a] (Element)	NA	NA	1117[b, c]	NA	NA	NA	Note 1[b]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; K_d = soil/water partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; NA = not applicable; ND = no data.

Note 1: Vanadium pentoxide as a typical vanadium compound: 8E+3 mg/L (reference temperature not given).

[a]Agency for Toxic Substances and Disease Registry (ATSDR), 1992, ***Toxicological Profile for Vanadium***, U.S. Department of Health and Human Services, Atlanta, Georgia, July, on line.

[b]Hazardous Substance Data Bank (HSDB), 2005, National Library of Medicine, on line, accessed 1 December.

[c]Midpoint of values determined for ammonium vanadate in 11 soils (range 10.8 to 2223).

2.0 Environmental Fate and Transport

Vanadium compounds are released naturally to air through the formation of continental dust, marine aerosols, and volcanic emissions (ATSDR, 1992; HSDB, 2005). Natural release greatly exceeds anthropogenic release. The most important anthropogenic contribution is from the combustion of fuel oil and other fossil fuels, with significant local contributions also from metallurgical and other industrial operations. Most anthropogenic releases to the atmosphere occur in the form of simple or complex vanadium oxides. Vanadium exists as particulates in the atmosphere. Small particles may remain in air for long periods of time and travel long distances. Removal is limited to wet and dry deposition.

The natural release of vanadium to water and soils occurs primarily as a result of weathering of rocks and soil erosion (ATSDR, 1992; HSDB, 2005). Anthropogenic sources include deposition from the atmosphere and the production and industrial use of vanadium and its compounds. Application of mineral fertilizers may lead to the accumulation of vanadium compounds in soil. Natural releases to water and sediment greatly exceed anthropogenic sources, although water pollution in the area of heaped-up or landfilled mine waste can be extensive in mining areas.

The behavior of vanadium in soils is not yet fully understood; however, it is known that the mobility of vanadium in soils is affected by pH (ATSDR, 1992; HSDB, 2005). Vanadium is fairly mobile in neutral or alkaline soils, relative to other metals, but its mobility decreases in acidic soils. Leaching is a potentially significant process, but great variability is expected based on soil characteristics as indicated by the range for K_d given above.

Vanadium in surface water exists largely as vanadyl and vanadate species (ATSDR, 1992; HSDB, 2005). Both forms are known to bind strongly to mineral or biogenic surfaces by adsorption or complexation, reducing the amount of soluble vanadium found in water. Biochemical removal may occur in marine environments. Some marine organisms particularly the ascidians (sea squirts) bioconcentrate vanadium, attaining body concentrations approximately 10,000 times greater than the ambient seawater. The potential for bioconcentration appears to be greater among the lower phyla.

Vanadium in freshwater has some potential for bioconcentration. A study in bluegills estimated BCFs of 51 to 92 L/kg; however, details of the study were not located (HSDB, 2005). Although empirical data are limited, it appears that biomagnification in terrestrial food chains is unlikely (ATSDR, 1992). The potential for bioconcentration in terrestrial plants appears to be greater among the lower phyla than among the seed producers. Since vanadium is unlikely to participate significantly in aquatic and terrestrial food-chain pathways relevant to humans, biotransfer factors are not compiled or estimated.

3.0 Toxicokinetics

Excretion studies with occupationally exposed humans and intratracheal administration studies with vanadyl chloride in rats suggest that pulmonary absorption occurs (ATSDR, 1992). Although quantitative data are not available, it appears that water soluble forms may be more readily absorbed from the lung. Vanadium is poorly absorbed from the GI tract (Lagerkvist et al., 1986). GI uptake of vanadium pentoxide in rats was estimated at about 2.6 percent of the administered dose. GI uptake of oxytartarovanadate by humans was estimated at 0.1 to 1 percent of the administered dose. GI absorption may be somewhat higher in the young than in adults. The International Commission on Radiological Protection (ICRP) (1960) estimate for GI absorption by humans of soluble vanadium compounds is 2 percent. Data regarding dermal uptake of vanadium were not located.

Absorbed vanadium is transported primarily in the blood plasma rather than in the cellular elements (ATSDR, 1992). Distribution following inhalation or oral exposure is generally widespread, with highest levels initially found in the lung, liver and kidney. The kidney is the primary excretory organ, which probably accounts for the relatively high levels observed in this organ during or shortly after administration. Vanadium that is not excreted eventually partitions to the skeleton where it may displace the phosphate radical and persist.

The kinetics of vanadium metabolism are not well understood. Metabolism is limited to interconversion between the vanadyl form (valence of +4) and the vanadate form (valence of +5) that presumably reaches equilibrium (ATSDR, 1992). This interconversion may occur within the GI tract as well as systemically following absorption (EPA, 2000). Vanadate is considered to be the more toxic form because it reacts with several enzymes and is a potent inhibitor of energy metabolism in cell membranes. This is a moot point, however, because of the equilibrium that would be reached following exposure to vanadium of either valence.

The kidney is the main excretory organ for systemically absorbed vanadium (ATSDR, 1992).

4.0 Dermal Exposure

The estimate of GI absorption of 2.6 percent (rounded to a decimal fraction of 0.03) by rats described above is recommended by EPA (2004a) as the GAF for vanadium.

Data were not located regarding the extent of dermal uptake of vanadium from soil, and EPA (2004a) provides no estimate of the extent of dermal absorption (ABS). EPA (2004a) recommends that dermal uptake from soil should not be quantified for chemicals without ABS recommendations, but that these chemicals should be discussed qualitatively as a source of uncertainty. Empirical data regarding the uptake of soluble forms of vanadium from water were not located. The EPA (2004a) default K_p for inorganic chemicals of 1E-3 cm/hour is selected for vanadium.

5.0 Noncancer Effects Evaluation

The oral toxicity of vanadium and compounds to humans is very low (Lagerkvist et al., 1986), probably because little vanadium is absorbed from the GI tract. A provisional chronic oral RfD of 7E-3 mg/kg-day was derived from a NOEL in rats in a lifetime drinking water study with vanadyl sulfate and an uncertainty factor of 100 (EPA, 1997). A target organ could not be identified for oral exposure. EPA (1997) adopted the chronic oral RfD as the provisional oral RfD for subchronic exposure as well. The provisional chronic and subchronic oral RfD from EPA (1997) has routinely been applied to vanadium and its compounds without speciation of the form of vanadium encountered in environmental media.

More recently, EPA (2000) reviewed four studies in which human volunteers were given various vanadium compounds *per os* for periods ranging from 6 to 24 weeks. Two studies involved healthy volunteers and two involved hospital patients. Endpoints evaluated in one or more of the studies included blood pressure, hematology, serum clinical chemistry, routine urinalysis, and fecal sterol levels, bile acids and fats. EPA (2000) concluded that collectively these studies identified a NOAEL of 0.3 mg vanadium/kg-day, although some GI distress was experienced by some of the subjects. It was assumed that GI distress would be unlikely at exposures near the oral RfD. Application of an uncertainty factor of 300 yielded a new provisional oral RfD of 1E-3 mg vanadium/kg-day. The uncertainty factor addressed expansion from short-term to chronic exposure, the protection of unusually sensitive individuals, and deficiencies in the data base, but individual factors for each of these sources of uncertainty were not given. Therefore, the provisional oral RfD of 1E-3 mg vanadium/kg-day is adopted for subchronic as well as chronic exposure. The provisional oral RfD of 1E-3 mg/kg-day should be applied to unspeciated vanadium and its compounds. EPA (2000) noted that kidney effects appear to be the critical effects in laboratory animals, suggesting that the kidney should be selected as the target organ for prolonged oral exposure to vanadium. Confidence in the provisional oral RfD is medium.

EPA (2005) reported the results of an old unpublished study in which rats were exposed to dietary levels of 10 or 100 ppm vanadium as vanadium pentoxide (approximately 17.9 or 179 ppm vanadium pentoxide) for 2.5 years. The criteria used to evaluate vanadium toxicity were limited to growth rate, survival, and hair cystine content. The only significant change reported was a decrease in the amount of cystine in the hair of rats in the high dose group. Therefore, the lower dose level (17.9 ppm vanadium pentoxide) was designated a NOAEL. The NOAEL is equivalent to a dose rate of 0.895 mg vanadium pentoxide/kg-day, assuming rats eat food equivalent to 5 percent of their body weight each day. Application of an uncertainty factor of 100 yields the verified chronic oral RfD of 9E-3 mg vanadium pentoxide/kg-day. EPA (1997) adopted the chronic oral RfD as the provisional oral RfD for subchronic exposure. The oral RfD of 9E-3 mg/kg-day should be applied only to vanadium pentoxide. Confidence in the oral RfD is low.

The only effect observed from exposure to vanadium pentoxide was reduced cystine content of the hair (EPA, 2005). It is unclear if this resulted in fragile or otherwise damaged hair shafts, and it is unclear whether it reflects altered hair follicle function or a more central effect on protein metabolism. A target organ cannot be identified and the critical effect cannot be more clearly elucidated because of the limited scope of evaluation of this study. Similar effects were not observed in occupationally exposed humans. A target organ or meaningful critical effect cannot be determined for oral exposure to vanadium pentoxide.

Effects in humans exposed by inhalation include upper and lower respiratory tract irritation (ATSDR, 1992). The respiratory tract is the target organ for inhalation exposure, but the data are inadequate for derivation of an inhalation RfC or RfD.

6.0 Carcinogenicity Evaluation

No empirical information was located regarding the carcinogenicity of vanadium.

7.0 Toxicity Summary

Toxicity values for vanadium and unspeciated vanadium compounds, and for vanadium pentoxide are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfc/ sRfD	cRfC/ cRfD	TO	WOE	SFo	WOE	URFi	SFi
Vanadium and Compounds										
1E-3	1E-3	K	ND	ND	NA	ND	ND	ND	ND	ND
Vanadium Pentoxide										
9E-3	9E-3	ND	ND	ND	NA	ND	ND	ND	ND	ND

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per milligram per cubic meter); SFi = inhalation cancer slope factor (risk per microgram per kilogram-day); ND = no data; NA = not applicable.
Target organ abbreviations: K = kidney.
[a]sRfDo and cRfDo should by multiplied by the GAF of 0.03 when applied to dermal exposure.

8.0 Preliminary Remediation Goals

EPA Region IX has developed preliminary remediation goals (PRG) that are useful for screening chemical concentrations in environmental media (EPA, 2004b). The Region IX PRGs are based on standard default exposure assumptions, and are often adapted for the risk-based screening step for selecting chemicals of potential concern for human health risk assessments.

PRGs are available for nearly 600 chemicals for soil for residential use, for soil for industrial use, for ambient air, and for tap water (EPA, 2004b). Exposure routes addressed by PRGs for soil include incidental ingestion, dermal contact, and inhalation of volatiles or dust; exposure routes addressed by PRGs for tap water include drinking water ingestion and inhalation of volatiles. EPA (2004b) provides the methodology and standard exposure default assumptions with which to estimate PRGs for chemicals not included in the tables. Generally, PRGs are developed for both cancer risk and noncancer hazard, and the smaller of the two estimates is chosen. Data regarding the carcinogenicity of vanadium are not available; therefore, only PRGs based on noncancer are considered herein.

EPA (2004b) provides PRGs for vanadium and compounds in soil and tap water based on the chronic oral RfD for vanadium of 1E-3 mg/kg-day described above. However, a PRG was not provided for vanadium in air, probably because exposure to vanadium in air independent of exposure to vanadium in soil is unlikely. PRGs are not available for vanadium pentoxide, probably because vanadium compounds are seldom speciated in environmental media. However, the PRGs provided for vanadium and compounds are sufficiently protective for application to vanadium pentoxide.

9.0 References

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EXPLOSIVES

2,4,6-TRINITROTOLUENE (TNT) (118-96-7)

Introduction and Physical Properties

TNT is an **SVOC** that occurs as a pale yellow solid, crystal or flake at ambient temperatures (HSDB, 2003). It is classified as a high explosive and is used as a military explosive in bombs and grenades (ATSDR, 1995; HSDB, 2003). It has found wide use in filling shells and airborne detonation bombs because it can withstand the shock of ejection from a gun barrel but can be exploded on impact with a detonator mechanism. It is used as a pure compound or combined with other explosive chemicals for military application. Small amounts are used in industrial explosives. Minor applications include use as a chemical intermediate in the manufacture of dyestuffs and photographic chemicals. Relevant physical properties are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
227.13[a]	1.60[a]	4.57E-7[a] (20°C)	3.20[a]	5.10E-2[b] (25°C)[c]	5.91E-6[b] (25°C)[c]	2.62E-7[a] (20°C)	1.30E+2[a] (20°C)	NA	NA	NA

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point of pure liquid compound (°K); T_c = critical temperature (°K); $\Delta H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole); NA = not applicable.
[a]Hazardous Substance Data Bank (HSDB), 2003, National Library of Medicine, on line, accessed 5 September. [b]Estimated as described in Introduction to Toxicity Profiles.
[c]Assumed.

Environmental Fate and Transport

TNT may be released to the environment in wastewater and air effluents from its production and use as a military explosive and propellant, and during the disposal or open detonation of outdated or unwanted munitions (ATSDR, 1995; HSDB, 2003). The behavior of TNT in the environment is expected to be controlled largely by its relatively high water solubility and relatively low vapor pressure. In addition, direct and indirect photolysis yields a large number of degradation products, many of which are persistent in environmental media. Photolysis products include dinitroanthrils, trinitrobenzaldehyde, trinitrobenzyl alcohol, various nitroanilines, condensed azo and axoxy derivatives, and 1,3,5-trinitrobenzene.

Although low, the vapor pressure of TNT is sufficient to suggest that the compound will exist largely in the vapor phase in the atmosphere, where it is expected to be subject to photolysis (HSDB, 2003). The photolysis half-life has been estimated at approximately 110 days. The solubility of TNT in water suggests that wet deposition may be a significant removal process.

TNT on the surface of soil is subject to photolysis (ATSDR, 1995; HSDB, 2003). Mobility in soil is expected to be low to moderate. Large quantities released to soil (e.g., from former munitions production works) may result in substantial concentrations in groundwater. TNT in soil is subject to degradation to a number of nitro reduction products (amino compounds, mono- and dinitro compounds).

TNT in surface water is subject to photolysis; volatilization and hydrolysis are not expected to be significant (ATSDR, 1995; HSDB, 2003). Photolysis gives rise to the persistent red or pink water condition frequently observed with TNT contamination. Biodegradation occurs too slowly to be an important removal process. TNT and some of its degradation products will partition moderately to sediment or suspended particles in water.

Bioconcentration or bioaccumulation are not expected to be significant for TNT (ATSDR, 1995; HSDB, 2003); therefore, biotransfer factors are not developed.

Data for Evaluating Dermal Exposure

Pharmacokinetic data are limited to studies of oral administration of radiolabeled compound to several species followed by collection and measurement of radioactivity in urine, gastrointestinal tract (including contents) and feces (ATSDR, 1995). Total recovery from these compartments ranged from 92 to 104 percent, suggesting little metabolism to radioactive metabolites that were exhaled. The percent of the dose recovered in the urine may be considered a minimal estimate of GI absorption, because the extent of biliary excretion and enterohepatic recirculation has not been investigated. Urinary recovery averaged 60 percent in rats, mice and dogs, and approximately 74 percent in rabbits.

EPA (2001) notes that organic chemicals are generally well absorbed from the GI tract, and recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly less than complete. Therefore, no GAF is developed for TNT and the oral toxicity values described below should be used for dermal exposure without adjustment for GI absorption.

Studies indicate that TNT is rapidly absorbed through the skin of occupationally exposed humans, but quantitative data were not located (ATSDR, 1995). Dermal absorption ranged from 17 to 68 percent of a single dose of radioactivity in studies using laboratory animals exposed for 24 hours to radiolabeled compound. Absorption appeared to be more complete in rabbits and mice than in rats and dogs, suggesting that species differences are significant. Data were not located regarding the dermal uptake of TNT from soil, which would account for the matrix effect, or the ability of soil to bind the chemical and retard its dermal uptake. In the absence of quantitative data, the default ABS of 0.1 for SVOCs recommended by EPA (2001) is adopted for this evaluation. K_p, τ, FA and B values are estimated by the EPA (2001) method as follows:

Chemical	K_p	τ	FA	B
2,4,6-Trinitrotoluene	9.64E-4	1.96E+0	1.0[a]	0[b]

K_p = permeability coefficient (cm/hour); τ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).
[a]Assumed.
[b]Sufficiently small to be rounded to zero.

Noncancer Effects Evaluation

Single-dose oral LD50 values for TNT include 1010 to 1320 mg/kg for male rats, 795 to 820 mg/kg for female rats, and 660 to 1014 mg/kg in mice (ATSDR, 1995; EPA, 1993; HSDB, 2003). Female rats appear to be slightly more sensitive than males, but no significant gender differences appear in mice. Acutely poisoned animals exhibit tremors and convulsions. The radicals produced during intracellular nitroreduction of TNT inflict damage on several organelles across many different cell and tissue types.

The critical effect of prolonged oral exposure of animals to TNT is liver damage (EPA, 2003). Dogs appear to be more sensitive than rats or mice. A verified RfD for chronic oral exposure of 5E-4

mg/kg-day was derived from a LOAEL of 0.5 mg/kg-day associated with hepatic swelling and hepatocytomegaly in a 26-week feeding study in dogs. An uncertainty factor of 1000 was applied. The UF of 1000 allows for uncertainties in laboratory animal-to-man dose extrapolation, interindividual sensitivity, subchronic-to-chronic extrapolation, and LOAEL-to-NOAEL extrapolation, although the individual uncertainty factors for each category were not given. Hemosiderosis, evidence of erythrocyte destruction, was observed in dogs treated at a dose rate as low as 2 mg/kg-day (ATSDR, 1995). Confidence in the oral RfD is medium. EPA (1997) adopted the verified chronic oral RfD as the provisional oral RfD for subchronic exposure.

Although the key study is described as a comprehensive and well designed subchronic study, only effects on the liver were reported by EPA (2003), presumably because the liver effects were the critical effects upon which the oral RfD is based. Specifically, observations regarding clinical chemistry, hematology, urinalyses, periodic electrocardiography and ophthalmic examinations were not reported. Additional information from other sources, however, indicates that anemia is one of the major signs of TNT toxicity consistently observed in rats, mice and dogs (ATSDR, 1995). TNT and/or its metabolites induce the oxidation of intracellular hemoglobin to methemoglobin, which results in erythrocytic hemolysis. Hemolytic anemia is followed by a compensatory response manifested primarily as reticulocytosis. Effects on the testes, including irreversible atrophy and decreased reproductive performance, apparently secondary to altered zinc and copper nutrition, are observed in rats treated with much higher dose rates (e.g., 125 mg/kg-day).

Target organs at or near the threshold for toxicity include the erythrocyte and liver. Effects on the erythrocyte arise from the oxidation of hemoglobin to methemoglobin, which is consistently observed with exposure to inorganic nitrates and nitrites, as well as with many other nitroaromatic compounds (HSDB, 2003). Mild effects on the liver occur at slightly lower doses; the mechanism of hepatotoxicity has not been elucidated. Effects on the testes at higher levels probably arise from reduced levels of circulating ceruloplasmin, which is necessary for proper zinc nutrition at the cellular level.

Information regarding the inhalation toxicity of TNT are limited to occupational studies, which probably also include dermal exposure, generally associated with the manufacture of explosives for World War I and World War II (ATSDR, 1995). Effects attributed to occupational exposure include deaths from liver disease and aplastic anemia, anemia, dermatitis and cataracts. The data are insufficient to derive an RfC for inhalation exposure to TNT.

Carcinogenicity Evaluation

TNT is classified in EPA weight-of-evidence Group C (possible human carcinogen) on the basis of positive mutagenicity studies and dietary studies that showed an increased incidence of urinary bladder tumors in rats (EPA, 2003). Human data are inadequate. An oral SF of 3.0E-2 per mg/kg-day is based on the incidence of bladder tumors in female rats in a 24-month dietary study. The data are inadequate for potency estimation for inhalation exposure.

Toxicity Summary

Toxicity values for TNT are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure[a]		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
5E-4	5E-4	L, E	ND	ND	NA	C	3.0E-2	C	ND	ND

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per microgram per kilogram-day); ND = no data; NA = not applicable.
Target organ abbreviations: L = liver; E = erythrocyte.
[a]sRfDo, cRfDo and SFo should be used for dermal exposure without adjustment for GI absorption.

References:

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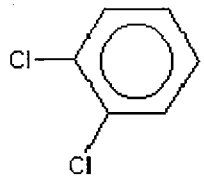
DICHLOROBENZENES



1,2-Dichlorobenzene

1.0 Introduction and Physical Properties

The dichlorobenzenes are **VOCs** that include 1,2-dichlorobenzene (o-dichlorobenzene), 1,3-dichlorobenzene (m-dichlorobenzene) and 1,4-dichlorobenzene (p-dichlorobenzene). 1,2-Dichlorobenzene and 1,3-dichlorobenzene exist as liquids at ambient temperatures; 1,4-dichlorobenzene exists as a solid (Lewis, 1997).

1,2-Dichlorobenzene is used in the production of other organic compounds (Lewis, 1997), predominantly as a precursor to the 3,4-dichloroaniline herbicides (ATSDR, 2004). It is also used as a solvent for a wide range of organic compounds, in metal cleaning and polishing, in degreasing hides and wool, as an insecticide and fumigant, in industrial odor control, and as a heat transfer agent. 1,3-Dichlorobenzene is used predominantly as a fumigant and insecticide. It is also used in the production of chlorophenols and arylene sulfide polymers (HSDB, 2004). 1,4-Dichlorobenzene is the most important isomer from a commercial perspective, and is used predominantly as a deodorant in toilets, garbage pails, urinals and diaper pails, as a moth control agent, insecticide, and as an intermediate in the production of certain resins (ATSDR, 2004). Less importantly, it is used in pesticides, dye synthesis, abrasives, floor waxes and finishes, and agricultural chemicals. Relevant physical properties are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
1,2-Dichlorobenzene (95-50-1)										
147.0[a]	3.38[a]	1.90E-3[b] (25□C)	2.79[b]	6.90E-2[b] (25□C)	7.90E-6[b] (25□C)	1.79E-3[c] (25□C)	1.56E+2[b] (20-25□C)	453.57[d]	705.00[d]	9.70E+3[d]
1,3-Dichlorobenzene (541-73-1)										
147.0[a]	3.60[a]	2.8E-3[c] (20□C)	3.60[c]	6.82E-2[e] (25□C)[f]	7.90E-6[e] (25□C)[f]	2.83E-3[c] (25□C)	1.25E+3[c] (25□C)	446.15[c]	688.45[c]	1.04E+4[c]
1,4-Dichlorobenzene (106-46-7)										
147.0[a]	3.39[a]	2.43E-3[b] (25□C)	2.79[b]	6.90E-2[b] (25□C)	7.90E-6[b] (25□C)	2.29E-3[c] (25□C)	7.38E+1[b] (20-25□C)	447.21[d]	684.75[d]	9.27E+3[d]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point (at 1 atm) of pure liquid compound (°K); T_c = critical temperature (°K); $H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole).

[a]U.S. Environmental Protection Agency (EPA), 2004, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final***, Office of Superfund Remediation and Technology Innovation, EPA/540/R/99/005, OSWER 9285.7-02EP, July.

[b]U.S. Environmental Protection Agency (EPA), 2001, ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites***, Peer Review Draft, Office of Solid Waste and Emergency Response, OSWER 9355.4-24, March.

[c]Hazardous Substance Data Bank (HSDB), 2004, National Library of Medicine, on line, accessed 10 November.

[d]U.S. Environmental Protection Agency (EPA), 2003, ***Users Guide for Evaluating Subsurface Vapor Intrusion into Buildings***, Office of Emergency and Remedial Response, Washington, DC, 19 June.

[e]Calculated as described in Introduction to Toxicity Profiles.

[f]Assumed.

2.0 Environmental Fate and Transport

The dichlorobenzenes may be released to the environment as emissions during their production, transport or use, or in various waste streams (ATSDR, 2004; HSDB, 2004). In particular, 1,4-dichlorobenzene is released to air during its use as a deodorizer, and 1,2- and 1,3-dichlorobenzene

are released during herbicide production or during the use of other products that contain the compounds. The volatility of this class of compounds results in releases largely to the atmosphere, where these compounds exist predominantly in the vapor phase. Vapor-phase dichlorobenzenes are degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals with an estimated atmospheric half-life of 22 to 50 days, depending on the isomer. Washout in rain may also be significant. Reactions with ozone or other atmospheric constituents are unlikely to be significant.

The dichlorobenzenes are expected to have moderate to low mobility in soils (HSDB, 2004). Volatilization from dry soil surfaces is expected to be an important fate process based upon the relatively high vapor pressures of these compounds. Volatilization from moist soil surfaces is also expected to be significant. The dichlorobenzenes are not expected to biodegrade significantly in soils.

The dichlorobenzenes are expected to adsorb to sediment or particulate matter in surface water, based on their K_{oc} values (HSDB, 2004). Volatilization from water surfaces is also expected to be significant. Estimated volatilization half-lives for a model river and model lake are 4 and 120 hours, respectively.

Although some laboratory tests suggest that bioconcentration of the dichlorobenzenes in fish may be significant (ATSDR, 2004; HSDB, 2004), details of the laboratory tests are not available. Furthermore, EPA (1995) concluded that the dichlorobenzenes are not of concern for human health through fish consumption. The dichlorobenzenes are unlikely to biomagnify in terrestrial soil-plant systems, and rapid metabolism and excretion reduce the likelihood that these compounds would be significant in terrestrial food-chain pathways (ATSDR, 2004; HSDB, 2004). Therefore, biotransfer factors are not estimated for the dichlorobenzenes.

3.0 Toxicokinetics

Quantitative data regarding the respiratory uptake of the dichlorobenzenes were not located; however, the observation of adverse effects, or measurable tissue levels and excretion of dichlorobenzene residues following inhalation exposure indicates that respiratory absorption occurs (ATSDR, 2004). The time at which peak levels were observed in blood following oral administration suggests that the dichlorobenzenes are readily absorbed from the GI tract. Excretion data and comparison of tissue levels following subcutaneous and oral administration suggest that GI absorption is rapid, and the extent of absorption is at least 50 percent and more likely approximates or exceeds 90 percent. Data regarding dermal absorption were not located, but the observation of high dermal LD_{50} values suggests that dermal uptake is neither rapid nor extensive.

Distribution throughout the body occurs rapidly after exposure, and highest levels are located in the fat, liver and kidney (ATSDR, 2004). Experiments with 1,2- and 1,4-dichlorobenzene in orally treated rats indicate that retention half-lives in body tissues vary from 8 to 20 hours, and body clearance is nearly complete by 72 hours.

Metabolism of the dichlorobenzenes involves cytochrome P450-mediated oxidation to an epoxide intermediate followed directly by conjugation, or followed by hydrolysis to the corresponding dichlorophenols before conjugation (ATSDR, 2004). Further oxidation to form various dichlorocatechols or dichlorohydroquinones that are subsequently conjugated represents a less prevalent pathway. Conjugating moieties include glutathione, sulfate or glucuronic acid.

Cytochrome P450 is widely distributed throughout many of the tissues of the body, but greatest activity is in the liver. Largely because of the "first pass" phenomenon (i.e., venous blood from the GI tract is shunted to the liver before being returned to the vena cava), the metabolism of the dichlorobenzenes following oral exposure is expected to differ substantially from that following inhalation exposure. Consequently, dose-response data from oral exposure are considered to be an inappropriate model for inhalation exposure, which precludes developing inhalation toxicity values from oral exposure data.

Excretion is generally rapid, occurring predominantly through the kidney, although biliary excretion and enterohepatic recirculation undoubtedly occur (ATSDR, 2004). Excretion occurs as metabolites rather than as the parent compound. Urinary excretion ordinarily reaches its peak within 24 hours, but enterohepatic recirculation delays the excretion of some dichlorobenzene metabolites.

4.0 Dermal Exposure

EPA (2004a) notes that organic chemicals are generally well absorbed from the GI tract, and recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly less than complete. Based on the toxicokinetic data reviewed above, no GAF is developed for the dichlorobenzenes and the oral toxicity values described below should be used for dermal exposure without adjustment for GI absorption.

Data were not located for dermal uptake of the dichlorobenzenes from soil. VOCs tend to volatilize from soil when applied to the skin, reducing dermal uptake to toxicologically insignificant levels (EPA, 2004a). Therefore, dermal uptake of the dichlorobenzene isomers from soil is not evaluated. t*, K_p, τ, FA and B values are provided by EPA (2004a) as follows:

Chemical	t*	K_p	τ	FA	B
1,2-Dichlorobenzene	1.71	4.1E-2	0.71	1	0.2
1,3-Dichlorobenzene	1.71	5.8E-2	0.71	1	0.3
1,4-Dichlorobenzene	1.71	4.2E-2	0.71	1	0.2
t* = time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); □ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).					

5.0 Noncancer Effects Evaluation

Note: many toxicity values for the dichlorobenzenes were developed during the early to mid-1990s; some were verified and are currently available on IRIS (EPA, 2004b). Several provisional toxicity values have also been developed. Recently, EPA (2004c) reevaluated the toxicity data for the dichlorobenzenes, as well as the protocols by which the dose-response relationships were quantified and the previously verified and provisional toxicity values were estimated. EPA (2004c) introduced several refinements and recalculated most of the toxicity values. These new EPA (2004c) derivations are not yet posted on the IRIS website, but they are available as IRIS summaries at the external review draft stage. The Shaw E&I toxicologist has painstakingly evaluated the new EPA (2004c) derivations and has concluded that in each and every case the new derivations reflect a more appropriate interpretation of the toxicity data (i.e., the relevance of effects reported in animals to human health), and that the refined dose-response quantifications are more in line with current methodology that makes better use of the entire data base. Therefore, this toxicity profile takes the

position that the new derivations supercede the previous, even though they are currently available only as an external review draft.

Oral LD_{50} values for 1,2-dichlorobenzene include 4.4 g/kg in mice, 500 mg/kg in rats, and 500 mg/kg in rabbits (Montgomery, 1996), suggesting that mice may be somewhat less sensitive than the other species to the acute toxicity of the compound. A previously verified chronic oral RfD of 9E-2 mg/kg-day, currently available on IRIS was based on a NOAEL in rats in a 2-year gavage study in rats and mice (EPA, 2004b). Dose levels of 0 (control), 60 or 120 mg/kg were administered 5 days per week, equivalent to dose rates of 0, 42.9 and 85.7 mg/kg-day. The higher dose rate (85.7 mg/kg-day) was judged to be a NOAEL; a LOAEL was not identified in this study. Application of an uncertainty factor of 1000 to the NOAEL yielded the previously verified RfD. More recently, EPA (2004c) reviewed this derivation and concluded that the lower dose rate (42.9 mg/kg-day) was a more appropriate NOAEL because liver effects were observed in rats treated at 89.3 mg/kg-day in a 13-week gavage study, very close to the 85.7 mg/kg-day dose rate in the 2-year study that was previously judged to be a NOAEL. This refinement in the study analysis that resulted in refining the threshold for toxic effects justified reducing the uncertainty factor from 1000 to 300. Application of the uncertainty factor of 300 to the NOAEL of 42.9 mg/kg-day yields a new verified chronic oral RfD of 1.4E-1 mg/kg-day. The uncertainty factor of 300 consists of factors of 10 each to account for inter- and intra-species variation, and a factor of 3 to account for deficiencies in the data base. Confidence in the new verified oral RfD is medium. The liver is the target organ for prolonged oral exposure to 1,2-dichlorobenzene.

The EPA (2004c) reevaluation of the toxicity data for 1,2-dichlorobenzene suggests that there are no significant differences in effects between chronic and subchronic exposure. Therefore, the new verified chronic oral RfD of 1.4E-1 mg/kg-day is adopted as sufficiently protective for subchronic exposure as well.

Data regarding the toxicity of acute oral exposure to 1,3-dichlorobenzene were limited to a 10-day gavage study in rats that noted minimal to mild hepatocellular necrosis at dose rates upwards of 147 mg/kg-day (EPA, 1998a). No adverse effects were observed at 37 mg/kg-day, the low dose rate in this study. A provisional chronic oral RfD of 9E-4 mg/kg-day had been based on effects in a comprehensive 90-day gavage study in rats (EPA, 1998a). The lowest dose rate tested, 9 mg/kg-day, was a LOAEL associated with reduced body weight gain, biochemical and histopathologic evidence of altered liver function and mild liver damage, and histopathologic evidence in the thyroid and pituitary of endocrinologic dysfunction. An uncertainty factor of 10,000 was applied. More recently, EPA (2004c) reevaluated the data from the 90-day gavage study and determined that the critical effects were the thyroid and pituitary alterations; that these effects occurred at dose rates below those associated with liver effects. A benchmark dose of 3 mg/kg-day was estimated for the thyroid and pituitary effects. Refinement of the threshold for the critical effect justified reducing the uncertainty factor from 10,000 to 3000. Application of the uncertainty factor of 3000 to the benchmark dose of 3 mg/kg-day results in the newly verified chronic oral RfD of 1E-3 mg/kg-day. The uncertainty factor consists of factors of 10 each to account for inter- and intra-species variation, and to expand from subchronic to chronic exposure, and a factor of 3 to account for deficiencies in the data base. Confidence in the verified chronic oral RfD is low. The pituitary and thyroid are the target organs for prolonged oral exposure to 1,3-dichlorobenzene.

A preliminary subchronic oral RfD can be estimated from the benchmark dose of 3 mg/kg-day estimated by EPA (2004c) from the 90-day gavage study in rats mentioned above. An uncertainty factor of 300 is applied to yield a subchronic oral RfD of 1E-2 mg/kg-day. The uncertainty factor of 300 reflects the chronic uncertainty factor of 3000 without the factor of 10 to expand from subchronic to chronic exposure.

The acute oral toxicity of 1,4-dichlorobenzene is considered to be medium, with oral LD_{50} values of 2950, 500 and 2830 mg/kg reported for mice, rats and rabbits, respectively (Montgomery, 1996). Prolonged oral exposure is associated with liver and kidney effects in laboratory animals. Earlier, EPA (1997a) derived a provisional RfD for chronic oral exposure of 3E-2 mg/kg-day from a NOAEL of 30 mg/kg-day in a two-generation reproduction study in rats. More recently, EPA (2004c) reevaluated the available data and determined that dogs may be more sensitive than rats. A benchmark dose for liver lesions of 0.237 mg/kg-day was estimated from a NOEL of 7 mg/kg-day and a LOAEL of 36 mg/kg-day from a study in which male and female beagle dogs were treated with 1,4-dichlorobenzene in gelatin capsules for 1 year. An uncertainty factor of 100 was applied to the benchmark dose to yield the newly verified chronic oral RfD of 2.4E-3 mg/kg-day. The uncertainty factor consisted of factors of 10 each for intra- and interspecies variation. Confidence in the verified oral RfD is medium. The liver is the target organ for prolonged oral exposure to 1,4-dichlorobenzene. The verified oral RfD is adopted as sufficiently protective for subchronic exposure as well.

Acute inhalation exposure of humans to high levels of 1,2-dichlorobenzene is associated with liver injury, secondary kidney injury, and CNS depression (ATSDR, 2004). Exposure to the levels generally encountered in occupational exposure is associated with irritation of the eyes and respiratory passages. Upper respiratory tract irritation was observed in a short-term inhalation study in mice. EPA (1997b) developed a provisional chronic inhalation RfC of 3E-2 mg/m^3 (8.6E-3 mg/kg-day) based on liver effects and body weight depression in a 2-generation inhalation study in rats. More recently, however, EPA (2004c) noted that the 2-generation study did not evaluate effects on the respiratory tract, which short-term and occupational studies suggest would be the likely target organ for inhalation exposure. EPA (2004c) concluded that the data were inadequate for development of an RfC for inhalation exposure to 1,2-dichlorobenzene. Therefore, the provisional RfC derived by EPA (1997b) is considered to be inappropriate and is not recommended for use in risk assessment.

Data regarding the effects of inhalation exposure of humans or laboratory animals to 1,3-dichlorobenzene are insufficient for development of an inhalation RfC (EPA, 1998b, 2004c).

EPA (2004b) previously verified an RfC of 8E-1 mg/m^3 (2.3E-1 mg/kg-day) for inhalation exposure to 1,4-dichlorobenzene based on increased liver weights in a multigeneration reproduction study in rats. More recently, EPA (2004c) reevaluated the data and determined that the effects on liver weights were not adverse because they were not accompanied by histopathological evidence of liver impairment or damage. Instead, EPA (2004c) determined that the most serious effect was reduced postnatal survival in the pups. A benchmark human equivalent concentration of 99.8 mg/m^3 was estimated for this effect. Application of an uncertainty factor of 100 yields a new verified inhalation RfC of 1 mg/m^3. The uncertainty factor consists of a factor of 10 to provide greater protection for unusually sensitive humans, and factors of 3 each to extrapolate from animals to humans and to account for deficiencies in the data base. Confidence in the RfC is medium. The RfC is equivalent

to an inhalation RfD of 2.9E-1 mg/kg-day. The neonate is considered the most sensitive "target organ" for inhalation exposure to 1,4-dichlorobenzene. The new verified chronic inhalation RfC is adopted as sufficiently protective for subchronic exposure as well.

6.0 Carcinogenicity Evaluation

Please see italicized note at the beginning of Section 5.0

EPA (2004b) classified 1,2-dichlorobenzene in EPA cancer weight-of-evidence Group D – not classifiable as to human carcinogenicity – based on no human data and evidence of both negative and positive trends for carcinogenic responses in rats and mice. EPA (2004c) reevaluated the data and essentially confirmed the Group D classification, judging that *the data are inadequate for an evaluation of human carcinogenic potential* under updated cancer assessment guidelines.

EPA (2004b) classified 1,3-dichlorobenzene in EPA cancer weight-of-evidence Group D – not classifiable as to human carcinogenicity – based on no human data, no animal data and limited data for genotoxicity. EPA (2004c) reevaluated the data and confirmed the Group D classification, judging that *the data are inadequate for an evaluation of human carcinogenic potential* under updated cancer assessment guidelines.

EPA (1996, 1997c) classified 1,4-dichlorobenzene as an EPA cancer weight-of-evidence Group C compound (possible human carcinogen), based on limited data in laboratory animals and no human data. The positive animal data consist of an association of 1,4-dichlorobenzene with kidney tumors in male rats and liver tumors in mice in a 2-year gavage study. A provisional oral SF of 2.4E-2 per mg/kg-day was based on the incidence of liver tumors in mice (EPA, 1997c). These data were also used to estimate a provisional inhalation SF (EPA, 1996). EPA (2004c) reevaluated the data in light of updated cancer assessment guidelines and determined that 1,4-dichlorobenzene is *likely to be carcinogenic to humans*. A new verified oral SF of 1.3E-2 per mg/kg-day was calculated from the incidence of liver tumors in the mice. The new verified oral SF differs from the previous provisional oral SF because of refinement in quantifying the dose-response relationship. EPA (2004c) judged that toxicokinetic differences between oral and inhalation exposure render oral dose-response data an inappropriate model for inhalation exposure. Therefore, the previously derived provisional inhalation SF is judged to be inappropriate and is not recommended for risk assessment.

7.0 Toxicity Summary

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure[a]		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
1,2-Dichlorobenzene										
1.4E-1	1.4E-1	L	ND	ND	NA	D	ND	D	ND	ND
1,3-Dichlorobenzene										
1E-2	1E-3	P, T	ND	ND	NA	D	ND	D	ND	ND
1,4-Dichlorobenzene										
2.4E-3	2.4E-3	L	1E+0/ 2.9E-1	1E+0/ 2.9E-1	Ne	C[b]	1.3E-2	C[b]	ND	ND

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo =

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure[a]		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data; NA = not applicable. Target organ or critical effect abbreviations: L = liver, P = pituitary, T = thyroid, Ne = neonate. [a]sRfDo, cRfDo and SFo should be used for dermal exposure without adjustment for GI absorption. [b]Likely to be carcinogenic to humans.										

8.0 Preliminary Remediation Goals

EPA Region IX has developed preliminary remediation goals (PRG) that are useful for screening chemical concentrations in environmental media (EPA, 2004d). The Region IX PRGs are based on standard default exposure assumptions, and are often adapted for the risk-based screening step for selecting chemicals of potential concern for human health risk assessments.

PRGs are available for nearly 600 chemicals for soil for residential use, for soil for industrial use, for ambient air, and for tap water (EPA, 2004d). Exposure routes addressed by PRGs for soil include incidental ingestion, dermal contact, and inhalation of volatiles or dust; exposure routes addressed by PRGs for tap water include drinking water ingestion and inhalation of volatiles. EPA (2004d) provides the methodology and standard exposure default assumptions with which to estimate PRGs for chemicals not included in the tables. Generally, PRGs are developed for both cancer risk and noncancer hazard, and the smaller of the two estimates is chosen. PRGs are currently available for the dichlorobenzenes; however, they are based largely on the outdated toxicity values described above. Therefore, new PRGs are developed for the dichlorobenzenes as follows:

Based on noncancer effects:

Chemical	Oral RfD (mg/kg-day)	Inhalation RfD (mg/kg-day)	VF_S (m^3/kg)	Preliminary Remediation Goal			
				Residential Soil (mg/kg)	Industrial Soil (mg/kg)	Ambient Air (µg/m^3)	Tap Water (µg/L)
1,2-Dichlorobenzene	1.4E-1	1.4E-1[a]	1.47E+4	2.5E+3	9.8E+3	5.1E+2	8.5E+2
1,3-Dichlorobenzene	1E-3	1E-3[a]	3.05E+4	3.0E+1	1.4E+2	3.7E+0	6.1E+0
1,4-Dichlorobenzene	2.4E-3	2.9E-1	1.30E+4	1.8E+2	2.2E+3	1.1E+3	8.4E+1
RfD = reference dose; VF_S = soil-to-air volatilization factor. [a]EPA (2004d) methodology adopts the oral RfD for inhalation exposure when a route-specific value is not available.							

The noncancer PRGs are based on an HI of 1.

Based on cancer risk:

Chemical	Oral SF (mg/kg-day)-1	Inhalation SF (mg/kg-day)-1	VF_S (m^3/kg)	Preliminary Remediation Goal			
				Residential Soil (mg/kg)	Industrial Soil (mg/kg)	Ambient Air (µg/m^3)	Tap Water (µg/L)
1,4-Dichlorobenzene	1.3E-2	1.3E-2[a]	1.30E+4	5.8E+0	1.3E+1	5.1E-1	8.5E-1
SF = cancer slope factor; VF_S = soil-to-air volatilization factor. [a]EPA (2004d) methodology adopts the oral SF for inhalation exposure when a route-specific value is not available.							

The cancer PRGs are based on a cancer risk of 1E-6.

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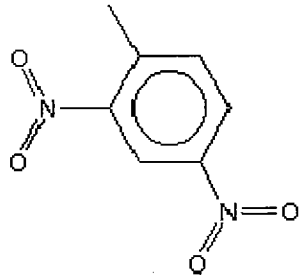
DINITROTOLUENE (DNT)



(2,4-Dinitrotoluene)

1.0 Introduction and Physical Properties

The dinitrotoluenes (DNT) are **SVOCs** that occur as yellow to orange to red needles or crystals at ambient temperatures (HSDB, 2004). They are used predominantly as intermediates in the production of polyurethanes, dyes, rubber, plastics, toluidines, toluenediisocyanates, flexible and rigid foams, surface coatings, and other organic chemicals (ATSDR, 1998; HSDB, 2004). The DNTs are also used as gelatinizing and waterproofing agents in the production of explosives. The DNTs may appear in environmental media as break down products of 2,4,6-trinitrotoluene (TNT). Isomers include 2,3-, 2,4-, 2,5-, 2,6-, 3,4- and 3,5-DNT. Analysis of technical grade DNT yielded the following results: 76.49 percent 2,4-DNT, 18.83 percent 2,6-DNT, 0.65 percent 2,5-DNT, 2.43 percent 3,4-DNT, 1.54 percent 2,3-DNT, 0.040 percent 3,5-DNT, 0.050 percent trinitrotoluene, 0.005 percent cresols, 0.003 percent mononitrobenzene, and 0.003 percent, 0.0005 percent, and 0.006 percent ortho-, meta-, and para-, mononitrotoluenes, respectively. The compounds of most interest in environmental exposure are limited to 2,4- and 2,6-DNT. Relevant physical properties are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
2,3-Dinitrotoluene (602-01-7)										
182.14[a]	2.2[a]	9.3E-8[a] (25°C)[b]	2.57[a]	5.91E-2[c] (25°C)[b]	6.85E-6[c] (25°C)[b]	5.26E-7[a] (25°C)	2.2E+2[d] (25°C)[b]	ND	ND	ND
2,4-Dinitrotoluene (121-14-2)										
182.1[e]	1.98[e]	9.27E-8[f] (25°C)	1.98[f]	2.03E-1[f] (25°C)	7.06E-6[f] (25°C)	1.93E-7[a] (22°C)	2.70E+2[f] (20-25°C)	590.0[g]	814.0[g]	1.35E+4[g]
2,5-Dinitrotoluene (619-15-8)										
182.14[a]	2.2[a]	9.3E-8[a] (25°C)[b]	2.56[a]	5.91E-2[c] (25°C)[b]	6.85E-6[c] (25°C)[b]	5.26E-7[a] (25°C)	2.2E+2[d] (25°C)[b]	ND	ND	ND
2,6-Dinitrotoluene (606-20-2)										
182.1[e]	1.72[e]	9.26E-8[a] (25°C)[b]	1.66[a]	5.91E-2[c] (25°C)[b]	6.85E-6[c] (25°C)[b]	7.46E-7[a] (25°C)	1.82E+2[h] (20-25°C)	558.0[g]	770.0[g]	1.29E+4[g]
3,4-Dinitrotoluene (610-39-9)										
182.14[e]	2.08[a]	9.3E-8[a] (25°C)[b]	2.56[a]	5.91E-2[c] (25°C)[b]	6.85E-6[c] (25°C)[b]	5.26E-7[a] (25°C)	1.00E+2[a] (25°C)	ND	ND	ND
3,5-Dinitrotoluene (618-85-9)										
182.14[e]	2.2[e]	9.3E-8[a] (25°C)[b]	2.56[a]	5.91E-2[c] (25°C)[b]	6.85E-6[c] (25°C)[b]	2.50E-6[e] (25°C)	ND	ND	ND	ND

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point (at 1 atm) of pure liquid compound (°K); T_c = critical temperature (°K); $H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole); ND = no data.

[a]Hazardous Substance Data Bank (HSDB), 2004, National Library of Medicine, on line, accessed 17 February.

[b]Assumed.

[c]Calculated as described in Introduction to Toxicity Profiles.

[d]Syracuse Research Corporation (SRC), 2004, ***CHEMFATE Data Base***, on line.

[e]U.S. Environmental Protection Agency (EPA), 2003, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim***, Office of Emergency and Remedial Response, EPA/540/R/99/005, OSWER 9285.7-02EP March.

[f]U.S. Environmental Protection Agency (EPA), 2001, ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites***, Peer Review

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$

Draft, Office of Solid Waste and Emergency Response, OSWER 9355.4-24, March.
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The physical properties of 2,4-DNT can be used for the DNT mixture (25321-14-6) because the 2,4-isomer predominates in the technical grade product.

2.0 Environmental Fate and Transport

The DNTs are released into the environment in waste streams from processes in which they are manufactured or used (ATSDR, 1998; HSDB, 2004). Also, they may form from degradation of TNT in gunpowder or explosives, particularly at TNT manufacturing or military sites. DNTs released to soil are expected to exhibit moderate mobility and may leach to groundwater. No information on biodegradation in soil was found; however, biodegradation may be an important fate process in soil based on the observation that all DNT isomers in surface water to which yeast extract was added were metabolized. DNTs are not expected to hydrolyze in soils.

DNTs released to water, may exhibit weak to moderate adsorption to sediment (ATSDR, 1998; HSDB, 2004). Evaporation from water is not expected to be an important removal process, based on the low Henry's Law constants for these compounds. Biodegradation may be an important fate process in water, as indicated above. DNTs in water may be susceptible to photolysis, based on the behavior of 2,4-DNT, which had photolytic half-lives ranging from 2.7 to 9.6 hours in natural water environments and 43 hours in distilled water.

DNTs released to the atmosphere are expected to exist solely in the vapor phase (HSDB, 2004). They may be susceptible to direct and indirect photolysis. The half-life for reaction with photochemically produced hydroxyl radicals is 84 days.

Bioconcentration of the DNTs is expected to be negligible (ATSDR, 1998; EPA, 1995; HSDB, 2004); therefore, biotransfer factors are not estimated.

3.0 Toxicokinetics

The rapid disappearance of radioactivity from the small intestine of rats following oral administration of radiolabeled 2,4- or 2,6-DNT suggests that absorption from the GI tract is rapid and essentially complete (ATSDR, 1998; EPA, 1992). Species differences in the excretion of the DNTs, however, confound quantification of the extent of GI absorption. Fecal excretion and the GI tract (tissue + contents) accounted for 9.2 to 17.3 percent of the dose of radioactivity 24 hours after oral administration of radiolabeled 2,4-DNT to rats, rabbits, dogs and monkeys (EPA, 1992). Fecal excretion and the GI tract accounted for 83.1 to 85 percent of an oral dose in mice in the same study. Biliary excretion appears to be more important in mice than in the other species tested. Together, the data for the 2,4-isomer suggest that the GI absorption of the DNTs is practically complete.

Body distribution of radioactivity was followed after administration of a ^{14}C-labeled oral dose of 2,4-DNT in male and female rats (ATSDR, 1998). Levels of radioactivity in the liver and kidneys exceeded levels in the plasma or erythrocytes by 5- to 10-fold; levels in other tissues were lower

than those in blood. The greater concentrations in the liver and kidneys probably represent metabolites rather than parent compound.

Metabolism of the DNTs involves both oxidative and reductive reactions as well as alkylation (ATSDR, 1998). Oxidative reactions occur primarily in the liver and involve stepwise enzymatic oxidation of the methyl group to the corresponding dinitrobenzyl alcohol, dinitrobenzylaldehyde and dinitrobenzoic acid. Dinitrobenzyl alcohol is subject to conjugation, particularly with gluconuric acid, before excretion via the urine or bile. Acetylation of one of the nitro groups of the dinitrobenzoic acid may also occur, yielding the corresponding (n-acetyl)amino nitrobenzoic acid, which is observed as a minor urinary metabolite.

Two types of reduction reactions involving metabolites excreted via the bile or GI tract are accomplished anaerobically by intestinal microflora (ATSDR, 1998). The first reaction involves lysis of the glucuronide conjugate described above to release the corresponding benzyl alcohol. The second reaction involves nitroreduction, resulting in transforming one or both of the nitro groups to amine groups, probably through nitroso and hydroxylamino intermediates. The amino and hydroxylamino benzyl alcohols are reabsorbed, completing the enterohepatic cycle.

The amine group on the reabsorbed benzyl alcohol is subject to partial oxidation in the liver to yield the corresponding hydroxylamino compound, potentially providing a second pathway for formation of these compounds (ATSDR, 1998). The hydroxylamino compounds may conjugate with sulfate, forming an unstable product that decomposes to yield carbonium or nitrenium ions that bond covalently with hepatic macromolecules, giving rise to the first stages of hepatic carcinogenesis. From the foregoing, it appears that microbial transformation and hepatic recirculation are involved in the carcinogenicity observed in laboratory rodents (Section 6.0).

4.0 Dermal Exposure

EPA (2003) notes that organic chemicals are generally well absorbed from the GI tract, and recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly less than complete. Therefore, no GAF is developed for the DNTs and the oral toxicity values described below should be used for dermal exposure without adjustment for GI absorption.

Urinary excretion data obtained from workers exposed to the DNTs indicates that dermal absorption occurs (ATSDR, 1998) but multiple exposure routes were involved and the extent of dermal uptake cannot be quantified. Empirical data regarding dermal uptake from soil were not located. Lacking empirical data, the EPA (2003) default ABS of 0.1 for SVOCs is adopted for the DNTs for this evaluation. t*, K_p, τ, FA and B values are provided by EPA (2003) or estimated by the EPA (2003) methods as follows:

Chemical	t*	K_p	τ	FA	B
2,3-Dinitrotoluene[a]	2.64	4.29E-3	1.10	1	0.0
2,4-Dinitrotoluene[b]	2.69	3.1E-3	1.12	1	0.0
2,5-Dinitrotoluene[a]	2.64	4.29E-3	1.10	1	0.0
2,6-Dinitrotoluene[b]	2.69	2.1E-3	1.12	1	0.0
3,4-Dinitrotoluene[a]	2.64	3.57E-3	1.10	1	0.0
3,5-Dinitrotoluene[a]	2.64	4.84E-3	1.10	1	0.0
t* = time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); □ = lag time					

Chemical	t*	K_p	τ	FA	B
for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless). [a]Estimated as described in Introduction to Toxicity Profiles. [b]U.S. Environmental Protection Agency (EPA), 2003, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim***, Office of Emergency and Remedial Response, EPA/540/R/99/005, OSWER 9285.7-02EP March.					

The estimated values for K_p for all the DNTs fell within the effective prediction domain.

5.0 Noncancer Effects Evaluation

Data regarding the toxicity of oral exposure to 2,3-DNT are limited to the statement that the 2,4-, 2,6- and 3,4-isomers are more toxic to rats than the 2,3- or 2,5-isomers (HSDB, 2004).

Acute oral exposure to 2,4-DNT induces methemoglobinemia; dogs appear to be more sensitive than rats, which are more sensitive than mice (ATSDR, 1998). Oral LD_{50} values include 270 mg/kg for rats, 1630 mg/kg for mice and 1300 mg/kg for guinea pigs (ATSDR, 1998; HSDB, 2004), establishing the rat as the species most sensitive to acute oral exposure. Subchronic or chronic oral exposure to 2,4-DNT in rats is associated with depressed weight gain, reticulocytosis and splenic hemosiderosis, and decreased spermatogenesis (HSDB, 2004). Some rats had widespread and stiff-legged gaits and demyelination in the cerebellum and brain stem. A verified chronic oral RfD of 2E-3 mg/kg-day for 2,4-DNT is based on neurotoxicity, hematologic effects and biliary tract hyperplasia in dogs given capsules containing the test substance for 2 years (EPA, 2004). Progressive paralysis, accompanied by degenerative lesions in the central nervous system, were observed in dogs treated with 10 mg/kg-day. Hematologic effects, including methemoglobinemia and its sequelae, were observed in dogs treated with 1.5 mg/kg-day, which is the LOAEL for this study. No adverse effects were observed in dogs treated with 0.2 mg/kg-day. Application of an uncertainty factor of 100 to the NOAEL of 0.2 mg/kg-day yields an RfD of 2E-3 mg/kg-day. Confidence in the RfD is high. The CNS, erythrocyte and liver appear to be the target organs for prolonged oral exposure, at least in dogs. EPA, 1997 adopted the verified chronic oral RfD as the preliminary RfD for subchronic oral exposure.

HSDB (2004) reports oral LD_{50} values for 2,5-DNT of 707 mg/kg for rats and 1231 mg/kg for mice. Data regarding the effects of prolonged oral exposure were not reported.

Oral LD_{50} values for 2,6-DNT for rats (177 to 665 mg/kg) are similar to those for mice (621 to 714 mg/kg) (ATSDR, 1998; HSDB, 2004). Dogs, however, appear to be more sensitive than rodents in subchronic studies. A provisional chronic oral RfD of 1E-3 mg/kg-day for 2,6-DNT is based on a 13-week dietary study with 2,6-DNT in dogs (EPA, 1997). The NOAEL in this study was 4 mg/kg-day, somewhat higher than the LOAEL for 2,4-DNT. An uncertainty factor of 3000 was applied. The CNS, erythrocyte, liver and kidney appear to be the target organs for prolonged oral exposure to 2,6-DNT. The oral data in dogs suggest that the 2,6-isomer is somewhat less toxic than the 2,4-isomer for prolonged oral exposure. The oral RfD for the 2,6-isomer, however, is less than the oral RfD for the 2,4-isomer. This apparent contradiction is an artifact of the lesser quality data base for 2,6-DNT and, consequently, the higher uncertainty factor used to derive the RfD for the 2,6-isomer. EPA (1997) derived a provisional subchronic oral RfD of 1E-2 mg/kg-day by applying an uncertainty factor of 300 to the NOAEL of 4 mg/kg-day in the 13-week dog study.

The verified chronic oral RfD of 2E-3 mg/kg-day and the provisional subchronic oral RfD of 2E-3 mg/kg-day for 2,4-DNT can be used for DNT mixtures and the other DNT isomers for which oral exposure data sufficient for RfD derivation are not available. The RfD for 2,4-DNT is chosen over the RfD for the 2,6-isomer because the 2,4-isomer predominates in the technical product and because the RfD for the 2,4-isomer is compromised by much less uncertainty.

Occupational studies indicate that acute exposure to the DNTs produces methemoglobinemia, which causes headache, irritability, dizziness, weakness, nausea, vomiting, dyspnea, drowsiness, unconsciousness and, in extreme cases, death (ACGIH, 1991). Occupational exposure may lead to increased risk of ischemic heart disease, possibly arising from decreased oxygen-carrying capacity of the blood. The data are insufficient to develop inhalation RfCs for the DNT isomers.

6.0 Carcinogenicity Evaluation

Carcinogenicity data for the DNTs are somewhat confusing. Treatment of rats and mice with purified 2,4-DNT generally yields no increased incidence of neoplasia, but treatment with technical grade DNT, 2,4-DNT containing as little as 2 percent 2,6-DNT, or with 2,6-DNT itself generally yields a positive neoplastic response (EPA, 2004). Initiation/promotion tests suggest that 2,6-DNT may be a complete carcinogen and 2,4-DNT may be a promoter.

EPA (2004) classified the 2,4-/2,6-DNT mixture in EPA cancer weight-of-evidence Group B2 (probable human carcinogen) on the basis of multiple tumor types in male and female rats and renal tumors in male mice in several dietary studies. Occupational data provide no evidence of carcinogenicity in humans, but the studies reviewed lack the power to reveal small differences in cancer risk (ACGIH, 1991). EPA (2004) verified an oral SF of 6.8E-1 per mg/kg-day for exposure to the 2,4-/2,6-DNT mixture based on an increased incidence of a variety of tumors in female rats. The test material contained approximately 98 percent 2,4-DNT and 2 percent 2,6-DNT. The B2 classification and the oral SF of 6.8E-1 per mg/kg-day are used in this evaluation for 2,6-DNT and the 2,4-/2,6-DNT mixture. Given the uncertainty about to potential carcinogenicity of the 2,4-isomer alone, and the likelihood that small amounts of the 2,6-isomer may be present, it is deemed prudent to apply the B2 classification and the oral SF of 6.8E-1 per mg/kg-day to the 2,4-isomer as well. The data are insufficient for development of potency factors for inhalation exposure. Data regarding the carcinogenicity of the other DNT isomers were not located.

7.0 Toxicity Summary

Toxicity values for the DNTs are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure[a, b]		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
2,4-Dinitrotoluene										
2E-3	2E-3	E, CNS, L	ND	ND	NA	B2	6.8E-1	ND	ND	ND
2,6-Dinitrotoluene										
1E-2	1E-3	E, CNS, L, K	ND	ND	NA	B2	6.8E-1	ND	ND	ND
sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose										

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure[a, b]		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
(milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data; NA = not applicable. Target organ abbreviations: E = erythrocyte; CNS = central nervous system; L = liver; K = kidney. [a]sRfDo, cRfDo and SFo should be used for dermal exposure without adjustment for GI absorption. [b]The cancer evaluation for the 2,4-/2,6-DNT mixture is applied to any DNT mixture containing 2,4- and 2,6-DNT (e.g., the technical grade material) as well as the individual 2,4- and 2,6-isomers.										

The oral RfD values for 2,4-DNT should be applied to the technical grade material, any 2,4-/2,6 mixture, and any isomers other than pure 2,6-DNT. The cancer weight-of-evidence group and the verified oral SF for the 2,4-/2,6-DNT mixture should not be applied to isomers other than 2,4- and 2,6-DNT because the potential for the other isomers to cause cancer has not been evaluated.

9.0 References

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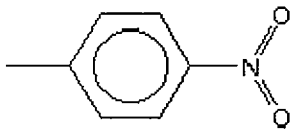
NITROTOLUENES



p-Nitrotoluene

1.0 Introduction and Physical Properties

The nitrotoluenes consist of three isomers: 2-nitrotoluene (o-nitrotoluene, 1-methyl-2-nitrobenzene), 3-nitrotoluene (m-nitrotoluene, 1-methyl-3-nitrobenzene) and 4-nitrotoluene (p-nitrotoluene, 1-methyl-4-nitrobenzene) (Lewis, 1997). 2-Nitrotoluene occurs as a yellowish liquid at ambient temperatures below 25 °F, and 3-nitrotoluene occurs as a yellowish liquid at ambient temperatures below 59 °F (HSDB, 2004). 4-Nitrotoluene occurs as colorless rhombic needles to yellowish crystals at ambient temperatures. All behave in the environment as **VOCs**. The nitrotoluenes, especially the 2- and 4-isomers, are used as intermediates in the synthesis of other organic chemicals, particularly toluidine, tolidine, fuchsine and other synthetic dyes, explosives, petrochemicals, pesticides, pharmaceuticals, rubber and agricultural chemicals, dyes and pigments (HSDB, 2004). Relevant physical properties are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
2-Nitrotoluene (88-72-2)										
137.13[a]	2.30[x]	5.6E-5[a] (25°C)	2.44[a]	7.14E-2[b] (25°C)[c]	8.27E-6[b] (25°C)[c]	1.32E-4[a] (20°C)	6.52E+2[a] (30°C)	495.2[a]	720[d]	1.22E+4[a]
3-Nitrotoluene (99-08-1)										
137.15[a]	2.45[a]	7.5E-5[a] (25-30°C)	2.16[a]	7.14E-2[b] (25°C)[c]	8.27E-6[b] (25°C)[c]	2.72E-4[a] (25°C)	4.98E+2[a] (30°C)	505.1[a]	734[d]	1.18E+4[a]
4-Nitrotoluene (99-99-0)										
137.14[a]	2.37[x]	5E-5[a] (25°C)	2.49[a]	7.14E-2[b] (25°C)[c]	8.27E-6[b] (25°C)[c]	1.32E-4[a] (20°C)	4.42E+2[a] (30°C)	511.5[a]	743[d]	1.19E+4[a]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point (at 1 atm) of pure liquid compound (°K); T_c = critical temperature (°K); $H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole).
[a]Hazardous Substance Data Bank (HSDB), 2004, National Library of Medicine, on line, accessed 17 December.
[b]Calculated as described in Introduction to the Toxicity Profiles.
[c]Assumed.
[d]Calculated as described by Lyman, W.J., W.F. Reehl and D.H. Rosenblatt, 1990, ***Handbook of Chemical Property Estimation Methods***, American Chemical Society, Washington, DC.

2.0 Environmental Fate and Transport

The major sources of release of nitrotoluenes to the environment appear to be facilities and plants that produce these compounds as by-products (HSDB, 2004). Nitrotoluenes may also enter the environment from the disposal of waste products which contain these compounds, and they may form from degradation of higher explosives.

Nitrotoluenes released to soil are expected to be resistant to oxidation and chemical hydrolysis (HSDB, 2004). The nitrotoluenes are reported to biodegrade under anaerobic conditions to form toluidines (nitroreduction products); one study under aerobic conditions in a mixed culture of soil microorganisms resulted in persistence exceeding 64 days. The nitrotoluenes are expected to be moderately to highly mobile in soil and volatilize slowly from dry soil surfaces.

Nitrotoluenes released to water are expected to be susceptible to photolysis, volatilization and aerobic biodegradation, provided suitable acclimation has been achieved (HSDB, 2004). Oxidation, chemical hydrolysis, adsorption to suspended solids and sediments and bioaccumulation in aquatic organisms are not expected to be significant removal processes. Insufficient data were available to indicate the significance of anaerobic biodegradation as a removal mechanism.

Nitrotoluenes released to the atmosphere are expected to exist entirely in the vapor phase (HSDB, 2004). The dominant removal mechanism is expected to be reaction with photochemically generated hydroxyl radicals (estimated half-life 8 hours) and direct photolysis. Photoproducts include 2-methyl-6-nitrophenol and 2-methyl-4-nitrophenol (from 2-nitrotoluene), 3-methyl-4-nitrophenol, 3-methyl-2-nitrophenol and 3-methyl-6-nitrophenol (from 3-nitrotoluene) and 2-methyl-6-nitrophenol (from 4-nitrotoluene).

The nitrotoluenes are not expected to bioconcentrate or bioaccumulate significantly (HSDB, 2004); therefore, biotransfer factors are not estimated.

3.0 Toxicokinetics

Excretion data indicate that the nitrotoluenes are rapidly and extensively absorbed from the GI tract (EPA, 2002a, b, c). Fecal excretion of radioactivity in rats treated with radiolabeled 2-, 3- or 4-nitrotoluene did not exceed 4, 12, or 7 percent of the administered dose, respectively. Biliary excretion has been shown to be important for the nitrotoluenes, so that GI uptake is probably greater than indicated by the fecal excretion data. The nitrotoluenes are also absorbed from the respiratory tract and through intact skin, although quantitative data were not available (HSDB, 2004).

Data regarding tissue distribution following absorption were not located. Metabolites identified in the urine of the rats discussed above include the corresponding 2-, 3- or 4-nitrobenzoic alcohol or nitrobenzoic acid derivatives of 2-, 3- and 4-nitrotoluene, respectively, indicating oxidation of the methyl group as an initial step in biotransformation of the nitrotoluenes (EPA, 2002a, b, c). The nitrobenzoic acid derivatives were excreted unchanged or as glucuronide, sulfate, cysteine or hippuric acid conjugates, depending on the nitrotoluene isomer given.

Excretion of radioactivity after oral administration of radiolabeled compound occurs rapidly primarily through the urine, but biliary excretion is significant, particularly for male rats, and pulmonary excretion accounts for small amounts (EPA, 2002a, b, c). Biliary excretion is followed by microbial nitroreduction followed by re-absorption of products that bind to hepatic macromolecules.

4.0 Dermal Exposure

EPA (2004) notes that organic chemicals are generally well absorbed from the GI tract, and recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly less than complete. As noted in Section 3.0, GI absorption is extensive. Therefore, no GAF is developed for the nitrotoluenes and the oral toxicity values described below should be used for dermal exposure without adjustment for GI absorption.

VOCs tend to volatilize from soil when applied to the skin, reducing dermal uptake to toxicologically insignificant levels (EPA, 2004). Therefore, dermal uptake of the nitrotoluenes from

soil is not evaluated. t*, K_p, τ, FA and B values are estimated as described by EPA (2004) as follows:

Chemical	t*	K_p	τ	FA	B
2-Nitrotoluene	1.48	8.91E-3	0.62	1	0[a]
3-Nitrotoluene	1.48	1.12E-2	0.62	1	0.1
4-Nitrotoluene	1.48	9.91E-3	0.62	1	0[a]

t* = time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); □ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).
[a]Sufficiently small to be rounded to zero.

5.0 Noncancer Effects Evaluation

Data regarding the acute toxicity of oral exposure to the nitrotoluenes were not located. Separate 13-week dietary studies with each of the three nitrotoluene isomers in rats and mice indicated that effects were most notable with 2-nitrotoluene (ACGIH, 1991). Effects included biochemical evidence of altered liver function, and splenic and renal lesions, probably secondary to hemolytic anemia associated with transformation of hemoglobin to methemoglobin by 2-nitrotoluene. EPA (1997) derived a provisional RfD of 1E-2 mg/kg-day for chronic oral exposure to all three nitrotoluene isomers from data for 2-nitrotoluene. In the key study, rats were treated by gavage for 6 months. The LOAEL was 200 mg/kg-day administered on 5 days per week (exposure-adjusted to 143 mg/kg-day) associated with lesions in the spleen. An uncertainty factor of 10,000 was applied to the LOAEL. The spleen was selected by EPA (1997) as the target organ for chronic oral exposure to 2-nitrotoluenes. EPA (1997) also developed a provisional subchronic oral RfD for 2-nitrotoluene of 1E-1 mg/kg-day by applying an uncertainty factor of 1000 to the LOAEL of 143 mg/kg-day.

More recently EPA (2002a) derived a provisional subchronic oral RfD for 2-nitrotoluene of 4E-2 mg/kg-day from a LOAEL of 44 mg/kg-day (lowest dose tested) in a more comprehensive dietary study in rats. In this study, groups of male and female rats were fed diets containing 2-nitrotoluene at concentrations of 0 (control), 625, 1250, 2500, 5000 or 10,000 ppm for 13 weeks. The LOAEL was associated with increased methemoglobin levels in female rats after only 3 weeks of treatment. More severe signs of anemia as well as liver pathology were observed in rats at higher dose levels. EPA (2002a) applied an uncertainty factor of 1000 to the LOAEL to derive the subchronic oral RfD of 4E-2 mg/kg-day. Confidence in the subchronic oral RfD is medium.

The provisional chronic oral RfD for 2-nitrotoluene of 1E-2 mg/kg-day developed by EPA (1997), and the provisional subchronic oral RfD of 4E-2 mg/kg-day developed by EPA (2002a) are adopted for this evaluation.

As noted above, the pathogenesis of 2-nitrotoluene appears to begin with the conversion of hemoglobin to methemoglobin in the erythrocyte, followed by hemolytic anemia, increased hematopoiesis, and, in severe cases, splenic, liver and kidney lesions. Since the erythrocyte clearly appears to be the most sensitive tissue and is probably involved in the signs and lesions observed at higher doses, the erythrocyte is selected as the sole target organ or prolonged oral exposure to 2-nitrotoluene.

EPA (1997) applied to 3-nitrotoluene the provisional chronic oral RfD of 1E-2 mg/kg-day developed from the 6-month gavage study of 2-nitrotoluene in rats. More recently EPA (2002b) derived a

provisional chronic oral RfD for 3-nitrotoluene of 2E-2 mg/kg-day from a LOAEL of 46 mg/kg-day (lowest dose tested) in a more comprehensive dietary study in rats. In this study, groups of male and female rats were fed diets containing 3-nitrotoluene at concentrations of 0 (control), 625, 1250, 2500, 5000 or 10,000 ppm for 13 weeks. Some of the treated feed batches at the nominal 625 ppm level inadvertently had been formulated to contain 675 ppm, yielding a dose rate of 46 to 48 mg/kg-day. The LOAEL was associated with decreased hematocrit, erythrocyte count and blood hemoglobin levels in male rats after 3 weeks but not after 13 weeks, and hemosiderin deposits in the spleens of the females at termination. The hematologic effects appeared to be transient, indicating the ability of the male rats to compensate. Application of an uncertainty factor of 3000 to the LOAEL of 46 mg/kg-day yielded the provisional chronic oral RfD of 2E-2 mg/kg-day. The uncertainty factor consisted of factors of 3 each to expand from subchronic to chronic exposure, to estimate a NOAEL from a mild LOAEL, and to account for deficiencies in the data base concerning reproductive and developmental effects, and factors of 10 each to extrapolate from animals to humans, and to provide additional protection for unusually sensitive individuals. Confidence in the provisional oral RfD is medium.

EPA (1997) applied to 3-nitrotoluene the provisional subchronic oral RfD of 1E-1 mg/kg-day developed from the 6-month gavage study of 2-nitrotoluene in rats. It appears, however, that a more defensible subchronic oral RfD can be developed from the 13-week dietary study that served as the basis of the provisional chronic oral RfD developed by EPA (2002b). Dividing the LOAEL of 46 mg/kg-day by an uncertainty factor of 1000 yields a preliminary subchronic oral RfD of 5E-2 mg/kg-day. The uncertainty factor of 1000 reflects the uncertainty factor of 3000 without the factor of 3 to expand from subchronic to chronic exposure.

The more recent provisional chronic oral RfD of 2E-2 mg/kg-day developed by EPA (2002b) from the 13-week dietary study is selected for this evaluation over the earlier provisional chronic oral RfD developed by EPA (1997). The preliminary subchronic oral RfD of 5E-2 mg/kg-day developed in the previous paragraph is selected for this evaluation.

The pathogenesis of 3-nitrotoluene appears to be very similar to that of 2-nitrotoluene, starting with degenerative effects on the erythrocyte. Therefore, the erythrocyte is adopted as the sole target organ for prolonged oral exposure to 3-nitrotoluene.

EPA (1997) applied to 4-nitrotoluene the provisional chronic oral RfD of 1E-2 mg/kg-day and the provisional subchronic oral RfD of 1E-1 mg/kg-day developed from the 6-month gavage study of 2-nitrotoluene in rats. More recently EPA (2002c) derived a provisional subchronic oral RfD for 4-nitrotoluene of 1E-2 mg/kg-day from a LOAEL of 42 mg/kg-day (lowest dose tested) in a more comprehensive dietary study in rats. In this study, groups of male and female rats were fed diets containing 4-nitrotoluene at concentrations of 0 (control), 625, 1250, 2500, 5000 or 10,000 ppm for 13 weeks. The LOAEL was associated with evidence of erythrocyte destruction – reduced erythrocyte count, blood hemoglobin concentration and hematocrit in females, and congestion and increased hematopoiesis and hemosiderin deposits in the males. More severe signs of anemia as well as kidney and liver pathology were observed in rats at higher dose levels. EPA (2002c) applied an uncertainty factor of 3000 to the LOAEL to derive the provisional subchronic oral RfD for 4-nitrotoluene of 1E-2 mg/kg-day.

EPA (2002c) also adopted the provisional subchronic oral RfD of 1E-2 mg/kg-day as sufficiently protective for chronic exposure to 4-nitrotoluene. Confidence in the provisional subchronic/chronic oral RfD is low. The erythrocyte is selected as the target organ for prolonged oral exposure to 4-nitrotoluene as described above for 2- and 3-nitrotoluene.

The data are inadequate for development of inhalation RfCs for the nitrotoluenes (EPA, 2002a, c, d).

6.0 Carcinogenicity Evaluation

Various *in vitro* and *in vivo* tests show that 2-nitrotoluene is not genotoxic to bacteria, but is genotoxic to mammalian cells following activation (EPA, 2002a). Studies in intact and bile-duct cannulated rats showed that intestinal microfloral reduction of hepatic metabolites is required for binding to various macromolecules including DNA. A wide variety of tumors, many of mesothelial origin, were observed in rats in the subchronic dietary study (as well as other studies) discussed in Section 5.0. Clear evidence of carcinogenicity in rats and mice was observed in a chronic (2-year) dietary study. EPA (2002a) classified 2-nitrotoluene in cancer weight-of-evidence Group B2 – probable human carcinogen, concluding that the compound is *likely to be carcinogenic to humans* – based on no data in humans and sufficient evidence of carcinogenicity in animals. Potency factors were estimated for the most prevalent tumor types observed in rats and mice in the 2-year dietary study. An oral SF of 2.3E-1 per mg/kg-day based on the increased incidence of skin fibromas and fibrosarcomas in male rats was selected as the provisional oral SF for 2-nitrotoluene. Data are insufficient for estimation of an inhalation URF for 2-nitrotoluene.

Data regarding the carcinogenicity of 3-nitrotoluene were not located in the available literature (EPA, 2002e). Enterohepatic recirculation results in the production of metabolites that bind to some cellular macromolecules but apparently not to DNA (EPA, 2002b), reducing concern for a carcinogenic role for 3-nitrotoluene. EPA (2002e) classified 3-nitrotoluene in cancer weight-of-evidence Group D (not classifiable as to carcinogenicity to humans), or *data are inadequate for assessment of human carcinogenic potential* based on the lack of data. Potency factors are not developed for Group D chemicals.

EPA (2002c) classified 4-nitrotoluene in cancer weight-of-evidence Group C – possible human carcinogen, concluding that there is *suggestive evidence of carcinogenicity to humans* – based on no data in humans and limited evidence of carcinogenicity in animals. The animal data consist of a 2-year dietary study with 4-nitrotoluene that yielded equivocal evidence for variety of tumor types in male and female rats and male mice. Studies in intact and bile-duct cannulated rats showed that intestinal microfloral reduction of hepatic metabolites is required for binding to various macromolecules (proteins and RNA). Binding to DNA has not been observed. Potency factors were estimated for the most prevalent tumor types observed in male and female rats and male mice in the 2-year dietary study. An oral SF of 1.7E-2 per mg/kg-day based on the increased incidence of clitoral tumors in female rats was selected as the provisional oral SF for 4-nitrotoluene. Data are insufficient for estimation of an inhalation URF for 4-nitrotoluene.

7.0 Toxicity Summary

Toxicity values for the nitrotoluenes are summarized as follows:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure[a]		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
2-Nitrotoluene										
4E-2	1E-2	E	ND	ND	NA	B2[b]	2.3E-1	B2[b]	ND	ND
3-Nitrotoluene										
5E-2	2E-2	E	ND	ND	NA	D[c]	ND	D[c]	ND	ND
4-Nitrotoluene										
1E-2	1E-2	E	ND	ND	NA	C[d]	1.7E-2	C[d]	ND	ND

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data; NA = not applicable.

Target organ abbreviations: E=erythrocyte; NA = not applicable

[a]sRfDo, cRfDo and SFo should be used for dermal exposure without adjustment for GI absorption.

[b]*Likely to be carcinogenic to humans.*

[c]*Data are inadequate for assessment of human carcinogenic potential.*

[d]*Suggestive evidence of carcinogenicity to humans.*

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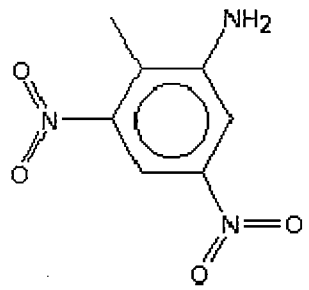
AMINODINITROTOLUENES (ADNT) and DIAMINONITROTOLUENES (DANT)



2-Amino-4-6-dinitrotoluene

1.0 Introduction and Physical Properties

The ADNTs, 2-amino-4,6-dinitrotoluene (2-ADNT) (35572-78-2) and 4-amino-2,6-dinitrotoluene (4-ADNT) (19406-51-0) are **SVOCs** that are present in environmental media presumably as microbial reduction products of 2,4,6-trinitrotoluene (TNT) (ATSDR, 1995; HSDB, 2005). Based on the melting point for 2-amino-4,6-dinitrotoluene of 129.14 °C (RAIS, 2005), it is assumed that the ADNTs occur as solids at ambient temperatures in the pure state. Relevant physical properties are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
2-Amino-4,6-Dinitrotoluene										
197.15[a]	1.84[a]	1.61E-10[a] (25°C)[b]	2.00[a]	5.61E-2[c] (25°C)[b]	6.49E-6[c] (25°C)[b]	1.41E-8[a] (25°C)[b]	1.22E+3[a] (25°C)[b]	625.2[a]	ND	ND

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point of pure liquid compound (°K); T_c = critical temperature (°K);.$H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole); ND = no data.
[a]Risk Assessment Information System (RAIS), 2005, "Chemical-Specific Factors," Oak Ridge National Laboratory, on line, accessed 6 December.
[b]Assumed.
[c]Calculated as described in Introduction to Toxicity Profiles.

The physical properties presented above for 2-ADNT should be applied also to 4-ADNT, for which chemical-specific data were not located.

Physical properties were not located for the DANTs, 2,4-diamino-6-nitrotoluene (2,4-DANT) (6629-29-4) and 2,6-diamino-4-nitrotoluene (2,6-DANT) (59229-75-3). However, some properties can be estimated, as follows:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
2,4-Diamino-6-nitrotoluene										
167.17[a]	0.55[b]	2.77E-10[b] (25°C)[c]	2.15[b]	6.26E-2[d] (25°C)[c]	7.25E-6[d] (25°C)[c]	3.55E-8[b] (25°C)	1.27E+3[b,e] (25°C)[c]	ND	ND	ND

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point of pure liquid compound (°K); T_c = critical temperature (°K);.$H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole); ND = no data.
[a]Estimated from molecular formula and periodic table.
[b]Estimated with the U.S. Environmental Protection Agency (EPA), 2004, ***EPI Suite Version 3.12*** Software for estimating physical properties, 30 November.
[c]Assumed.
[d]Calculated as described in Introduction to Toxicity Profiles.
[e]Based on molecular fragments method.

The physical properties presented above for 2-DANT should be applied also to 4-DANT. The value for H classifies the DANTs as SVOCs. The estimated melting point for 2-DANT of at least 121.14 °C suggests that these compounds would occur as solids at ambient temperatures in the pure state.

2.0 Environmental Fate and Transport

The ADNTs may be released to the environment as degradation products of TNT or similar compounds (HSDB, 2005). ATSDR (1995) shows the DANTs as mammalian metabolic nitroreduction products of the ADNTs, which are nitroreduction products of TNT metabolism. The DANTs have been identified as major metabolites in the urine of rats treated with a single oral dose of TNT. Environmental degradation and mammalian biotransformation of organic compounds frequently parallel; therefore, it is expected that DANTs occur in the environment as nitroreduction products of TNT and the ADNTs.

Data regarding the environmental fate of the ADNTs and the DANTs were not located in the available literature. It is assumed, however, that the ADNTs and DANTs may behave similarly to TNT because of the structural similarity of these compounds. Under this assumption, the ADNTs and DANTs are likely to persist in soil; hydrolysis and volatilization are unlikely to be significant (HSDB, 2005). They are likely to occur almost entirely in the vapor phase in the atmosphere, and may be subject to direct photolysis and photochemical degradation.

The capability of microorganisms to biotransform TNT under anaerobic conditions in soil and water is well established; however, reduction rates under aerobic conditions are very slow (HSDB, 2005). It is unclear the extent to which the ADNTs or DANTs may be subject to further microbial reduction. Photolysis, which is the most important removal process for TNT in surface water, may also be significant for the ADNTs and DANTs. Hydrolysis and volatilization are not significant for TNT and also are not expected to be significant for the ADNTs or DANTs. The extent of adsorption to suspended or benthic sediment is expected to be moderate.

Generally TNT is not expected to bioconcentrate in aquatic systems or to participate significantly in food chain pathways under normal environmental conditions (ATSDR, 1995; HSDB, 2003). It is assumed that the ADNTs and DANTs will not bioconcentrate significantly and biotransfer factors are not estimated. This is supported by the observation that metabolites of TNT, including the ADNTs and DANTs, are rapidly cleared from the body, primarily through the urine and also through the feces (ATSDR, 1995).

3.0 Toxicokinetics

EPA (2003) states that 2- and 4-ADNT appear to be well absorbed and rapidly excreted in the urine and bile of mammals. This is consistent with TNT, for which the data indicate that a minimum of 60 to 75 percent of a single oral dose is absorbed from the GI tract (ATSDR, 1995). Studies with bile-duct-cannulated rats, however, suggest that biliary excretion is significant, and that enterohepatic recirculation may have resulted in artificially low estimates of GI absorption in the TNT studies. It is assumed that the ADNTs and DANTs (as well as TNT) are readily and extensively absorbed from the GI tract.

ATSDR (1995) identifies 2-ADNT and 4-ADNT as metabolites of TNT in mammals. The ADNTs are subject to further nitroreduction to form the DANTs, oxidation of the methyl group to form the corresponding benzyl alcohol or benzoic acid derivatives, and oxidation of the aromatic ring to for the corresponding amino-dinitrocresols. Metabolites are rapidly excreted; however, marked differences in the color or urine from different species suggests that the metabolites produced, or at least their relative proportions, are species dependent.

4.0 Dermal Exposure

EPA (2004a) notes that organic chemicals are generally well absorbed from the GI tract, and recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly less than complete. Therefore, no GAF is developed for the ADNTs and the DANTs, and the oral toxicity values described below should be used for dermal exposure without adjustment for GI absorption.

Data regarding the extent of dermal uptake of the ADNTs or DANTs from soil were not located. Therefore, the EPA (2004a) default ABS of 0.1 for SVOCs is used in this evaluation. From the MW and log K_{ow} values given above and the EPA (2004a) method, t*, K_p, τ, FA and B values are estimated as follows:

Chemical	t*	K_p	τ	FA	B
Aminodinitrotoluenes	3.20	2.04E-3	1.33	1[a]	0[b]
Diaminonitrotoluenes	2.18	4.23E-4	0.91	1[a]	0[b]

t* = Time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); □ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).
[a]Assumed.
[b]Sufficiently small to be rounded to zero.

5.0 Noncancer Effects Evaluation

Data regarding the acute toxicity of oral exposure to the ADNTs are limited to LD_{50} values as summarized below (EPA, 2003):

Oral LD50 Values in Rats (mg/kg)		
Chemical	Males	Females
TNT	1010	820
2-ADNT	2240	1394
4-ADNT	1360	959
Oral LD50 Values in Mice (mg/kg)		
TNT	1009	1014
2-ADNT	1522	1722
4-ADNT	1342	1495

The data suggest that the acute toxicity of the ADNTs is not greater than TNT. Acute toxicity data for the DANTs were not located.

Data were not located regarding the chronic oral toxicity of the ADNTs. EPA (2003) evaluated the toxicity of TNT, 2,4-dinitrotoluene and 2,6-dinitrotoluene in the context of the ADNTs, and concluded, based on structural similarities alone, that TNT is the most appropriate surrogate for the ADNTs. Further justification for this approach is the observation that the ADNTs are known metabolites of TNT in mammalian systems. A verified oral RfD for TNT of 5E-4 mg/kg-day is based on a LOAEL for liver effects of 0.5 mg/kg-day in a 26-week feeding study in dogs (EPA, 2005a). An uncertainty factor of 1000 (for laboratory animal-to-man dose extrapolation, interindividual sensitivity, subchronic-to-chronic extrapolation, and LOAEL-to-NOAEL extrapolation) was applied to the LOAEL to derive the oral RfD. Data reviewed by ATSDR (1995) clearly identify the erythrocyte (methemoglobinemia and hemolytic anemia) as another target for

low-level exposure of mice, rats and dogs to TNT. Target organs for TNT, therefore, include the liver and erythrocyte.

EPA (2003) estimated a LOAEL for the ADNTs of 0.58 mg/kg-day by adjusting the TNT LOAEL of 0.5 mg/kg-day by the difference in molecular weight (MW) (i.e., MW of TNT divided by MW of ADNT). EPA (2003) applied an uncertainty factor of 3000 to yield a provisional RfD for chronic oral exposure to the ADNTs of 2E-4 mg/kg-day. The uncertainty factor of 3000 includes the uncertainty factor of 1000 used in the derivation of the verified chronic oral RfD for TNT and an additional factor of 3 for deficiencies in the data base for the ADNTs. The liver and erythrocyte are assumed to be the target organs for prolonged oral exposure to the ADNTs. Confidence in the provisional chronic oral RfD is low. EPA (2003) adopted the provisional chronic oral RfD of 2E-4 mg/kg-day as the provisional subchronic oral RfD.

A similar approach can be used to estimate a provisional chronic/subchronic oral RfD for the DANTs. Justification for this approach is based on structural similarity and the observation that the DANTs are metabolites of TNT in mammalian systems. The LOAEL for TNT of 0.5 mg/kg-day corresponds to a LOAEL for the DANTs of 0.68 mg/kg-day when corrected for differences in MW. Application of an uncertainty factor of 3000 as described above yields a preliminary chronic/subchronic oral RfD of 2.27E-4 mg/kg-day, which is rounded to 2E-4 mg/kg-day. Confidence in the oral RfD is low.

Data are not available regarding the toxicity of inhalation exposure to the ADNTs or DANTs; therefore, inhalation RfCs cannot be estimated.

It should be noted that EPA (2005b, c) reviewed the toxicity data available for the ADNTs and concluded that they were insufficient for estimation of peer-reviewed oral RfDs or inhalation RfCs. These reviews, however, found no fault with the estimations developed in the earlier (EPA, 2003) evaluation. Therefore, the toxicity values developed by EPA (2003) for the ADNTs and extrapolated above to the DANTs will be applied in this evaluation.

6.0 Carcinogenicity Evaluation

EPA (1993) classified the ADNTs in EPA cancer weight-of-evidence Group D, not classifiable as to carcinogenicity in humans, to reflect a total lack of human or animal data. Cancer potency factors are unavailable. Data were not located regarding the carcinogenicity of the DANTs. It should be noted that EPA (2005d) reviewed the toxicity data available for the ADNTs and concluded that they were *inadequate for an assessment of human carcinogenic potential.* This conclusion is consistent with the EPA (1993) review, which is continued herein and applied also to both the ADNTs and DANTs.

7.0 Toxicity Summary

Toxicity values for the ADNTs are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfc/ sRfD	cRfC/ cRfD	TO	WOE	SFo	WOE	URFi	SFi
2E-4	2E-4	L, E	ND	ND		D	NA	D	NA	NA
sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference										

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfc/ sRfD	cRfC/ cRfD	TO	WOE	SFo	WOE	URFi	SFi
concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data; NA = not applicable. Target organ abbreviations: L = liver; E = erythrocyte. [a]sRfDo and cRfDo should be used for dermal exposure without adjustment for GI absorption.										

The toxicity values presented above for the ADNTs apply also to the DANTs.

8.0 Preliminary Remediation Goals

EPA Region IX has developed preliminary remediation goals (PRG) that are useful for screening chemical concentrations in environmental media (EPA, 2004b). The Region IX PRGs are based on standard default exposure assumptions, and are often adapted for the risk-based screening step for selecting chemicals of potential concern for human health risk assessments.

PRGs are available for nearly 600 chemicals, including the ADNTs, but not the DANTs. However, the PRGs available for the ADNTs should be applied also to the DANTs.

9.0 References

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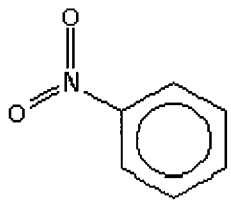
U.S. Environmental Protection Agency (EPA), 2005d, ***Provisional Peer Reviewed Toxicity Values for 2-Amino-4,6-Dinitrotoluene (CASRN 35572-78-2) and 4-Amino-2,6-Dinitrotoluene (CASRN 19406-51-0), Derivation of a Carcinogenicity Assessment***, National Center for Environmental Assessment, Cincinnati, OH, 17 May.

NITROBENZENE (98-95-3)



1.0 Introduction and Physical Properties

Nitrobenzene is a **VOC** that occurs as greenish-yellow crystals below 42 °F (5.56 °C) (HSDB, 2004). It occurs as a colorless to yellow liquid at and above these temperatures. Nitrobenzene is used primarily in the captive production of aniline, as a solvent, and as an intermediate in a very wide variety of other organic synthetic processes (ATSDR, 1990; HSDB, 2004). Other lesser but significant uses include, ingredient in various kinds of polishes, ingredient in soaps, in the refining of lubricating oils, as a substitute for almond essence, and in perfumes. Relevant physical properties are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
123.11[a]	1.85[a]	2.4E-5[b] (25°C)	1.81[b]	7.60E-2[b] (25°C)	8.60E-6[b] (25°C)	3.22E-4[a] (25°C)	2.09E+3[b] (20-25°C)	483.95[c]	719[c]	1.06E+4[c]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point (at 1 atm) of pure liquid compound (°K); T_c = critical temperature (°K); $H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole).

[a]Hazardous Substance Data Bank (HSDB), 2004, National Library of Medicine, on line, accessed 19 August.

[b]U.S. Environmental Protection Agency (EPA), 2001, ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites***, Review Draft, Office of Solid Waste and Emergency Response, Washington, DC, 9355.4-24, March.

[c]U.S. Environmental Protection Agency (EPA), 2003, ***Users Guide for Evaluating Subsurface Vapor Intrusion into Buildings***, Office of Emergency and Remedial Response, Washington, DC, 19 June.

2.0 Environmental Fate and Transport

Nitrobenzene may enter environmental media as inadvertent releases during its manufacture or use (HSDB, 2004), or possibly from the degradation of 2,4,6-trinitrotoluene or other similar nitroaromatic compounds. Nitrobenzene may also form in the atmosphere from the photochemical reaction of benzene with oxides of nitrogen.

Nitrobenzene is expected to exist solely as a vapor in the ambient atmosphere (HSDB, 2004). Nitrobenzene will degrade in the atmosphere primarily by photolysis (38 percent degradation in five hours in laboratory tests). Vapor-phase nitrobenzene is also degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals; the half-life for this reaction in air is estimated to be about 115 days. Removal of nitrobenzene through hydroxyl addition results in the formation of dinitrobenzene, nitrophenols, and dicarbonyls as reaction products. Results of modeling studies and field experiments suggest that wet deposition will have little effect on nitrobenzene removal from the atmosphere. Vapor settling (nitrobenzene vapor is heavier than air) may also remove the chemical from the atmosphere (ATSDR, 1990).

The low log K_{oc} estimated for nitrobenzene suggests that the compound will exhibit moderate to very high mobility in soil (HSDB, 2004). Volatilization of nitrobenzene from moist soil surfaces may be significant. Nitrobenzene is expected to biodegrade under both aerobic and anaerobic

conditions in soil. Nitrobenzene was completely removed from Rhine River water during soil filtration (bank or dune infiltration). Generally bank filtration takes 1 to 12 months and dune filtration takes 2 to 3 months, by which time the soil microorganisms are well acclimated. In another study, only 60% removal was obtained during infiltration through dunes consisting of fine-grained sand mixed with clay and lens-shaped peat layers. In a soil column experiment, 20 to 40 percent of the added nitrobenzene was degraded in 45 days. Nitrobenzene had a half-life of 56 days in an aerobic soil column. A proposed catabolic pathway involves the reduction of nitrobenzene to nitrosobenzene, to phenylhydroxyamine and to 2-aminophenol which then undergoes meta ring cleavage to 2-aminomuconic semialdehyde. Under anaerobic conditions, nitrobenzene forms aniline as a reaction product.

Nitrobenzene is not expected to adsorb strongly to suspended solids and sediment in water (HSDB, 2004). Nitrobenzene may volatilize significantly from water surfaces. The half-life of nitrobenzene in the Rhine River in The Netherlands was estimated as 1 day by measuring the concentration reduction between sampling points. Nitrobenzene may be degraded in water by photolysis (a half-life of 133 days), by reaction with hydrated electrons in eutrophic lakes (a half-life of 22 days), or by reaction with sunlight and nitrate (a measured half-life of 11 hours. Nitrobenzene in anaerobic sediments is expected to be rapidly reduced by abiotic mechanisms. In model waste stabilization ponds that were continuously fed with a synthetic waste feedstock and retained for 12 days, 89.5 percent of the added nitrobenzene was degraded, 4.9 percent volatilized, 2.3 percent adsorbed to sediment, 2.3 percent was lost in effluent, and 1 percent remained in the water column. The biodegradation half-life in the pond was 3.8 days. Results of aerobic aqueous screening tests are conflicting with results ranging from rapid degradation to no degradation. This compound is expected to readily biodegrade under anaerobic conditions; using a sewage inoculum in a batch reactor, 50 percent degradation was reported in 14 days, including an 8-day lag period.

The relatively low log K_{ow} for nitrobenzene suggests that the compound is unlikely to participate significantly in food-chain pathways. Although nitrobenzene has been taken up from soil by plants, empirical data confirm that bioconcentration in aquatic or terrestrial food chains is unlikely (ATSDR, 1990; HSDB, 2004). Nitrobenzene is identified as a chemical that does not pose concern to human health through the fish ingestion pathway (EPA, 1995). For these reasons biotransfer factors are not developed for nitrobenzene.

3.0 Toxicokinetics

One study in humans concluded that pulmonary absorption averages approximately 80 percent, although there was considerable individual variation (ATSDR, 1990). The ATSDR (1990) report stated that the extent of absorption was dose-dependent. Although not stated, it is expected that the relationship between airborne concentration and the extent of absorption is inverse.

The extent of GI absorption can be approximated from excretion data. A study in rats reported that 65 percent and 16 percent of a single oral dose was recovered in the urine and feces, respectively, during a 5-day post-treatment period. These observations suggest that a minimum of 84 percent of the administered dose was absorbed from the GI tract.

Airborne nitrobenzene vapor is absorbed by the skin to a significant extent by human volunteers exposed to 1 or 5.5 ppm (ATSDR, 1990). The appearance of toxic effects confirms that dermal application of liquid nitrobenzene to animals results in significant uptake.

The distribution of nitrobenzene and metabolites has not been well studied, probably at least in part because microbial degradation in the GI tract reduces the compound to aniline before significant absorption occurs. Nitrobenzene reduction products following oral administration were found in highest levels in the blood, followed by the kidney, liver and lung.

One of the most predictable toxic effects associated with nitrobenzene is methemoglobin formation followed by hemolytic anemia (Section 5.0), and metabolism has been studied largely from that perspective. Nitrobenzene administered orally to normal rats is sequentially reduced by microflora in the gut to form nitrosobenzene, phenylhydroxyamine, and finally aniline (ATSDR, 1990). However, it is likely that unchanged compound is also absorbed. An early report that similar treatment of germ-free rats did not result in methemoglobinemia led to the speculation that one or more of the microbial reduction products were required to produce this toxic effect. Both nitrosobenzene and phenylhydroxyamine have been shown to bind to hemoglobin in rats and mice.

The foregoing, however, does not fully explain the relationship between metabolism and methemoglobin formation. Methemoglobinemia also follows inhalation or dermal exposure (HSDB, 2004), which greatly reduces the potential for microbial reduction in the GI tract.

Excretion appears to be predominantly via the urine (ATSDR, 1990). The major metabolites in human poisoning cases include p-aminophenol and p-nitrophenol, indicating that para-hydroxylation of the benzene ring is an important metabolic pathway for systemically absorbed compound.

4.0 Dermal Exposure

It is assumed that a minimum of 84 percent of an oral dose is absorbed from the GI tract as noted above. The oral RfD, however, is derived from an inhalation study in which it was assumed that 80 percent of the inhaled dose was absorbed and that GI absorption would be complete. This approach requires assuming a GAF of 1 for estimation of a dermal RfD.

Nitrobenzene appears to be significantly absorbed dermally following topical application of neat compound or dermal exposure to vapor (see above). Data were not located for dermal uptake from soil; however, EPA (2004) assumes that dermal uptake of VOCs from soil is generally not significant. Therefore, no ABS is estimated for nitrobenzene.

Data regarding the dermal uptake of nitrobenzene from water were not located. Values for t*, K_p, τ, B and FA estimated according to EPA (2004) methodology follow:

Chemical	t*	K_p	τ	FA	B
Nitrobenzene	1.23	5.39E-3	0.514	1	0

t* = time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); □ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).

5.0 Noncancer Effects Evaluation

Acute oral exposure to nitrobenzene is characterized by methemoglobin formation, probably involving nitrobenzene reduction by the microflora of the small intestine (ACGIH, 1991) as described above. It is unlikely that oral administration is required, however, because methemoglobinemia occurs following inhalation or dermal exposure (HSDB, 2004). An oral LD_{50}

of 600 mg/kg is reported for rats (ATSDR, 1990; ACGIH, 1991). Data regarding the effects of chronic oral exposure to nitrobenzene were not located in the available literature.

Acute exposure of humans to nitrobenzene vapors induces frank methemoglobinemia (ACGIH, 1991). Occupational exposure is associated with methemoglobinemia, liver damage, paresthesia and various symptoms of neurologic damage. Hemolytic anemia and liver damage are also observed in animals exposed by inhalation (EPA, 2005). In the key inhalation study, groups of male and female rats and mice were exposed intermittently to nitrobenzene vapors 6 hours/day, 5 days/week for 90 days. The 25 mg/m^3 concentration, equivalent to an absorbed dose of 4.6 mg/kg-day, was associated with hemolytic anemia (in rats) and vacuolization of adrenal cortical cells (in mice). Liver and kidney lesions were observed in both species at the 81 mg/m^3 level. Application of an uncertainty factor of 10,000 to the LOAEL of 4.6 mg/kg-day yields a verified oral RfD of 5E-4 mg/kg-day. The uncertainty factor consists of factors of 10 each for interspecies variation, intraspecies variation, to extrapolate a NOAEL from a LOAEL, and to expand from subchronic to chronic exposure. Confidence in the oral RfD is low. EPA (2005) stated that the liver and kidneys appear to be the target organs of exposure to nitrobenzene. It appears, however, that the erythrocyte is the more sensitive target (hemolytic anemia occurred at a lower exposure concentration than liver and kidney lesions); therefore, the erythrocyte is also considered a target organ for this evaluation.

A provisional subchronic oral RfD of 5E-3 mg/kg-day was derived by EPA (1997) from the LOAEL in the subchronic inhalation study described above by application of an uncertainty factor of 1000. The uncertainty factor of 1000 reflects the chronic uncertainty factor of 10,000 without the factor of 10 to expand from subchronic to chronic exposure.

A provisional chronic inhalation RfC of 2E-3 mg/m^3 was derived from the same inhalation study by applying an uncertainty factor of 10,000 to the LOAEL of 25 mg/m^3 (EPA, 1997). The provisional chronic inhalation RfC is equivalent to a chronic inhalation RfD of 5.7E-4 mg/kg-day (rounded by EPA [1997] to 6E-4 mg/kg-day). EPA (1997) also derived a provisional subchronic inhalation RfC of 2E-2 mg/m^3 by applying an uncertainty factor of 1000 to the LOAEL. The provisional subchronic inhalation RfC is equivalent to a subchronic inhalation RfD of 6E-3 mg/kg-day. The liver, kidney and erythrocyte are considered to be the target organs of prolonged inhalation exposure to nitrobenzene.

6.0 Carcinogenicity Evaluation

Nitrobenzene is assigned to EPA cancer weight-of-evidence Group D (not classifiable as to carcinogenicity to humans) because there are no data regarding the carcinogenicity of nitrobenzene to humans or animals (EPA, 2005).

7.0 Toxicity Summary

The toxicity values for nitrobenzene are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
5E-3	5E-4	L,K,E	2E-2/ 6E-3	2E-3/ 6E-4	L,K,E	D	ND	D	ND	ND
sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per										

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data. Target organ or critical effect abbreviations: L = liver; K = kidney; E = erythrocyte. [a]sRfDo and cRfDo should be used for dermal exposure without adjustment for GI absorption.										

8.0 References

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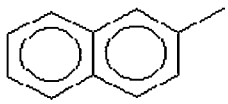
Semivolatile Organic Compounds

METHYLNAPHTHALENES



2-Methylnaphthalene

1.0 Introduction and Physical Properties

The methylnaphthalenes are the simplest alkylated polyaromatic hydrocarbons (PAH). Two monomethylnaphthalene isomers are possible: 1-methylnaphthalene (occasionally incorrectly called 4-methylnaphthalene) (90-12-0) and 2-methylnaphthalene (91-57-6). A commercial preparation of mixed isomers (1321-94-4) is mentioned (ATSDR, 2005; HSDB, 2005), but the proportion of the individual isomers was not reported. Both 1- and 2-methylnaphthalene are **VOCs**. 1-Methylnaphthalene occurs as a colorless liquid in the pure form at ambient temperatures (HSDB, 2005). 2-Methylnaphthalene reportedly occurs as a solid, but the melting point is 34.6°C (approximately 94 °F), indicating that at high ambient temperatures the compound would occur as a liquid.

1-Methylnaphthalene is a component of petroleum and a product of incomplete combustion (HSDB, 2005). The compound is also used as a chemical intermediate and a general solvent. 2-Methylnaphthalene is used as an intermediate in organic chemical synthesis, as a dye carrier, in the manufacture of pesticides, as an adjuvant in pesticide formulations, and, in its pure form, in the manufacture of vitamin K. 2-Methylnaphthalene also is a component of crude oil and a product of combustion, which is produced and released to the environment during natural fires. Relevant physical properties are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
1-Methylnaphthalene (90-12-0)										
142.19[a]	3.87[a]	5.14E-4[a] (25°C)	3.36[a]	6.97E-2[b] (25°C)[c]	8.08E-6[b] (25°C)[c]	8.82E-5[a] (25°C)	2.58E+1[a] (25°C)	515[d]	772[d]	1.37E+4[d]
2-Methylnaphthalene (91-57-6)										
142.20[a]	3.86[a]	5.18E-4[a] (25°C)[c]	3.81[a]	6.97E-2[b] (25°C)[c]	8.08E-6[b] (25°C)[c]	7.24E-5[a] (25°C)	2.46E+1[a] (25°C)	514[d]	761[d]	1.08E+4[d]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point (at 1 atm) of pure liquid compound (°K); T_c = critical temperature (°K); $H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole); ND = no data.

[a]Hazard Substances Data Bank (HSDB), 2005, National Library of Medicine, on line accessed 14 December.

[b]Calculated as described in Introduction to Toxicity Profiles.

[c]Assumed.

[d]National Institute of Standards and Technology (NIST), 2005, ***NIST Chemistry WebBook***, on line, accessed 14 December.

2.0 Environmental Fate and Transport

Emissions from petroleum refining, coal tar distillation, and gasoline and diesel fueled engines are major contributors of methylnaphthalenes to the environment (HSDB, 2005). Because of the widespread use of the methylnaphthalenes in a variety of products, they are also released to the environment in manufacturing effluents, the disposal of waste byproducts, through landfills, municipal waste water treatment facilities and waste incinerators. Forest fires and uncontrolled combustion are relatively insignificant contributors (ATSDR, 2005).

Based upon their relatively high vapor pressure, the methylnaphthalenes are expected to exist entirely in the vapor phase in ambient air (HSDB, 2005). Direct photolysis of the methylnaphthalenes is likely to occur; however, only aqueous photolysis data are available. Reactions of the methylnaphthalenes with photochemically produced hydroxyl radicals (half-life = 7.4 hours) and ozone (half-life = 29 to 88 days) are likely to be important removal processes in ambient air. The formation of nitro derivatives in night-time air is also likely to be an important removal process for these compounds.

Data regarding the biodegradation of the methylnaphthalenes in soil were not available (HSDB, 2005). However, based upon aqueous screening test data and die-away tests for ground and marine water, the methylnaphthalenes are expected to biodegrade fairly rapidly in soils acclimated to PAHs and at a moderate rate in unacclimated soils. The methylnaphthalenes are not expected to undergo hydrolysis in soils; however, they are expected to undergo direct photolysis in sunlit surface soils. Mobility in soil is likely to be very low. Volatilization from moist soils may be a significant removal mechanism, although it will be attenuated by adsorption.

The methylnaphthalenes will partition from the water column to organic matter contained in sediments and suspended solids (HSDB, 2005). Volatilization is likely to be an important removal process for these compounds. Volatilization half-lives for a model river and model lake were estimated to be 5.5 hours and 5.3 days, respectively. The methylnaphthalenes are expected to degrade rapidly in marine water and waters acclimated to PAHs. Degradation is expected to be less rapid in unacclimated aquatic systems. The methylnaphthalenes are not expected to undergo hydrolysis in water; however, direct photolysis in sunlit waters is likely to be a significant removal process. The direct photolysis half-life for midday, midsummer sunlight at 40° N latitude was predicted to be 22 and 54 hours for 1- and 2-methylnaphthalene, respectively, in water solution.

The methylnaphthalenes are not expected to participate significantly in food-chain pathways (ATSDR, 2005; HSDB, 2005); therefore, biotransfer factors are not provided.

3.0 Toxicokinetics

Data regarding the toxicokinetics of the methylnaphthalenes are very limited. Data regarding the toxicokinetics of naphthalene, often used as a surrogate for the methylnaphthalenes, is somewhat more complete.

The observation that inhalation exposure to naphthalene leads to adverse effects in humans suggests that the methylnaphthalenes are also absorbed by the respiratory tract (ATSDR, 2005).

An excretion study with radiolabeled 2-methylnaphthalene in guinea pigs suggests that GI absorption is rapid and nearly complete, as 80 percent of the administered dose of radioactivity was recovered from the urine within 24 hours (ATSDR, 2005).

Data were not located regarding dermal uptake of the methylnaphthalenes. However, serious adverse health effects have been observed in humans dermally exposed to naphthalene, and animal studies show that naphthalene is rapidly and extensively absorbed through the skin, although using soil as the vehicle slows dermal absorption (ATSDR, 2005). These observations suggest that dermal uptake of the methylnaphthalenes may be significant.

Limited distribution data following oral administration of radiolabeled 2-methylnaphthalene to guinea pigs revealed that the presence of radioactivity in the liver almost immediately after treatment (ATSDR, 2005). Relatively high levels were located in the gall bladder, liver and kidney, all of which represent excretion. Data from orally administered naphthalene suggests that distribution to adipose tissue is probably substantial, and that the methylnaphthalenes will probably cross the placenta and distribute to milk.

As stated above, naphthalene is often used as a surrogate for the methylnaphthalenes because of structural similarity. Similarity in structure implies similarity in physical, chemical, toxicokinetic and toxicological characteristics. The focus of the discussion on metabolism that follows is to explore the appropriateness of applying naphthalene as a toxicological surrogate.

The sole initial step in naphthalene metabolism is oxidation at the 1,2-position to form the epoxide, 1,2-naphthalene oxide (ATSDR, 2005). The epoxide may rearrange spontaneously to form 1- and 2-naphthol, or undergo enzymatic conversion to 1,2-dihydroxy, 1,2-dihydronaphthalene. The epoxide formed in the first step is recognized as an intermediate that reacts with tissue macromolecules inducing toxic effects, particularly in the lung. 1-Naphthol may undergo further oxidation to form 1,4-naphthoquinone, which has also been shown to interact with macromolecules, particularly in the liver. 1,2-Dihydroxy, 1,2-dihydronaphthalene may undergo further oxidation to form 1,2-naphthoquinone or 1,2-dihydroxy-3,4-epoxy-1,2,3,4-tetrahydronaphthalene. 1,2-Naphthoquinone may be the ultimate toxicant associated with naphthalene-induced cataracts. The toxicological significance of 1,2-dihydroxy-3,4-epoxy-1,2,3,4-tetrahydronaphthalene is unclear.

The presence of the methyl group on 1- or 2-methylnaphthalene may greatly alter the metabolic scheme for these chemicals compared with naphthalene. Data are available only for 2-methylnaphthalene, but the metabolism of 1-methylnaphthalene may be similar. The predominant pathway of 2-methylnaphthalene metabolism involves stepwise oxidation of the methyl group to form 2-hydroxymethylnaphthalene and 2-naphthoic acid, possibly through the aldehyde intermediate (ATSDR, 2005). This pathway accounts for 50 to 80 percent of 2-methylnaphthalene, depending on the species. The end products of this pathway are conjugated with glycine or glucuronic acid and excreted. Ring epoxidation at the 3,4-, 5,6- or 7,8- positions accounts for 15 to 20 percent of 2-methylnaphthalene. These epoxides may be subject to conjugation or may be further oxidized to form the corresponding dihydrols and other derivatives, which in turn undergo conjugation. Experiments with mice suggest that glutathione conjugation may be an important detoxication mechanism.

Although data regarding the biological activity of methylnaphthalene metabolites is not as complete as data regarding the biological activity of the naphthalene metabolites, the differences in the metabolites formed are considerable, raising concerns about the application of naphthalene as a toxicological surrogate for the methylnaphthalenes. Nonetheless, the addition of the methyl group to the aromatic rings may have the overall effect of decreasing toxicity as has been shown for benzene and ethylbenzene (EPA, 1996), so that the use of naphthalene as a surrogate for the methylnaphthalenes is not unreasonable until chemical-specific toxicological data become available.

Data regarding excretion of the methylnaphthalenes is limited to a study of 2-methylnaphthalene in guinea pigs. Approximately 80 percent of the radiolabel from a single oral dose was recovered within 24 hours in the urine; approximately 10 percent was recovered from the feces. Conjugated

metabolites of the products of methyl group oxidation accounted for approximately 76 percent of the recovered radioactivity. Approximately 18 percent of the recovered radiolabel represented epoxidation at the 7,8- positions.

4.0 Dermal Exposure

EPA (2004a) notes that organic chemicals are generally well absorbed from the GI tract, and recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly (50 percent) less than complete. Therefore, no GAF is developed for the methylnaphthalenes and the oral toxicity values described below should be used for dermal exposure without adjustment for GI absorption.

Data were not located regarding the dermal uptake of the methylnaphthalenes from soil. VOCs tend to volatilize from soil when applied to the skin, reducing dermal uptake to toxicologically insignificant levels (EPA, 2004a). Therefore, dermal uptake of the methylnaphthalenes from soil is not evaluated. t*, K_p, τ, FA and B values are estimated by the EPA (2004a) method as follows:

Chemical	t*	K_p	τ	FA	B
1-Methylnaphthalene	1.58	9.08E-2	0.657	1	0.42
2-Methylnaphthalene	1.58	8.94E-2	0.657	1	0.41
T* = time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); □ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).					

5.0 Noncancer Effects Evaluation

Data regarding the effects of human exposure to 1-methylnaphthalene were not located. Subchronic and chronic dietary studies with 1-methylnaphthalene in mice suggest that the toxic potency is low. An increased incidence of pulmonary alveolar proteinosis was the only lesion observed in mice treated at a dose rate of 73 mg/kg-day (lowest dose rate tested) in an 81-week study, but not in mice treated at a dose rate of approximately 1200 mg/kg-day (highest dose rate tested) in a 13-week study (EPA, 1998). These observations suggest that duration of exposure is very important in the toxicity of 1-methylnaphthalene. The lack of a NOAEL from the chronic study compromises the use of these data to develop an RfD.

Effects in humans from exposure to low levels of 2-methylnaphthalene appear to be limited to skin irritation and photosensitization (HSDB, 2005). Acute exposure to high levels may induce headaches, nausea, vomiting, diarrhea, anemia, jaundice, euphoria, dermatitis, visual disturbances, convulsions and coma. Data regarding the acute toxicity of 2-methylnaphthalene in animals are limited to an oral LD_{Lo} in rats of 5000 mg/kg (Sax, 1984). Chronic dietary studies with 2-methylnaphthalene in mice suggest that the toxic potency is low. An increased incidence of pulmonary alveolar proteinosis was the only lesion observed in mice treated at a dose rate of 52.3 mg/kg-day (lowest dose rate tested) in an 81-week study. The lack of a NOAEL from the chronic study compromises the use of this study to develop an RfD.

Chronic toxicity data for 1- or 2-methylnaphthalene sufficient to derive an oral RfD were not located. In the absence of sufficient chemical-specific data, EPA (1996) evaluated the toxicity of naphthalene, and adopted the provisional chronic oral RfD for naphthalene of 4E-2 mg./kg-day for application to 2-methylnaphthalene. Since the EPA (1996) evaluation, EPA (2005) verified a chronic oral RfD for naphthalene of 2E-2 based on decreased mean terminal body weights in male

rats treated by gavage with naphthalene in corn oil for 13 weeks. An uncertainty factor of 3000 was applied to the NOAEL of 71 mg/kg-day. The uncertainty factor consists of factors of 10 each to extrapolate from rats to humans, to protect sensitive humans, and to extrapolate from subchronic to chronic exposure, and a factor of 3 for database deficiencies. The LOAEL in this study was 142 mg/kg-day, based on decreased terminal body weights in males in the absence of reduced food intake. Confidence in the verified chronic oral RfD for naphthalene is low.

Occupational exposure to naphthalene is associated with cataract formation (EPA, 1993a). Adults, children and neonates exposed to moth balls have exhibited hemolytic anemia, evidence of liver disease and neurological deficits (EPA, 1993a, 1998). The liver effects and neurological deficits may be secondary to hemolytic anemia and reduced oxygen-carrying capacity of the blood. Hemolytic anemia and cataract formation have been seen also in orally exposed humans (EPA, 1998). The data suggest that the erythrocyte and eye may be the tissues in humans most sensitive to naphthalene. Among commonly used species of laboratory mammals, hemolytic anemia is seen only in dogs (EPA, 1998). Cataracts are seen in several laboratory mammal species, but only at relatively high doses. The key study identified reduced body weight as the critical effect in rats. Rats, however, do not exhibit hemolytic anemia, and exhibit cataracts only at very high doses, suggesting that rats may not be a totally acceptable model for the toxicity of naphthalene to humans. Therefore, based on the effects observed in humans, the erythrocyte and eye are selected as target organs for prolonged oral exposure to naphthalene. Reduced body weight is also included as a critical effect because this was the only endpoint observed in rats in the critical study with naphthalene.

Following the lead established by EPA (1996), the verified chronic oral RfD for naphthalene of 2E-2 mg/kg-day is adopted as a preliminary chronic oral RfD for 1- and 2-methylnaphthalene for the purposes of this evaluation. The erythrocyte, eye and reduced body weight are considered to be the "target organs" for prolonged oral exposure to 1- or 2-methylnaphthalene.

No EPA-derived subchronic oral RfD is available for the methylnaphthalenes. However, a preliminary subchronic oral RfD can be derived by adjusting the preliminary chronic oral RfD upward by a factor of 10. The factor of 10 reflects removal of the uncertainty factor applied by EPA (2005) to expand from subchronic to chronic exposure. The preliminary subchronic oral RfD so derived is 2E-1 mg/kg-day.

Data regarding chronic inhalation exposure of humans or animals to 1- or 2-methylnaphthalene were not located in the available literature. EPA (1993b) concluded that it is not feasible to derive an inhalation RfC for 2-methylnaphthalene. Since the EPA (1993b) evaluation, EPA (2005) verified a chronic inhalation RfC for naphthalene of 3E-3 mg/m^3 based on a LOAEL human equivalent concentration of 9.3 mg/m^3 associated with hyperplasia and metaplasia in the nasal and olfactory epithelia in mice intermittently exposed by inhalation for 2 years. An uncertainty factor of 3000 was used. The chronic inhalation RfC is equivalent to a chronic inhalation RfD of 8.6E-4 mg/kg-day. Confidence in the chronic inhalation RfC is medium. Consistent with the approach to evaluating oral exposure to 2-methylnaphthalene, the verified chronic inhalation RfC of 3E-3 mg/m^3 equivalent to 8.6E-4 mg/kg-day for naphthalene is adopted as a preliminary chronic inhalation RfC for 1- and 2-methylnaphthalene for the purposes of this evaluation. The nasal and olfactory epithelia are considered the target tissues for inhalation exposure to 1- or 2-methylnaphthalene. The preliminary chronic inhalation RfC is adopted as sufficiently protective for subchronic exposure as well.

6.0 Carcinogenicity Evaluation

Dietary exposure of mice to high doses of 1-methylnaphthalene or 2-methylnaphthalene was associated with significantly increased incidences of bronchiolar/alveolar adenomas and adenocarciomas (combined) in the males (EPA, 1998). An increase in tumor development was not observed in females in this study. These data are inadequate for weight-of-evidence determination or development of potency estimates. EPA (1993c) classified 2-methylnaphthalene in cancer weight-of-evidence Group D – not classifiable as to carcinogenicity to humans. Quantitative estimates are not derived for Group D chemicals. The Group D designation is applied also to 1-methylnaphthalene.

7.0 Toxicity Summary

Toxicity values for 1- and 2-methylnaphthalene are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
2E-1	2E-2	E,Ey, BW	3E-3/ 8.6E-4	3E-3/ 8.6E-4	NOE	D	NA	D	NA	MA

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data; NA = not applicable.

Target organ or critical effect abbreviations: E = erythrocyte; Ey = eye; BW = reduced body weight; NOE = nasal and olfactory epithelia.

[a]sRfDo and cRfDo should be used for dermal exposure without adjustment for GI absorption.

8.0 Preliminary Remediation Goals

EPA Region 9 has developed preliminary remediation goals (PRG) that are useful for screening chemical concentrations in environmental media (EPA, 2004b). The Region IX PRGs are based on standard default exposure assumptions, and are often adapted for the risk-based screening step for selecting chemicals of potential concern for human health risk assessments.

PRGs are available for nearly 600 chemicals for soil for residential use, for soil for industrial use, for ambient air, and for tap water (EPA, 2004b). Exposure routes addressed by PRGs for soil include incidental ingestion, dermal contact, and inhalation of volatiles or dust; exposure routes addressed by PRGs for tap water include drinking water ingestion and inhalation of volatiles. EPA (2004b) provides the methodology and standard exposure default assumptions with which to estimate PRGs for chemicals not included in the tables. Generally, PRGs are developed for both cancer risk and noncancer hazard, and the smaller of the two estimates is chosen. Toxicity values for the cancer risk of the methylnaphthalenes are not available; therefore, only PRGs based on noncancer effects are developed herein.

PRGs are not available for the methylnaphthalenes presumably because EPA-verified toxicity values are not available. The chronic oral and inhalation RfDs described above are used in the absence of EPA-verified toxicity values. The PRGs are tabulated below:

Chemical	Oral RfD (mg/kg-day)	Inhalation RfD (mg/kg-day)	VF_s (m^3/kg)	Preliminary Remediation Goal			
				Residential Soil (mg/kg)	Industrial Soil (mg/kg)	Ambient Air (µg/m^3)	Tap Water (µg/L)
1-Methylnaphthalene	2E-2	8.6E-4	6.78E+4	8.6E+1	2.9E+2	3.1E+0	6.2E+0

RfD = reference dose; VF_s = soil-to-air volatilization factor; PRG = preliminary remediation goal.
[a]The methylnaphthalenes are sufficiently similar in physical properties so that the PRGs estimated for 1-methylnaphthalene can be applied also to 2-methylnaphthalene.

The PRGs are based on a hazard index of 1.

9.0 References

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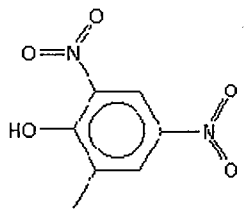
DINITROCRESOLS (DINITROMETHYLPHENOLS)



4,6-Dinitro-2-methylphenol

1.0 Introduction and Physical Properties

Several dinitrocresol isomers are possible; however, the isomer most frequently encountered in environmental media is 4,6-dinitro-2-methylphenol (4,6-dinitro-o-cresol, or DNOC) (534-52-1) (ATSDR, 1995). DNOC behaves as an **SVOC** in the environment; it exists in the pure state as yellow crystals or needles at ambient temperatures (HSDB, 2005). DNOC has been used as an insecticide and a herbicide against broadleaf weeds. 2,6-Dinitro-p-cresol (609-93-8) is used in the synthesis of fungicides, dyes and pharmaceuticals. DNOC has been used in the past as an aid to weight loss because of its mechanism of action, which is to uncouple oxidative phosphorylation and increase basal metabolic rate. Relevant physical properties for DNOC are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
198.13[a]	2.13[a]	NA (See text)	2.15[a,b]	5.59E-2[c] (25°C)[d]	6.47E-6[c] (25°C)[d]	1.84E-7[a] (25°C)	1.98E+2[a] (20°C)	NA	NA	NA

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point (at 1 atm) of pure liquid compound (°K); T_c = critical temperature (°K); $H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole); NA = not applicable.

[a]Hazardous Substance Data Bank (HSDB), 2005, National Library of Medicine, on line, accessed 14 December.

[b]Midpoint of ranges in different types of soils.

[c]Estimated as described in Introduction to Toxicity Profiles.

[d]Assumed.

A value for H could be estimated but it would be vanishingly small because DNOC is an ionizing compound with a pK_a of 4.4. This means that the compound will be predominantly dissociated in water, all but precluding volatilization from water or moist surfaces.

2.0 Environmental Fate and Transport

Insecticidal spraying was probably the major emission source of release of DNOC to the environment when it was used in this manner (HSDB, 2005). It is no longer used as a pesticide. In addition, wastewater effluents from chemical plants have been found to contain the compound.

DNOC usually disappears from soil within a few weeks to 2 months of being applied at normal pesticidal rates. Biodegradation is probably the main process for removing the compound from agricultural soils (ATSDR, 1995; HSDB, 2005), although several different tests yielded a wide range of results for biodegradation. DNOC at low concentrations has been shown to significantly increase carbon dioxide evolution from soil, suggesting the compound is completely mineralized by soil microorganisms, at least under some conditions. Other products of biodegradation include 6-amino-4-nitro-o-cresol, 6-acetamino-4-nitro-o-cresol, 2-methyl-6-nitrocatechol, 2-methyl-6-aminocatechol and 2,3,5-trihydroxytoluene. DNOC is expected to exhibit moderate to very high mobility in soil.

Greatest mobility is expected in coarse-textured sandy soils and the least mobility in fine textured clay and organic soils.

A pK_a of 4.4 indicates that a significant portion of DNOC in surface water will exist in the ionized form (ATSDR, 1995; HSDB, 2005). Aquatic hydrolysis, volatilization and adsorption to sediments are not expected to be important processes for removing DNOC from surface water. Direct photolysis may occur at the water surface. Indirect photolytic processes also may be significant. The half-life for the photolysis of DNOC in water has been reported as approximately 253 days at 20 °C. Biodegradation half-lives for DNOC in natural water were reported as 7 days under aerobic conditions and 2.8 days under anaerobic conditions. The results of one screening study suggest that concentration may be an important factor in determining the ability of microbes to biotransform the compound. High concentrations appear to be toxic to microbes.

DNOC is expected to exist in both the vapor phase and adsorbed to particles in the atmosphere (HSDB, 2005). DNOC in the vapor phase will react with photochemically produced hydroxyl radicals at an estimated half-life of 160 days. Particulate phase DNOC will be subject to wet and dry deposition. DNOC in the atmosphere may be subject to direct photolysis.

DNOC is fairly water-soluble and is generally rapidly metabolized (ATSDR, 1995; HSDB, 2005). It is markedly toxic to fish, which probably precludes significant bioconcentration. EPA (1995a) lists DNOC as a compound for which bioaccumulation in fish is not a significant source of exposure to humans. It is concluded that food-chain pathways are not likely to be significant for DNOC and biotransfer factors are not compiled.

3.0 Toxicokinetics

DNOC is rapidly absorbed following inhalation exposure (ATSDR, 1995), but data regarding the extent of absorption were not located. Similarly, DNOC appears to be absorbed rapidly following ingestion. Excretion and tissue data indicate that at least 40 to 85 percent of an ingested dose is absorbed, but the extent of absorption appears to depend on species and the size of the dose. The data are insufficient to clarify the extent to which biliary excretion and enterohepatic recirculation may obscure the full extent of GI absorption, which is probably greater than the figures given above. Dermal absorption occurs in animals and humans. Although the rate and extent of dermal uptake has not been quantified, incidental dermal exposure has caused death in at least one occupationally exposed human.

Distribution of DNOC metabolites appears to be widespread, at least following ingestion (ATSDR, 1995). Highest specific tissue levels are identified in the GI tract and contents, blood, liver and kidney. DNOC shows strong affinity and binding to serum albumin and probably albumin in other body compartments that may slow metabolism and excretion. Binding to albumin may also account for large amounts located in the "remaining carcass" after specific organs have been removed for analysis in distribution studies.

DNOC is subject to a variety of metabolic reactions; the biotransformation products identified, largely in the urine, depend on dose and species (ATSDR, 1995). Generally, reactions include oxidation of the methyl group to the corresponding alcohol or acid, and reduction of one or both of the nitro groups. Nitroreduction may be followed by acetylation. Most but not all DNOC biotransformation products are conjugated before excretion. Metabolism appears to be largely a

detoxication mechanism. Animals appear to be more efficient metabolizers and detoxifiers than humans.

DNOC metabolites appear to be excreted largely in the urine following all routes of exposure although the extent is variable, depending on route of exposure, species and dose. The potential significance of excretion by other routes, particularly biliary excretion and enterohepatic recirculation, has not been elucidated.

4.0 Dermal Exposure

EPA (2004) notes that organic chemicals are generally well absorbed from the GI tract, and recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly less than complete. Therefore, no GAF is developed for DNOC and the oral toxicity values described below should be used for dermal exposure without adjustment for GI absorption.

DNOC in the form of insecticide or herbicide spray formulations appears to be readily absorbed by the skin in quantities sufficient to induce illness or death (ATSDR, 1995); however, data were not located regarding the extent of dermal uptake of DNOC from soil. In the absence of quantitative data, the EPA (2004) default ABS of 0.1 for SVOCs is adopted for this evaluation. From the MW and log K_{ow} values given above and the EPA (2004) method, t*, K_p, τ, FA and B values are estimated as follows:

Chemical	t*	K_p	τ	FA	B
DNOC	3.24	3.14E-3	1.35	1.0	0.02

t* = time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); □ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).

5.0 Noncancer Effects Evaluation

Oral LD_{50} values for DNOC include 16.4 to 21 mg/kg for mice and 25 to 65 mg/kg for rats (ATSDR, 1995; HSDB, 2005). The clinical signs of acute oral toxicity include listlessness, loss of appetite and activity, deepened and more rapid respiration, sweating (in some animals only), thirst, oliguria, muscular weakness, prostration, dyspnea and death, with terminal hyperpyrexia. Signs may appear within a few minutes if large amounts have been ingested; otherwise they may be delayed for several hours. Death is due to dyspnea, lung congestion and elevated body temperature due to uncoupling of oxidative phosphorylation.

Prolonged oral exposure is associated with elevated basal metabolic rate, weight loss, altered pituitary and thyroid function, sweating, lassitude, headache and cataract formation in humans (EPA, 1995b). Decreased growth rate, decreased organ weights and stomach irritation are observed in laboratory animals subjected to prolonged exposure. The animal data, however, are inadequate to develop an oral RfD. A review of the human data, particularly the use of DNOC in humans as a weight-loss aid, identified 0.35 mg/kg-day for up to one year as a LOAEL associated with sweating and fatigue. Application of an uncertainty factor of 3000 yields a provisional chronic oral RfD of 1E-4 mg/kg-day (EPA, 1995b). The uncertainty factor consists of factors of 10 each for estimation of a NOAEL from a LOAEL, to provide additional protection for unusually sensitive humans, and to expand from subchronic to chronic exposure, and a factor of 3 for data base deficiencies. Confidence in the provisional chronic oral RfD is low. Altered cellular respiration is considered the

target for prolonged oral exposure to DNOC. Lacking more definitive information, the provisional oral RfD of 1E-4 mg/kg-day for DNOC is applied to all dinitrocresols.

No EPA-derived subchronic oral RfD was located for DNOC. A preliminary subchronic oral RfD can be derived by applying an uncertainty factor of 300 to the subchronic LOAEL of 0.35 mg/kg-day described above. The uncertainty factor of 300 reflects the chronic uncertainty factor of 3000 without the factor of 10 to expand from subchronic to chronic exposure. The preliminary subchronic oral RfD so derived is 1E-3 mg/kg-day.

Several reports show that human inhalation exposure or occupational exposure (both inhalation and dermal) induce toxic signs and occasionally death (ATSDR, 1995; HSDB, 2005). The exposure data, however, are not sufficient to permit estimation of airborne concentrations or dose rates. Therefore, the data are insufficient for estimation of an inhalation RfC.

6.0 Carcinogenicity Evaluation

Data regarding the carcinogenicity of the dinitrocresols were not located.

7.0 Toxicity Summary

Toxicity values for DNOC are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
1E-3	1E-4	CR	ND/ ND	ND/ ND	NA	ND	ND	ND	ND	ND

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data; NA = not applicable.
Target organ or critical effect abbreviations: CR = cellular respiration.
[a]sRfDo and cRfDo should be used for dermal exposure without adjustment for GI absorption.

8.0 References

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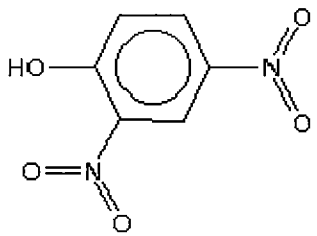
U.S. Environmental Protection Agency (EPA), 2004, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final***, Office of Superfund Remediation and Technology Innovation, Washington, DC, EPA/540/R/99/005, OSWER 9285.7-02EP, NTIS No. PB99-963312, July.

DINITROPHENOLS



2,4-Dinitrophenol

1.0 Introduction and Physical Properties

There are 6 theoretically possible dinitrophenol isomers: 2,3-, 2,4-, 2,5-, 2,6-, 3,4- and 3,5-dinitrophenol. A commercial mixture is available that usually consists of the 2,3- 2,4- and 2,6-isomers (25550-58-7) (ATSDR, 1995). The dinitrophenols enjoy a wide range of uses, including the manufacture of dyes (especially sulfur colors), picric and picramic acids, the photographic developer diaminophenol hydrochloride, and various explosives (HSDB, 2005). It is used in reagents for the identification of potassium and ammonium ions. 2,4-Dinitrophenol has been used as a wood preservative and insecticide. Relevant environmental data have been located for the 2,4-, 2,5- and 2-6-isomers, but the 2-4 isomer appears to be the one most commonly encountered (HSDB, 2005). Therefore, this profile is limited to the 2,4, 2,5- and 2,6-isomers. These isomers are **SVOCs** that occur as solids at ambient temperatures. Relevant physical properties are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
2,4-Dinitrophenol (51-28-5)										
184.1[a]	1.54[a]	4.44E-7[b] (25°C)	-1.99[b,c]	2.73E-2[b] (25°C)	9.06E-6[b] (25°C)	5.13E-7[d] (20°C)	2.79E+3[b] (20-25°C)	NA	NA	NA
2,5-Dinitrophenol (329-71-5)										
184.11[d]	1.75[d]	2.8E-8[d] (25°C)[e]	NA[f]	5.87E-2[g] (25°C)[e]	6.80E-6[g] (25°C)[e]	1.38E-6[d] (20°C)	6.8E+2[d] (25°C)[e]	NA	NA	NA
2,6-Dinitrophenol 573-56-8)										
184.11[d]	1.37[d]	2.8E-8[d] (25°C)[e]	NA[f]	5.87E-2[g] (25°C)[e]	6.80E-6[g] (25°C)[e]	1.58E-8[d] (25°C)	4.2E+2[d] (25°C)[e]	NA	NA	NA

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point (at 1 atm) of pure liquid compound (°K); T_c = critical temperature (°K);.$H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole); ND = no data.

[a]U.S. Environmental Protection Agency (EPA), 2004, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final***, Office of Superfund Remediation and Technology Innovation, Washington, DC, EPA/540/R/99/005, OSWER 9285.7-02EP, NTIS No. PB99-963312, July.

[b]U.S. Environmental Protection Agency (EPA), 2002, ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites***, Office of Solid Waste and Emergency Response, OSWER 9355.4-24, December.

[c]Very low log K_{oc} reflects dissociation in solution to the anionic form, which is expected to be highly mobile in soil; sorption to soil and sediment constituents is expected to be insignificant.

[d]Hazardous Substances Data Bank (HSDB), 2005, National Library of Medicine, on line accessed 16 December.

[e]Assumed.

[f]Compound expected to be largely dissociated to the anionic form in solution; please see footnote [c].

[g]Calculated as described in Introduction to Toxicity Profiles.

2.0 Environmental Fate and Transport

The production and use of the dinitrophenols as described above may result in their release to the environment in various waste streams (HSDB, 2005).

Dinitrophenols are expected to be very mobile in soil because they behave as weak acids with pK_a values ranging from approximately 3 to 5, which indicates that these compounds will exist primarily as anions in moist soil (HSDB, 2005). Anions have very high mobility in soils. Volatilization of dinitrophenols from moist soil surfaces is not expected to be an important removal process because

anions will not volatilize and the non-dissociated component has a very low Henry's Law constant. The dinitrophenols are not expected to volatilize from dry soil surfaces because of their low vapor pressures. The dinitrophenols inhibit microbial growth in natural environmental systems because they uncouple the metabolic process of oxidative phosphorylation. Nonetheless, biodegradation half-lives for 2,4-dinitrophenol were reported as 32 days in an acidic soil and 4.6 days in a basic soil. This suggests that the undissociated form is the moiety that uncouples oxidative phosphorylation and the ionic form is more susceptible to microbial attack.

The dinitrophenols will exist predominantly as anions in water (HSDB, 2005). Sorption to sediment and volatilization are not expected to be a significant removal processes. Biodegradation half-lives for 2,4-dinitrophenol of 68 days and 2.8 days were reported for aerobic and anaerobic water systems, respectively.

Their relatively low vapor pressures indicate that the dinitrophenols are expected to exist in both the vapor and particulate phases in the ambient atmosphere (HSDB, 2005). Vapor-phase dinitrophenols are degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals with an estimated half-life of approximately 24 to 32 days. Particulate phase dinitrophenols may be removed from the air by wet and dry deposition. The dinitrophenols are likely to undergo direct photolysis in the environment.

The low log K_{ow} values for the dinitrophenols suggest that they would not participate significantly in food-chain pathways (HSDB, 2005). Furthermore, their high water solubility and the tendency of the dinitrophenols to dissociate would further inhibit bioconcentration (ATSDR, 1995). 2,4-Dinitrophenol is identified as a compound unlikely to bioconcentrate in fish (EPA, 1995). Because of the evidence that the dinitrophenols are unlikely to participate significantly in food-chain pathways, biotransfer factors are not estimated or compiled for these chemicals.

3.0 Toxicokinetics

The observation of adverse effects and fatalities, and the recovery of 2,4-dinitrophenol from the urine and tissues of workers exposed to 2,4-dinitrophenol in the munitions industry indicates that respiratory uptake is significant (ATSDR, 1995). The contribution of dermal uptake, however, is unclear.

Clinical studies with humans treated with 2,4-dinitrophenol as a diet aid and toxicokinetic studies in animals indicate short half-times both for GI absorption and excretion of metabolites (ATSDR, 1995), indicating that GI absorption is rapid and probably essentially complete.

The recovery of urinary metabolites in workers exposed to 2,4-dinitrophenol dust and the observation of mortality in guinea pigs exposed dermally to 2,4-dinitrophenol indicates that dermal absorption occurs (ATSDR, 1995). The contribution of inhalation exposure in the occupational scenario cannot be ascertained, but higher levels of urinary metabolites occurred during hot weather when dermal uptake may be greater, supporting the assumption of dermal absorption. Quantitative data were not located.

Data regarding the tissue distribution of the dinitrophenols is essentially limited to pharmacokinetic studies in mice that showed rapid uptake and rapid elimination from all tissues except the kidney

(ATSDR, 1995). The authors of the original study suggested that retention in the kidney could be related to tissue binding, but the evidence for this suggestion was not presented.

Animal studies indicate that metabolism of 2,4-dinitrophenol involves step-wise nitroreduction of the two nitro groups (ATSDR, 1995). At least in mice and probably also in rats, reduction of 2-nitro group is the first step and 2-amino-4-nitrophenol is the predominant circulating metabolite. In vitro studies indicate that 4-amino-2-nitrophenol is formed in lesser quantity than the 2-amino metabolite. The parent compound and the nitroreduction metabolites may be conjugated with glucuronic acid or sulfate before excretion, which is largely through the urine.

4.0 Dermal Exposure

EPA (2004) notes that organic chemicals are generally well absorbed from the GI tract, and recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly less than complete. Therefore, no GAF is developed for the dinitrophenols and the oral toxicity values described below should be used for dermal exposure without adjustment for GI absorption.

The dinitrophenols appear to be readily absorbed through the skin (ATSDR, 1995), however, data regarding the extent of dermal uptake from soil were not located. In the absence of empirical data, the EPA (2004) default ABS of 0.1 for SVOCs is selected for this evaluation.

t*, K_p, τ, FA and B values are provided by EPA (2004) or estimated by the EPA (2004) methodology as follows:

Chemical	t*	K_p	τ	FA	B
2,4-Dinitrophenol[a]	2.76	1.5E-3	1.15	1.0	0.0
2,5-Dinitrophenol[b]	2.71	2.11E-3	1.13	1	0.01
2,6-Dinitrophenol[b]	2.71	1.18E-3	1.13	1	0.0

t* = time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); □ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).
[a]Provided by EPA (2004).
[b]Calculated by the method of EPA (2004).

5.0 Noncancer Effects Evaluation

2,4-Dinitrophenol is moderately acutely toxic, with oral LD_{50} values in adult laboratory animals clustered between 30 to 45 mg/kg (ATSDR, 1995; HSDB, 2005). Weanling rats and mice had oral LD_{50} values of 71 to 72, suggesting that the young may be less susceptible to the acute toxicity of the compound. Death appeared to be due to the pyretic effects resulted from increased metabolic rate. The oral LD_{50} in rats of 2-amino-4-nitrophenol, the predominant metabolite of 2,4-dinitrophenol, was reported at 2400 mg/kg, suggesting that nitroreduction is a detoxication mechanism.

2,4-Dinitrophenol has been used as a diet aid because of its ability to increase basal metabolic rate (ATSDR, 1995; EPA, 2005). A common sequela to the use of 2,4-dinitrophenol as a diet aid in humans is cataract formation, associated with dose rates as low as 2 mg/kg-day, the lower end of the recommended therapeutic range. The 2 mg/kg-day dose was designated a LOAEL; a NOAEL was not identified. Application of an uncertainty factor of 1000 to the LOAEL of 2 mg/kg-day yields a verified chronic oral RfD of 2E-3 mg/kg-day. The uncertainty factor of 1000 adjusts for extrapolation of a NOAEL from a LOAEL, expands from subchronic to chronic exposure and

provides additional protection for unusually sensitive individuals, but individual factors were not designated for each of these adjustments. Confidence in the chronic oral RfD is low. The eye and increased basal metabolic rate are considered the target organ/critical effect of prolonged oral exposure to 2,4-dinitrophenol. EPA (1997) adopted the verified chronic oral RfD as the provisional subchronic oral RfD.

EPA (1997) evaluated the data available regarding the toxicity of 2,3-, 2,5-, 2,6- and 3,5-dinitrophenol and determined that the data (essentially nonexistent) were insufficient for estimation of an oral RfD. In the absence of chemical-specific data, the chronic and subchronic oral RfD for 2,4-dinitrophenol of 2E-3 mg/kg-day can be applied also to the other dinitrophenol isomers.

Accidental occupational exposure to high levels of 2,4-dinitrophenol, probably involving both inhalation and dermal uptake, is associated with a wide range of symptoms and signs, including marked fatigue, extreme thirst and profuse sweating, increased body temperature, flushing of the face, nausea, vomiting, abdominal pain and occasionally diarrhea (HSDB, 2005). Other signs include tachycardia, hyperpnea, dyspnea, cyanosis and muscle cramps. CNS signs and symptoms include restlessness, anxiety, and excitement often followed by depression. Death is probably due to respiratory collapse. Sequellae include decreased urine output accompanied by albuninuria, casts and pigment (evidence of renal glomerular damage), jaundice and tenderness over the region of the liver (evidence of toxic hepatitis), agranulocytic angina, skin rashes and hypersensitivity reactions, peripheral neuropathy and cataract formation.

In subacute poisoning due to repeated daily exposures, some individuals complain of lassitude, headache, and malaise, while others experience a disarming sense of well-being, energy, and drive (HSDB, 2005). Irritation of the mucous membranes of the eyes, respiratory tract, larynx and esophagus has also been reported. Although the data are complete for accidental exposure, the data for chronic exposure to lower levels are essentially lacking, precluding development of an inhalation RfC.

6.0 Carcinogenicity Evaluation

Data regarding the carcinogenicity of the dinitrophenols are very limited. 2,4-Dinitrophenol was not a tumor promoter in skin painting studies in female mice using dimethylbenzoic acid as an initiator (ATSDR, 1995). 2,4-Dinitrophenol was negative for genotoxicity in several tests; however, some of its metabolites appear to be genotoxic. EPA has not evaluated the carcinogenicity of the dinitrophenols.

7.0 Toxicity Summary

Toxicity values for 2,4-dinitrophenol are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
2E-3	2E-3	Eye, BMR	ND/ ND	ND/ ND	NA	ND	ND	ND	ND	ND

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo =

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data; NA = not applicable. Target organ or critical effect abbreviations: Eye = eye; BMR = basal metabolic rate. [a]sRfDo and cRfDo should be used for dermal exposure without adjustment for GI absorption.										

8.0 References

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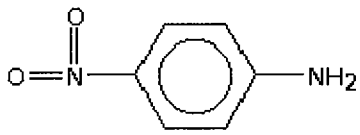
NITROANILINES



4-Nitroaniline

1.0 Introduction and Physical Properties

There are three nitroaniline isomers: 2-nitroaniline (o-nitroaniline), 3-nitroaniline (m-nitroaniline) and 4-nitroaniline (p-nitroaniline). The nitroanilines are **SVOCs** that occur as yellow-to-orange crystals or needles at ambient temperatures (HSDB, 2004). They are used as chemical intermediates for the synthesis of a wide range of red, yellow and orange pigments and dyes. 2-nitroaniline is also used in the synthesis of photographic antifogging agents, and 2- and 4-nitroaniline are used in the synthesis of phenylenediamine coccidiostats for treatment of poultry. 3-nitroaniline is used also in the production of 3-aminoacetanilide. 4-nitroaniline is also used to improve the fastness of dyes, and as an intermediate in the synthesis of antioxidants and gasoline gum inhibitors. Relevant physical properties are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
2-Nitroaniline (88-74-4)										
138.14[a]	1.85[a]	1.81E-8[a] (25□C)	1.79[a]	7.11E-2[b] (25□C)[c]	8.23E-6[b] (25□C)[c]	3.64E-6[a] (25□C)	1.47E+3[a] (25□C)	557.2[a]	ND	ND
3-Nitroaniline (99-09-2)										
138.12[a]	1.37[a]	7.2E-9[a] (25□C)	1.94[a]	7.11E-2[b] (25□C)[c]	8.23E-6[b] (25□C)[c]	4.76E-8[a] (25□C)	9.1E+2[a] (25□C)	579.2[a,d]	ND	2.6E+4[a]
4-Nitroaniline (100-01-6)										
138.12[a]	1.39[a]	1.81E-8[a] (25□C)[c]	1.93[a]	7.11E-2[b] (25□C)[c]	8.23E-6[b] (25□C)[c]	5.26E-6[a] (25□C)	7.24E+2[a] (25□C)	605.2[a]	ND	1.72E+4[a]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point (at 1 atm) of pure liquid compound (°K); T_c = critical temperature (°K); $H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole); ND = no data.

[a]Hazardous Substance Data Bank (HSDB), 2004, National Library of Medicine, on line, accessed 11 November.

[b]Calculated as described in Introduction to Toxicity Profiles.

[c]Assumed.

[d]Decomposes.

2.0 Environmental Fate and Transport

The nitroanilines may be released to the environment in waste effluents generated at sites of its commercial production or use as a chemical intermediate (HSDB, 2004). 2-Nitroaniline may also occur as a microbial decomposition product of dinitrobenzene. 4-Nitroaniline also may be released to the environment through stack emissions from waste incineration.

The nitroanilines released to the atmosphere are expected to exist largely in the vapor phase and degrade rapidly by reaction with photochemically produced hydroxyl radicals; half-lives less than 2 days have been estimated for these reactions for all isomers (HSDB, 2004). Direct photolysis may also contribute to the removal of these compounds. Wet and dry deposition may remove small amounts sorbed to airborne particulates. The potential for widespread dispersion of the nitroanilines in air is low.

Based on their relatively low K_{oc} values, the nitroanilines are expected to be highly mobile in soil and readily leach to groundwater (HSDB, 2004). However, the nitroanilines undergo covalent chemical bonding with humic materials in soil that can result in chemical alteration to latent forms

and tight sorption to organic matter. When covalently bound in this latent form, significant leaching in soil systems is not expected to occur. This covalent bonding proceeds in two steps; a rapid and reversible bonding followed by a slower and much less reversible reaction. Leaching in soil may occur prior to the second bonding reaction. The nitroanilines on soil surfaces exposed to sunlight may be susceptible to photodegradation. Various biological screening tests suggest that these compounds are generally resistant to biodegradation. The compounds are not expected to volatilize from moist or dry soils.

The nitroanilines released to surface water undergo chemical bonding with humic materials and clay in the water column and in the sediment (HSDB, 2004). Nitroaniline near the water surface may be susceptible to degradation by direct photolysis and photooxidation. Various biological screening tests suggest that these compounds are generally resistant to biodegradation. Aquatic hydrolysis and volatilization are not expected to be environmentally important removal processes, based upon the lack of hydrolyzable functional groups, low Henry's Law constants, and high water solubility. Benthic sediment may act as a sink for the nitroanilines.

The relatively low log K_{ow} values, reasonably high water solubility and toxicokinetic lability of the nitroanilines suggest that participation in food-chain pathways is unlikely to be significant. Therefore, biotransfer factors are not estimated for this class of compounds.

3.0 Toxicokinetics

EPA (2002a) reported that approximately 86 to 98 percent of the radioactivity from a single oral dose of radiolabeled 4-nitroaniline was recovered from the urine of male rats within 24 hours of treatment. Fecal recovery within 48 hours of treatment accounted for less than 1 percent to 5.8 percent of the dose of radioactivity. This suggests that GI absorption is rapid and essentially complete. Comparison of excretion dynamics following intravenous and oral administration of 4-nitroaniline to male rats revealed biphasic elimination with a whole-body half-life of approximately 1 hour (HSDB, 2004). This supports the assumption that GI absorption is rapid and essentially complete. Respiratory tract uptake of inhaled vapors and dusts, and dermal uptake of the nitroanilines through intact skin also occurs, but quantitative data were not available.

Data regarding distribution were not located; however, the elimination kinetics described above suggest that the nitroanilines are rapidly and widely distributed with no organ or tissue acting as a depot.

In vitro and *in vivo* experiments indicate that hydroxylation of the phenyl ring and nitroreduction are the predominant Phase I metabolic pathways for the nitroanilines (HSDB, 2004). Both unchanged parent compound and metabolites, including sulfate conjugates of unspecified metabolites, are excreted predominantly in the urine and to a lesser extent in the feces, indicating the potential for biliary excretion. Clearance from the body is almost complete within 3 days.

4.0 Dermal Exposure

EPA (2004) notes that organic chemicals are generally well absorbed from the GI tract, and recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly less than complete. Therefore, no GAF is developed for the nitroanilines and the oral toxicity values described below should be used for dermal exposure without adjustment for GI absorption.

The nitroanilines are readily absorbed through intact skin (HSDB, 2004); however, data regarding dermal uptake from soil were not located. Lacking empirical data, the EPA (2004) default ABS of 0.1 for SVOCs is adopted for the nitroanilines for this evaluation. t*, K_p, τ, FA and B values are estimated by the EPA (2004) methods as follows:

Chemical	t*	K_p	τ	FA	B
2-Nitroaniline	1.5	4.44E-3	0.623	1	0[a]
3-Nitroaniline	1.5	2.14E-3	0.623	1	0[a]
4-Nitroaniline	1.5	2.21E-3	0.623	1	0[a]

t* = time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); □ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).
[a]Value sufficiently small to be rounded to zero.

5.0 Noncancer Effects Evaluation

Oral LD_{50} values for 2-nitroaniline include 400 to 3650 mg/kg in rats, 2350 mg/kg in guinea pigs and 1070 to 1290 mg/kg in mice (EPA, no date # 1; HSDB, 2004; Montgomery, 1996), suggesting that the acute toxicity is low. Prolonged oral exposure to 2-nitroaniline is associated with methemoglobinemia. EPA (no date #1) provided a provisional chronic oral RfD for 2-nitroaniline of 3E-4 mg/kg-day by applying an additional uncertainty factor of 10 to a provisional oral RfD for 4-nitroaniline of 3E-3 mg/kg-day (EPA, no date #2). More recently EPA (2002b) reevaluated the derivation described above and determined that an uncertainty factor of 10 was not required to extrapolate from 4-nitroaniline to 2-nitroaniline because the former is more acutely toxic than the latter. Therefore, the provisional chronic oral RfD of 3E-3 mg/kg-day originally derived for 4-nitroaniline is adopted as the provisional chronic oral RfD for 2-nitroaniline. Confidence in the chronic oral RfD is low. EPA (2002b) also adopted the provisional chronic oral RfD as the provisional subchronic oral RfD for 2-nitroaniline. The target organ for prolonged oral exposure to 2-nitroaniline is the erythrocyte; oxidation of hemoglobin to methemoglobin is the mechanism of toxicity.

Oral LD_{50} values for 3-nitroaniline include 535 to 900 mg/kg in rats, 450 to 540 mg/kg in guinea pigs and 308 to 450 mg/kg in mice (EPA, no date # 1; HSDB, 2004; Montgomery, 1996), suggesting that the acute toxicity of 3-nitroaniline is somewhat greater than 2-nitroaniline. 3-Nitroaniline induces methemoglobinemia in rats (HSDB, 2004). EPA (no date #2) provided a provisional chronic oral RfD for 3-nitroaniline of 3E-4 mg/kg-day by applying an additional uncertainty factor of 10 to a provisional oral RfD for 4-nitroaniline of 3E-3 mg/kg-day. EPA (2002a) reevaluated the data and concurred with the provisional chronic oral RfD of 3E-4 mg/kg-day for 3-nitroaniline. Confidence in the provisional chronic oral RfD for 3-nitroaniline is low. The target organ for prolonged oral exposure to 3-nitroaniline is the erythrocyte; oxidation of hemoglobin to methemoglobin is the mechanism of toxicity. The provisional chronic oral RfD for 3-nitroaniline of 3E-4 mg/kg-day is adopted as the preliminary subchronic oral RfD.

Oral LD_{50} values for 4-nitroaniline include 750 to 3250 mg/kg in rats, 450 mg/kg in guinea pigs and 810 mg/kg in mice (EPA, no date # 1; Montgomery, 1996), suggesting that the acute toxicity of 4-nitroaniline is somewhat greater than 2-nitroaniline, at least in guinea pigs. Prolonged oral exposure to 4-nitroaniline is associated with methemoglobinemia, with hemolytic anemia and increased hematopoiesis as common sequellae (EPA, no date # 2). Rats appear to be more sensitive than mice.

A 2-year gavage study in rats identified 0.25 mg/kg-day as a NOAEL and 1.5 mg/kg-day as a LOAEL, with increased mortality at 9 mg/kg-day, the highest dose rate tested. The LOAEL was associated with increased blood methemoglobin concentration, decreased blood hemoglobin concentration, decreased erythrocyte count and increased reticulocyte count. Brown pigment deposits (probably hemosiderin associated with erythrocyte destruction) were observed in the liver and spleen. Application of an uncertainty factor of 100 to the NOAEL yields a provisional chronic oral RfD for 4-nitroaniline of 3E-3 mg/kg-day. EPA (2002c) reevaluated the data and came to the same conclusions, confirming the provisional chronic oral RfD of 3E-3 mg/kg-day. Confidence in the chronic oral RfD is high. The target organ for prolonged oral exposure to 4-nitroaniline is the erythrocyte; oxidation of hemoglobin to methemoglobin is the mechanism of toxicity. The provisional chronic oral RfD for 4-nitroaniline of 3E-3 mg/kg-day is adopted as the preliminary subchronic oral RfD.

Occupational exposure to the nitroanilines is associated with methemoglobinemia and possibly liver damage (HSDB, 2004). An earlier provisional chronic inhalation RfC of 2E-4 mg/m^3 for 2-nitroaniline had been based on a LOAEL of 9.8 mg/m^3 in a 4-week intermittent inhalation study in male rats (EPA, 1997). The LOAEL was associated with methemoglobinemia and increased hematocrit. An uncertainty factor of 10,000 was applied. More recently, EPA (2002b) reevaluated these data and applied updated dosimetric conversions to estimate a LOAEL human equivalent concentration of 0.3 mg/m^3. Refinement of the dosimetric conversion justified reducing the uncertainty factor to 3000. Application of the new uncertainty factor of 3000 to the new LOAEL human equivalent concentration of 0.3 mg/m^3 yields a new provisional chronic inhalation RfC of 1E-4 mg/m^3 for 2-nitroaniline. The chronic inhalation RfC is equivalent to an inhalation RfD of 2.9E-5 mg/kg-day. The target organ for prolonged inhalation exposure to 2-nitroaniline is the erythrocyte; oxidation of hemoglobin to methemoglobin is the mechanism of toxicity. EPA (2002b) also derived a new provisional subchronic inhalation RfC of 1E-3 mg/m^3 by application of an uncertainty factor of 300 to the LOAEL human equivalent concentration. The uncertainty factor of 300 reflects the chronic uncertainty factor of 3000 without a factor of 10 that was used to expand from chronic to subchronic exposure. The subchronic inhalation RfC is equivalent to an inhalation RfD of 2.9E-4 mg/kg-day. Confidence in the new provisional RfC is low.

EPA (2002d) derived a provisional chronic inhalation RfC for 3-nitroaniline of 1E-3 mg/m^3 by applying an uncertainty factor of 3 to the provisional chronic inhalation RfC for 4-nitroaniline of 4E-3 mg/m^3 (EPA, 2002e) described below. The provisional chronic inhalation RfC is equivalent to 2.9E-4 mg/kg-day. The target organ for prolonged inhalation exposure to 3-nitroaniline is the erythrocyte; oxidation of hemoglobin to methemoglobin is the mechanism of toxicity. Confidence in the provisional chronic inhalation RfC for 3-nitroaniline is low. The uncertainty factor applied by EPA (2002e) to derive the chronic inhalation RfC for 4-nitroaniline contained a factor of 10 to expand from subchronic to chronic exposure. Therefore, a preliminary subchronic inhalation RfC for 3-nitroaniline can be derived by multiplying the provisional chronic inhalation RfC by a factor of 10. The preliminary subchronic inhalation RfC of 1E-2 mg/m^3 (2.9E-3 mg/kg-day) is so derived.

EPA (2002e) reported increased blood methemoglobin formation and various morphological changes in the erythrocytes of rats exposed by inhalation to an aerosol of 4-nitroaniline on 6 hours per day, 5 days per week for 4 weeks. The NOAEL was 10 mg/m^3, 32 mg/m^3 was the LOAEL. The NOAEL was adjusted to a human equivalent concentration of 4.2 mg/m^3. Application of an uncertainty factor of 1000 yields the provisional chronic inhalation RfC for 4-nitroaniline of 4E-3

mg/m^3, which is equivalent to 1.1E-3 mg/kg-day. The target organ for prolonged inhalation exposure to 4-nitroaniline is the erythrocyte; oxidation of hemoglobin to methemoglobin is the mechanism of toxicity. Confidence in the RfC is low. The chronic uncertainty factor of 1000 consists of factors of 10 each to provide additional protection for more sensitive individuals and to expand from subchronic to chronic exposure, and factors of 3 each to extrapolate from animals to humans and to account for deficiencies in the data base. A preliminary subchronic inhalation RfC can be derived by applying an uncertainty factor of 100 to the NOAEL human equivalent concentration of 4.2 mg/m^3. The uncertainty factor of 100 reflects the chronic uncertainty factor of 1000 without the factor of 10 to expand from subchronic to chronic exposure. The preliminary subchronic inhalation RfC derived is 4E-2 mg/m^3, which is equivalent to 1.1E-2 mg/kg-day.

6.0 Carcinogenicity Evaluation

EPA (2002b) reviewed the data regarding the potential carcinogenicity of 2-nitroaniline, including the advisability of developing an assessment by analogy to 4-nitroaniline, and concluded that the data are inadequate for an assessment of human carcinogenic potential.

EPA (2002f) reviewed the data regarding the potential carcinogenicity of 3-nitroaniline and concluded that 3- and 4-nitroaniline are sufficiently similar in physical properties, acute toxicity and genotoxicity that the EPA cancer weight-of-evidence Group C designation for 4-nitroaniline (EPA, 2002g) (see below) can be applied as well to 3-nitroaniline. Furthermore, the provisional oral SF of 2.1E-2 per mg/kg-day derived for 4-nitroaniline was adopted as the provisional oral SF for 3-nitroaniline. The data were insufficient for estimation of potency factors for inhalation exposure to 3-nitroaniline.

EPA (2002g) classified 4-nitroaniline in cancer weight-of-evidence Group C or *likely to be carcinogenic to humans* on the basis of limited (equivocal) evidence of carcinogenicity in male mice (vascular tumors) in a 2-year gavage study. There was no evidence of carcinogenicity in rats in a similar 2-year study. EPA (2002g) estimated a provisional oral SF of 2.1E-2 per mg/kg-day from the incidence of vascular tumors in male mice. The data were inadequate for estimation of an inhalation unit risk for exposure to 4-nitroaniline.

7.0 Toxicity Summary

Toxicity values for the nitroanilines are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure[a]		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
2-Nitroaniline										
3E-3	3E-3	E	1E-3/ 2.9E-4	1E-4/ 2.9E-5	E	Section 6.0	NA	Section 6.0	NA	NA
3-Nitroaniline										
3E-4	3E-4	E	1E-2/ 2.9E-3	1E-3/ 2.9E-4	E	C	2.1E-2	C	ND	ND
4-Nitroaniline										
3E-3	3E-3	E	4E-2/ 1.1E-2	4E-3/ 1.1E-3	E	C	2.1E-2	C	ND	ND

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data; NA = not applicable.
Target organ or critical effect abbreviations: E = erythrocyte.
[a]sRfDo, cRfDo and SFo should be used for dermal exposure without adjustment for GI absorption.

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METHYLPHENOLS (CRESOLS)

(NIST Figure)

1.0 Introduction and Physical Properties

The methylphenols, also known as cresols, exist as three isomers: 2-methylphenol (o-cresol), 3-methylphenol (m-cresol) and 4-methylphenol (p-cresol). The commercial cresol mixture (1319-77-3) consists of approximately 20 percent o-cresol, 40 percent m-cresol and 30 percent p-cresol with small amounts of phenol and xylenols (HSDB, 2005). All cresol isomers are **SVOCs** based on their H values. o-Cresol and p-cresol occur in the pure form as solids at ambient temperatures; m-cresol occurs as a liquid (HSDB, 2005). The cresols are used as disinfectants, in ore flotation, as textile scouring agents, surfactants, and as intermediates in the production of phenolic resins, tricresyl phosphate, coumarin, herbicides and pharmaceuticals (HSDB, 2005; Lewis, 1997). o-Cresol is used in tanning and metal degreasing, and in the explosive, petroleum, photographic, paint, and agricultural industries (HSDB, 2005). m-Cresol is also used in photographic developers, and in the synthesis of salicylaldehyde, synthetic pyrethroid insecticides, 3-methyl-6-t-butylphenol, and trinitro-m-cresol for explosives. It is also used as a disinfected in hospital, critical care and veterinary facilities, and in the production of synthetic food flavors and antioxidants (ATSDR, 1992). Relevant physical properties are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
o-Cresol (95-48-7)										
108.1[a]	1.95[a]	1.20E-6[b] (25°C)	1.96[b]	7.40E-2[b] (25°C)	8.30E-6[b] (25°C)	3.93E-4[c] (25°C)	2.60E+4[b] (20-25°C)	464.2[d]	697.6[d]	1.08E+4[d]
m-Cresol (108-39-4)										
108.1[a]	1.96[a]	8.7E-7[c] (25°C)	1.54[c]	8.37E-2[e] (25°C)f	9.69E-6[e] (25°C)[f]	1.84E-4[c] (25°C)	2.27E+4[c] (25°C)	475[c]	615.6[c]	1.13E+4[c]
p-Cresol (106-44-5)										
108.1[a]	1.95[a]	1E-6[c] (25°C)	2.25[c,g]	8.37E-2[e] (25°C)f	9.69E-6[e] (25°C)[f]	1.45E-4[c] (25°C)	1.8E+4[h] (25°C)	474.95[c]	704.6[c]	1.13E+4[c]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point (at 1 atm) of pure liquid compound (°K); T_c = critical temperature (°K);.$H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole); ND = no data.

[a]U.S. Environmental Protection Agency (EPA), 2004, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final***, Office of Superfund Remediation and Technology Innovation, Washington, DC, EPA/540/R/99/005, OSWER 9285.7-02EP, NTIS No. PB99-963312, July.

[b]U.S. Environmental Protection Agency (EPA), 2002, ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites***, Office of Solid Waste and Emergency Response, OSWER 9355.4-24, December.

[c]Hazard Substances Data Bank (HSDB), 2005, National Library of Medicine, on line, accessed 13 December.

[d]U.S. Environmental Protection Agency (EPA), 2003, ***Users Guide for Evaluating Subsurface Vapor Intrusion into Buildings***, Office of Emergency and Remedial Response, Washington, DC, 19 June.

[e]Calculated as described in Introduction to Toxicity Profiles.

[f]Assumed.

[g]Midpoint of reported range.

[h]Montgomery, J.H., 1996, ***Groundwater Chemicals Desk Reference, Second Edition***, Lewis Publishers, New York, pp. 722-728.

2.0 Environmental Fate and Transport

Cresols are released to the environment by natural and anthropogenic processes (ATSDR, 1992; HSDB, 2005). Production and use of the cresols as solvents, disinfectants and chemical intermediates may result in their release to the environment as fugitives and through various waste streams. Combustion of coal and other fuels, and incineration of municipal waste may release cresols to the atmosphere. In particular, o-cresol is also released to the environment through automobile exhaust, coal tar and petroleum refining, and wood pulping. m-Cresol and p-cresol are also released to the environment through automobile exhaust and tobacco smoke. Cresols are widespread in nature occurring in many plants and trees, as products of microbial activity, and in the excreta of many mammals. Processing of crude oil, coal tar and wood products and wood

combustion may release cresols to the atmosphere. Although the cresols are fairly ubiquitous in the environment, their concentrations are generally low, reflecting their relatively rapid removal rates.

The vapor pressures of the cresols suggest that they will occur in the atmosphere predominantly or entirely in the vapor phase (ATSDR, 1992; HSDB, 2005). Empirical data validate this assumption. Vapor-phase cresols are degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals during the day and with nitrate radicals at night. Half-lives for these reactions are on the order of 6 to 9 hours. The cresols are relatively water soluble; wet deposition may also be a significant removal mechanism. The cresols are not expected to travel in the atmosphere far from their point of release.

The relatively low log K_{oc} values indicate that the cresols are expected to be highly mobility in soil, and may readily leach to groundwater (ATSDR, 1992; HSDB, 2005). However, the hydroxyl moiety of the cresols is capable of forming strong hydrogen bonds with some soil constituents. The potential for this reaction is highly dependent on soil pH, organic matter content, iron oxide content and anion exchange capacity. The cresols may be only slightly mobile in soils in which hydrogen bonding occurs strongly. Volatilization of the cresols from moist soil surfaces is expected to occur slowly as a result of the low Henry's Law constants for these compounds. Their relatively low vapor pressures indicate that the cresols are not expected to volatilize significantly from dry soil surfaces. Biodegradation half-lives of 0.5 to 11.3 days in agricultural soils suggest that this may be the most important process for removing the cresols from soil. Biodegradation appears to occur more consistently and quickly under aerobic conditions than under anaerobic conditions.

Based on their log K_{oc} values, o-cresol and m-cresol are not expected to sorb to suspended solids and sediment in water (ATSDR, 1992; HSDB, 2005). However, sorption may be significant for p-cresol or under conditions that favor formation of hydrogen bonds as described above. Volatilization from water surfaces is expected to be relatively slow based upon the Henry's Law constants for these compounds. Volatilization half-lives for a model river of 31 to 54 days and for a model lake of 235 to 394 days have been estimated for the cresols. Biodegradation is expected to be the most important process for removing cresols from water. Half-lives on the order of 2 to 50 days are expected under aerobic conditions, although the results of different tests are quite variable. Half-lives may be extended to weeks or months under anaerobic conditions.

BCF modeling as well as empirical data suggest that bioconcentration will not be important, and that the cresols are unlikely to participate significantly in aquatic or terrestrial food-chain pathways (ATSDR, 1992; HSDB, 2005). Therefore, biotransfer factors are not estimated for the cresols.

3.0 Toxicokinetics

Quantitative data were not located regarding the extent of respiratory uptake from inhalation exposure. The observation of adverse effects including mortality in laboratory animals exposed by inhalation suggests that respiratory uptake is probably significant (ATSDR, 1992). Excretion studies in animals indicate that GI absorption is at least 65 percent. Although quantitative data were not located, the observation of adverse effects including mortality in dermally exposed laboratory animals suggests that dermal uptake is probably significant.

Data were not located regarding the tissue distribution of absorbed cresols or their metabolites; however, the relatively high solubility in water of the cresols suggest that distribution is probably widespread throughout the water compartment of the body.

Data regarding metabolism of absorbed cresols is limited. It appears that metabolism is extensive and that the predominant metabolites recovered from the urine of laboratory animals are glucuronide and sulfate ethereal conjugates (ATSDR, 1992). The proportions of specific conjugates appear to vary with dose and species of laboratory animal. Also, o- and m-cresol may undergo oxidation of the aromatic ring to form 2,5-dihydroxytoluene. Oxidation of the methyl group of p-cresol may yield p-hydroxybenzoic acid.

Excretion appears to occur primarily through the kidney, as 65 to 84 percent of an oral dose of various cresols in rabbits was recovered in the urine within 24 hours of treatment (ATSDR, 1992). Not more than 2 percent of the dose was recovered as unchanged and unconjugated compound. Data were not located regarding the potential for excretion by other routes.

4.0 Dermal Exposure

EPA (2004) notes that organic chemicals are generally well absorbed from the GI tract, and recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly less than complete. Therefore, no GAF is developed for the cresols and the oral toxicity values described below should be used for dermal exposure without adjustment for GI absorption.

As noted above, the cresols are absorbed through the skin at levels sufficient to produce toxicity or death (ATSDR, 1992); however, data regarding the dermal uptake of the cresols from soil were not located. Therefore, the EPA (2004) default ABS of 0.1 for SVOCs is adopted for all the cresols for this evaluation. t*, K_p, τ, FA and B values are provided by EPA (2001) as follows:

Chemical	t*	K_p	τ	FA	B
o-Cresol	1.03	7.7E-3	0.43	1.0	0.0
m-Cresol	1.03	7.8E-3	0.43	1.0	0.0
p-Cresol	1.03	7.7E-3	0.43	1.0	0.0
t* = time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); □ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).					

5.0 Noncancer Effects Evaluation

Oral LD_{50} values include 1350, 2020, and 1800 mg/kg for o-cresol, m-cresol and p-cresol, respectively, in rats, and 500 to 2050 mg/kg for various cresol formulations in mice (ATSDR, 1992). Acute oral exposure of laboratory animals to any of the cresols results in convulsions, coma and death (HSDB, 2005). Prolonged oral exposure to o-cresol induces CNS stimulation, rapid respiration, behavioral changes and deficits, and reduced body weights in the absence of organ-specific histopathologic lesions (EPA, 2005). Although it is not entirely clear from the IRIS record, reduced food intake alone does not appear to fully account for the reduced body weights. The rapid respiration was probably a manifestation of CNS stimulation. EPA (2005) presents a verified chronic oral RfD for o-cresol of 5E-2 mg/kg-day based on a NOAEL of 50 mg/kg-day and an uncertainty factor of 1000. The key study was a 90-day gavage study in rats in which each of the cresol isomers was evaluated individually. (The IRIS record states that the test substance was p-

cresol rather than o-cresol. However, there was no discussion in the IRIS record regarding extrapolation from p- to o-cresol. It is suspected that the mention of p-cresol is an oversight, and that the results from the o-cresol study serve as the basis of the oral RfD for o-cresol.) Confidence in the chronic oral RfD is medium. The critical effects/target organs for prolonged oral exposure to o-cresol include reduced body weight and CNS effects.

EPA (1997) presents a provisional subchronic oral RfD for o-cresol of 5E-1 mg/kg-day, based on the same study as the verified chronic oral RfD. The subchronic oral RfD was derived by applying an uncertainty factor of 100 to the subchronic NOAEL of 50 mg/kg-day. The uncertainty factor of 100 reflects the chronic uncertainty factor of 1000 without a factor of 10 to expand from subchronic to chronic exposure.

EPA (2005) presents a verified chronic oral RfD of 5E-2 mg/kg-day for m-cresol based on a NOAEL of 50 mg/kg-day in the same gavage study described above, with m-cresol used as the test substance. The dose-effect response for m-cresol was virtually identical to that for o-cresol. An uncertainty factor of 1000 was applied to the NOAEL, as was the case for o-cresol. Confidence in the chronic oral RfD is medium. The critical effects/target organs for prolonged oral exposure to m-cresol include reduced body weight and CNS effects.

EPA (1997) presents a provisional subchronic oral RfD for m-cresol of 5E-1 mg/kg-day, based on the same study as the verified chronic oral RfD. The subchronic oral RfD was derived by applying an uncertainty factor of 100 to the subchronic NOAEL of 50 mg/kg-day. The uncertainty factor of 100 reflects the chronic uncertainty factor of 1000 without a factor of 10 to expand from subchronic to chronic exposure.

Data reviewed by EPA (1997) suggest that rabbits may be more sensitive than rats to the CNS effects of p-cresol. A provisional chronic oral RfD of 5E-3 mg/kg-day is based on maternal effects in rabbits treated by gavage on gestation days 6-18. Effects reported include hypoactivity, respiratory distress and maternal deaths. An uncertainty factor of 1000 was applied to the NOAEL of 5 mg/kg-day. The respiratory distress, which was also seen in rats treated with o-cresol or m-cresol, is probably a manifestation of CNS stimulation. The critical effects/target organs for prolonged oral exposure to p-cresol identified by EPA (1997) are limited to CNS effects. EPA (1997) adopted the provisional chronic oral RfD of 5E-3 mg/kg-day as the provisional subchronic oral RfD for p-cresol.

ACGIH (1991) states that p-cresol is more toxic to humans than o-cresol, which is more toxic than m-cresol under conditions of occupational exposure. The data are inadequate for development of inhalation RfCs for any of the cresols.

6.0 Carcinogenicity Evaluation

EPA (2005) classified o-cresol in cancer weight-of-evidence Group C – possible human carcinogen – on the basis of an increased incidence of skin papillomas in mice in an initiation-promotion study. Also, the three cresols produced positive results in genetic toxicity studies both alone and in combination. Human cancer data are not available. The data are inadequate for estimation of a SF for oral exposure or a URF for inhalation exposure to o-cresol.

EPA (2005) classified m-cresol in cancer weight-of-evidence Group C – possible human carcinogen – on the basis of an increased incidence of skin papillomas in mice in an initiation-promotion study. As noted above, the three cresols produced positive results in genetic toxicity studies both alone and in combination. Human cancer data are not available. The data are inadequate for estimation of a SF for oral exposure or a URF for inhalation exposure to m-cresol.

EPA (2005) classified p-cresol in cancer weight-of-evidence Group C – possible human carcinogen – on the basis of an increased incidence of skin papillomas in mice in an initiation-promotion study. As noted above, the three cresol isomers produced positive results in genetic toxicity studies both alone and in combination. Human cancer data are not available. The data are inadequate for estimation of a SF for oral exposure or a URF for inhalation exposure to p-cresol.

7.0 Toxicity Summary

Toxicity values for the cresols are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
o-Cresol										
5E-1	5E-2	Bw, CNS	ND/ ND	ND/ ND	NA	C	ND	C	ND	ND
m-Cresol										
5E-1	5E-2	Bw, CNS	ND/ ND	ND/ ND	NA	C	ND	C	ND	ND
p-Cresol										
5E-3	5E-3	CNS	ND/ ND	ND/ ND	NA	C	ND	C	ND	ND

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data; NA = not applicable.
Target organ or critical effect abbreviations: Bw = body weight; CNS = central nervous system.
[a]sRfDo and cRfDo should be used for dermal exposure without adjustment for GI absorption.

8.0 References

Agency for Toxic Substances and Disease Registry (ATSDR), 1992, ***Toxicological Profile for Cresols: o-Cresol, p-Cresol, m-Cresol***, U.S. Department of Health and Human Services, Atlanta, Georgia, on line, July.

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Lewis, R.J., Sr., 1997, ***Hawley's Condensed Chemical Dictionary***, Thirteenth Edition, John Wiley & Sons, Inc., New York, p. 309.

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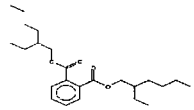
U.S. Environmental Protection Agency (EPA), 2005, ***Integrated Risk Information System (IRIS)***, National Center for Environmental Assessment, Cincinnati, OH, on line, accessed 13 December.

PHTHALATES



bis(2-Ethylhexyl)phthalate

1.0 Introduction and Physical Properties

The phthalic acid esters (PAE) are a large group of ubiquitous compounds with considerable variability regarding physical characteristics. The PAEs of common environmental interest occur as clear, pale or colorless oily or viscous liquids, except for dimethyl phthalate, which occurs as pale yellow crystals at room temperature (HSDB, 2005). All are considered to be **SVOCs** except di-n-octyl phthalate, which is a **VOC** because it has an unusually high Henry's Law constant. It should be noted that EPA (2004a) does not consider di-n-octyl phthalate to be a VOC. The PAEs are used predominantly to impart flexibility to plastics, which may contain up to 50 percent PAE by weight (ATSDR, 1995, 1997, 2001, 2002; EPA, 1991). Diethyl phthalate is used largely in plastics for food packaging. Minor uses include pesticide carriers, cosmetics, fragrances, munitions, industrial oils and insect repellents. Relevant physical properties for the more environmentally important PAEs are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
bis(2-Ethylhexyl)phthalate (SVOC) (117-81-7)										
391[a]	5.11[a]	1.02E-7[b] (25°C)	7.18[b]	3.51E-2[b] (25°C)	3.66E-6[b] (25°C)	9.51E-11[c] (25°C)	3.40E-1[b] (20-25°C)	NA	NA	NA
Butyl benzyl phthalate (SVOC) (85-68-7)										
312.39[c]	4.73[d]	1.26E-6[b] (25°C)	4.76[b]	1.74E-2[b] (25°C)	4.83E-6[b] (25°C)	1.13E-8[c] (20°C)	2.69E+0[b] (20-25°C)	NA	NA	NA
Di-n-butyl phthalate (SVOC) (84-74-2)										
278[a]	4.13[a]	9.39E-10[b] (25°C)	4.53[b]	4.38E-2[b] (25°C)	7.86E-6[b] (25°C)	2.64E-8[c] (25°C)	1.12E+1[b] (20-25°C)	NA	NA	NA
Diethyl phthalate (SVOC) (84-66-2)										
222[a]	2.47[a]	4.51E-7[b] (25°C)	2.46[b]	2.56E-2[b] (25°C)	6.35E-6[b] (25°C)	2.76E-6[b] (25°C)	1.08E+3[b] (20-25°C)	NA	NA	NA
Dimethyl phthalate (SVOC) (131-11-3)										
194[a]	1.56[a]	2.07E-7[c] (25°C)	5.02[c]	5.67E-2[e] (25°C)[f]	6.56E-6[e] (25°C)[f]	4.05E-6[e] (25°C)	4.0E+3[c] (25°C)	NA	NA	NA
Di-n-octyl phthalate (VOC) (117-84-0)										
390.56[c]	8.10[c]	6.68E-5[b] (25°C)	7.92[b]	1.51E-2[b] (25°C)	3.58E-6[b] (25°C)	3.42E-9[c] (25°C)	2.00E-2[b] (20-25°C)	704.09[g]	862.22[g]	1.40E+4[g]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point (at 1 atm) of pure liquid compound (°K); T_c = critical temperature (°K); $H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole); NA = not applicable.

[a]U.S. Environmental Protection Agency (EPA), 2004, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final***, Office of Superfund Remediation and Technology Innovation, Washington, DC, EPA/540/R/99/005, OSWER 9285.7-02EP, NTIS No. PB99-963312, July.

[b]U.S. Environmental Protection Agency (EPA), 2002, ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites***, Office of Solid Waste and Emergency Response, OSWER 9355.4-24, December.

[c]Hazard Substances Data Bank (HSDB), 2005, National Library of Medicine, on line, accessed 13 December.

[d]U.S. Environmental Protection Agency (EPA), 2004, ***EPI Suite Version 3.12*** Software for estimating physical properties, online, 30 November.

[e]Calculated as described in Introduction to Toxicity Profiles.

[f]Assumed.

[g]U.S. Environmental Protection Agency (EPA), 2003, ***Users Guide for Evaluating Subsurface Vapor Intrusion into Buildings***, Office of Emergency and Remedial Response, Washington, DC, 19 June.

2.0 Environmental Fate and Transport

The PAEs are widely used and are released inadvertently and in waste streams during their production, use and disposal, either in landfills or by incineration (ATSDR, 1995, 1997, 2001, 2002; EPA, 1991). bis(2-Ethylhexyl) phthalate and diethyl phthalate are the PAEs most frequently encountered in environmental media.

The VP values compiled above indicate that the PAEs will exist in both the vapor and particulate phases in the atmosphere (ATSDR, 1995, 1997, 2001, 2002; HSDB, 2005). The lower molecular weight PAEs such as dimethyl and diethyl phthalate will exist solely or predominately in the vapor phase. PAEs in the vapor phase are degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals. Half-lives of approximately 18 hours to 28 days have been estimated for this reaction. Particulate phase PAEs are physically removed from the atmosphere by wet and dry deposition.

PAEs in soil sorb to other soil constituents, the extent of adsorption directly related to molecular weight (ATSDR, 1995, 1997, 2001, 2002; HSDB, 2005). Dimethyl phthalate may exhibit moderate to high mobility and the potential to leach to groundwater. Diethyl phthalate, butyl benzyl phthalate and di-n-butyl phthalate are expected to exhibit low mobility in soil; bis(2-ethylhexyl) phthalate and di-n-octyl phthalate are expected to be practically immobile. Biodegradation is probably the most important removal process under aerobic conditions and, for some of the PAEs, also under anaerobic conditions. Volatilization is not expected to be significant from either wet or dry soil.

PAEs released to water sorb to sediment and deposit on the bottom, but some remains in solution (ATSDR, 1995, 1997, 2001, 2002; HSDB, 2005). Hydrolysis is expected to occur slowly or practically not at all, depending on the molecular weight of the individual chemical. Biodegradation is the most significant removal process. Volatilization from water surfaces is not expected to be significant.

Empirical data in fish suggest that bioconcentration is somewhat less than predicted by models based on K_{ow}, probably because fish efficiently metabolize the PAEs (ATSDR, 1995, 1997, 2001, 2002; HSDB, 2005). For example, experiments with rainbow trout (*Salmo gairdneri*) showed that the majority of radiolabeled bis(2-ethylhexyl) phthalate did not reach the systemic circulation of the fish, but was present in the exposure water as metabolites as a result of presystemic branchial metabolism of this compound during uptake from the water to the blood. The limited empirical data indicate that BCF values are larger for aquatic organisms at the lower trophic levels. EPA (1995a) lists the PAEs as compounds that are not bioaccumulative chemicals of concern in fish. Bioaccumulation in terrestrial food chains is unlikely because mammals readily metabolize and eliminate the PAEs (ATSDR, 1995, 1997, 2001, 2002; HSDB, 2005). Therefore, biotransfer factors are not developed for the PAEs.

3.0 Toxicokinetics

The toxicokinetics of bis(2-ethylhexyl)phthalate has been studied more intensively than the other PAEs, but some data are available for the others. All the PAEs appear to behave similarly regarding toxicokinetics. Therefore, this discussion focuses largely on bis(2-ethylhexyl)phthalate.

The available data indicate that the PAEs are absorbed from the respiratory tract, although quantitative data were not located (ATSDR, 1995, 1997, 2001, 2002).

Data regarding GI absorption of the PAEs is incomplete and inconsistent. Urinary excretion studies in laboratory rodents indicate that di-n-butyl phthalate is essentially completely absorbed, although most is probably absorbed as the monoester mono-n-butyl phthalate following hydrolysis in the gut (ATSDR, 2001). Hydrolysis of an ester linkage to form the monoester probably precedes GI

absorption of all the PAEs (ATSDR, 1997), including bis(2-ethylhexyl)phthalate (ATSDR, 2002). ATSDR(2002) concluded that approximately 20 to 25 percent of ingested bis(2-ethylhexyl)phthalate is absorbed, based on urinary excretion of metabolites (11-15 percent of a single oral dose) and the observation in laboratory animals that biliary excretion is significant. However, there appear to be substantial species differences in the extent of biliary excretion, and therefore, the potential for enterohepatic recirculation. It seems likely that GI uptake of bis(2-ethylhexyl)phthalate and its various intestinal hydrolysis products is essentially complete, although enterohepatic recirculation and other routes of excretion may mask its true extent, depending on the position of radiolabeled carbon used in the tracer studies. Also, animal studies indicate that GI absorption in saturable so that efficiency of absorption decreases with increasing dose.

Dermal uptake may be substantial for neat diethyl phthalate; *in vivo* studies in rats indicate approximately 50 percent absorption (ATSDR, 1995). Tests with the other PAEs in the same study showed that the rate and extent of dermal uptake was inversely correlated with the length (above four carbon atoms) of the side chain.

The results of tissue distribution studies can be confounded by the presence of PAEs used as components of laboratory plasticware (ATSDR, 2002). Highest tissue levels, however, appear in adipose tissue, liver, kidney and blood.

Metabolism of the PAEs appears to follow the same pattern in all species, namely hydrolysis of one or both ester linkages followed by oxidation of the remaining attached or the released side chain, possibly with reduction of the number of carbon atoms (ATSDR, 1997, 2002). Conjugation with glucuronic acid also occurs.

Excretion of PAE metabolites occurs via the kidney, but biliary excretion is also important (ATSDR, 1995, 1997, 2001, 2002). It is possible that smaller carbon units from hydrolysed side chains may be assimilated into the 1- or 2-carbon pool, eventually to be released as exhaled carbon dioxide, although the data are unclear.

4.0 Dermal Exposure

EPA (2004b) notes that organic chemicals are generally well absorbed from the GI tract, and recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly less than complete. Therefore, no GAFs are developed for the PAEs and the oral toxicity values described below should be used for dermal exposure without adjustment for GI absorption.

Data with neat PAEs or compound applied using organic solvents indicate that dermal uptake is substantial, although less in humans than laboratory animals (ATSDR, 2001, 2002). Data regarding the dermal uptake of the PAEs from soil were not located. The EPA (2004b) default ABS of 0.1 is used for all the PAEs except bis(2-ethylhexyl)phthalate, for which the ABS of 0.004 (EPA, 1993) is used, and except for di-n-octyl phthalate. VOCs tend to volatilize from soil when applied to the skin, reducing dermal uptake to toxicologically insignificant levels (EPA, 2004b). Therefore, dermal uptake of di-n-octyl phthalate from soil is not quantified.

EPA (2004b) provides t*, K_p, τ, FA and B values, or they are derived by the EPA (2004b) methodology, as follows:

Chemical	t*	K_p	τ	FA	B
bis(2-Ethylhexyl)phthalate[a]	39.93	2.5E-2	16.64	0.8	0.2
Butyl benzyl phthalate[b]	14.2	3.74E-2	5.90	1	0.3
Di-n-butyl phthalate[a]	9.27	2.4E-2	3.86	0.9	0.2
Diethyl phthalate[a]	4.50	3.9E-3	1.87	1.0	0.0
Dimethyl phthalate[a]	3.13	1.4E-3	1.30	1.0	0.0
Di-n-octyl phthalate[b]	See text below.				

T* = time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); □ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).

[a]U.S. Environmental Protection Agency (EPA), 2004, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final***, Office of Superfund Remediation and Technology Innovation, Washington, DC, EPA/540/R/99/005, OSWER 9285.7-02EP, NTIS No. PB99-963312, July.

[b]Calculated by the method described by EPA (2004).

ATSDR (1995) noted that the rate of dermal uptake of the PAEs is inversely correlated with the length of the side chain. On this basis, it would be expected that dermal uptake of di-n-octyl phthalate would be least of the PAEs included in this profile. The unusually high log K_{ow}, however, results in the computation of parameters that would suggest that the compound is readily absorbed. The unusually high log K_{ow} is considered to be anomalous; therefore, parameters for dermal uptake of di-n-octyl phthalate from water are not developed and this exposure route is not evaluated herein.

5.0 Noncancer Effects Evaluation

The acute oral toxicity of the PAEs is considered to be low, with oral LD_{50} values in laboratory animals ranging from 1 to 34 g/kg (EPA, 1991). Prolonged exposure induces liver effects in laboratory animals, but generally only at relatively high doses. EPA (2005) verified a chronic oral RfD of 2E-2 mg/kg-day for bis(2-ethylhexyl) phthalate based on a LOAEL of 19 mg/kg-day in a one-year dietary study in guinea pigs. An uncertainty factor of 1000 was used. The uncertainty factor consisted of factors of 10 each for inter- and intra-species variation, and a factor of 10 both to estimate a NOAEL from a LOAEL and to expand to lifetime exposure. Confidence in the oral RfD is medium. The LOAEL is associated with mild liver effects, and the liver is considered the target organ for oral exposure to bis(2-ethylhexyl) phthalate. EPA (1997) declined to adjust the uncertainty factor to develop a provisional subchronic oral RfD. Therefore, the chronic oral RfD for bis(2-ethylhexyl)phthalate of 2E-2 mg/kg-day is adopted as sufficiently conservative for subchronic exposure as well.

A verified chronic oral RfD for butyl benzyl phthalate of 2E-1 mg/kg-day was derived from a NOAEL of 159 mg/kg-day in a six-month dietary study in rats (EPA, 2005). The next higher dose, 470 mg/kg-day, was a LOAEL for mild liver effects, which identifies the liver as the target organ for butyl benzyl phthalate. An uncertainty factor of 1000 was used in this derivation. The uncertainty factor consisted of individual factors of 10 each for intra- and inter-species variation, and to expand from subchronic to chronic exposure. Confidence in the RfD is low. EPA (1997) developed a provisional subchronic oral RfD of 2E+0 mg/kg-day from the same study by eliminating the uncertainty factor of 10 to expand from subchronic to chronic exposure.

A group of male rats fed a diet that provided a dose rate of di-n-butyl phthalate of 600 mg/kg-day for one year experienced a high rate of mortality (EPA, 2005). Survivors apparently suffered no ill

effects, including histopathological effects in unspecified organs. No adverse effects were observed in another group fed a diet that provided 125 mg/kg-day. Application of an uncertainty factor of 1000 to the NOAEL of 125 mg/kg-day yields a verified RfD for chronic oral exposure of 1E-1 mg/kg-day. The uncertainty factors consists of components of 10 each for inter- and intra-species variation, and a factor of 10 for both expanding from subchronic to chronic exposure and to cover for deficiencies in the data base. Confidence in the oral RfD is low. The data are inadequate to identify a target organ for oral exposure to di-n-butyl phthalate. EPA (1997) developed a provisional subchronic oral RfD of 1E+0 mg/kg-day from the same study by eliminating the uncertainty factor of 10 to expand from subchronic to chronic exposure.

A verified RfD for chronic oral exposure to diethyl phthalate of 8E-1 mg/kg-day was derived by application of an uncertainty factor of 1000 to the NOAEL of 750 mg/kg-day from a 16-week study in which rats were fed a diet containing 1 percent of the test material (EPA, 2005). The uncertainty factor consists of components of 10 each for inter- and intra-species variation, and for expanding from subchronic to chronic exposure. A dietary concentration of 5 percent (3160 mg/kg-day) was a LOAEL associated with decreased food intake and weight gain, and altered organ weights. Histopathological lesions were not observed in this or other oral exposure studies reviewed by EPA (2005); the data are inadequate to identify a target organ. Confidence in the RfD is low. EPA (1997) developed a provisional subchronic oral RfD of 8E+0 mg/kg-day from the same study by eliminating the uncertainty factor of 10 to expand from subchronic to chronic exposure.

The chronic toxicity of dimethyl phthalate appears to be low. A two-year study reported no effects in rats fed a diet containing 2 percent dimethyl phthalate (EPA, 1991). Slight but significant effects on growth were observed in rats fed diets containing 4 or 8 percent dimethyl phthalate. Chronic nephritis was reported in rats fed the diet containing 8 percent dimethyl phthalate. The study was not of sufficient quality for verification of an oral RfD; however, a previously derived oral RfD of 1E+1 mg/kg-day is still in use in some EPA regions (EPA, 2004a), and is adopted herein as the chronic oral RfD. The kidney is considered the target organ for prolonged oral exposure to dimethyl phthalate because of the chronic nephritis mentioned above. The chronic oral RfD for dimethyl phthalate of 1E+1 mg/kg-day is adopted for subchronic oral exposure as well.

EPA (1997) lists a provisional RfD of 2E-2 mg/kg-day for chronic oral exposure to di-n-octyl phthalate. The RfD is based on a LOAEL of 175 mg/kg-day in a 7- to 12-month dietary study in rats. The LOAEL was associated with increased liver and kidney weight and biochemical evidence of liver damage. An uncertainty factor of 1000 was applied to the LOAEL to estimate the RfD. The liver and kidney are considered the target organs for prolonged oral exposure to di-n-octyl phthalate. EPA (1997) adopted the provisional chronic oral RfD as sufficiently protective for subchronic oral exposure as well. More recently the EPA's National Center for Environmental Assessment (NCEA) developed a peer-reviewed provisional chronic oral RfD for di-n-octyl phthalate of 4E-2 mg/kg-day (EPA, 2004a). The NCEA assessment has since been retired; therefore, details of the provisional chronic oral RfD are not available. It is likely that NCEA also provided a subchronic oral RfD somewhat larger than the chronic RfD; however, details are not available. Lacking these details, the provisional chronic oral RfD of 4E-2 mg/kg-day is adopted as sufficiently protective for subchronic exposure as well. The liver and kidney are still considered the target organs for prolonged exposure.

The data are inadequate to derive chronic inhalation RfCs for any of the PAEs that are the subject of this evaluation (EPA, 1995b). However, EPA (1996) derived a provisional subchronic inhalation

RfC for bis(2-ethylhexyl)phthalate. In the key study, groups of 27 male and 17 female rats were exposed to bis(2-ethylhexyl(phthalate) at 0, 11, 49 or 94 mg/m^3 intermittently on 6 hours/day, 5 days/week for 4 weeks via an apparatus that delivered a finely divided aerosol to the head and nose only. Twelve rats per sex per exposure group were sacrificed for necropsy at the end of the exposure period; the remaining rats were allowed an 8-week recovery period. The 49 mg/m^3 exposure group was a NOAEL; the 94 mg/m^3 group was the LOAEL associated with slight alteration of clinical chemistry endpoints, increased lung and liver weights, and minimal histopathological changes in the lungs. The NOAEL of 49 mg/m^3 was adjusted to a human equivalent concentration for lung effects in continuously exposed humans of 13 mg/m^3. Application of an uncertainty factor of 1000 yields the provisional subchronic inhalation RfC of 1.3E-2 mg/m^3, which is rounded to 1E-2 mg/m^3. The unrounded RfC is equivalent to a subchronic inhalation RfD of 3.7E-3 mg/kg-day. The lung is considered to be the most sensitive target organ for subchronic inhalation exposure to bis(2-ethylhexyl)phthalate; the liver is included as a target organ.

6.0 Carcinogenicity Evaluation

EPA (2005) classified bis(2-ethylhexyl) phthalate as a cancer weight-of-evidence Group B2 chemical (probable human carcinogen), based on significantly dose-related increases in liver tumor responses in rats and mice of both sexes in a two-year dietary study. The human data were inadequate. An oral SF of 1.4E-2 per mg/kg-day was based on liver tumors in male mice in this study. The oral SF is adopted for use for inhalation exposure (EPA, 1995c). The inhalation SF of 1.4E-2 per mg/kg-day is equivalent to a URF of 4.0E-6 per μg/m^3.

EPA (2005) classified butyl benzyl phthalate as a cancer weight-of-evidence Group C chemical (possible human carcinogen), based on a statistically significant increase in mononuclear cell leukemia in female rats in a two-year dietary study. There was no such response in mice. Human data are nonexistent. The qualitative weaknesses of the liver tumor response do not provide a compelling basis to model the dose-response data, and SFs were not derived.

EPA (2005) classified di-n-butyl phthalate and diethyl phthalate as cancer weight-of-evidence Group D chemicals (not classifiable as to carcinogenicity to humans) because of an absence of human or animal data. Data regarding the carcinogenicity of dimethyl phthalate and di-n-octyl phthalate were not located in the available literature.

7.0 Toxicity Summary

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure[a]		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
Bis(2-Ethylhexyl)phthalate										
2E-2	2E-2	L	1E-2/ 3.7E-3	ND/ ND	Lu, L	B2	1.4E-2	B2	4.0E-6	1.4E-2
Butyl benzyl phthalate										
2E+0	2E-1	L	ND/ ND	ND/ ND	NA	C	ND	C	ND	ND
Di-n-butyl phthalate										
1E+0	1E-1	ND	ND/ ND	ND/ ND	NA	D	NA	D	NA	NA
Diethyl phthalate										
8E+0	8E-1	ND	ND/ ND	ND/ ND	NA	D	NA	D	NA	NA

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure[a]		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
Dimethyl phthalate										
1E+1	1E+1	K	ND/ ND	ND/ ND	NA	ND	ND	ND	ND	ND
Di-n-octyl phthalate										
4E-2	4E-2	L, K	ND/ ND	ND/ ND	NA	ND	ND	ND	ND	ND

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data; NA = not applicable.
Target organ or critical effect abbreviations: L = liver; Lu = lung; K = kidney.
[a]sRfDo, cRfDo and SFo should be used for dermal exposure without adjustment for GI absorption.

8.0 References

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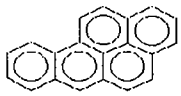
*POLYNUCLEAR AROMATIC HYDROCARBONS a.k.a. POLYCYCLIC AROMATIC HYDROCARBONS a.k.a. POLYAROMATIC HYDROCARBONS (PAH) (*130498-29-2)



Benzo(a)Pyrene
(A representative and the most studied member of this class of compounds.)

1.0 Introduction and Physical Properties

The PAHs regularly observed in environmental media and addressed in this profile include acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene and pyrene. All exist as solids at room temperature. Classification as **SVOC** or **VOC** is made in the following table. PAHs are the products of incomplete combustion of fossil fuels or other organic matter, hence include both natural and anthropogenic sources (ATSDR, 1995a; HSDB, 2004). Several are also components of crude oil. Naphthalene is used in the synthesis of phthalic anhydride, the insecticide carbaryl, leather tanning agents and surface active agents, and is a component of diesel and other fuels (ATSDR, 1995b). Relevant physical properties are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
Acenaphthene (83-32-9) **(VOC)**										
154.21[a]	3.92[a]	1.55E-4[b] (25°C)	3.85[b]	4.21E-2[b] (25°C)	7.69E-6[b] (25°C)	3.29E-6[a] (25°C)	4.24E+0[b] (20-25°C)	550.54[c]	803.15[c]	1.22E+4[c]
Acenaphthylene (208-96-8) **(VOC)**										
152.20[a]	4.07[a]	1.13E-5[a] (25°C)	3.42[a]	6.67E-2[d] (25°C)[e]	7.72E-6[d] (25°C)[e]	1.20E-6[a] (25°C)	3.93E+0[a] (25°C)	543.2[a]	797[f]	1.1E+4[g]
Anthracene (120-12-7) **VOC)**										
178.23[a]	4.45[a]	6.51E-5[b] (25°C)	4.47[b]	3.24E-2[b] (25°C)	7.74E-6[b] (25°C)	3.51E-9[a] (25°C)	4.34E-2[b] (20-25°C)	615.18[c]	873.00[c]	1.31E+4[c]
Benzo(a)anthracene (56-55-3) **(SVOC)**										
228.3[h]	5.66[h]	3.34E-6[b] (25°C)	5.60[b]	5.10E-2[b] (25°C)	9.00E-6[b] (25°C)	2.50E-9[a] (25°C)	9.40E-3[b] (20-25°C)	708.15[c]	1004.8[c]	1.60E+4[c]
Benzo(a)pyrene (50-32-8) **(SVOC)**										
252.3[a]	6.10[h]	1.13E-6[b] (25°C)	6.01[b]	4.30E-2[b] (25°C)	9.00E-6[b] (25°C)	7.22E-12[a] (25°C)	1.62E-3[b] (20-25°C)	715.90[c]	969.27[c]	1.90+4[c]
Benzo(b)fluoranthene (205-99-2) **(VOC)**										
252.3[h]	6.12[h]	1.11E-4[b] (25°C)	6.09[b]	2.26E-2[b] (25°C)	5.56E-6[b] (25°C)	6.58E-10[a] (20°C)	1.50E-3[b] (20-25°C)	715.90[c]	969.27[c]	1.70+4[c]
Benzo(k)fluoranthene (207-08-9) **(SVOC)**										
252.32[a]	6.84[a]	8.29E-7[b] (25°C)	6.09[b]	2.26E-2[b] (25°C)	5.56E-6[b] (25°C)	1.28E-12[a] (25°C)	8.00E-4[b] (20-25°C)	753.15[c]	1019.7[c]	1.80E+4[c]
Benzo(g,h,i)perylene (191-24-2) **(SVOC)**										
276.34[a]	6.63[a]	2.66E-7[a] (20°C)	4.98[a]	4.48E-2[d] (25°C)[e]	5.19E-6[d] (25°C)[e]	1.3E-13[a] (25°C)	2.6E-4[a] (25°C)	823[a]	1097[f]	1.96E+4[g]
Chrysene (218-01-9) **(VOC)**										
228.3[h]	5.66[h]	9.46E-5[b] (25°C)	5.60[b]	2.48E-2[b] (25°C)	6.21E-6[b] (25°C)	8.20E-12[a] (25°C)	1.60E-3[b] (20-25°C)	714.15[c]	979.0[c]	1.65E+4[c]
Dibenz(a,h)anthracene (53-70-3) **(SVOC)**										
278.4[h]	6.84[h]	1.47E-8[b] (25°C)	6.58[b]	2.02E-2[b] (25°C)	5.18E-6[b] (25°C)	1.32E-13[a] (20°C)	2.49E-3[b] (20-25°C)	743.24[c]	990.41[c]	3.00E+4[c]
Fluoranthene (206-44-0) **(VOC)**										
202.3[h]	4.95[h]	1.61E-5[b] (25°C)	5.03[b]	3.02E-2[b] (25°C)	6.35E-6[b] (25°C)	1.21E-8[a] (25°C)	2.06E-1[b] (20-25°C)	655.95[c]	905.0[c]	1.38E+4[c]
Fluorene (86-73-7) **(VOC)**										
166.21[a]	4.18[i]	6.37E-5[b] (25°C)	4.14[b]	3.63E-2[b] (25°C)	7.88E-6[b] (25°C)	4.21E-7[a] (20°C)	1.98E+0[b] (20-25°C)	570.44[c]	870.0[c]	1.27E+4[c]
Indeno(1,2,3-cd)pyrene (193-39-5) **(SVOC)**										
276.3[h]	6.58[h]	1.60E-6[b] (25°C)	6.54[b]	1.90E-2[b] (25°C)	5.66E-6[b] (25°C)	1.71E-13[a] (25°C)	2.20E-5[b] (20-25°C)	809.15[c]	1078.2[c]	1.90E+4[c]
Naphthalene (91-20-3) **(VOC)**										
		4.83E-4[b]		5.90E-2[b]	7.50E-6[b]	1.12E-4[a]	3.10E+1[b]			

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
128.2[h]	3.30[h]	(25°C)	3.30[b]	(25°C)	(25°C)	(25°C)	(20-25°C)	491.14[c]	748.40[c]	1.04E+4[c]
Phenanthrene (85-01-8) **(VOC)**										
178.2[h]	4.46[h]	1.24E-4[a] (25°C)	4.36[a]	6.00E-2[d] (25°C)[e]	6.95E-6[d] (25°C)[e]	8.95E-7[a] (25°C)	1.29E+0[a] (25°C)	613.2[a]	869.2[j]	1.42E+4[a]
Pyrene (129-00-0) **(VOC)**										
202.26[a]	4.88[a]	1.1E-5[b] (25°C)	5.02[b]	2.72E-2[b] (25°C)	7.24E-6[b] (25°C)	1.17E-7[a] (25°C)	1.35E-1[b] (20-25°C)	667.95[c]	936.0[c]	1.44E+4[c]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point (at 1 atm) of pure liquid compound (°K); T_c = critical temperature (°K); $H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole); ND = no data.

[a]Hazardous Substance Data Bank (HSDB), 2004, National Library of Medicine, on line, accessed 23 April.

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[d]Calculated as described in Introduction to Toxicity Profiles.

[e]Assumed.

[f]Estimated from Equation 12-4 in Lyman, W.J., W.F. Reehl and D.H. Rosenblatt, 1990, ***Handbook of Chemical Property Estimation Methods***, American Chemical Society, Washington, DC.

[g]Estimated from Equation 13-5 in Lyman, W.J., W.F. Reehl and D.H. Rosenblatt, 1990, ***Handbook of Chemical Property Estimation Methods***, American Chemical Society, Washington, DC.

[h]U.S. Environmental Protection Agency (EPA), 2003, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim***, Office of Emergency and Remedial Response, EPA/540/R/99/005, OSWER 9285.7-02EP March.

[i]Syracuse Research Corporation (SRC), 2004, ***CHEMFATE Search Results***, on line, accessed 23 April.

[j]National Institute of Standards and Technology (NIST), 2004, Standard Reference Data Program, Online Data Bases, accessed 23 April.

2.0 Environmental Fate and Transport

The PAHs are ubiquitous products of incomplete combustion; natural sources include volcanoes and forest fires (ATSDR, 1995a, b; HSDB, 2004). There is some evidence for biosynthesis by plants, bacteria and algae. Some of the PAHs occur naturally in fossil fuels. Anthropogenic releases to the environment, primarily to the atmosphere, greatly outweigh the natural sources and include any processes that involve incomplete combustion of fossil fuels and organic matter, including wood-burning for home heat (the predominant source), cigarette smoke, internal combustion engine exhaust, and fuel oil emissions. Industrial sources include coal mining, processing and storing, wood treatment (creosote), manufactured gas plants (coal tar), power generation, production of coal tar, coke and asphalt, petroleum cracking and industrial and municipal incineration. Other sources include various crude oils, fresh and used motor oils, gasolines, charcoal-broiled foods, processed foods, various oils, margarine, butter and fats, fruits, vegetables, and cereals, roasted coffee and tea. Indoor sources include unvented kerosene heaters and gas cooking and heating appliances. Naphthalene is released during its manufacture and processes that involve its use (e.g., vaporization from moth balls).

Although PAHs generally occur in mixtures, certain chemicals tend to predominate in different sources so that the PAH pattern observed in a given medium may provide a clue to the source. The following compilation relates individual PAHs and sources:

Source[a]	Individual PAHs
Residential wood burning	Acenaphthylene
Auto emissions	Benzo(g,h,i)perylene, pyrene
Diesel exhaust particulates	Fluoranthene, phenanthrene, pyrene
Diesel exhaust vapors	Phenanthrene, anthracene
Diesel total emissions	Acenaphthene, fluorene, phenanthrene
Fly ash & bottom ash from U.S. municipal waste incinerators	Phenanthrene
Fly ash from U.K. municipal waste incinerators	Benzo(g,h,i)perylene
Particulate emissions from municipal waste incinerator	Benzo(a)fluoranthene, benzo(g,h,i)perylene, chrysene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene
Municipal/medical waste	

Source[a]	Individual PAHs
incinerator	Benzo(a)anthracene, benzo(g,h,i)perylene
Rotary kiln incinerator charged with polyethylene, no afterburner	Fluoranthene, phenanthrene, pyrene (see next entry)
Rotary kiln incinerator charged with polyethylene with afterburner	Benzo(a)anthracene, phenanthrene (total PAH emissions reduced 100-fold compared with no afterburner)
Coal tar pitch emissions	Phenanthrene and pyrene 20 to 80 X > benzo(a)pyrene, benzo(g,h,i)perylene
Natural gas home appliances – fine particulate emissions	Chrysene, fluoranthene, pyrene, triphenylene
Groundwater near coal & oil gasification plant	Acenaphthylene, acenaphthene, fluorene, phenanthrene, fluoranthene, pyrene, chrysene
Groundwater near wood treatment facilities	Benzo(a)pyrene, phenanthrene
[a]Agency for Toxic Substances and Disease Registry, (ATSDR), 1995, ***Update Toxicological Profile for Polycyclic Aromatic Hydrocarbons (PAHs)***, U.S. Public Health Service, Atlanta, Georgia, August, on line.	

Data compiled for soils are not included in the table above because the lists are long and the variation from one site to another is great, so that the information is not useful for identifying sources. Similarly, sediment is a sink for PAHs from all sources including atmospheric deposition from far distant locations, and the patterns observed in sediment do not necessarily reflect a nearby source (ATSDR, 1995a). Generally, PAHs associated with combustion exhibit highly condensed ring structures and little alkylation (i.e., benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, benzo(a)pyrene, benzo(e)pyrene, chrysene, fluoranthene, pyrene).

Crude petroleum and products made from crude petroleum (e.g., asphalts, fuels, oils) contain PAHs, but the patterns observed depend on the location of the source (ATSDR, 1995a; Potter and Simmons, 1998). Phenanthrene and alkylated forms of PAHs, particularly the methylnaphthalenes, often predominate in petroleum products.

The partitioning and fate of the PAHs in environmental media depend largely on VP (tendency to exist in air as a vapor), H (indicator of partitioning between air and water) and K_{oc} (indicator of affinity to bind to organic matter in soil and sediment). ATSDR (1995a) noted that H and K_{oc} are roughly directly related to MW, and that VP is roughly inversely related to MW. Therefore, they grouped the PAHs into the following categories to facilitate understanding their behavior in the environment:

- Low MW (152 to 178 g/mole) – acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, phenanthrene
- Medium MW (approximately 202 g/mole) – fluoranthene, pyrene
- High MW (228 to 278 g/mole) – benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene.

PAHs exist in the atmosphere as vapors or adsorbed to particulates, the proportion depending on the vapor pressure of the individual chemical and atmospheric conditions such as temperature and humidity (ATSDR, 1995a, b; HSDB, 2004). Generally, the two- and three-ring compounds (low and medium MW except pyrene) exist predominantly as vapors; the four-ring compounds exist in both

the vapor and particulate phase, and compounds with 5 or more rings (benzo[a]pyrene, benzo[g,h,i]perylene exist predominantly as particulates. Increasing atmospheric temperature and relative humidity favors existence in the vapor phase. PAHs may travel short or long distances before removal from the air. Vapor forms are subject to chemical oxidation processes in the air, which reduces the distance they may travel. Residence time and transport distance is inversely related to the size of the particles on which the PAHs are adsorbed. Small particles may have residence times of weeks, permitting transport for hundreds or upwards of a thousand miles. Wet and dry deposition accounts for removal of the particulates.

The predominant sources of PAHs in surface water are deposition from the atmosphere, industrial and sewage effluent and oil spills (ATSDR, 1995a, b). Runoff and erosion can also contribute PAHs to surface water bodies. Volatilization is a significant fate process for PAHs with H values of 1E-5 atm-m^3/mole or greater (generally the low and medium MW compounds). Volatilization is a very limited removal process for most of the high MW compounds. Volatilization is enhanced by high temperature, turbulence and high wind. Sorption to benthic or suspended sediment and biodegradation are competing removal processes. Generally, volatilization and biodegradation are the predominant removal processes for the low MW compounds, and volatilization and sorption are the predominant removal processes for medium and high MW compounds. Naphthalene is relatively water soluble and may remain largely in solution. PAHs in sediment may biodegrade, recycle back to the water column (lower MW compounds) or accumulate in the lower trophic levels of living organisms.

Deposition from the atmosphere is the principal source of PAHs in soil (ATSDR, 1995a, b). Other sources include industrial activities, disposal of sewage sludge, and leaching from coal storage sites. Most PAHs sorb to soil constituents because of their low solubility and high affinity for organic matter. Volatilization is an important removal process for the low molecular weight compounds. Some of the low molecular weight compounds, particularly naphthalene, may leach fairly rapidly to groundwater.

The high lipophilicity of many PAHs evidenced by high log K_{ow} values suggest that the PAHs might cross biologic membranes and participate significantly in food-chain pathways involving fish, fruit and vegetable, and meat and milk consumption. This, however, is not the case. For example, the PAHs are efficiently metabolized and excreted by fin fish, greatly reducing the likelihood of bioconcentration from water or bioaccumulation from sediment (ATSDR, 1995a). Consequently, there are often great discrepancies between modeled BCF values and empirical BCF values, where care was taken to identify the parent compound rather than PAH metabolites in fish tissue. This distinction is necessary because aromatic fragments from PAH metabolism are readily assimilated as normal endogenous components of biological tissue. PAH concentrations in aquatic food-chain systems usually decrease with increasing trophic level, reflecting the generally greater efficiency of metabolism in the higher trophic organisms. Approximate tissue-to-sediment PAH concentration ratios were reported to be 0.6 to 1.2 for amphipods, 0.1 for clams, and 0.05 for fin fish and shrimp.

It has been reported that terrestrial plants can accumulate PAHs from soil by uptake through the roots (ATSDR, 1995a). More careful investigation, however, reveals that root uptake is quite low, and there is no evidence of bioconcentration or biomagnification. For example, PAH ratios in vegetation to soil in one survey ranged from 0.001 to 0.18 for total PAHs, and from 0.002 to 0.33 for benzo(a)pyrene. It is likely that most of the PAH contamination on the vegetation resulted from

atmospheric deposition. Increased concentrations in vegetation have not been observed when soil PAH concentrations were greatly increased by amendment with sewage sludge. Data from carrots (*Daucus carotu*) showed that PAHs adhere to the outer skin of the root but show little tendency to penetrate to deeper layers, and even less tendency to translocate to aerial parts.

The inability of plants to bioconcentrate PAHs from soil reduces concern for bioconcentration in agricultural products such as meat and milk. It should be noted, however, that measurable concentrations of PAHs may accumulate on the aerial parts of plants because of deposition from the atmosphere (ATSDR, 1995a). Also, food-producing animals ingest a substantial amount of soil while grazing or consuming mechanically harvested forage crops. Mammals, however, efficiently metabolize the PAHs to polar compounds that are readily excreted, reducing concern for bioconcentration.

In summary, the PAHs are highly lipophilic, which implies significance in food-chain exposure pathways. Empirical data, however, show that fish and mammals efficiently metabolize and eliminate these compounds. Furthermore, bioconcentration in plants because of uptake from soil is not significant. Therefore, it is unlikely that the PAHs would participate significantly in food-chain pathways, and biotransfer factors are not estimated.

3.0 Toxicokinetics

The PAHs are absorbed by all routes of exposure, but the rate and extent depends on the compound, the species of animal and the vehicle (or nature of the particulates) (ATSDR, 1995a). PAHs are readily absorbed during inhalation exposure; however, intratracheal instillation studies indicate that particle size is the most important determiner of the extent of pulmonary uptake.

Toxicokinetic studies of several PAHs summarized by ATSDR (1995a) provide limited quantitative information regarding the extent of GI absorption. Limitations arise largely because biliary excretion complicates quantification of uptake from the GI tract. A study of benzo(a)pyrene in rats suggests that GI absorption ranges from 38 to 58 percent. A study in rats reported absorption efficiency for anthracene ranging from 53 to 74 percent. GI absorption of pyrene, chrysene and dibenzo(a,h)anthracene is described as high. Administration of the test compound in oil or in a high-fat diet appears to increase the extent of GI absorption.

Empirical data with pure compound dissolved or suspended in various vehicles suggest that dermal uptake of benzo(a)pyrene is extensive (ATSDR, 1995a). One occupational study reported that approximately 75 percent of systemically absorbed pyrene entered the body through dermal uptake rather than through inhalation exposure. Combining PAHs with soil appears to significantly reduce the extent of dermal uptake compared with oleaginous or acetone vehicles. Anecdotal evidence from using cloth diapers stored in contact with naphthalene indicates that naphthalene is absorbed by the skin, but quantitative data are not available (ATSDR, 1995b).

Distribution of absorbed PAHs is generally widespread, with highest levels located initially in lipid-rich tissues (ATSDR, 1995a). Highest levels of metabolites (radioactivity following administration of radiolabeled compounds) are located in the liver and GI tract, even after inhalation exposure, probably reflecting extensive metabolism in the liver followed by biliary excretion. Ciliary clearance and deglutition probably contribute to levels associated with the GI tract. Concentrations of radioactivity following administration of radiolabeled compound reveal fetal levels approximately

2- to 10-fold lower than maternal levels, although this depends on the specific compound administered.

Metabolism of the PAHs, particularly benzo(a)pyrene, has been extensively studied (ATSDR, 1995a). Metabolism proceeds rapidly, yielding products that are more water soluble and readily excreted than the parent compound. All tissues have the ability to metabolize the PAHs, potentially to carcinogenic intermediates, which probably accounts for the observation that cancers occur at the point of contact. There is considerable variability in tissue metabolic activity; however, the liver is probably the most active in most cases.

ATSDR (1995a) distinguishes between "alternant" and "nonalternant" PAHs, based on the nature of the electron density associated with the molecule, which influences how that compound is metabolized to its ultimate carcinogen. Alternant PAHs (e.g., benzo[a]pyrene, benzo[a]anthracene, chrysene, dibenz[a,h]anthracene) exhibit a uniformly distributed electron density. Nonalternant PAHs (e.g., fluoranthene, benzo[k]fluoranthene, indeno[1,2,3-cd]pyrene) behave more like two separate molecules because of uneven electron distribution.

Alternant PAHs (based on data for benzo[a]pyrene) are initially metabolized by the microsomal cytochrome P-450 system to several arene oxides (ATSDR, 1995a). These may re-arrange spontaneously to phenols or undergo hydration to form the corresponding trans-dihydrodiols. Further oxidation of the dihydrodiols results in formation of quinones, phenol diols and dihydrodiol epoxides. Phenols may be formed by direct insertion of oxygen into a ring. Many of the metabolites resulting from the reactions described above are subject to conjugation with various substrates followed rapidly by excretion. The dihydrodiol epoxides that form in the "bay" region (the three-sided concave region formed by the fusion of three benzene rings) are most likely the ultimate carcinogens that covalently bind to macromolecules such as DNA, resulting in alkylation or other adducts that yield genetic errors.

Metabolism of the nonalternant PAHs differs from the alternant PAHs in that more extensive oxidation to hydroxy-epoxy-diols may be important to achieve genotoxicity (ATSDR, 1995a). Dihydrodiol epoxide formation in the bay region is associated with carcinogenicity of the PAHs generally; however, some of the nonalternant PAHs yield reactive metabolites that deviate from the classical bay region model.

PAH metabolites are readily excreted, largely through the bile, although some metabolites are excreted by the kidney (ATSDR, 1995a). The extent of elimination is species specific. In one inhalation study rats excreted metabolites much more efficiently than dogs or monkeys.

4.0 Dermal Exposure

EPA (2003) recommends that oral toxicity values for the PAHs should not be adjusted when applied to dermal exposure because GI absorption probably exceeds 50 percent. Therefore, no GAF is estimated and the oral toxicity values described below should be used for dermal exposure without adjustment.

Empirical data with pure compound dissolved or suspended in various vehicles suggest that dermal uptake of benzo(a)pyrene is extensive (ATSDR, 1995a). Anecdotal evidence from using cloth diapers stored in contact with naphthalene indicates that naphthalene is absorbed by the skin, but

quantitative data are not available (ATSDR, 1995b). EPA (2003) reviewed empirical data regarding dermal uptake of benzo(a)pyrene and recommended an ABS of 0.13 for the PAHs. However, EPA (2003) also notes that VOCs tend to volatilize from soil when applied to the skin, reducing dermal uptake to toxicologically insignificant levels. Therefore, the ABS of 0.13 is applied to all the PAHs identified above as SVOCs. Dermal uptake of the PAHs identified as VOCs is not quantified.

Values for t*, K_p, τ, FA and B are provided or estimated as follows:

Chemical	t*	K_p	τ	FA	B
Acenaphthene[a]	1.84	8.39E-2	7.67E-1	1	0.4
Acenaphthylene[a]	1.79	1.08E-1	7.47E-1	1	0.5
Anthracene[a]	4.06	1.38E-1	1.05E+0	1	0.7
Benzo(a)anthracene[b]	8.53	4.7E-1	2.03E+0	1.0	2.8
Benzo(a)pyrene[b]	11.67	7.0E-1	2.69E+0	1.0	4.3
Benzo(b)fluoranthene[b]	12.03	7.0E-1	2.77E+0	1.0	4.3
Benzo(k)fluoranthene[a]	12.40	2.00E+0	2.72E+0	0.4	12
Benzo(g,h,i)perylene[a]	8.89	1.07E+0	3.70E+0	0.7	6.8
Chrysene[b]	8.53	4.7E-1	2.03E+0	1.0	2.8
Dibenz(a,h)anthracene[b]	17.57	1.5E+0	3.88E+0	0.6	9.7
Fluoranthene[b]	5.68	2.2E-1	1.45E+0	1.0	1.2
Fluorene[a]	2.15	1.07E-1	8.95E-1	1	0.5
Indeno(1,2,3-cd)pyrene[b]	16.83	1.0E+0	3.78E+0	0.6	6.7
Naphthalene[b]	1.34	4.7E-2	5.6E-1	1	0.2
Phenanthrene[b]	4.11	1.4E-1	1.06E+0	1	0.7
Pyrene[a]	3.42	1.94E-1	1.43E+0	1	1.1

t* = time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); □ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).

[a]Estimated as described in Introduction to Toxicity Profiles.

[b]Provided by U.S. Environmental Protection Agency (EPA), 2003, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim***, Office of Emergency and Remedial Response, EPA/540/R/99/005, OSWER 9285.7-02EP March.

5.0 Noncancer Effects Evaluation

The PAHs are generally divided into two EPA cancer weight-of-evidence groups: Group D – not classifiable as to carcinogenicity to humans, and Group B2 – probable human carcinogens. The Group D PAHs have not been evaluated for carcinogenicity by toxicity testing; therefore, cancer SFs or URFs cannot be estimated for these compounds (EPA, 1986, 2004). Risk evaluation of these compounds is limited to noncancer effects. It is theoretically possible that cancer risk could be the "driver" for some of these compounds. However, the mechanism of carcinogenicity of the PAHs is fairly well understood to be correlated with molecular morphology and the propensity to form certain active metabolites (ATSDR, 1995a). The Group D PAHs either do not fit the morphologic mold or have been shown empirically to be unlikely to cause cancer, reducing greatly the uncertainty that significant cancer risk is being overlooked.

Cancer SFs and URFs are available for the Group B2 compounds, but noncancer RfDs or RfCs are not. Therefore, risk evaluation of these compounds is limited to cancer risk. These compounds have the morphologic requirements for carcinogenicity; therefore, it has been thought that cancer risk is the driver, and that noncancer effects are relatively insignificant, although empirical data were lacking until recently.

Recent data support this assumption. De Jong et al. (1999) reported a study in which male rats were treated by gavage with benzo(a)pyrene 5 days per week for 35 days at dose rates of 0 (control), 3, 10, 30 or 90 mg/kg. Significantly reduced rate of body weight gain and altered organ weights were observed in the 90 mg/kg group. Fore stomach lesions were found in the 30 and 90 mg/kg groups. Decreased thymus weights and hematological evidence of erythrocyte toxicity were observed in a dose-related manner in rats treated with 10 mg/kg and above. Subtle alterations in measures of immune function were also observed in these groups, establishing 10 mg/kg as the LOAEL and 3 mg/kg as the NOAEL for this study. The 3 mg/kg dose is equivalent to a NOAEL of 2.1 mg/kg-day when adjusted for continuous exposure. Application of an uncertainty factor of 1000 (factor of 10 to expand from subchronic to chronic exposure, and factors of 10 each to provide additional protection for intra- and interspecies variation) allows development of a preliminary oral RfD of 2E-3 mg/kg-day. Uncertainty surrounding the preliminary oral RfD is very high because the data base for the noncancer effects of benzo(a)pyrene is essentially limited to one study and several toxicological endpoints (e.g., developmental, reproductive, neurological) were not investigated.

The sole purpose for developing this oral RfD is to evaluate the potential for noncancer effects to be the driver for the Group B2 PAHs. The RfD was not developed with sufficient rigor to be used in the risk assessment of the noncancer effects of benzo(a)pyrene. The oral SF for benzo(a)pyrene is 7.3 per mg/kg-day (please see below), from which it is estimated that the oral RfD is equivalent to a cancer risk of 1.5E-2. This cancer risk is orders of magnitude above the EPA (1990) risk management range of 1E-6 to 1E-4, strengthening the position that noncancer effects are unlikely to be the driver for the Group B2 PAHs.

Data regarding the toxicity of acute oral exposure to the PAHs are generally scarce. Prolonged oral exposure to the Group D PAHs is associated with a number of renal, hematologic and other effects, depending on the compound.

Subchronic (90 day) gavage treatment of mice with acenaphthene is associated with histopathologic evidence of liver hypertrophy. A verified RfD of 6E-2 mg/kg-day for chronic oral exposure was derived from the NOAEL of 175 mg/kg-day and an uncertainty factor of 3000 (EPA, 2004). The LOAEL in this study was 350 mg/kg-day. Confidence in the RfD is low. The liver is considered the target organ for prolonged oral exposure to acenaphthene. EPA (1997) derived a provisional subchronic oral RfD for acenaphthene of 6E-1 mg/kg-day from the same mouse study using an uncertainty factor of 300.

A verified RfD of 3E-1 mg/kg-day for chronic oral exposure to anthracene was derived from a NOEL of 1000 mg/kg-day, the highest dose tested, in a 90-day gavage study in mice (EPA, 2004). An uncertainty factor of 3000 was applied. Confidence in the RfD is low. The data are inadequate to identify a target organ for prolonged oral exposure to anthracene. EPA (1997) derived a provisional subchronic oral RfD for anthracene of 3E+0 mg/kg-day from the same mouse study using an uncertainty factor of 300.

Subchronic exposure to fluoranthene induces liver and kidney effects and hematologic alterations in orally treated mice (EPA, 2004). A verified RfD of 4E-2 mg/kg-day for chronic oral exposure was derived from a NOAEL of 125 mg/kg-day in a 13-week gavage study. The LOAEL was 250 mg/kg-day in this study. An uncertainty factor of 3000 was applied. Confidence in the oral RfD is low. The kidney, liver and blood cells are chosen as the target organs for prolonged oral exposure to

fluoranthene. EPA (1997) derived a provisional subchronic oral RfD for fluoranthene of 4E-1 mg/kg-day from the same mouse study using an uncertainty factor of 300.

Subchronic exposure to fluorene induces hemolytic anemia in orally treated mice (EPA, 2004). A verified RfD of 4E-2 mg/kg-day for chronic oral exposure was derived from a NOAEL of 125 mg/kg-day in a 13-week gavage study. The LOAEL was 250 mg/kg-day in this study. An uncertainty factor of 3000 was applied. Confidence in the oral RfD is low. The erythrocyte is the target organ for prolonged oral exposure to fluorene. EPA (1997) derived a provisional subchronic oral RfD for fluorene of 4E-1 mg/kg-day from the same mouse study using an uncertainty factor of 300.

Single-dose LD_{50} values for naphthalene include 533 to 710 mg/kg for mice and 2200 to 2400 mg/kg for rats, establishing the mouse as more sensitive to the lethal effects of acute oral exposure (ATSDR, 1995b). Decreased terminal body weights, accompanied by a remarkable absence of hematological and histopathological effects, were observed in rats treated by gavage for 13 weeks (EPA, 2004). The LOAEL in this study was 142 mg/kg-day associated with greater than 10 percent reduction in terminal body weights. The NOAEL was 71 mg/kg-day. The high dose rate, 286 mg/kg-day was a FEL associated with increased mortality. Application of an uncertainty factor of 3000 (10 to extrapolate from rats to humans, 10 to protect sensitive humans, 10 to extrapolate from subchronic to chronic exposure, and 3 for database deficiencies) to the NOAEL of 71 mg/kg-day yields the verified chronic oral RfD of 2E-2 mg/kg-day. Confidence in the RfD is low. A preliminary subchronic oral RfD can be derived for naphthalene by applying an uncertainty factor of 300 to the NOAEL of 71 mg/kg-day described above. The uncertainty factor of 300 reflects the chronic uncertainty factor of 3000 without the factor of 10 to expand from subchronic to chronic exposure. The preliminary subchronic oral RfD so derived is 2E-1 mg/kg-day.

The key study described above is not sufficient to identify target organs for prolonged oral exposure to naphthalene. Adults, children and neonates exposed to moth balls exhibit hemolytic anemia, evidence of liver disease and neurological deficits (EPA, 1993a, 1998). The liver effects and neurological deficits may be secondary to hemolytic anemia and reduced oxygen-carrying capacity of the blood. Hemolytic anemia and cataract formation have been seen also in orally exposed humans (EPA, 1998). The data suggest that the erythrocyte may be the most sensitive tissue in humans. Among common species of laboratory mammals, hemolytic anemia is seen only in dogs (EPA, 1998). Cataracts are seen in several laboratory mammals, but only at relatively high doses. The key study identifies reduced body weight as the critical effect in rats. Rats, however, do not exhibit hemolytic anemia, and exhibit cataracts only at very high doses, suggesting that rats may not be a totally acceptable model for the toxicity of naphthalene to humans. Therefore, based on the effects observed in humans, the erythrocyte and eye are selected as target organs for prolonged oral exposure to naphthalene. Reduced body weight is also included as a critical effect because this was the only endpoint observed in rats in the key study.

EPA (1993a, 2004) reported a 2-year study in which mice were exposed to naphthalene vapors for 6 hours/day on 5 days/week. Inflammation of the nasal and olfactory epithelium was the most consistently observed sign; granulomatous lesions in the lungs were also observed. There was equivocal evidence of hematologic involvement. The lowest exposure concentration, 10 ppm, was a LOAEL for the nasal effects, which are considered the critical effects of inhalation exposure. The LOAEL is equivalent to a human equivalent concentration of 9.3 mg/m^3 (EPA, 2004). Application

of an uncertainty factor of 3000 yields a verified chronic inhalation RfC of 3E-3 mg/m^3, which is equivalent to a chronic inhalation RfD of 8.6E-4 mg/kg-day. The nasal and olfactory epithelia are the target organs for inhalation exposure to naphthalene. Confidence in the RfC is medium. The chronic inhalation RfC of 3E-3 mg/m^3, equivalent to an inhalation RfD of 8.6E-4 mg/kg-day, is adopted as sufficiently protective for subchronic inhalation exposure as well.

Subchronic exposure to pyrene induces mild renal tubular degeneration and reduced kidney weight in orally treated mice (EPA, 2004). A verified RfD of 3E-2 mg/kg-day for chronic oral exposure was derived from a NOAEL of 75 mg/kg-day in a 13-week gavage study. The LOAEL was 125 mg/kg-day in this study. An uncertainty factor of 3000 was applied. Confidence in the oral RfD is low. The kidney tubule is chosen as the target organ for chronic oral exposure to pyrene. EPA (1997) derived a provisional subchronic oral RfD for pyrene of 3E-1 mg/kg-day from the same mouse study using an uncertainty factor of 300.

Data regarding prolonged oral exposure are not available for several of the Group D PAHs, which hinders estimation of an RfD or RfC and compromises evaluation of the potential for noncancer effects. Therefore, surrogates are used to develop toxicity values for the noncancer effects.

Generally surrogates are chosen on the basis of the following hierarchy:

- Toxicological similarity (effects and dose-response relationship).
- Toxicokinetic similarity, assuming that likeness in absorption, distribution and especially products of biotransformation suggests toxicological similarity.
- Structural similarity, assuming that likeness in structure suggests similarity in toxicokinetics.

Selection of defensible surrogates for the PAHs is compromised because toxicological and toxicokinetic data are virtually non-existent (except for benzo[a]pyrene), and the structural similarities often are not very convincing, which imparts a great deal of uncertainty to the effort. Therefore, the most defensible approach for some of the PAHs is to select the most conservative surrogate; i.e., the PAH with the smallest verified oral RfD, which happens to be pyrene.

Data regarding the effects of chronic or subchronic exposure to acenaphthylene were not located in the available literature. Acenaphthene is adopted as a reasonable surrogate for acenaphthylene based on structural similarity, since the surrogate differs from the principal chemical only in the presence of two hydrogen atoms and the absence of a double bond. Therefore, the verified chronic oral RfD of 6E-2 mg/kg-day for acenaphthene is adopted as the RfD for chronic oral exposure to acenaphthylene. The liver, which is the target organ for acenaphthene, is adopted for oral exposure to acenaphthylene. Similarly, the provisional subchronic oral RfD of 6E-1 mg/kg-day for acenaphthene is adopted as the RfD for subchronic oral exposure to acenaphthylene.

Data regarding the effects of chronic or subchronic exposure to benzo(g,h,i)perylene were not located in the available literature. Pyrene is adopted as a reasonable surrogate for benzo(g,h,i)perylene based somewhat on structural similarity, but more on the selection of a conservative approach as justified above. Therefore, the verified oral RfD of 3E-2 mg/kg-day for

pyrene is adopted as the oral RfD for chronic exposure to benzo(g,h,i)perylene. Similarly, the provisional subchronic oral RfD of 3E-1 mg/kg-day for pyrene is adopted as the RfD for subchronic oral exposure to benzo(g,h,i)perylene. The kidney tubule, which is the target organ for pyrene, is adopted for oral exposure to benzo(g,h,i)perylene.

Relevant data regarding chronic or subchronic exposure to phenanthrene were not located. Potential surrogates based on similarity in chemical structure include anthracene and pyrene. Pyrene is selected as the surrogate only because it is the more conservative choice. Therefore, the verified oral RfD of 3E-2 mg/kg-day for pyrene is adopted as the oral RfD for chronic exposure to phenanthrene. Similarly, the provisional subchronic oral RfD of 3E-1 mg/kg-day for pyrene is adopted as the RfD for subchronic oral exposure to phenanthrene. The kidney tubule, which is the target organ for pyrene, is adopted for oral exposure to phenanthrene.

Data regarding inhalation exposure sufficient for development of inhalation RfCs were not located for any of the PAHs with the exception of naphthalene as noted above.

6.0 Carcinogenicity Evaluation

Acenaphthylene, anthracene, benzo(g,h,i)perylene, fluoranthene, fluorene, phenanthrene and pyrene are classified in EPA cancer weight-of-evidence Group D (not classifiable as to carcinogenicity to humans) because of a lack of human data and inadequate animal data (EPA, 2004). Data regarding the carcinogenicity of acenaphthene were not located. Benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, , chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene are classified in EPA weight-of-evidence Group B2 (probable human carcinogens) (EPA, 1997, 2004). Benzo(a)pyrene is the most extensively studied member of the class, inducing tumors in tissues at the point of contact of practically all laboratory species tested by all routes of exposure.

Although epidemiology studies suggested that complex mixtures that contain PAHs (coal tar, soots, coke oven emissions, cigarette smoke) are carcinogenic to humans, the carcinogenicity cannot be attributed to PAHs alone because of the presence of other potentially carcinogenic substances in these mixtures (ATSDR, 1995a). In addition, recent investigations showed that the PAH fraction of roofing tar, cigarette smoke and coke oven emissions accounted for only 0.1-8% of the total mutagenic activity in *Salmonella* of the unfractionated complex mixture (Lewtas, 1988). Aromatic amines, nitrogen heterocyclic compounds, highly oxygenated quinones, diones, and nitrooxygenated compounds, none of which would be expected to arise from in vivo metabolism of PAHs, probably accounts for the majority of the mutagenicity of coke oven emissions and cigarette smoke. Furthermore, coal tar, which contains a mixture of many PAHs, has a long history of use in the clinical treatment of a variety of skin disorders in humans (ATSDR, 1995a).

Because of the lack of human cancer data, assignment of individual PAHs to EPA cancer weight-of-evidence groups is based largely on the results of animal studies with large doses of purified compound (EPA, 2004). Frequently, unnatural routes of exposure, including implants of the test chemical in beeswax and trioctanoin in the lungs of female rats, intratracheal instillation, and subcutaneous or intraperitoneal injection, were used. Although the carcinogenicity of benzo(a)pyrene in animals managed in an unnatural manner in laboratory conditions has been well established, the potential for carcinogenicity to humans in environmental settings involving exposure to low concentrations remains unclear.

EPA (2004) verified a SF for oral exposure to benzo(a)pyrene of 7.3E+0 per mg/kg-day, based on several dietary studies in mice and rats. Recent reevaluations of the carcinogenicity and mutagenicity of the Group B2 PAHs suggest that there are large differences between individual PAHs in cancer potency (Krewski et al., 1989). Based on the available cancer and mutagenicity data, and assuming that there is a constant relative potency between different potential carcinogens across different bioassay systems and that the PAHs under consideration have similar dose-response curves, EPA (1993b) adopted relative potency values for several PAHs. These values and the corresponding oral SFs, based on a relative potency for benzo(a)pyrene of 1.0, are presented below:

Relative Potency Estimates for PAHs				
			Inhalation	
PAH	Relative Potency	Oral Slope Factor (per mg/kg-day)	Unit Risk Factor (per µg/m^3)	Slope Factor (per mg/kg-day)
Benzo(a)pyrene	1.0	7.3E+0	8.8E-4	3.1E+0
Benzo(a)anthracene	0.1	7.3E-1	8.8E-5	3.1E-1
Benzo(b)fluoranthene	0.1	7.3E-1	8.8E-5	3.1E-1
Benzo(k)fluoranthene	0.01	7.3E-2	8.8E-6	3.1E-2
Chrysene	0.001	7.3E-3	8.8E-7	3.1E-3
Dibenz(a,h)anthracene	1.0	7.3E+0	8.8E-4	3.1E+0
Indeno(1,2,3-cd)pyrene	0.1	7.3E-1	8.8E-5	3.1E-1

Although the EPA has not verified SFs for Group B2 PAHs other than benzo(a)pyrene, the SFs above represent reasonable estimates based on the data available. The relative potency approach employed here meets criteria considered to be desirable for this type of analysis (Lewtas, 1988). For example, the chemicals compared have similar chemical structures and would be expected to have similar toxicokinetic fate in mammalian systems. In addition, the available data suggest that the Group B2 PAHs have a similar mechanism of action, inducing frameshift mutations in *Salmonella* and tumor initiation in the mouse skin painting assay. Similar noncancer effects (minor changes in the blood, liver, kidneys) of the Group D PAHs support the hypothesis of a common mechanism of toxicity. Finally, the same endpoints of toxicity, i.e., potency in various cancer assays, and related data, were used to derive the relative potency values (Krewski et al., 1989). The oral SF for benzo(a)pyrene of 7.3E+0 per mg/kg-day, and the SFs presented above for the other Group B2 PAHs are adopted for the purposes of this evaluation.

An EPA (1994) evaluation of the inhalation cancer data suggests adoption of an inhalation SF for benzo(a)pyrene of 3.1E+0 per mg/kg-day, based on the incidence of upper respiratory and digestive tract tumors in hamsters. Applying the relative potency estimates presented above yield the inhalation URFs and SFs for the other Group B2 PAHs presented above.

EPA (2004) classified naphthalene in EPA cancer weight-of-evidence group C – possible human carcinogen – based on benign respiratory tumors and one carcinoma in female mice exposed to naphthalene by inhalation. Cancer potency factors are not available because the data are not sufficient.

7.0 Toxicity Summary

Toxicity values for the PAHs are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure[a]		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
Acenaphthene										
6E-1	6E-2	L	ND	ND	NA	ND	NA	ND	NA	NA
Acenaphthylene										
6E-1	6E-2	L	ND	ND	NA	D	NA	D	NA	NA
Anthracene										
3E+0	3E-1	ND	ND	ND	NA	D	NA	D	NA	NA
Benzo(a)anthracene										
ND	ND	NA	ND	ND	NA	B2	7.3E-1	B2	8.8E-5	3.1E-1
Benzo(a)pyrene										
ND	ND	NA	ND	ND	NA	B2	7.3E+0	B2	8.8E-4	3.1E+0
Benzo(b)fluoranthene										
ND	ND	NA	ND	ND	NA	B2	7.3E-1	B2	8.8E-5	3.1E-1
Benzo(k)fluoranthene										
ND	ND	NA	ND	ND	NA	B2	7.3E-2	B2	8.8E-6	3.1E-2
Benzo(g,h,i)perylene										
3E-1	3E-2	K	ND	ND	NA	D	NA	D	NA	NA
Chrysene										
ND	ND	NA	ND	ND	NA	B2	7.3E-3	B2	8.8E-7	3.1E-3
Dibenz(a,h)anthracene										
ND	ND	NA	ND	ND	NA	B2	7.3E+0	B2	8.8E-4	3.1E+0
Fluoranthene										
4E-1	4E-2	L,K,B	ND	ND	NA	D	NA	D	NA	NA
Fluorene										
4E-1	4E-2	E	ND	ND	NA	D	NA	D	NA	NA
Indeno(1,2,3-cd)pyrene										
ND	ND	NA	ND	ND	NA	B2	7.3E-1	B2	8.8E-5	3.1E-1
Naphthalene										
2E-1	2E-2	E, Ey, BW	3E-3/ 8.6E-4	3E-3/ 8.6E-4	Ne, Oe	C	ND	C	ND	ND
Phenanthrene										
3E-1	3E-2	K	ND	ND	NA	D	NA	D	NA	NA
Pyrene										
3E-1	3E-2	K	ND	ND	NA	D	NA	D	NA	NA

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data; NA = not applicable.

Target organ or critical effect abbreviations: B = blood cells; BW = reduced body weight; E = erythrocyte; Ey = eye; L = liver; K = kidney; Ne = nasal epithelium; Oe = olfactory epithelium.

[a]sRfDo, cRfDo and SFo should be used for dermal exposure without adjustment for GI absorption.

8.0 Preliminary Remediation Goals

EPA (2002) provides PRGs for all of the PAHs discussed above except acenaphthylene, benzo(g,h,i)perylene and phenanthrene. However, acenaphthene was selected as a surrogate for estimation of oral RfDs for acenaphthylene; therefore, the PRG for acenaphthene can be used in place of a PRG for acenaphthylene. Similarly, pyrene was selected as a surrogate for estimation of oral RfDs for benzo(g,h,i)perylene and phenanthrene; therefore, the PRG for pyrene can be used in place of PRGs for benzo(g,h,i)perylene and phenanthrene.

It should be noted that derivation of the EPA (2002) PRGs for several Group B2 PAHs – benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene and indeno(1,2,3-cd)pyrene – is based in part on adopting the SFo as the SFi, instead of using the SFi values based on the hamster inhalation study (EPA, 1994) described above. In all cases, however, adopting the SFo as the SFi provides the more conservative PRG estimation, although the differences are slight. Therefore, it is deemed unnecessary to recalculate the PRGs using the SFi values based on the EPA (1994) evaluation, and the EPA (2002) PRGs are judged to be satisfactory for all screening procedures.

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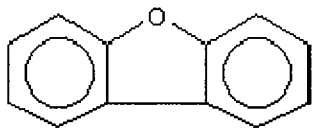
DIBENZOFURAN (DIPHENYLENE OXIDE) (132-64-9)



1.0 Introduction and Physical Properties

Dibenzofuran is a **VOC** used as an insecticide (Lewis, 1997), used together with biphenyl as a component of heat-transfer oils (HSDB, 2004), together with methylnaphthalenes as a carrier for dyeing and printing textiles (HSDB, 2004), and as a research chemical (Montgomery, 1996). Dibenzofuran derivatives are used as intermediates for naphtol AS and chromium complex dye production (HSDB, 2004). It is also a component of petroleum and petroleum products such as coal tar, diesel fuel and other similar products (HSDB, 2004). The compound occurs as a crystalline solid at ambient temperatures (HSDB, 2004). Relevant physical properties are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
168.19[a]	4.12[a]	2.1E-4[a] (25°C)	3.62[a]	6.24E-2[b] (25°C)[c]	7.22E-6[b] (25°C)[c]	3.26E-6[a] (25°C)	3.1E+0[a] (25°C)	560.2[a]	824[a]	2.02E+4[d,e]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point (at 1 atm) of pure liquid compound (°K); T_c = critical temperature (°K); $H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole); ND = no data.

[a] Hazardous Substance Data Bank (HSDB), 2004, National Library of Medicine, on line, accessed 27 July.

[b] Calculated as described in Introduction to Toxicity Profiles.

[c] Assumed.

[d] National Institute of Standards and Technology (NIST), 2004, ***NIST Chemistry WebBook***, on line, accessed 27 July.

[e] Most recent of four estimates.

2.0 Environmental Fate and Transport

Dibenzofuran may be released to the environment in wastewater and emissions as a result of its manufacture from coal tar and use as a component of heat-transfer oils, dye carrier, and chemical intermediate (HSDB, 2004). More significantly, since dibenzofuran is a component of creosote, (widely used as a wood preservative), and blended for use as a coal tar fuel and road tar, dibenzofuran may be released in wastewater, solid waste, and emissions at wood preserving facilities, coking oven, and other facilities that produce or use coal tar and coal tar products. The incomplete combustion of propane has been shown to form dibenzofuran. Sources of dibenzofuran released to the atmosphere include the combustion of coal, biomass, refuse, diesel fuel, and residual oil, during coal gasification, and in tobacco smoke. Environmental photolysis of chlorinated biphenyl ethers in surface waters by sunlight yields dibenzofuran as the major photolytic product.

Dibenzofuran is expected to exhibit low mobility in soil (HSDB, 2004). Monitoring of leaching in soil associated with creosote contamination has indicated that leaching may proceed somewhat faster than predicted by K_{oc}, although this leaching was monitored in a very low organic content soil in the presence of co-contaminants that may have facilitated leaching. Dibenzofuran is biodegraded at contaminated sites where populations of adapted microorganisms are present; otherwise biodegradation may be slow. Photoreactor studies indicate that photodegradation may occur in surface soil but degradation rates appear to be slow. Volatilization from moist soil surfaces may be an important removal process.

Dibenzofuran is expected to adsorb very strongly to sediment and particulate matter in the water column (HSDB, 2004). Dibenzofuran may volatilize from water based on its estimated Henry's Law constant. Estimated volatilization half-lives for a model river and model lake are 5 hours and 7 days, respectively. However, these estimates assume that dibenzofuran is dissolved in the water column; adsorption will greatly limit removal via volatilization. Studies have demonstrated that dibenzofuran is readily biodegraded by adapted microbes in the presence of sufficient oxygen. However, in aquatic sediments where oxygen is limited or lacking, biodegradation may be slow. The potential for biodegradation to be a significant removal mechanism in groundwater is variable.

Monitoring of ambient air has shown that dibenzofuran exists primarily in the gas-phase in the atmosphere with a small fraction, about 2.4 percent, existing in the particulate phase (HSDB, 2004). Gas-phase dibenzofuran reacts with photochemically-produced hydroxyl radicals; the half- life for this reaction is 4 days at an average ambient concentration of hydroxyl radicals. Data are not available to predict the rate at which particulate-phase dibenzofuran may degrade in air; however, the rate is expected to be much slower than dibenzofuran in the gas-phase. For particle-associated dibenzofuran, the dominant tropospheric removal processes are expected to be wet and dry deposition. A tropospheric lifetime of more than 10 days is expected, which is sufficient for long-range transport to occur. Rainwater monitoring indicates that both gas-phase and particulate dibenzofuran are removed from air via wet deposition. Washout ratios (concentration of chemical in rainwater/concentration in air) are approximately 1000.

BCFs measured for dibenzofuran in a 33-day model ecosystem study are as follows: alga, 82 L/kg; snail, 2858 L/kg; mosquito, 2094 L/kg; fish (not otherwise specified), 947 L/kg (HSDB, 2004). Equilibrium BCFs in fathead minnows ranged from 1100 L/kg to 1700 L/kg during 28-day flow-through experiments. Equilibrium concentrations were reached after 2 to 4 days of exposure. However, over 97 percent of the accumulated dibenzofuran was eliminated in 2 days during depuration tests, suggesting that elimination is rapid and indicating that food-chain exposure is unlikely to be significant. Therefore, biotransfer factors are not estimated for dibenzofuran.

3.0 Toxicokinetics

Data regarding the toxicokinetics of dibenzofuran were not located in the available literature. Jones and Owen (1989) compiled GI absorption data for 19 organic compounds. GI absorption generally approximated or exceeded 90 percent except for the polyaromatic hydrocarbon (PAH) benzo(a)pyrene, for which GI absorption was 50 percent. Lacking a reliable basis for quantification, it is assumed that the GI absorption of dibenzofuran occurs readily, which is the case for most lipophilic organics.

The high lipophilicity of dibenzofuran as indicated by its relatively high log K_{ow} suggests that absorbed compound will probably partition preferentially to tissues that are relatively high in fat, such as the liver, CNS, and adipose tissue depots of the body.

Data regarding the metabolism of dibenzofuran are limited to several studies of microbial degradation. Collectively, these studies suggest that dibenzofuran is subject to multiple oxidation reactions resulting in the addition of hydroxyl groups, probably at least in part through an epoxide intermediate (Cerniglia et al., 1979; Monna et al., 1993; Hammer et al., 2001; Stope et al., 2002). The hydroxylated derivatives were shown in some cases to be conjugated with glucose. Another microbial pathway involves meta-cleavage of the central 5-membered ring to yield salicylic acid and

gentisic acid. It is likely that mammalian metabolism would closely resemble that seen in the microbial systems. The observation of glycosyl residues in the microbial systems suggests that conjugation with other moieties (e.g., glucuronic acid, glycine, sulfate) would be likely in mammalian systems.

Data regarding excretion of dibenzofuran or its degradation products were not located.

4.0 Dermal Exposure

EPA (2003) notes that organic chemicals are generally well absorbed from the GI tract, and recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly less than complete. As noted above, it is assumed that GI absorption of dibenzofuran occurs readily. Therefore, no GAF is developed for dibenzofuran and the oral toxicity values described below should be used for dermal exposure without adjustment for GI absorption.

Data were not located for dermal uptake of dibenzofuran from soil. VOCs tend to volatilize from soil when applied to the skin, reducing dermal uptake to toxicologically insignificant levels (EPA, 2003). Therefore, dermal uptake of dibenzofuran from soil is not evaluated. Values for K_p, τ, B and FA were developed by the EPA (2003) methodology as follows:

Chemical	t*	K_p	τ	FA	B
Dibenzofuran	2.20	9.49E-2	9.18	0.6	4.7

t* = time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); □ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).

5.0 Noncancer Effects Evaluation

Data regarding the toxicity of acute oral exposure to dibenzofuran were not located. Data regarding prolonged oral exposure are limited to a 1940 study in which groups of 5 female rats were fed diets containing dibenzofuran at 0 (control), 250, 500, 1000, 2000 or 4000 mg/kg for 200 days (EPA, 2002). Two additional rats were fed diets containing dibenzofuran at 8000 mg/kg for approximately 100 days. None of the rats exhibited abnormal behavior or altered food intake, but the treated rats consumed more water than controls. Effects observed at 500 mg/kg and higher included reduced body length, increased body fat, and kidney abnormalities upon histopathological evaluation. The apparent effect on body length did not follow a dose-related pattern and the toxicological significance of this effect is doubtful. The study appears to identify a LOAEL of 500 mg/kg in the diet (25 mg/kg-day) and a NOAEL of 250 mg/kg (12.5 mg/kg-day). However, histopathologic evaluation was not performed on rats fed the 250 mg/kg diet, so confidence in the designation of this dietary level as a NOAEL is reduced. Therefore, EPA (2002) selected the LOAEL as the basis for estimation of a chronic oral RfD. An uncertainty factor of 10,000 was applied to the LOAEL to derive the provisional chronic oral RfD of 2E-3 mg/kg-day. The uncertainty factor consists of factors of 10 each to account for inter- and intra-species variation, and to extrapolate from a subchronic study to chronic exposure, and factors of $10^{(0.5)}$ each to extrapolate from a minimal LOAEL to a NOAEL and to account for deficiencies in the data base. Confidence in the provisional chronic oral RfD is low. The kidney is considered the target organ for chronic oral exposure to dibenzofuran.

A preliminary subchronic oral RfD can be estimated from the EPA (2002) evaluation of the rat study described above. EPA (2002) identified the LOAEL of 25 mg/kg-day as the appropriate basis for the provisional chronic oral RfD. An uncertainty factor of 1000 can be applied to the LOAEL to estimate a preliminary subchronic oral RfD of 2E-2 mg/kg-day. The uncertainty factor of 1000 reflects the chronic uncertainty factor of 10,000 without the factor of 10 to expand from subchronic to chronic exposure. Confidence in the preliminary subchronic oral RfD is low. The kidney is considered the target organ for subchronic oral exposure to dibenzofuran.

Data regarding the toxicity of inhalation exposure to dibenzofuran were not located; an inhalation RfC cannot be developed.

6.0 Carcinogenicity Evaluation

EPA (2004) classified dibenzofuran in cancer weight-of-evidence Group D – not classifiable as to carcinogenicity to humans – because of the absence of cancer data for humans or animals. Cancer potency estimates are not available for Group D chemicals.

7.0 Toxicity Summary

Toxicity values for dibenzofuran are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
2E-2	2E-3	K	ND	ND	NA	D	NA	D	NA	NA

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data; NA = not applicable.
Target organ or critical effect abbreviations: K = kidney.
[a]sRfDo and cRfDo should be used for dermal exposure without adjustment for GI absorption.

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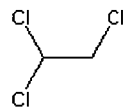
VOLATILE ORGANIC COMPOUNDS

1,1,2-TRICHLOROETHANE (79-00-5)



1.0 Introduction and Physical Properties

1,1,2-Trichloroethane is a **VOC** that occurs as a clear, colorless liquid at ambient temperatures (HSDB, 2005). It is used primarily as a chemical intermediate in the synthesis of 1,1-dichloroethene (ATSDR, 1989; HSDB, 2005). A minor use is as a solvent where its high solvency is needed. It is also used in adhesives, in the production of teflon tubing, in lacquer, and in various coating formulations. Relevant physical properties are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
133.4[a]	2.05[a]	9.12E-4[b] (25°C)	1.70[b]	7.80E-2[b] (25°C)	8.80E-6[b] (25°C)	3.03E-2[c] (25°C)	4.42E+3[b] (20-25°C)	386.15[d]	602.00[d]	8.32E+3[d]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point (at 1 atm) of pure liquid compound (°K); T_c = critical temperature (°K); $H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole); ND = no data.

[a]U.S. Environmental Protection Agency (EPA), 2004, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final***, Office of Superfund Remediation and Technology Innovation, Washington, DC, EPA/540/R/99/005, OSWER 9285.7-02EP, NTIS No. PB99-963312, July.

[b]U.S. Environmental Protection Agency (EPA), 2002, ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites***, Office of Solid Waste and Emergency Response, OSWER 9355.4-24, December.

[c]Hazard Substances Data Bank (HSDB), 2005, National Library of Medicine, on line accessed 15 December.

[d]U.S. Environmental Protection Agency (EPA), 2003, ***Users Guide for Evaluating Subsurface Vapor Intrusion into Buildings***, Office of Emergency and Remedial Response, Washington, DC, 19 June.

2.0 Environmental Fate and Transport

1,1,2-Trichloroethane enters the atmosphere from its use in the manufacture of 1,1-dichloroethene and its use as a solvent (HSDB, 2005). It also is discharged in wastewater associated with these uses and in leachates and volatile emissions from landfills. Based upon a relatively high vapor pressure, 1,1,2-trichloroethane is expected to exist almost entirely in the vapor-phase in the ambient atmosphere. It is expected to degrade slowly in an average ambient atmosphere by reaction with photochemically produced hydroxyl radicals (estimated half-life of 24 to 50 days). Its reaction under simulated smog conditions is much faster, the half-life being approximately 16 hours. Physical removal from air via wet deposition is possible since 1,1,2-trichloroethane is relatively soluble in water.

The principal removal mechanism for 1,1,2-Trichloroethane in water is volatilization into the atmosphere (HSDB, 2005). Little of the chemical will be lost by adsorption to sediment, biodegradation or hydrolysis.

When released to land 1,1,2-trichloroethane should volatilize or infiltrate into deeper layers, depending on the rate and amount of material released (HSDB, 2005). The compound is expected to be moderately to highly mobile in soil. Empirical data regarding the potential for biodegradation are confusing; however, it appears that biotransformation may occur slowly under anaerobic conditions, such as the methanogenic conditions found in landfills. Vinyl chloride is the principal product of its degradation.

1,1,2-Trichloroethane is not expected to bioconcentrate or participate significantly in food-chain pathways because of its low K_{ow} (HSDB, 2005). Empirical data support this conclusion; therefore, biotransfer factors are not estimated.

3.0 Toxicokinetics

A single-breath study in one human volunteer revealed that approximately 90 percent had been absorbed (ATSDR, 1989). The potential for saturation of absorption or elimination pathways associated with inhalation exposure was not evaluated.

Excretion studies in laboratory animals indicate that upwards of 80 percent of an ingested dose is absorbed (ATSDR, 1989).

Application of liquid 1,1,2-trichloroethane (vehicle, if any, not identified) to the skin of guinea pigs or mice showed that dermal uptake is rapid and extensive (ATSDR, 1989).

Data regarding the distribution of absorbed 1,1,2-trichloroethane are limited, but inhalation studies suggest that distribution is widespread (ATSDR, 1989). The lipophilic nature of the compound suggests that highest levels may be found in the liver, brain and adipose tissue.

Metabolism of 1,1,2-trichloroethane appears to proceed by two main pathways (ATSDR, 1989). One is direct conjugation with glutathione involving dehalogenation to yield S-carboxymethylcysteine and thiodiacetic acid, both of which are excreted in the urine. This is considered to be a detoxication reaction. The second pathway involves mixed function oxidase (MFO) dehalogenation and oxidation to yield chloroacetic acid. Chloroacetic acid is a predominant urinary metabolite, but some may bind to cellular macromolecules. Other free radical MFO oxidation products also bind to macromolecules. The free radicals and chloroacetic acid that bind to macromolecules appear to be responsible for the adverse effects associated with exposure. Data regarding the relationships of these two pathways were not located; however, xenobiotics that induce MFO have been shown to exacerbate the toxicity of 1,1,2-trichloroethane.

As much as 7 to 10 percent of an oral or intraperitoneal dose of 1,1,2-trichloroethane given to rats or mice was excreted unchanged in expired air (ATSDR, 1989). Urinary excretion of metabolites accounted for 72 to 87 percent of the dose. Approximately 1 percent was excreted in the feces and 1 to 3 percent remained in the carcass after 48 hours.

4.0 Dermal Exposure

EPA (2004) notes that organic chemicals are generally well absorbed from the GI tract, and recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly less than complete. Therefore, no GAF is developed for the 1,1,2-trichloroethane and the oral toxicity values described below should be used for dermal exposure without adjustment for GI absorption.

Data regarding dermal uptake of 1,1,2-trichloroethane from soil were not located. VOCs tend to volatilize from soil when applied to the skin, reducing dermal uptake to toxicologically insignificant levels (EPA, 2004). Therefore, dermal uptake of 1,1,2-trichloroethane from soil is not evaluated. t*, K_p, τ, FA and B values are provided by EPA (2004) as follows:

Chemical	t*	K_p	τ	FA	B
1,1,2-Trichloroethane	1.43	6.4E-3	0.60	1.0	0.0
t* = time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); □ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).					

5.0 Noncancer Effects Evaluation

Oral LD_{50} values for 1,1,2-trichloroethane range from 100 to 837 mg/kg in rats, and 378 to 491 mg/kg in mice (ATSDR, 1989; HSDB, 2005). Prolonged oral exposure of laboratory rodents is associated with depressed humoral immune function, effects on the erythrocytes and clinicopathologic evidence of altered liver function. EPA (2005) verified an RfD of 4E-3 mg/kg-day for chronic oral exposure to 1,1,2-trichloroethane, based on a NOAEL of 3.9 mg/kg-day and an uncertainty factor of 1000. In the key study, mice were provided with drinking water containing 1,1,2-trichloroethane for 90 days. The LOAEL was 44 mg/kg-day. Effects on the immune system appear to be the critical effects of prolonged oral exposure, and the immune system is chosen as the target organ. Confidence in the oral RfD is medium. EPA (1997) derived a provisional subchronic oral RfD of 4E-2 mg/kg-day from the same NOAEL by applying an uncertainty factor of 100. The uncertainty factor of 100 excludes a factor of 10 to expand from subchronic to chronic exposure that was included in the chronic uncertainty factor.

Data regarding the effects of inhalation exposure of humans to 1,1,2-trichloroethane were not located in the available literature. Acute exposure of animals induces excitement followed by central nervous system depression (ATSDR, 1989). Prolonged inhalation exposure is associated with altered liver function, but the data are not sufficient for estimation of an inhalation RfC.

6.0 Carcinogenicity Evaluation

EPA (2005) classified 1,1,2-trichloroethane in EPA cancer weight-of-evidence Group C (possible human carcinogen) on the basis of no human data, sufficient evidence in animals, and structural similarity to 1,2-dichloroethane, which is classified as a probable human carcinogen. The animal data consist of a 78-week gavage study in rats and mice. No significant evidence of carcinogenicity was observed in the rats. An increased incidence of hepatocellular carcinomas was observed in male and female mice, and an increased incidence of pheochromocytomas was observed in the female mice. A verified oral SF of 5.7E-2 per mg/kg-day was derived from the data for hepatocellular carcinomas. The oral SF was adopted by EPA (2005) for use for inhalation exposure as well. The SF corresponds to a URF of 1.6E-5 per $\mu g/m^3$ (1.65E-2 per mg/m^3).

7.0 Toxicity Summary

Toxicity values for 1,1,2-trichloroethene are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure[a]		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
4E-2	4E-3	I	ND/ ND	ND/ ND	NA	C	5.7E-2	C	1.65E-5	5.7E-2
sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per										

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure[a]		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data; NA = not applicable. Target organ or critical effect abbreviations: I = immune system. [a]sRfDo, cRfDo and SFo should be used for dermal exposure without adjustment for GI absorption.										

8.0 References

Agency for Toxic Substances and Disease Registry (ATSDR), 1989, ***Toxicological Profile for 1,1,2-Trichloroethane***, U.S. Department of Health and Human Services, Atlanta, Georgia, December, on line.

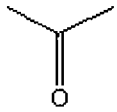
Hazardous Substance Data Bank (HSDB), 2005, National Library of Medicine, on line, accessed 15 December.

U.S. Environmental Protection Agency (EPA), 1997, ***Health Effects Assessment Summary Tables, FY 1997 Update***, Office of Solid Waste and Emergency Response, Washington, DC, 9200.6-303(97-1), EPA 540/R-97-036, PB97-921199.

U.S. Environmental Protection Agency (EPA), 2004, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final***, Office of Superfund Remediation and Technology Innovation, Washington, DC, EPA/540/R/99/005, OSWER 9285.7-02EP, NTIS No. PB99-963312, July.

U.S. Environmental Protection Agency (EPA), 2005, ***Integrated Risk Information System (IRIS)***, National Center for Environmental Assessment, Cincinnati, OH, on line, accessed 15 December.

ACETONE (67-64-1)



1.0 Introduction and Physical Properties

Acetone is a **VOC** used principally as an intermediate in chemical synthesis and as a solvent in a wide variety of applications (ATSDR, 1994; HSDB, 2004). It occurs as a colorless liquid at room temperature. Relevant physical properties are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
58.08[a]	-0.24[a]	3.88E-5[b] (25°C)	-0.24[b]	1.24E-1[b] (25°C)	1.14E-5[b] (25°C)	3.04E-1[a] (25°C)	Miscible[b]	329.20[c]	508.10[c]	6.96E+3[c]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point (at 1 atm) of pure liquid compound (°K); T_c = critical temperature (°K); $H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole).

[a]Hazardous Substance Data Bank (HSDB), 2004, National Library of Medicine, on line, accessed 15 December.

[b]U.S. Environmental Protection Agency (EPA), 2001, ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites***, Peer Review Draft, Office of Solid Waste and Emergency Response, OSWER 9355.4-24, March.

[c]U.S. Environmental Protection Agency (EPA), 2003, ***Users Guide for Evaluating Subsurface Vapor Intrusion into Buildings***, Office of Emergency and Remedial Response, Washington, DC, 19 June.

2.0 Environmental Fate and Transport

The production and use of acetone as a solvent or extracting agent in many applications may result in its release to the environment through various waste streams (HSDB, 2004). Its use as a starting material or intermediate in the manufacture of chemical products may also lead to its release to the environment. Other important sources include vehicular exhaust, tobacco smoke, wood burning and pulping, refuse and polyethylene combustion, off-gassing from petroleum storage, and landfills (ATSDR, 1994). Acetone occurs naturally as a metabolic byproduct of plants and animals and is released into the atmosphere by animals, plants, volcanoes and forest fires. Municipal and industrial discharge to landfills may lead to soil contamination and, by leaching, to groundwater contamination.

Acetone is expected to exist in the ambient atmosphere solely as a vapor, based on its high vapor pressure (ATSDR, 1994; HSDB, 2004). Vapor-phase acetone is degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals and by photodecomposition by sunlight. Half-life estimates range from 20 to 80 days, suggesting the potential for long distance transport in the atmosphere. Acetone is expected to have very high mobility in soils based upon its low K_{oc} and miscibility with water, indicating that the compound will leach readily to groundwater. Volatilization from moist or dry soil surfaces is expected to be a major removal process for acetone. Acetone is expected to biodegrade under aerobic and anaerobic conditions. Acetone in water is not expected to adsorb to suspended solids or sediment. Volatilization from water surfaces is expected to be an important removal process. Because of its low K_{ow}, acetone is not expected to participate significantly in food-chain pathways; therefore, biotransfer factors are not developed.

3.0 Toxicokinetics

Acetone is one of three endogenous ketones formed in the liver and to a lesser extend in the lung and kidney as a component of the Kreb's tricarboxylic acid cycle (ATSDR, 1994). Endogenous levels vary greatly throughout the day depending on many physiological factors related to cellular energy demands. Physiological states that require high levels of energy generally result in increased fatty

acid utilization and increased production of acetone. Acetone not utilized within the Kreb's cycle may be excreted via the lung or to a much lesser extent by the kidney.

Exogenous exposure via inhalation results in pulmonary uptake of 30 to 80 percent of the inhaled amount (ATSDR, 1994). The wide range of uptake for inhalation exposure reflects a phenomenon called wash-in/wash-out, in which inspired acetone dissolves in epithelial cells during inspiration (wash-in) and volatilizes from the cells during expiration (wash-out). Animal studies indicate that absorption from the GI tract is rapid and extensive, with pulmonary excretion of unchanged parent compound and carbon dioxide accounting for 74 to 83 percent of an oral dose. Neat acetone is readily absorbed by the skin of humans and laboratory animals, but quantitative data regarding rate or extent were not located.

Data following inhalation exposure indicate that acetone is widely distributed throughout the body, particularly within the water compartment (ATSDR, 1994). Transplacental transfer also occurs. Prolonged exposure results in slightly higher levels in lung and liver than other tissues, but clearance is rapid. Acetone does not appear to preferentially distribute to or accumulate in any tissue.

Metabolism of acetone from endogenous or exogenous sources, which occurs predominantly in the liver, is similar in animals and humans (ATSDR, 1994). Acetone participates in three separate gluconeogenic pathways that result in the production of glucose, adenosine triphosphate and carbon dioxide. One of the pathways yields formate as a degradation product. Formate may be responsible for the effects on the kidney. Acetone also serves as a three-carbon moiety that is incorporated into other physiological substances including amino acids, fatty acids, heme, cholesterol, choline and urea.

Excretion is primarily via the lungs and includes unchanged compound and carbon dioxide (ATSDR, 1994). Little acetone is excreted via the urine.

4.0 Dermal Exposure

As noted above, acetone is readily absorbed following oral administration to laboratory animals (ATSDR, 1994). EPA (2004a) notes that organic chemicals are generally well absorbed from the GI tract, and recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly less than complete. Therefore, no GAF is developed for acetone and the oral toxicity values described below should be used for dermal exposure without adjustment for GI absorption.

Application of neat compound to the skin of humans results in fairly rapid absorption, as noted above (ATSDR, 1994). Data regarding dermal uptake from soil, however, were not located. VOCs tend to volatilize from soil when applied to the skin, reducing dermal uptake to toxicologically insignificant levels (EPA, 2004a). Therefore, dermal uptake of acetone from soil is not evaluated. t*, K_p, τ, FA and B values are estimated by the EPA (2004a) methods as follows:

Chemical	t*	K_p	τ	FA	B
Acetone	0.53	5.20E-4	0.22	1	0[a]

t* = time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); □ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).

[a]Sufficiently small to be rounded to zero.

The estimated value for K_p fell within the effective prediction domain.

5.0 Noncancer Effects Evaluation

Oral LD_{50} values for adult rats range from 5.8 to 10.7 g/kg, indicating that the acute toxicity of acetone is low (ATSDR, 1994). Prolonged oral exposure toxicity data include a comprehensive 90-day gavage study in rats, in which 100 mg/kg-day was a NOEL and 500 mg/kg-day was a LOAEL associated with increased liver and kidney weight and tubular nephropathy (EPA, 2004b). More recently, rats were administered acetone in the drinking water at concentrations of 0, 2,500, 5,000, 10,000, 20,000, or 50,000 mg/L for 13 weeks (EPA, 2004b). Drinking water administration is considered more relevant than gavage administration to the modes of exposure expected for humans. No deaths occurred in any group. Water consumption was decreased in rats in the two highest dose groups. No clinical signs of toxicity or ophthalmic abnormalities were observed in any group. Altered spermatogenesis and testicular effects were observed in high-dose males. Nephropathy, observed only in male rats, was identified as the critical effect. The LOAEL and NOAEL for mild nephropathy were 10,000 and 20,000 mg/L (900 and 1700 mg/kg-day), respectively. Nephropathy in the male rats was accompanied by mild macrocytic normochromic anemia as a secondary effect. A similar drinking water study in mice indicated that rats are more sensitive and the more appropriate species from which to develop an oral RfD.

A verified RfD for chronic oral exposure of 9E-1 mg/kg-day was derived by applying an uncertainty factor of 1000 to the NOAEL of 900 mg/kg-day from the drinking water study in rats (EPA, 2004b). The uncertainty factor of 1000 consists of factors of 10 each for intraspecies variation and to account for deficiencies in the data base, and factors of 3 ($10^{1/2}$ rounded to one significant figure) to provide additional protection for unusually sensitive individuals and to expand from subchronic to chronic exposure. Confidence in the chronic oral RfD is medium. The kidney is considered to be the target organ for prolonged oral exposure to acetone.

EPA (1997) developed a provisional RfD for subchronic oral exposure to acetone from the NOEL of 100 mg/kg-day identified in the gavage study in rats described above. The more recent drinking water study reviewed by EPA (2004b), however, necessitates estimation of a new subchronic oral RfD. A preliminary subchronic oral RfD can be estimated for acetone from the NOAEL of 900 mg/kg-day used as the basis of the verified chronic oral RfD. Application of an uncertainty factor of 300 to the NOAEL of 900 mg/kg-day yields a preliminary subchronic oral RfD for acetone of 3E+0 mg/kg-day. The uncertainty factor of 300 reflects the chronic uncertainty factor of 1000 without the factor of 3 to expand from subchronic to chronic exposure.

Studies of workers exposed to acetone reveal irritation of the ocular and respiratory tract mucosa, and, at high concentrations, central nervous system (CNS) effects (ACGIH, 1991; EPA, 2004b). Rats exposed by inhalation to high concentrations exhibit narcosis and slight decreases in organ and body weight, compared with controls, but no clinicopathological or histopathological evidence of organ damage. The data, however, are insufficient for derivation of an inhalation RfC for acetone.

6.0 Carcinogenicity Evaluation

EPA (2004b) concluded that the "*data are inadequate for an assessment of the human carcinogenic potential*" of acetone, based on the availability of one human study of limited quality, no chronic animal studies, and no additional information on structural analogues with known carcinogenic

potential. Acetone has tested negative in almost all genotoxicity studies. Quantitative cancer potency estimates are not available.

7.0 Toxicity Summary

The toxicity of acetone is summarized as follows:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
3E+0	9E-1	K	ND	ND	NA	Inade-quate	ND	Inade-quate	ND	ND

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data; NA = not applicable.
Target organ or critical effect abbreviations: K = kidney.
[a]sRfDo and cRfDo should be used for dermal exposure without adjustment for GI absorption.

8.0 References

Agency for Toxic Substances and Disease Registry, (ATSDR), 1994, ***Toxicological Profile for Acetone***, U.S. Public Health Service, Atlanta, Georgia, May, on line.

American Conference of Governmental Industrial Hygienists (ACGIH), 1991, ***Documentation of the Threshold Limit Values and Biological Exposure Indices***, Sixth Edition, ACGIH, Cincinnati, OH, pp. 10-11.

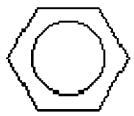
Hazardous Substance Data Bank (HSDB), 2004, National Library of Medicine, on line, accessed 15 December.

U.S. Environmental Protection Agency (EPA), 1997, ***Health Effects Assessment Summary Tables, FY 1997 Update***, Office of Solid Waste and Emergency Response, Washington, DC, 9200.6-303(97-1), EPA 540/R-97-036, PB97-921199.

U.S. Environmental Protection Agency (EPA), 2004a, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final***, Office of Superfund Remediation and Technology Innovation, Washington, DC, EPA/540/R/99/005, OSWER 9285.7-02EP July.

U.S. Environmental Protection Agency (EPA), 2004b, ***Integrated Risk Information System (IRIS)***, National Center for Environmental Assessment, Cincinnati, OH, on line, accessed 15 December.

BENZENE (71-43-2)



1.0 Introduction and Physical Properties

Benzene is a naturally occurring **VOC**, present in low levels in many plants and animals, as well as a synthetic compound derived from petroleum (ATSDR, 1997). It occurs as a colorless or slightly yellow liquid, or as a solid at temperatures below approximately 5.5 °C (HSDB, 2004). Benzene is widely used as a solvent and in the manufacturing of other organic compounds such as styrene, phenol, detergents, pesticides, explosives, polychlorinated biphenyls, flavors, perfumes, paints and coatings, nylon intermediates and photographic chemicals, among others. It is also used in food processing and leather tanning and occurs as a component of gasoline. Relevant physical properties are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
78.1[a]	2.13[a]	5.56E-3[b] (25□C)	1.77[b]	8.80E-2[b] (25□C)	9.80E-6[b] (25□C)	1.25E-1[c] (25□C)	1.75E+3[b] (20-25□C)	353.24[d]	562.16[d]	7.34E+3[d]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point (at 1 atm) of pure liquid compound (°K); T_c = critical temperature (°K); $H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole).

[a]U.S. Environmental Protection Agency (EPA), 2003, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim***, Office of Emergency and Remedial Response, EPA/540/R/99/005, OSWER 9285.7-02EP March

[b]U.S. Environmental Protection Agency (EPA), 2001, ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites***, Peer Review Draft, Office of Solid Waste and Emergency Response, OSWER 9355.4-24, March.

[c]Hazardous Substance Data Bank (HSDB), 2004, National Library of Medicine, on line, accessed 21 April.

[d]U.S. Environmental Protection Agency (EPA), 2003, ***Users Guide for Evaluating Subsurface Vapor Intrusion into Buildings***, Office of Emergency and Remedial Response, Washington, DC, 19 June.

2.0 Environmental Fate and Transport

Benzene enters the atmosphere primarily from fugitive emissions and automobile exhaust because of its presence in gasoline (ATSDR, 1997; HSDB, 2004). Other important sources are emissions associated with its production and use as a solvent, as an industrial intermediate in the production of the materials mentioned above, and coke oven blast furnaces and coke by-product recovery plants. In addition, there are discharges into water from industrial effluents and losses during spills. Sources of release to soil include land disposal of benzene-containing wastes, industrial discharge, and leaks from underground storage tanks and associated plumbing.

Benzene released to the atmosphere will exist almost exclusively in the vapor phase (ATSDR, 1997; HSDB, 2004). It is not subject to direct photolysis but it will react with photochemically produced hydroxyl radicals with a half-life of approximately 13 days. The reaction time in polluted atmospheres containing nitrogen oxides or sulfur dioxide is accelerated with the half-life being reported as 4 to 6 hours. Products of photooxidation include phenol, nitrophenols, nitrobenzene, formic acid, and peroxyacetyl nitrate. Benzene is fairly soluble in water and is removed from the atmosphere in rain.

Benzene released to soil will be subject to rapid volatilization near the surface; that which does not evaporate will be highly to very highly mobile in the soil and may leach to groundwater (ATSDR, 1997; HSDB, 2004). Benzene may be subject to biodegradation under aerobic conditions.

Microbial transformation proceeds through formation of cis-dihydrodiols to catechols, which lead to destruction of the aromatic ring.

Benzene may be subject to photooxidation and biodegradation in shallow, aerobic groundwaters, but probably not significantly under deeper or anaerobic conditions (ATSDR, 1997; HSDB, 2004). Benzene released to surface water will be subject to rapid volatilization. It is not expected to sorb to sediment or to hydrolyze significantly. Biodegradation is unlikely to be a significant fate process in sediment.

Benzene is not expected to participate significantly in food-chain pathways (ATSDR, 1997; EPA, 1995; HSDB, 2004); therefore, biotransfer factors are not provided.

3.0 Toxicokinetics

Benzene is rapidly and readily absorbed during inhalation exposures of humans or laboratory animals to vapors (ATSDR, 1997). However, the extent of uptake and retention decrease with increasing concentration or time of exposure, reflecting saturation of the metabolic processes that remove the substance from the blood. Excretion data from laboratory animals show that absorption is rapid and essentially complete following oral administration. Dermal uptake of liquid benzene through intact skin has been demonstrated in humans and may be toxicologically significant. The extent of dermal uptake of benzene vapor has not been quantified in humans, but experiments in laboratory animals suggest this exposure route also may be toxicologically significant.

Benzene is widely distributed following any route of exposure (ATSDR, 1997). Highest levels were located in adipose and other tissues high in fat such as the brain following inhalation exposure. Highest levels following oral administration were located in liver, kidney and bone marrow.

Quantitative aspects of the metabolism of benzene are somewhat species-, exposure route- and dose-dependent (ATSDR, 1997), but certain relevant generalizations pertain. The first metabolic step appears to be cytochrome P-450-catalyzed oxidation of benzene to benzene epoxide in the liver, which rearranges to phenol. Phenol is transformed to hydroxyquinone, which is further oxidized to benzoquinone, considered to be a major toxicant in bone marrow. Alternatively, phenol may be further oxidized to catechol and possibly to trihydroxybenzene. Phenol and all its derivatives except benzoquinone have been shown to undergo detoxication by conjugation with glucuronide or sulfate, followed by excretion.

A second general pathway involves the further oxidation of benzene oxide to benzene dihydrodiol, which leads to ring-opening and the formation of muconic dialdehyde, a known hematotoxin, primarily in the liver (ATSDR, 1997).

Absorbed benzene is excreted through the lungs as unchanged compound, and through the urinary tract as conjugated metabolites (ATSDR, 1997). Urinary excretion predominates.

Nothing in this review of toxicokinetics suggests that laboratory animals would not serve as appropriate models for the toxicity of benzene to humans.

4.0 Dermal Exposure

EPA (2003) notes that organic chemicals are generally well absorbed from the GI tract, and recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly less than complete. Therefore, no GAF is developed for benzene and the oral toxicity values described below should be used for dermal exposure without adjustment for GI absorption.

As mentioned above, benzene in the liquid and vapor form are absorbed through the skin (ATSDR, 1997). Combining benzene with soil slows dermal uptake. EPA (2003) notes that VOCs tend to volatilize from soil when applied to the skin, reducing dermal uptake to toxicologically insignificant levels. Therefore, dermal uptake of benzene from soil is not evaluated. EPA (2003) provides t*, K_p, τ, B and FA values as follows:

Chemical	t*	K_p	τ	FA	B
Benzene	0.70	1.5E-2	0.29	1	0.1

t* = time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); □ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).

5.0 Noncancer Effects Evaluation

Short-term exposure to benzene induces central nervous system (CNS) effects such as drowsiness, dizziness and headaches; long-term exposure may induce anemia (ATSDR, 1997). Oral dosing in animals induces hematopoietic and immune effects. EPA (2004) verified a chronic oral RfD of 4E-3 mg/kg-day, based on hematological effects (reduced lymphocyte count) in a cross-sectional occupational study of 44 workers exposed to benzene. The workers were exposed for 0.7 to 16 years, with a mean of 6.3 years. Because the mean fell below 7 years, the minimal length considered to be chronic, the study is judged to be subchronic in duration. The control group consisted of an equal number of age- and gender-matched unexposed workers. The exposed workers were divided into two equal groups of 22: those exposed to airborne concentrations below and those exposed to airborne concentrations above the median concentration for all workers of 99 mg/m^3. An exposure-adjusted benchmark concentration (BMC) for minimal hematologic effects of 8.2 mg/m^3 was estimated. Assuming that uptake from the respiratory tract is approximately 50 percent of that from the GI tract allowed application of inhalation-to-oral extrapolation to estimate a benchmark dose (BMD) of 1.2 mg/kg-day. Application of an uncertainty factor of 300 to the BMD yielded the verified chronic oral RfD of 4E-3 mg/kg-day. The uncertainty factor of 300 consists of factors of 3 each for extrapolation from a BMC for minimal adverse effects to a BMC for no adverse effects, to expand from subchronic to chronic exposure, and to reflect deficiencies in the data base; a factor of 10 was used to provide additional protection for more sensitive human subpopulations. The blood cells (specifically inhibited hematopoiesis) are the target for prolonged oral exposure to benzene. Confidence in the chronic oral RfD is medium.

A preliminary subchronic oral RfD can be developed from the BMD described above. The subchronic oral RfD is derived by applying an uncertainty factor of 100 to the BMD of 1.2 mg/kg-day. The uncertainty factor of 100 reflects the uncertainty factor of 300 developed by EPA (2004) without the factor of 3 to expand from subchronic to chronic exposure. The preliminary subchronic oral RfD so derived is 1.2E-2 mg/kg-day, which is rounded to 1E-2 mg/kg-day.

A verified chronic inhalation RfC of 3E-2 mg/m^3 for benzene was based on the exposure-adjusted BMC of 8.2 mg/m^3 in the occupational exposure study from which the oral RfD values were derived (EPA, 2004). Application of the uncertainty factor of 300 (as described for the verified chronic oral RfD) to the BMC of 8.2 mg/m^3 yielded the chronic RfC of 3E-2 mg/m^3. The RfC is equivalent to an inhalation RfD of 8.6E-3 mg/kg-day. Confidence in the chronic inhalation RfC is medium. The blood cells (specifically inhibited hematopoiesis) are the target for prolonged inhalation exposure to benzene. A preliminary subchronic inhalation RfC can be derived by application of an uncertainty factor of 100 to the BMC of 8.2 mg/m^3 in the same manner as was done to derive the subchronic oral RfD. The subchronic inhalation RfC so derived is 8.2E-2 mg/m^3, rounded to 8E-2 mg/m^3. The preliminary subchronic inhalation RfC is equivalent to an inhalation RfD of 2.3E-2 mg/kg-day.

6.0 Carcinogenicity Evaluation

Benzene is classified as an EPA cancer weight-of-evidence Group A chemical – a known human carcinogen for all routes of exposure based upon convincing human evidence as well as supporting evidence from animal studies (EPA, 2004). Epidemiologic studies and case studies provide clear evidence of a causal association between exposure to benzene and acute nonlymphocytic leukemia, and also provide supportive evidence for chronic nonlymphocytic leukemia and chronic lymphocytic leukemia. Other neoplastic conditions in humans that are associated with benzene exposure include hematologic neoplasms, blood disorders such as preleukemia and aplastic anemia, Hodgkin's lymphoma, and myelodysplastic syndrome. Experimental animal data add to the weight of evidence that exposure to benzene increases the risk of cancer in multiple species at multiple organ sites (hematopoietic, oral and nasal, liver, forestomach, preputial gland, lung, ovary, and mammary gland). A verified URF range for inhalation exposure of 2.2E-6 to 7.8E-6 per µg/m^3 was based on the incidence of leukemia in humans exposed to benzene while employed in the Pliofilm industry (EPA, 2004). A low-dose linearity model utilizing maximum likelihood estimates was used to estimate the URF. The range reflects differences in the exposure assumptions estimated from the study. EPA (2004) concluded that neither any specific URF value nor either end of the range is more defensible than the other. Therefore, the upper end of the range, 7.8E-6 per µg/m^3, is conservatively selected for this evaluation. The URF of 7.8E-6 per µg/m^3 is equivalent to an inhalation SF of 2.7E-2 per mg/kg/day.

The occupational data that serve as the basis for the inhalation URF also serve as the basis for a verified oral SF for benzene (EPA, 2004). The inhalation URF range was mathematically converted to an equivalent oral SF range by applying standard inhalation rate and body weight assumptions, and by adjusting for route-specific differences in absorption as described for the chronic oral RfD derivation. The oral SF range so derived is 1.5E-2 to 5.5E-2 per mg/kg-day. The upper end of the range, 5.5E-2 per mg/kg-day, is conservatively selected as the oral SF for this evaluation.

7.0 Toxicity Summary

Toxicity values for benzene are summarized as follows:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure[a]		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
1E-2	4E-3	Bc	8E-2/ 2.3E-2	3E-2/ 8.6E-3	Bc	A	5.5E-2	A	7.8E-6	2.7E-2
sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per										

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure[a]		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day). Target organ abbreviations: Bc = blood cells. [a]sRfDo, cRfDo and SFo should be used for dermal exposure without adjustment for GI absorption.										

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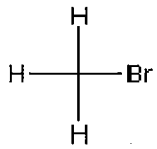
BROMOMETHANE (METHYL BROMIDE (74-83-9)



1.0 Introduction and Physical Properties

Bromomethane is a **VOC** that occurs as a colorless gas at ambient temperatures above 3.3°C and as a liquid below that temperature (HSDB, 2006). It is used primarily as a space or soil fumigant to control insects, fungi, weed seeds and rodents (ATSDR, 1992; HSDB, 2006). It is also used in ionization chambers, for degreasing wool, for extracting oils from nuts, seeds, and flowers, as a solvent for aniline dyes, as a methylating agent, especially in the preparation of antipyrine and other pharmaceuticals, and to control termites in structures. It as been used as a fire extinguishing agent, primarily in Europe, but that use never became widespread in the U.S. Relevant physical properties are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
95[a]	1.19[a]	6.24E-3[b] (25°C)	1.02[b]	7.28E-2[b] (25°C)	1.21E-5[b] (25°C)	2.13E-0[c] (25°C)	1.52E+4[b] (20-25°C)	276.71[d]	467[d]	5.71E+3[d]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point (at 1 atm) of pure liquid compound (°K); T_c = critical temperature (°K);.$H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole).

[a]U.S. Environmental Protection Agency (EPA), 2004b, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final***, Office of Superfund Remediation and Technology Innovation, Washington, DC, EPA/540/R/99/005, OSWER 9285.7-02EP, NTIS No. PB99-963312, July.

[b]U.S. Environmental Protection Agency (EPA), 2002, ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites***, Office of Solid Waste and Emergency Response, OSWER 9355.4-24, December.

[c]Hazardous Substances Data Bank (HSDB), 2006, National Library of Medicine, on line accessed 9 January.

[d]U.S. Environmental Protection Agency (EPA), 2003, ***Users Guide for Evaluating Subsurface Vapor Intrusion into Buildings***, Office of Emergency and Remedial Response, Washington, DC, 19 June.

2.0 Environmental Fate and Transport

The predominant source of bromomethane detected in the environment is believed to be its release from oceans where it is produced by a wide variety of marine organisms (HSDB, 2006). The gross flux of bromomethane to the atmosphere from the oceans is approximately 4E+4 metric tons per year. Global biomass burning could contribute an average of 1E+4 to 5E+4 metric tons per year to the atmosphere.

The production and various uses of bromomethane are expected to result in its direct release to the environment through various waste streams or as atmospheric emissions (HSDB, 2006). In 1992, emissions of bromomethane from soil fumigation and other pesticide use approximated 2.9E+4 to 6.4E+4 metric tons.

Bromomethane released to soil will be very highly mobile (HSDB, 2006). Volatilization from both wet and dry soil surfaces is expected to be an important removal process. Whether percolation to greater depth and leaching to groundwater will occur or whether volatilization will predominate will depend largely on the amount released to a given surface area. Chemical reactions, most likely nucleophilic substitutions in soil organic matter, were identified as the predominate pathway through which bromomethane is degraded. Degradation half-lives for the reaction of bromomethane with water and aniline (the model for reaction with soil organic matter) were 20 days and 2.9 days at 24° C, respectively. Volatilization and chemical degradation/biodegradation may remove approximately the same amounts of bromomethane released to soil.

Volatilization is probably the most important mechanism for removing bromomethane from surface water (HSDB, 2006). Volatilization half-lives for a model river and model lake have been estimated at 1.0 hours and 3.9 days, respectively. Chemical hydrolysis is the primary degradation mechanism for bromomethane in water. Half-lives of 20 to 26.7 days have been estimated for this reaction. The products of hydrolysis are methanol and bromide ion. Bromomethane was anaerobically degraded in salt marsh sediments by chemical reaction with free sulfide. The product of this reaction was methanethiol, which underwent further chemical and bacterial transformation to form dimethyl sulfide.

Its very high vapor pressure indicates that bromomethane will exist entirely in the vapor phase in the ambient atmosphere, where it is subject to reaction with photochemically-produced hydroxyl radicals (HSDB, 2006). The half-life for this reaction in air is approximately one year. Direct photolysis is unlikely to occur in the troposphere due to the lack of absorption in the environmental UV spectrum present at that level. Upward diffusion of bromomethane to the stratosphere is believed to be the dominant loss mechanism of this compound from the troposphere. In the stratosphere, into which lower wavelength light can penetrate, photolysis is expected to be the predominant removal mechanism.

Bromomethane is not expected to participate significantly in food-chain pathways based on its high water solubility and volatility, its low log K_{ow}, and its rapid metabolism and elimination from living organisms (ATSDR, 1992; HSDB, 2006). EPA (1995) lists bromomethane as a compound for which biotransfer through fish to humans is unlikely to be significant. Therefore, biotransfer factors are not compiled or estimated.

3.0 Toxicokinetics

Data from rats indicate that approximately 50 percent of the inhaled concentration of bromomethane is retained unless the concentration is increased so that removal mechanisms (probably the rate of metabolism) become limiting factors (ATSDR, 1992). Animal excretion studies indicate that GI absorption is essentially complete. Data were not located regarding dermal uptake.

Tissue distribution of radioactivity in rats following inhalation exposure to ^{14}C-bromomethane is widespread (ATSDR, 1992), which would be expected for highly water soluble compounds. Highest levels of radioactivity were measured in lung, adrenal, liver and kidney. Tissue distribution of radiolabel in orally treated rats is similarly widespread with highest levels of activity in the liver and kidney. Tissue levels of the parent compound have a very short half-life – approximately 15 to 30 minutes – indicating the rapidity with which metabolism occurs in many tissues of the body.

Absorbed bromomethane is subject to two major metabolic pathways (ATSDR, 1992). The first involves nucleophilic replacement of the bromide ion with water resulting in the release of methanol, which has been detected as a metabolite in laboratory animals. The second metabolic pathway involves nucleophilic replacement of the bromide ion with organic thiols to release S-methyl derivatives such as S-methylcysteine, which has been identified in the hemoglobin of treated mice, and S-methyl glutathione, which is expected but has not been identified. Methanol and the S-methyl derivatives further degrade to release carbon dioxide (approximating 40 to 50 percent of the dose) and various non-volatile metabolites (approximating 20 to 25 percent of the dose).

The mode of excretion following inhalation or oral exposure is similar, including primarily exhalation of carbon dioxide and urinary excretion of other non-volatile metabolites (ATSDR, 1992).

The observation that bromomethane metabolism yields methylated organic thiols prompted further investigation of mechanism of toxicity as reviewed by EPA (2003a). Studies with rats exposed orally or by inhalation revealed that bromomethane is a potent methylating agent producing methylated adenine and guanine adducts in DNA. Highest levels of altered DNA were found in the stomach and forestomach, independent of route of exposure, followed by the liver and lung.

4.0 Dermal Exposure

GI absorption is essentially complete as noted above. EPA (2004) notes that organic chemicals are generally well absorbed from the GI tract, and recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly less than complete. Therefore, no GAF is developed for bromomethane and the oral toxicity values described below should be used for dermal exposure without adjustment for GI absorption.

Data were not located for dermal uptake of bromomethane. VOCs tend to volatilize from soil when applied to the skin, reducing dermal uptake to toxicologically insignificant levels (EPA, 2004). Therefore, dermal uptake of bromomethane from soil is not evaluated. t*, K_p, τ, FA and B values are provided by EPA (2004) as follows:

Chemical	t*	K_p	τ	FA	B
Bromomethane	0.87	2.8E-3	0.36	1.0	0.0
t* = time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); □ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).					

5.0 Noncancer Effects Evaluation

The oral LD_{50} for rats is listed as 100 mg/kg (Montgomery, 1996). Acute exposure is associated with marked central nervous system disturbances (EPA, 1980). Prolonged oral exposure is associated with epithelial hyperplasia of the forestomach of rats at relatively low levels and anemia at higher levels (EPA, 2006). A verified chronic oral RfD of 1.4E-3 mg/kg-day is based on an adjusted NOAEL of 1.4 mg/kg-day in a 13-week gavage study in rats. An uncertainty factor of 1000 (factors of 10 each for inter- and intra-species variation and to expand from subchronic to chronic exposure) was used. Confidence in the oral RfD is medium. The LOAEL in this study was 7.1 mg/kg-day and 35.7 mg/kg-day was the highest dose tested. No central nervous system signs were observed at any dose rate.

Recently EPA (2003b) derived a provisional subchronic oral RfD of 5E-3 mg/kg-day from the same study used as the basis of the verified chronic oral RfD. Application of an uncertainty of 300 to the adjusted NOAEL yields the provisional subchronic oral RfD. The uncertainty factor of 300 consists of factors of 10 each for inter- and intra-species variation, and a factor of 3 to reflect deficiencies in the overall data base. Confidence in the provisional subchronic oral RfD is medium.

Data were not located regarding the effects of bromomethane in orally exposed humans. Most human exposure involves inhalation and dermal contact (ATSDR, 1992; HSDB, 2006). Effects in humans include nervous system depression, sometimes late in onset, and impaired kidney function. The significance of the epithelial hyperplasia of the forestomach in rats to orally exposed humans is unclear, because humans do not have a non-glandular forestomach similar to rats. Therefore, although epithelial hyperplasia of the forestomach is the most sensitive effect in rats, the erythrocyte (because of anemia in the key study) and kidney are chosen as the target organ for prolonged oral exposure of humans to bromomethane.

Inhalation LC_{50} values include 302 ppm (1190 mg/m^3) in rats exposed for 8 hours, and 1540 mg/m^3 in mice exposed for 2 hours (Montgomery, 1996). Prolonged inhalation exposure is associated with degenerative lesions of the olfactory epithelium of the nasal cavity (EPA, 2006). A verified chronic inhalation RfC of 5E-3 mg/m^3 is estimated from a LOAEL of 11.7 mg/m^3 in rats intermittently exposed for over 2 years. The LOAEL is equivalent to a continuous exposure concentration for humans of 0.48 mg/m^3. An uncertainty factor of 100 was applied to the human equivalent concentration. Confidence in the inhalation RfC is high. The RfC is equivalent to a chronic inhalation RfD of 1.4E-3 mg/kg-day. The olfactory epithelium is considered the target organ for prolonged inhalation exposure to bromomethane.

EPA (2003c) noted that the dose-response curve for bromomethane is steep, and that small increases in dose or exposure duration result in progression from a NOAEL to a FEL. They noted, however, that rats appear to be more sensitive to inhalation exposure than mice, rabbits or monkeys. Olfactory degeneration in rats intermittently exposed for 13 weeks was the endpoint selected for development of a provisional subchronic inhalation RfC. The exposure concentration of 233 mg/m^3 was the NOAEL and 466 mg/m^3 was the LOAEL in the critical study. The NOAEL was converted to a human equivalent concentration of 4 mg/m^3. Application of an uncertainty factor of 30 (3 for inter- and 10 for intra-species variation) yielded the provisional subchronic inhalation RfC of 1E-1 mg/m^3, which is equivalent to a subchronic inhalation RfD of 2.9E-2 mg/kg-day. Confidence in the provisional subchronic inhalation RfC is high.

6.0 Carcinogenicity Evaluation

EPA (2006) classified bromomethane in EPA cancer weight-of-evidence Group D – not classifiable as to carcinogenicity to humans – because of an inadequate prospective mortality study in male chemical workers, and inadequate gavage, dietary and inhalation studies in several animal species. The EPA (2006) evaluation considered data up through 1989, but noted that bromomethane was undergoing inhalation testing for carcinogenicity by the National Toxicology Program. Those tests and others have been completed and were recently reviewed by EPA (2003a). EPA (2003a) determined that the inhalation studies adequately demonstrated no evidence of carcinogenicity in two strains of rats and two strains of mice, and concluded that *bromomethane is not likely to be carcinogenic to humans*. Cancer potency estimates are not available.

7.0 Toxicity Summary

Toxicity values for bromomethane are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
5E-3	1.4E-3	E, K	1E-1/ 2.9E-2	5E-3/ 1.4E-3	OE	See text	ND	See text	ND	ND

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data.
Target organ or critical effect abbreviations: E = erythrocyte; K = kidney; OE = olfactory epithelium.
[a]sRfDo and cRfDo should be used for dermal exposure without adjustment for GI absorption.

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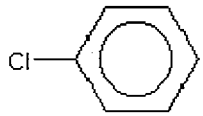
CHLOROBENZENE (108-90-7)



1.0 Introduction and Physical Properties

Chlorobenzene is a **VOC** that occurs as a colorless liquid in the pure form at ordinary ambient temperatures (EPA, 2002; HSDB, 2005). It is used primarily as a solvent, dry cleaning agent, heat transfer medium, cleanser and degreaser, fiber swelling agent and dye carrier in textile processing, and as an intermediate in the synthesis of chloronitrobenzene and a wide variety of other organic chemicals such as DDT, phenol, aniline, and various dyestuffs (ATSDR, 1990; HSDB, 2005). Relevant physical properties are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
112.6[a]	2.84[a]	3.71E-3[b] (25°C)	2.34[b]	7.30E-2[b] (25°C)	8.70E-6[b] (25°C)	1.58E-2[c] (25°C)	4.72E+2[b] (20-25°C)	404.87[d]	632.40[d]	8.41E+3[d]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point (at 1 atm) of pure liquid compound (°K); T_c = critical temperature (°K); $H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole); ND = no data.

[a]U.S. Environmental Protection Agency (EPA), 2004, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final***, Office of Superfund Remediation and Technology Innovation, Washington, DC, EPA/540/R/99/005, OSWER 9285.7-02EP July.

[b]U.S. Environmental Protection Agency (EPA), 2002, ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites***, Office of Solid Waste and Emergency Response, Washington, DC, 9355.4-24, December.

[c]Hazardous Substance Data Bank (HSDB), 2005, National Library of Medicine, on line, accessed 22 August.

[d]U.S. Environmental Protection Agency (EPA), 2003, ***Users Guide for Evaluating Subsurface Vapor Intrusion into Buildings***, Office of Emergency and Remedial Response, Washington, DC, 19 June.

2.0 Environmental Fate and Transport

Release of chlorobenzene to the environment is estimated to be due mostly to volatilization losses associated with its production and use as a solvent, in pesticide formulations, in chloronitrobenzene manufacture, and in degreasing and other industrial applications (HSDB, 2005). Disposal of industrial wastes is probably another significant source of chlorobenzene release. Release is primarily to the atmosphere; less than 1 percent of releases occur directly to water or soil.

Chlorobenzene is expected to exist solely as a vapor in the ambient atmosphere because of its high vapor pressure (HSDB, 2005). Vapor-phase chlorobenzene is degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals; the half-life for this reaction in air is estimated to be 21 days. Chlorobenzene absorbs light in the environmental spectrum, suggesting a potential for direct photolysis. Monochlorobiphenyl has been identified as a product of photolysis.

A range of K_{oc} values from 4.8 to 313.1 indicates that chlorobenzene is expected to have moderate to very high mobility in soil (HSDB, 2005). Volatilization from moist soil surfaces is expected to be an important process for removal from soil. The potential for volatilization of chlorobenzene from dry soil surfaces also exists, as indicated by its vapor pressure. Results of biodegradation tests for chlorobenzene in terrestrial environments vary. Chlorobenzene was not significantly mineralized after 8 months incubation in one soil test. However, bacterial isolates obtained from groundwater and soils contaminated with chlorobenzene mineralized approximately 54 percent of the chlorobenzene within 7 days when supplemented with ammonium and phosphate. Biodegradation half-lives ranging from 240 days to 88 years were reported in a study with several different soil types in Oklahoma.

Based on its K_{oc} value, some adsorption of chlorobenzene to suspended solids and sediment in the water column is expected (HSDB, 2005). Chlorobenzene is expected to volatilize from water surfaces. Estimated volatilization half-lives for a model river and model lake are 3.3 hours and 4.3 days, respectively. Photolysis half-lives of 17.5 hours and 3.80 hours were measured in distilled water and Isar River water, Germany, respectively; chlorophenol and phenol were identified as products of photolysis in river water. Chlorobenzene is not expected to undergo hydrolysis in the environment due to the lack of hydrolyzable functional groups. The biodegradation half-life of chlorobenzene was reported to be 150 days in river water and 75 days in sediment. A half-life of 46.2 days was measured for chlorobenzene in an anaerobic estuarine sediment that was pre-exposed to various anthropogenic chemicals from the surrounding industries. Benzene was identified as the product of biodegradation.

Empirical data yield BCF values ranging from 4.3 to 40 in carp, but the experimental conditions were not described (HSDB, 2005). BCF values ranging from 0.25 (from sediment) to 11 (from interstitial water) were measured in midge larvae in a low-organic-matter system under equilibrium conditions. Higher BCF values were measured under non-equilibrium conditions. A BCF value of 450 was measured in fathead minnows, but the conditions of the study were not described. A BCF of 63 could be estimated from the log K_{ow} using the method described in the Introduction to Toxicity Profiles, suggesting that the potential for bioconcentration is low to moderate. Based on data from the Great Lakes, EPA (1995) concluded that chlorobenzene does not bioconcentrate sufficiently in fish to represent a threat to human health. Chlorobenzene appears to be readily metabolized and eliminated by mammals (see next section), indicating that its participation in terrestrial food chains is unlikely to be significant. For these reasons biotransfer factors are not estimated for chlorobenzene.

3.0 Toxicokinetics

Literature on chlorobenzene toxicokinetics is upwards of 20 years old and the studies were incompletely reported and are difficult to interpret, which imparts some uncertainty to understanding the toxicokinetics of this compound. Studies in occupationally exposed humans and laboratory animals indicate that chlorobenzene is absorbed during inhalation exposure (ATSDR, 1990), but the data are insufficient to quantify the rate or extent of pulmonary uptake.

ATSDR (1990) reviewed studies in a single human volunteer as well as in rats and rabbits treated orally and concluded that at least 31, 18 and 22 percent of the administered dose was absorbed from the GI tract by the three species, respectively. This conclusion appears to be based on recovery of urinary metabolites alone. The authors of the rabbit study, however, concluded that most of the absorbed compound may have been eliminated through the expired air, in which case the absorption estimates mentioned above are far less than actual. Another study in rabbits (HSDB, 2005 [see below]) indicated that urinary excretion accounted for 72 percent of an oral dose, indicating much greater GI absorption. More recent toxicokinetic data demonstrate that the more highly chlorinated benzenes (e.g., 1,2-dichlorobenzene) are readily and extensively absorbed from the GI tract (ATSDR, 2004). This suggests that the chlorinated benzenes as a larger chemical class are readily and extensively absorbed, which is generally the case for halogenated organic compounds of this nature. Therefore, the position taken in this profile is that chlorobenzene is probably readily and extensively absorbed, although the documentation for this assumption is inconsistent.

Data were not located regarding the dermal uptake of chlorobenzene.

Data regarding the distribution of absorbed radiolabeled chlorobenzene are limited to inhalation studies in rats that showed that greatest levels of radioactivity were located in fat (ATSDR, 1990). The ability of adipose tissue to accumulate or store the compound was not investigated.

Metabolism of chlorobenzene is a two-phase process that begins with mono-oxygenase-mediated oxidation to an epoxide intermediate that probably (ATSDR, 1990):

- Rearranges to form 4-chlorophenol.
- Acquires a molecule of water to form 3,4-dihydro-3,4-dihydroxychlorobenzene, which is reduced to 4-chlorocatechol.
- Conjugates directly with glutathione followed by condensation to form 4-chlorophenylmercapturic acid.

Direct hydroxylation, without passage through the epoxide intermediate, to form 2- and 3-chlorophenol presumably also occurs, but is probably less important than the epoxide pathway. The chlorophenols and chlorocatechols participate in Phase II conjugation reactions that probably increase water solubility and accelerate urinary excretion.

The metabolic scheme proposed by ATSDR (1990) is supported by the observation that:

- *In vitro* studies with various mono-oxygenase systems reveal the biotransformation of chlorobenzene to 2-, 3-, and 4-chlorophenol. 2-Chlorophenol and 3-chlorophenol appear to result from direct hydroxylation.
- 4-Chlorocatechol and 4-chlorophenylmercapturic acid are the predominant urinary metabolites found in the urine of humans following inhalation or oral exposure.
- 4- Chlorocatechol and 4-chlorophenylmercapturic acid are the predominant urinary metabolites also found in the urine of rats, mice and rabbits following oral or intraperitoneal administration.
- Other urinary metabolites found in rats and rabbits include 2- and 3-chlorophenol, hydroquinone, 3-chlorocatechol, and 2- and 3-chlorophenylmercapturic acid. The formation of hydroquinone would necessarily involve dehalogenation as well as oxidation at the para-position.

Rats subjected to inhalation exposure to radiolabeled chlorobenzene showed two-compartment kinetics for the elimination of radioactivity (ATSDR, 1990). Increasing the exposure concentration from 100 to 700 ppm greatly decreased total body clearance by reducing clearance from the central compartment. These observations suggest that metabolism, which enhances elimination from the body, is a saturable process. In one study reviewed by ATSDR (1990), urinary excretion in rabbits appears to account for approximately 22 percent of a (presumably) oral dose. The remainder was thought to have been excreted through expired air. This is somewhat inconsistent with a study

reviewed by HSDB (2005) in which rabbits given a single oral 500 mg/kg dose eliminated 27 percent of the dose unchanged in expired air, and 72 percent as various metabolites in the urine (total recovery of 99 percent).

It appears that 4-chlorocatechol is the predominant metabolite in human urine and that 4-chlorophenylmercapturic acid is a minor metabolite. The opposite appears to be true in rats.

Tissue radiograms from mice exposed to radiolabeled chlorobenzene suggest that the epoxide may be the moiety that binds to tissues (HSDB, 2005) accounting for the toxicity of exposure to chlorobenzene.

4.0 Dermal Exposure

EPA (2004) notes that organic chemicals are generally well absorbed from the GI tract, and recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly less than complete. As noted above, it is assumed that chlorobenzene is readily and extensively absorbed from the GI tract. Therefore, no GAF is developed for chlorobenzene and the oral toxicity values described below should be used for dermal exposure without adjustment for GI absorption.

Data regarding the dermal uptake of chlorobenzene were not located. VOCs in soil, however, tend to volatilize when applied to the skin, reducing dermal uptake to toxicologically insignificant levels (EPA, 2004). Therefore, dermal uptake of chlorobenzene from soil is not evaluated. Values for t*, Kp, τ, FA and B taken from EPA (2004) follow:

Chemical	t*	K_p	τ	FA	B
Chlorobenzene	1.09	2.8E-2	0.46	1.0	0.1

5.0 Noncancer Effects Evaluation

Oral LD_{50} data include 2.29 g/kg in rats, 1.44 g/kg in mice, 2.25 g/kg in rabbits and 5.06 g/kg in guinea pigs (HSDB, 2005), indicating that the toxicity of acute ingestion exposure is low. The target organs for acute oral exposure appear to be the liver, kidney and spleen (ATSDR, 1990). Prolonged oral exposure induces pathological changes in the liver and kidney, with the liver apparently the more sensitive organ. EPA (2005) verified an RfD for chronic oral exposure of 2E-2 mg/kg-day by applying an uncertainty factor of 1000 to an exposure-adjusted NOAEL of 19 mg/kg-day in a 13-week study in which beagle dogs were treated with chlorobenzene in gelatin capsules. The uncertainty factor of 1000 consisted of factors of 10 each to extrapolate from animals to humans, to provide additional protection for unusually sensitive humans, and to expand from subchronic to chronic exposure. The exposure-adjusted LOAEL of 39 mg/kg-day was associated with a variety of mild histopathologic changes in the liver. Confidence in the chronic oral RfD is medium.

An RfD for subchronic oral exposure to chlorobenzene was not located. However, a preliminary subchronic oral RfD can be estimated by applying an uncertainty factor of 100 to the NOAEL of 19 mg/kg-day from the dog study described above. The uncertainty factor of 100 is equivalent to the chronic uncertainty factor of 1000 without the factor of 10 to expand from subchronic to chronic exposure. The preliminary subchronic oral RfD so estimated is 2E-1 mg/kg-day. The liver is the target organ for prolonged oral exposure to chlorobenzene.

Acute inhalation exposure of laboratory animals to high levels of chlorobenzene leads to death associated with CNS depression (ATSDR, 1990; HSDB, 2005). Prolonged exposure induces changes in the liver and kidneys. EPA (1997) presents a provisional inhalation RfC of 2E-2 mg/m^3 (equivalent to an inhalation RfD of 5.7E-3 mg/kg-day) based on a LOAEL of 75 ppm in a two-year intermittent-exposure study in rats. An uncertainty factor of 10,000 was used. EPA (1997) declined to propose a provisional subchronic inhalation RfC. Therefore, the chronic inhalation RfC of 2E-2 mg/m^3 (equivalent to 5.7E-3 mg/kg-day) is adopted for subchronic inhalation exposure. The liver and kidney are the target organs for prolonged inhalation exposure to chlorobenzene.

6.0 Carcinogenicity Evaluation

EPA (2005) classified chlorobenzene as a cancer weight-of-evidence Group D chemical (not classifiable as to carcinogenicity to humans), based on one inadequate gavage study in rats and mice and an absence of human data. Cancer potency factors are not available.

7.0 Toxicity Summary

The toxicity values for chlorobenzene are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
2E-1	2E-2	L	2E-2/ 5.7E-3	2E-2/ 5.7E-3	L, K	D	NA	D	NA	NA

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); NA = not applicable.
Target organ or critical effect abbreviations: L = liver; K = kidney.
[a]sRfDo and cRfDo should be used for dermal exposure without adjustment for GI absorption.

9.0 References

Agency for Toxic Substances and Disease Registry (ATSDR), 1990, ***Toxicological Profile for Chlorobenzene***, U.S. Department of Health and Human Services, Atlanta, GA, on line, December.

Agency for Toxic Substances and Disease Registry (ATSDR), 2004, ***Update Toxicological Profile for Dichlorobenzenes***, U.S. Department of Health and Human Services, Atlanta, GA, on line, September.

Hazardous Substance Data Bank (HSDB), 2005, National Library of Medicine, on line, accessed 23 August.

U.S. Environmental Protection Agency (EPA), 1995, "Final Water Quality Guidance for the Great Lakes System; Final Rule," (40 CFR 9, 122, 123, 131, and 132), ***Federal Register***, 60(56): 15365-15425.

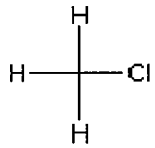
U.S. Environmental Protection Agency (EPA), 1997, ***Health Effects Assessment Summary Tables, FY 1997 Update***, Office of Solid Waste and Emergency Response, 9200.6-303 (97-1), EPA-540-R-97-036, NTIS No. PB97-921199.

U.S. Environmental Protection Agency (EPA), 2002, ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites***, Office of Solid Waste and Emergency Response, Washington, DC, 9355.4-24, December.

U.S. Environmental Protection Agency (EPA), 2004, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final***, Office of Superfund Remediation and Technology Innovation, Washington, DC, EPA/540/R/99/005, OSWER 9285.7-02EP July.

U.S. Environmental Protection Agency (EPA), 2005, ***Integrated Risk Information System (IRIS)***, National Center for Environmental Assessment, Cincinnati, OH, on line, accessed 22 August.

CHLOROMETHANE (METHYL CHLORIDE) (74-87-3)



1.0 Introduction and Physical Properties

Chloromethane is a **VOC** that exists as a colorless gas at ambient temperatures (HSDB, 2004). It is used largely as a methylating agent in the production of silicones, tetramethyl lead, methyl cellulose, methylene chloride, methyl mercaptan, plastics, pesticides, pharmaceuticals, dyes, perfumes, ethers, resins, agricultural chemicals, quaternary amines and butyl rubber (ACGIH, 1991; ATSDR, 1998; HSDB, 2004). It is also used as an extractant for fats, oils and resins, as a blowing agent and as a refrigerant. It was formerly used as a propellant in various aerosol products. Relevant physical properties are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
50.5[a]	0.91[a]	8.82E-3[b] (25□C)	1.15[b]	1.39E-1[c] (25□C)[d]	1.49E-5[e] (20□C)	5.66E+0[b] (25□C)	5.32E+3[b] (25 □C)	247[f]	416[f]	5.15E+3[f]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point (at 1 atm) of pure liquid compound (°K); T_c = critical temperature (°K); $H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole).

[a]U.S. Environmental Protection Agency (EPA), 2004, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final***, Office of Superfund Remediation and Technology Innovation, EPA/540/R/99/005, OSWER 9285.7-02EP, July.

[b]Hazardous Substance Data Bank (HSDB), 2004, National Library of Medicine, on line, accessed 9 November.

[c]Calculated as described in Introduction to Toxicity Profiles.

[d]Assumed.

[e]Montgomery, J.H., 1996, ***Groundwater Chemicals Desk Reference, Second Edition***, Lewis Publishers, New York, pp. 664-666.

[f]National Institute of Standards and Technology (NIST), 2004, ***NIST Chemistry WebBook***, on line, accessed 9 November.

2.0 Environmental Fate and Transport

Chloromethane is one of the few halogenated organic chemicals for which natural sources are significant. Natural sources include volcanoes, volatilization from plants, and forest fires (HSDB, 2004). It is produced in seawater by the reaction of methyl iodide with chloride ions. Methyl iodide is produced photosynthetically by several marine organisms, and there may be other oceanic sources as well. The mean air flux of 1.3E-6 g/cm^2-year for the eastern Pacific Ocean, when extrapolated to global waters, provides an adequate source to explain the atmospheric reservoir of chloromethane. Chloromethane is released from brush and forest fires. The estimated 0.6 g of chloromethane released per kg of vegetation burned is believed to make a significant impact on the global burden of the compound.

The production and many uses of chloromethane may result in its release to the environment through various waste streams (HSDB, 2004). It is also released in tobacco smoke and turbine exhaust. Just as forest fires contribute to natural sources, wood burning, field burning, and backyard burning also contribute to atmospheric burdens. Chloromethane is formed in the chlorination of drinking water and sewage effluent, and is found in the effluent of some publically owned treatment works.

Most chloromethane is released to the atmosphere where it is expected to exist solely as a gas (HSDB, 2004). Gas-phase chloromethane is degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals; the half-life for this reaction in air is estimated to be 310 days, which provides opportunity for widespread dispersion. The dominant process for removal from the troposphere is upward diffusion, although washout by rain may also be important. From

the tropopause to about 30 km, both upward diffusion and reaction with hydroxyl radicals will be of approximately equal importance, and above 30 km in the stratosphere, diffusion, reaction with hydroxyl radicals, and photodissociation will have approximately equal importance. The surface half-life resulting from upward diffusion is approximately 80 days.

Based on its very low estimated K_{oc} value, chloromethane is expected to have very high mobility in soil (HSDB, 2004). Its relatively high water solubility suggests the compound released in sufficient quantity in the liquid phase or dissolved in water could leach readily to groundwater. Volatilization from moist soil surfaces is expected to be an important removal process for small quantities released to the surface. Volatilization from dry soil surfaces may also be important. Field and laboratory studies demonstrate that several halogenated aliphatics may biodegrade slowly under anaerobic conditions, but not under aerobic conditions. Biodegradation is not expected to be a significant removal process.

Chloromethane is not expected to adsorb to suspended solids and sediment in surface water (HSDB, 2004). Volatilization from water surfaces is expected to be a significant removal mechanism; volatilization half-lives for a model river and model lake are 46 minutes and 3 days, respectively. Field and laboratory studies demonstrate that several halogenated aliphatics may biodegrade slowly under anaerobic conditions, but not under aerobic conditions. Biodegradation is not expected to be a significant removal process. Hydrolysis may occur, but very slowly, with a half-life of approximately 2 years (ATSDR, 1998). Hydrolysis will not be a significant removal process for chloromethane in surface water, but may be the only significant removal process for the compound in groundwater, where it has been shown to persist.

Chloromethane is water soluble, volatile and labile, and is not expected to participate significantly in food-chain pathways (ATSDR, 1998; HSDB, 2004). Therefore, biotransfer factors are not estimated for this compound.

3.0 Toxicokinetics

Studies regarding the toxicokinetics of chloromethane are limited to inhalation exposure. Chloromethane is readily absorbed by the respiratory system and equilibrium conditions are reached in approximately one hour in exposed humans and laboratory animals (ATSDR, 1998). Data regarding the extent of respiratory absorption were not located. Although data were not located for GI absorption, it is expected that GI absorption would be rapid and extensive because the compound is a low MW organic substance that is readily absorbed by the respiratory system. HSDB (2004) stated that dermal absorption can occur, but no other information was provided.

Radioactivity is rapidly and extensively distributed throughout the body following inhalation exposure to radiolabeled chloromethane, with highest levels of radioactivity measured in liver, kidney, testis and lung (ATSDR, 1998). Approximately 20 percent of the radiolabel in liver and testis was found to have been metabolically incorporated into the cellular structure, reflecting uptake and utilization from the one-carbon atom pool of the body.

The primary and predominant metabolic pathway of chloromethane involves enzymatic conjugation with glutathione to form S-methylglutathione (ATSDR, 1998). Further metabolism involves deamination to yield S-methylcysteine and other sulfur-containing conjugation derivatives, which are excreted in the urine. Another metabolic pathway involves dehalogenation of chloromethane to

form formaldehyde (a toxicant in its own right) and formic acid. These intermediates contribute to the one-carbon atom pool that is available for incorporation into the tissues or for mineralization to carbon dioxide followed by excretion through the lungs.

Studies have shown that adult humans, unlike laboratory animals, may be divided into two groups – fast or slow metabolizers – depending on the activity in their erythrocytes of glutathione-S-transferase, which is responsible for the first conjugation reaction (ATSDR, 1998). Fast metabolizers clear chloromethane from the body more rapidly than slow metabolizers. Whether the unborn, new born or young children exhibit this characteristic is unknown. The implications of glutathione-S-transferase activity regarding population differences in toxic potency are unclear. On the one hand, it may appear that fast metabolizers should be more tolerant of chloromethane because of their enhanced ability to clear the compound from the body. On the other hand, experiments in laboratory animals suggest that a metabolite of S-methylglutathione may be the ultimate toxicant, in which case fast metabolizers may be more sensitive to chloromethane toxicity.

Chloromethane residues are rapidly cleared from the body following the cessation of inhalation exposure (ATSDR, 1998). Clearance in laboratory animals and humans is biphasic, consistent with a linear 2-compartment model. The half-lives for both phases were measured in minutes, indicating the rapidity with which clearance occurs. The exception is that the β-phase in some humans (slow metabolizers) approximated 1.5 hours.

4.0 Dermal Exposure

EPA (2004a) notes that organic chemicals are generally well absorbed from the GI tract, and recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly less than complete. Chloromethane is assumed to be absorbed readily from the GI tract; therefore, no GAF is developed.

Data regarding the dermal uptake of chloromethane were not located, except that HSDB (2004) stated that dermal absorption could occur. VOCs tend to volatilize from soil when applied to the skin, reducing dermal uptake to toxicologically insignificant levels (EPA, 2004a). Therefore, dermal uptake of chloromethane from soil is not quantified. EPA (2004a) provides t*, K_p, τ, FA and B values as follows:

Chemical	t*	K_p	τ	FA	B
Chloromethane	0.49	3.3E-3	0.20	1	0

t* = time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); □ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).

5.0 Noncancer Effects Evaluation

Data regarding the toxicity of oral exposure to chloromethane consist of the statement that liver effects were not observed in rats given a single oral dose of 420 mg/kg (ATSDR, 1998; EPA, no date). EPA (no date) derived a provisional chronic oral RfD of 4E-3 mg/kg-day based on a LOAEL of 69.32 mg/m^3 for subtle neurobehavioral effects from an occupational (inhalation) study. Subsequently, EPA (2004b) reviewed the data and determined that ingestion exposure is not applicable because the compound exists as a gas at ambient temperatures. They also noted that the oral exposure data are insufficient to develop an oral RfD. Therefore, the EPA (no date) derivation is considered to be not applicable and no oral RfD is offered herein.

EPA (2004b) verified a chronic inhalation RfC of 9E-2 mg/m^3 based on a NOAEL of 50 ppm (103.2 mg/m^3) from an 11-day continuous exposure study in mice. The NOAEL corresponds to a human equivalent concentration (HEC) of 94.6 mg/m^3. The LOAEL in this study, 100 ppm (206.4 mg/m^3 or a HEC of 189.2 mg/m^3) was associated with slight to moderate degenerative changes in the granule cells of the cerebellum. EPA (2004b) applied an uncertainty factor of 1000 to the NOAEL HEC of 94.6 mg/m^3 to derive the RfC of 9E-2 mg/m^3. The uncertainty factor consists of factors of 10 each to provide additional protection for unusually sensitive humans and to expand from a short-term to lifetime exposure, and factors of 3 each to extrapolate from mice to humans and to address the uncertainty regarding the potential for CNS effects in the developing young. Confidence in the verified chronic inhalation RfC is medium. The verified inhalation RfC is equivalent to an inhalation RfD of 2.6E-2 mg/kg-day. The CNS is the target organ for prolonged inhalation exposure to chloromethane.

EPA (1996) developed a provisional chronic RfC based on subtle neurobehavioral effects from an occupational (inhalation) study. They adopted the provisional chronic RfC for subchronic application, noting no significant differences in response between chronic and subchronic exposure. However, given the EPA (2004b) reevaluation and verification of a more conservative chronic RfC, it is deemed prudent to adopt the verified chronic RfC rather than the provisional chronic RfC as sufficiently protective for subchronic exposure.

6.0 Carcinogenicity Evaluation

Previous EPA (1997, 1998) evaluations classified chloromethane in EPA weight-of-cancer Group C (possible human carcinogen), and developed an oral SF and an inhalation URF. More recently, EPA (2004b) reevaluated the data, noting that chloromethane is a naturally occurring compound, and concluded that it is more appropriately classified in Group D (not classifiable as to its human carcinogenicity). Applying more recent cancer assessment guidelines, EPA (2004b) concluded that the available data suggest that chloromethane would be classified as an agent whose carcinogenic potential *cannot be determined.* Previously developed potency factors are considered to be not applicable; no potency factors are offered herein for chloromethane.

7.0 Toxicity Summary

Toxicity values for chloromethane are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
ND	ND	NA	9E-2/ 2.6E-2	9E-2/ 2.6E-2	CNS	D	NA	D	NA	NA

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); ND = no data; NA = not applicable.
Target organ or critical effect abbreviations: CNS = central nervous system.

8.0 References

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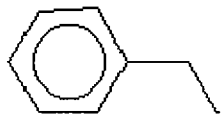
ETHYLBENZENE (PHENYLETHANE) (100-41-4)



1.0 Introduction and Physical Properties

Ethylbenzene, also known as phenylethane, is a **VOC** that exists in the pure state as a colorless liquid at ambient temperatures (HSDB, 2004). It is used primarily as a precursor in the manufacture of styrene (ATSDR, 1999). It is also used as a solvent and diluent, and as an intermediate in the manufacturing of cellulose acetate, rubber and other organic compounds (ATSDR, 1999; HSDB, 2004). It is also a constituent of asphalt, naphtha, and automotive and aviation fuels. Relevant physical properties are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
106.2[a]	3.15[a]	7.88E-3[b] (25°C)	2.56[b]	7.50E-2[b] (25°C)	7.80E-6[b] (25°C)	1.26E-2[c] (25°C)	1.69E+2[b] (20-25°C)	409.34[d]	617.20[d]	8.50E+3[d]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point (at 1 atm) of pure liquid compound (°K); T_c = critical temperature (°K); $H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole).

[a]U.S. Environmental Protection Agency (EPA), 2004, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final***, Office of Superfund Remediation and Technology Innovation, EPA/540/R/99/005, OSWER 9285.7-02EP, July.

[b]U.S. Environmental Protection Agency (EPA), 2001, ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites***, Peer Review Draft, Office of Solid Waste and Emergency Response, OSWER 9355.4-24, March.

[c]Hazardous Substance Data Bank (HSDB), 2004, National Library of Medicine, on line, accessed 22 April.

[d]U.S. Environmental Protection Agency (EPA), 2003, ***User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings***, Office of Emergency and Remedial Response, Washington, DC, June 19.

2.0 Environmental Fate and Transport

Ethylbenzene enters the atmosphere primarily from fugitive emissions and exhaust connected with its use in gasoline (ATSDR, 1999; HSDB, 2004). More localized sources to the air and other environmental media include fugitive emissions, waste water and spills from its production and industrial use, leaking underground storage tanks, land disposal of ethylbenzene-containing waste, and municipal and hazardous waste combustion.

Ethylbenzene exists in the air in the vapor phase (ATSDR, 1999; HSDB, 2004). It is somewhat water soluble and may be removed by precipitation; however, it is likely to reenter the air by volatilization. Ethylbenzene is transformed in air by various oxidative processes to yield ethylphenols, benzaldehyde, acetophenone, and m- and p-nitroethylbenzene. Reaction with photolytically generated hydroxyl radicals is probably the most significant reaction, with a half-life estimated to be 55 hours, suggesting that ethylbenzene will not persist in the air or travel long distances.

Ethylbenzene released to soil will volatilize rapidly (ATSDR, 1999; HSDB, 2004). That which infiltrates is expected to be quite mobile in soil and may leach to groundwater because sorption to soil particles is not sufficiently strong to retard movement. Biodegradation in soil in aerobic conditions involves oxidation of the ethyl side chain, ring hydroxylation and ring cleavage, and may be a significant source of removal. Anaerobic degradation is expected to be insignificant.

Ethylbenzene released to surface water will volatilize rapidly to air (ATSDR, 1999; HSDB, 2004). Biodegradation in aerobic conditions will significantly reduce water-borne concentrations. Photolysis and hydrolysis are unlikely to be significant. Ethylbenzene partitions weakly to sediment.

Ethylbenzene is not expected to participate significantly in food-chain pathways (ATSDR, 1999; EPA, 1995; HSDB, 2004); therefore, biotransfer factors are not provided.

3.0 Toxicokinetics

Ethylbenzene is rapidly absorbed during inhalation exposure, with retention near or exceeding 50 percent of the inhaled concentration (ATSDR, 1999). The compound is similarly rapidly absorbed following oral administration. Excretion data in rabbits suggest that a minimum of 72 to 92 of an oral dose is absorbed. Liquid ethylbenzene applied to the skin of humans is rapidly absorbed, but ethylbenzene vapor is poorly absorbed.

Ethylbenzene appears to be efficiently and widely distributed throughout the body following inhalation exposure (ATSDR, 1999). The same is expected following oral and dermal exposure, but data are lacking.

Metabolism in humans of absorbed ethylbenzene following either inhalation or oral exposure predominantly involves successive oxidation of the ethyl side-chain through 1-phenylethanol, acetophenone, ω-hydroxyacetophenone, and 1-phenyl-1,2-ethanediol to form mandelic acid and phenylglyoxylic acid (ATSDR, 1999). Small quantities of the first 4 intermediates are conjugated and excreted in the urine. Mandelic acid and phenylglyoxylic acid are excreted without conjugation and comprise the majority of excreted metabolites. A minor metabolic pathway involves epoxide formation and hydroxylation of the phenyl ring with or without oxidation of the ethyl group to yield small quantities of metabolites that are conjugated and excreted. Experiments with laboratory animals reveal species differences in the predominance of certain metabolites, but the pathways described above appear to hold. There is no evidence that the metabolites are more toxic than the parent compound.

Excretion of metabolites, primarily through the urine, is rapid and extensive in humans and laboratory animals (ATSDR, 1999). Pulmonary excretion of carbon dioxide is a minor pathway.

Nothing in this review of toxicokinetics suggests that laboratory animals would not serve as appropriate models for the toxicity of ethylbenzene to humans.

4.0 Dermal Exposure

EPA (2004a) notes that organic chemicals are generally well absorbed from the GI tract, and recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly less than complete. GI absorption of ethylbenzene is extensive as discussed in Section 3.0. Therefore, no GAF is developed for ethylbenzene and the oral toxicity values described below should be used for dermal exposure without adjustment for GI absorption.

Data were not located for dermal uptake of ethylbenzene from soil. VOCs tend to volatilize from soil when applied to the skin, reducing dermal uptake to toxicologically insignificant levels (EPA,

2004a). Therefore, dermal uptake of ethylbenzene from soil is not evaluated. Values for t*, K_p, τ, FA and B are provided by EPA (2004a) as follows:

Chemical	t*	K_p	τ	FA	B
Ethylbenzene	1.01	4.9E-2	0.42	1.0	0.2

t* = time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); □ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).

5.0 Noncancer Effects Evaluation

An oral LD_{50} in rats of 5.46 g/kg (HSDB, 2004) suggests that the acute toxicity of ingested ethylbenzene is low. Subchronic to chronic oral exposure of laboratory animals to ethylbenzene induces mild liver and kidney lesions (EPA, 2004b). EPA (2004b) presents a verified chronic oral RfD for ethylbenzene of 1E-1 mg/kg-day based on a NOEL for liver and kidney lesions in female rats of 136 mg/kg-day in a six-month gavage study. The LOAEL in this study was 408 mg/kg-day. An uncertainty factor of 1000 was applied to the NOEL to derive the chronic oral RfD. The uncertainty factor consists of factors of 10 each to extrapolate from animals to humans, to provide additional protection for more sensitive humans, and to expand from subchronic to chronic exposure. Confidence in the oral RfD is low. The liver and kidney are the target organs for prolonged oral exposure to ethylbenzene.

No EPA-derived subchronic oral RfD is available for ethylbenzene. A preliminary subchronic oral RfD can be made, however, by applying an uncertainty factor of 100 to the NOEL of 136 mg/kg-day in the 6-month rat study described above. The uncertainty factor of 100 reflects the chronic uncertainty factor of 1000 without the factor of 10 for expansion from subchronic to chronic exposure. The preliminary subchronic oral RfD so derived is 1E+0 mg/kg-day.

Acute inhalation exposure induces irritation of the mucous membranes in animals and humans (ACGIH, 1991). Prolonged inhalation exposure induces liver enzymes and results in elevated liver and kidney weights; prolonged exposure to relatively high levels is associated with mild histopathological lesions of the liver, kidney and testes (ACGIH, 1991; EPA, 2004b). EPA (2004b) considered that the effects on the liver at the lower exposure concentrations are adaptive rather than adverse. EPA (2004b) presented a verified chronic inhalation RfC of 1E+0 mg/m^3 derived from a human equivalent adjusted NOAEL of 434 mg/m^3 from studies on developmental effects in rats and rabbits. An uncertainty factor of 300 was used. The human equivalent adjusted LOAEL of 4340 mg/m^3 was associated with equivocal evidence of reduced fetal size in rabbits, an increased incidence of extra ribs in rat fetuses, and increased liver, kidney and spleen weights in the rats. The inhalation RfC is equivalent to 2.9E-1 mg/kg-day. Confidence in the RfC is low. The chronic inhalation RfC is adopted as being sufficiently conservative for subchronic as well as chronic inhalation exposure.

The key study from which the inhalation RfC is derived does not clearly identify target organ(s) for inhalation exposure to ethylbenzene. The entire inhalation exposure data base, however, suggests that the liver, kidneys and fetus may be the most significant target organs for prolonged inhalation exposure.

6.0 Carcinogenicity Evaluation

Ethylbenzene is currently verified as a cancer weight-of-evidence Group D compound (not classifiable as carcinogenicity to humans) (EPA, 2004b) based on an absence of human or animal cancer studies. Cancer potency factors are not estimated for Group D compounds.

7.0 Toxicity Summary

Toxicity values for ethylbenzene are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
1E+0	1E-1	L, K	1E+0/ 2.9E-1	1E+0/ 2.9E-1	L, K, F	D	NA	D	NA	NA

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); NA = not applicable.

Target organ or critical effect abbreviations: L = liver; K = kidney; F = fetus.

[a]sRfDo and cRfDo should be used for dermal exposure without adjustment for GI absorption.

8.0 References

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METHYLENE CHLORIDE (DICHLOROMETHANE) (75-09-2)

1.0 Introduction and Physical Properties

Methylene chloride is a **VOC** used predominantly as a paint remover and as a solvent and flammability depressant in aerosol products such as coatings, paint removers, hair sprays, room deodorants, herbicides and insecticides (ATSDR, 2000; HSDB, 2005). Methylene chloride is also used in the foam blowing of polyurethanes, in metal degreasing, stripping and degreasing of electronic components, in resin production, photographic film splicing, adhesive production, and other solvent, cleaning and thinning applications. It occurs as a colorless liquid at ambient temperatures. Relevant physical properties are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
84.9[a]	1.25[a]	2.19E-3[b] (25°C)	1.07[b]	1.01E-1[b] (25°C)	1.17E-5[b] (25°C)	5.72E-1[c] (25°C)	1.30E+4[b] (20-25°C)	313[d]	510[d]	6.71E+3[d]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point (at 1 atm) of pure liquid compound (°K); T_c = critical temperature (°K); $H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole); ND = no data.

[a]U.S. Environmental Protection Agency (EPA), 2004, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final***, Office of Superfund Remediation and Technology Innovation, Washington, DC, EPA/540/R/99/005, OSWER 9285.7-02EP, NTIS No. PB99-963312, July.

[b]U.S. Environmental Protection Agency (EPA), 2002, ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites***, Office of Solid Waste and Emergency Response, OSWER 9355.4-24, December.

[c]Hazard Substances Data Bank (HSDB), 2005, National Library of Medicine, on line, accessed 12 December.

[d]U.S. Environmental Protection Agency (EPA), 2003, ***Users Guide for Evaluating Subsurface Vapor Intrusion into Buildings***, Office of Emergency and Remedial Response, Washington, DC, 19 June.

2.0 Environmental Fate and Transport

Methylene chloride is highly volatile; therefore, most environmental releases are to the atmosphere (ATSDR, 2000; HSDB, 2005). Large amounts (greater than a hundred million pounds) are released each year during its industrial and consumer use. Methylene chloride exists solely as a vapor in air and may travel long distances before removal. It is subject to reaction with photochemically generated hydroxyl radicals with a half-life of a few months. It is also subject to direct photolysis.

Methylene chloride released to soil will be highly mobile and will infiltrate or leach to greater depths or to groundwater (ATSDR, 2000; HSDB, 2005). Some will also volatilize. Methylene chloride released to water will be rapidly lost primarily by volatilization. It is not expected to partition to sediment. It is subject to hydrolysis and biodegradation, but these processes are less significant than volatilization. Methylene chloride is not expected to participate significantly in food-chain pathways; therefore, biotransfer factors are not provided.

3.0 Toxicokinetics

Pulmonary uptake approximates 70 to 75 percent of an inhaled dose at the beginning of exposure, but drops to steady state levels as exposure continues (ATSDR, 2000). The point at which steady state is reached depends on the exposure concentration and duration, and is governed by the rate at which metabolism becomes saturated. Animal studies reveal that GI absorption is rapid and essentially complete. Dermal uptake occurs but quantitative data were not located.

Distribution appears to be widespread and independent of route of exposure (ATSDR, 2000). Highest levels are located in liver and adipose tissue. Methylene chloride has been shown to cross

the placenta and to be excreted via lactation. Body clearance is rapid; the compound and its metabolites demonstrate no tendency to accumulate in body tissues.

Metabolism appears to involve two competing pathways; species differences involve the extent to which either pathway predominates (ATSDR, 2000). The first pathway involves mixed function oxidase (MFO) oxidation by cytochrome P450 enzymes (CYP2E1) to yield formyl chloride and carbon monoxide. Formyl chloride may also yield carbon dioxide as well as carbon monoxide, although the significance of this sub-pathway is unclear. The second pathway involves glutathione-S-transferase conjugation and dechlorination to form S-methyl glutathione, which rearranges to release glutathione and either formaldehyde or acetic acid. Formaldehyde and acetic acid undergo additional oxidation to yield carbon dioxide without forming carbon monoxide as an intermediate. The CYP2E1 pathway is high affinity -low capacity, but the glutathione pathway is low affinity-high capacity, which means that the CYP2E1 pathway will predominate initially and at low concentrations, but will saturate before the glutathione pathway. The glutathione pathway reaches its maximum only after the CYP2E1 pathway is saturated.

Both metabolic pathways produce toxic intermediates (ATSDR, 2000); therefore, at least the early stages of metabolism appear to be toxication rather than detoxication phenomena. The CYP2E1 pathway yields intermediates that appear to be particularly damaging to the Clara cells of the lung, probably accounting for the damage to this organ from acute inhalation exposure. Carbon monoxide, also a product of the CYP2E1 pathway, causes the conversion of hemoglobin to carboxyhemoglobin, which is ineffective as an oxygenator and leads to erythrocyte destruction. Both major metabolic pathways yield potentially carcinogenic intermediates.

There is no empirical evidence that children are more susceptible than adults to the toxic effects of exposure to methylene chloride (ATSDR, 2000). Generally MFO activity in the fetus and neonate are somewhat less than adult levels, which is consistent with the observation mentioned above, and does not raise concern that the young may be more susceptible.

Excretion of methylene chloride metabolites is primarily through the lungs (carbon monoxide and carbon dioxide), regardless of route of exposure (ATSDR, 2000). Lesser amounts are excreted in the urine and feces.

4.0 Dermal Exposure

Animal studies indicate that methylene chloride is readily absorbed from the GI tract (ATSDR, 2000). EPA (2004) notes that organic chemicals are generally well absorbed from the GI tract, and recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly less than complete. Therefore, no GAF is developed for methylene chloride and the oral toxicity values described below should be used for dermal exposure without adjustment for GI absorption.

VOCs tend to volatilize from soil when applied to the skin, reducing dermal uptake to toxicologically insignificant levels (EPA, 2004). Therefore, dermal uptake of methylene chloride from soil is not evaluated. t^*, K_p, τ, FA and B values are provided by EPA (2004) as follows:

Chemical	t*	K_p	τ	FA	B
Methylene Chloride	0.76	3.5E-3	0.32	1.0	0.0

t* = time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); □ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).

5.0 Noncancer Effects Evaluation

Oral LD_{50} values in rats and mice approximate 2 g/kg (ATSDR, 2000), suggesting that the acute toxicity of methylene chloride is low to moderate. Prolonged oral exposure induces liver lesions in laboratory animals. EPA (2005) verified an RfD for chronic oral exposure of 6E-2 mg/kg-day by applying an uncertainty factor of 100 to a NOAEL of about 6 mg/kg-day in a two-year drinking water study in rats. The LOAEL, about 55 mg/kg-day, was associated with histopathologic lesions in the liver. Confidence in the RfD is medium. In addition, metabolism of methylene chloride is known to yield carbon monoxide, which combines with hemoglobin to form carboxyhemoglobin in the erythrocytes. Carboxyhemoglobin is incapable of transporting oxygen to the tissues. This mechanism of toxicity should also be considered when combining hazard indices for simultaneous exposure to multiple chemicals. Therefore, the liver and erythrocyte are the target organs for prolonged oral exposure to methylene chloride. EPA (1997) adopted the verified chronic oral RfD of 6E-2 mg/kg-day as the provisional RfD for subchronic oral exposure.

Occupational exposure to high concentrations of methylene chloride is associated with a wide variety of neurological dysfunctions and elevated blood levels of carbon monoxide and carboxyhemoglobin (ACGIH, 1991). Chronic inhalation exposure of laboratory animals induces liver effects. EPA (1997) derived a provisional chronic inhalation RfC of 3E+0 mg/m^3 based on a NOAEL of 695 mg/m^3 in a two-year intermittent exposure study in rats. An uncertainty factor of 100 was used. Higher levels were associated with unspecified effects on the liver. The RfC is equivalent to an inhalation RfD of 8.6E-1 mg/kg-day. In addition, inhalation exposure to methylene chloride is known to yield carbon monoxide. Therefore, the liver and erythrocyte are considered the target organs for prolonged inhalation exposure to methylene chloride. EPA (1997) adopted the provisional chronic inhalation RfC of 3E+0 mg/m^3 (8.6E-1 mg/kg-day) as the provisional inhalation RfC for subchronic exposure.

6.0 Carcinogenicity Evaluation

Methylene chloride is classified in EPA cancer weight-of-evidence Group B2 (probable human carcinogen), based on inadequate human data and sufficient evidence of carcinogenicity in animals (EPA, 2005). Animal inhalation studies showed increased incidence of hepatocellular neoplasms and alveolar/bronchiolar neoplasms in male and female mice, mammary tumors in rats of either sex, salivary gland sarcomas in male rats and leukemia in female rats. Oral studies were inconclusive. An oral SF of 7.5E-3 per mg/kg-day was based on the incidence of liver tumors in two inhalation studies in mice. An inhalation URF of 4.7E-7 per ug/m^3, equivalent to 4.7E-4 per mg/m^3, was based on the incidence of liver and lung tumors in one inhalation study. The inhalation URF is equivalent to 1.6E-3 per mg/kg-day.

7.0 Toxicity Summary

Toxicity values for methylene chloride are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure[a]		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
6E-2	6E-2	L, E	8.8E+0/ 8.8E+0	8.8E+0 / 8.8E+0	L, E	B2	7.5E-3	B2	4.7E-4	1.6E-3

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day).
Target organ or critical effect abbreviations: L = liver; E = erythrocyte.
[a]sRfDo, cRfDo and SFo should be used for dermal exposure without adjustment for GI absorption.

8.0 References

Agency for Toxic Substances and Disease Registry, (ATSDR), 2000, ***Update Toxicological Profile for Methylene Chloride***, U.S. Department of Health and Human Services, Atlanta, Georgia, September, on line.

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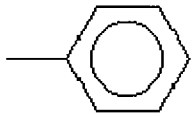
U.S. Environmental Protection Agency (EPA), 2005, ***Integrated Risk Information System (IRIS)***, National Center for Environmental Assessment, Cincinnati, OH, on line, accessed 12 December.

TOLUENE (METHYLBENZENE) (108-88-3)



1.0 Introduction and Physical Properties

Toluene is a **VOC** that occurs as a colorless liquid at ambient temperatures (HSDB, 2004). It is back-blended into gasoline to improve octane rating, used to produce benzene, used as a solvent in paints, coatings, adhesives, inks and cleaning agents, and used in the synthesis of a wide range of organic chemicals, particularly benzene and its derivatives (ATSDR, 2000; HSDB, 2004). Relevant physical properties are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
92.1[a]	2.73[a]	6.63E-3[b] (25°C)	2.26[b]	8.70E-2[b] (25°C)	8.60E-6[b] (25°C)	3.74E-2[c] (25°C)	5.26E+2[b] (20-25°C)	383.78[d]	591.79[d]	7.93E+3[d]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point (at 1 atm) of pure liquid compound (°K); T_c = critical temperature (°K); $H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole); ND = no data.

[a]U.S. Environmental Protection Agency (EPA), 2003, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim***, Office of Emergency and Remedial Response, EPA/540/R/99/005, OSWER 9285.7-02EP March.

[b]U.S. Environmental Protection Agency (EPA), 2001, ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites***, Peer Review Draft, Office of Solid Waste and Emergency Response, OSWER 9355.4-24, March.

[c]Hazardous Substance Data Bank (HSDB), 2004, National Library of Medicine, on line, accessed 23 April.

[d]U.S. Environmental Protection Agency (EPA), 2003, ***Users Guide for Evaluating Subsurface Vapor Intrusion into Buildings***, Office of Emergency and Remedial Response, Washington, DC, 19 June.

2.0 Environmental Fate and Transport

Large amounts of toluene are released into the atmosphere each year, principally from the production, transport and use of gasoline (ATSDR, 2000; HSDB, 2004). Other major sources include volatilization of toluene-based solvents and thinners, and motor vehicle exhaust. Considerable amounts are discharged into waterways or spilled on land during the storage, transport and disposal of fuels and oils. Natural sources include emissions from volcanoes, forest fires and crude oil.

Toluene in the atmosphere will exist predominantly or entirely in the vapor phase, where it is subject to reaction with photochemically produced hydroxyl radicals (ATSDR, 2000; ATSDR, 2004). It is also subject to reaction with various oxidizing agents in the atmosphere, but these reactions are far less significant. Wet deposition is another important process for removal of toluene from the atmosphere.

Toluene is expected to be moderately to highly mobile in soil and may leach to groundwater (ATSDR, 2000; HSDB, 2004). Volatilization is an important removal process for toluene near the surface of the soil. Biodegradation may also be significant in soil. Toluene in water will be lost by both volatilization to the atmosphere and biodegradation. Which process predominates will depend on water temperature, mixing conditions and the existence of acclimated microorganisms at the site.

The compound is not expected to sorb significantly to sediment or suspended organic matter in water.

Toluene theoretically may be expected to bioconcentrate because of its lipophilicity, but empirical data show that it is subject to rapid biotransformation, which greatly reduces this tendency (ATSDR, 2000). Overall, biotransfer is not expected to be significant (EPA, 1995) and biotransfer factors are not provided.

3.0 Toxicokinetics

Excretion data from humans and laboratory animals indicate that toluene is rapidly and extensively absorbed during inhalation and following oral administration (ATSDR, 2000). Data from humans suggest that pulmonary retention ranges from 50 to 83 percent of the inhaled concentration. GI absorption is practically complete in humans and animals. Administration of toluene in soil slows the rate but does not reduce the extent of GI absorption. Toluene is absorbed by the skin of humans and laboratory animals when applied as a liquid or as a water solution. Dermal uptake of toluene vapor has been demonstrated in animals. Data were not located regarding dermal uptake from soil.

Absorbed toluene is rapidly and widely distributed throughout the body (ATSDR, 2000). Highest levels are generally found in highly vascular and lipid-rich tissues, including the brain, particularly following inhalation, and the liver, particularly following ingestion. Levels in maternal tissues are generally much higher than those in fetal tissues. The nervous system is an important target for exposure to toluene, particularly following inhalation exposure.

The predominant metabolic pathway for toluene involves oxidation of the methyl group to form benzyl alcohol which is further oxidized to benzoic acid, followed by conjugation with glycine to form hippuric acid, which is recovered as the major urinary metabolite (ATSDR, 2000). A minor pathway involves hydroxylation of the benzene ring to form various cresol isomers, which undergo conjugation and excretion by the kidneys. Another minor pathway involves glutathione conjugation of benzyl alcohol to yield a mercapturic acid urinary metabolite. Quantitative differences in the relevance of these pathways have been shown for different species and different human racial groups.

The liver is the primary site of toluene biotransformation. The enzyme activity involved in toluene metabolism is low in the fetal liver, but reaches adult levels soon after birth. Low levels of detoxication activity in the fetus may increase the likelihood of developmental effects.

Toluene metabolites are rapidly excreted from the body, although excretion appears to be multi-phasic, reflecting release of toluene from adipose depots (ATSDR, 2000).

Nothing in this review of toxicokinetics suggests that laboratory animals would not serve as appropriate models for the toxicity of toluene to humans.

4.0 Dermal Exposure

EPA (2003) notes that organic chemicals are generally well absorbed from the GI tract, and recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly less than complete. As noted above, GI absorption is practically complete. Therefore, no GAF is developed for toluene and the oral

toxicity values described below should be used for dermal exposure without adjustment for GI absorption.

Data were not located for dermal uptake of toluene from soil. VOCs tend to volatilize from soil when applied to the skin, reducing dermal uptake to toxicologically insignificant levels (EPA, 2003). Therefore, dermal uptake of toluene from soil is not evaluated. EPA (2003) provides t*, K_p, τ, B and FA values as follows:

Chemical	t*	K_p	τ	FA	B
Toluene	0.84	3.1E-2	0.35	1.0	0.1
t* = time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); □ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).					

5.0 Noncancer Effects Evaluation

Acute inhalation (glue sniffing, solvent abuse, industrial accidents) or ingestion exposure to high levels of toluene induces CNS dysfunction and narcosis (ATSDR, 2000). Acute oral LD_{50} values include 2.6 to 7.5 g/kg in rats (HSDB, 2004), suggesting the acute toxicity is not high. Acute ingestion is associated with lesions in the heart, liver, lungs and kidneys (ATSDR, 2000). Prolonged oral exposure to lower levels is associated with pathological changes in the liver, kidney and brain. Changes in liver and kidney weights were observed in rats treated by gavage for 13 weeks at a dose rate of 446 mg/kg-day (EPA, 2004). The NOAEL in this study was 223 mg/kg-day. Application of an uncertainty factor of 1000 yields a verified RfD of 2E-1 mg/kg-day for chronic oral exposure. Confidence in the RfD is medium. The liver, kidney and central nervous system are considered the target organs for oral exposure to toluene. EPA (1997) derived a provisional subchronic oral RfD of 2E+0 mg/kg-day by applying an uncertainty factor of 100 to the NOAEL of 223 mg/kg-day described above. The uncertainty factor of 100 does not include a factor of 10 to expand from subchronic to chronic exposure that was used in derivation of the chronic oral RfD.

Prolonged occupational (inhalation) exposure to toluene at concentrations near 100 ppm induces upper respiratory tract irritation and CNS dysfunction (EPA, 2004). The CNS effects appear to be the more sensitive endpoint, and serve as the basis for a verified inhalation RfC of 4E-1 mg/m^3. The key study is a cross-sectional study involving 30 exposed female workers employed at an electronic assembly plant where toluene was emitted from glue. Toluene levels were measured from personal sample monitoring devices. The RfC is based on an exposure-adjusted LOAEL of 119 mg/m^3 and an uncertainty factor of 300. The RfC is equivalent to an inhalation RfD of 1.1E-1 mg/kg-day. Confidence in the RfC is medium. The CNS and upper respiratory tract are the target organs for inhalation exposure to toluene. The verified chronic inhalation RfC of 4E-1 mg/m^3 (1.1E-1 mg/kg-day) is adopted as the subchronic inhalation RfC.

6.0 Carcinogenicity Evaluation

EPA (2004) verified toluene as a cancer weight-of-evidence Group D compound (not classifiable as to carcinogenicity to humans) based on a lack of human data and inadequate animal testing data. Potency factors are not available for Group D compounds.

7.0 Toxicity Summary

Toxicity values for toluene are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
2E+0	2E-1	L, K, CNS	4E-1/ 1.1E-1	4E-1/ 1.1E-1	URT, CNS	D	NA	D	NA	NA

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); NA = not applicable.

Target organ or critical effect abbreviations: L = liver; K = kidney, CNS = central nervous system; URT = upper respiratory tract.

[a]sRfDo and cRfDo should be used for dermal exposure without adjustment for GI absorption.

8.0 References

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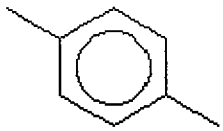
XYLENES (DIMETHYLBENZENE), TOTAL (1330-20-7)



p-Xylene

1.0 Introduction and Physical Properties

The xylenes, also known as dimethylbenzenes, exist as three isomers: 2-xylene (1,2-dimethylbenzene, ortho- or o-xylene) (95-47-6), 3-xylene (1,3-dimethylbenzene, meta- or m-xylene) (108-38-3) and 4-xylene (1,4-dimethylbenzene, para- or p-xylene) (106-42-3) (HSDB, 2004). The o-, m-, and p-xylene nomenclature will be used herein to be consistent with the manner in which xylene concentrations in environmental media are usually reported by the analytical laboratories.

The xylenes are **VOCs** derived from coal tar, coal gas, and petroleum distillation (ATSDR, 1995; HSDB, 2004). They occur as clear liquids in the pure state at most ambient temperatures, although 4-xylene occurs as colorless plates or prisms at temperatures below 56°F (13.33°C). Natural sources include petroleum, forest fires and volatiles from plants.

Xylenes are used in the manufacture of other organic compounds, dyes, insecticides and pharmaceuticals, and as solvents (ATSDR, 1995; HSDB, 2004). They are components of aviation gasoline, asphalt and naphtha, and automobile exhaust. Technical xylene consists of approximately 44 percent m-xylene, 20 percent o-xylene, 20 percent p-xylene, and 15 percent ethylbenzene. Relevant physical properties are compiled below:

MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
o-Xylene (95-47-6)										
106.16[a]	3.12[a]	5.20E-3[b] (25°C)	2.56[b]	8.70E-2[b] (25°C)	1.00E-5[b] (25°C)	8.70E-3[a] (25°C)	1.78E+2[b] (20-25°C)	417.60[c]	630.30[c]	8.66E+3[c]
m-Xylene (108-38-3)										
106.2[d]	3.20[d]	7.34E-3[b] (25°C)	2.61[b]	7.00E-2[b] (25°C)	7.80E-6[b] (25°C)	1.09E-2[a] (25°C)	1.16E+2[b] (20-25°C)	412.27[c]	617.05[c]	8.52E+3[c]
p-Xylene (106-42-3)										
106.16[a]	3.15[a]	7.66E-3[b] (25°C)	2.59[b]	7.69E-2[b] (25°C)	8.44E-6[b] (25°C)	1.16E-2[a] (25°C)	1.85E+2[b] (20-25°C)	411.52[c]	616.20[c]	8.53E+3[c]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point (at 1 atm) of pure liquid compound (°K); T_c = critical temperature (°K); $H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole).

[a]Hazardous Substance Data Bank (HSDB), 2004, National Library of Medicine, on line, accessed 23 April.

[b]U.S. Environmental Protection Agency (EPA), 2001, ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites***, Peer Review Draft, Office of Solid Waste and Emergency Response, OSWER 9355.4-24, March.

[c]U.S. Environmental Protection Agency (EPA), 2000, ***User's Guide for the Johnson and Ettinger (1991) Model for Subsurface Vapor Intrusion into Buildings, Revised***, Office of Emergency and Remedial Response, Washington, DC, December.

[d]U.S. Environmental Protection Agency (EPA), 2003, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim***, Office of Emergency and Remedial Response, EPA/540/R/99/005, OSWER 9285.7-02EP March.

It is recommended that the physical properties for m-xylene should be applied to mixed xylene isomers or data where the specific isomer is not identified, because m-xylene is the major component of the technical mixture and is likely to predominate following xylene releases.

2.0 Environmental Fate and Transport

Naturally occurring sources of xylenes are petroleum, forest fires and volatiles from plants (ATSDR, 1995; HSDB, 2004). The production and use of xylenes in petroleum products and as chemical

solvents and intermediates may result in their release to the environment as fugitives and through various waste streams. Outgassing from landfills and automobile exhaust are other significant sources. Spills, leaking underground storage tanks and associated plumbing, and leaching from landfills may release xylenes to soil and groundwater.

Xylenes will exist solely in the vapor phase in the ambient atmosphere, where they are subject to degradation by reaction with photochemically-produced hydroxyl radicals as the only significant removal process (ATSDR, 1995; HSDB, 2004). The atmospheric lifetime of xylenes is about 1 to 2 days. Products of photooxidation include a wide variety of ring hydroxylation and ring cleavage products.

Volatilization is expected to be the major removal mechanism for xylenes released to surface soil, but, depending on the size and rate of release, the majority of the release may infiltrate to subsurface soil (ATSDR, 1995). Photooxidation may degrade a significant part of the small amount that remains at the surface. Biodegradation is probably the only significant subsurface removal mechanism, but it is expected to be slow. A wide range of experimental K_{oc} values have been reported in soil samples with differing pH and organic carbon content (HSDB, 2004), suggesting a wide range in the extent to which the xylenes adsorb to soil particles. Generally, however, xylene is fairly mobile and may readily leach to groundwater.

Volatilization is probably the most significant removal mechanism for xylenes in surface water (ATSDR, 1995). Biodegradation may occur in surface water, groundwater and landfill leachate, although quite slowly. Oxidative reactions are expected to be insignificant. Xylenes are expected to adsorb somewhat to suspended solids and sediment in water (HSDB, 2004).

Xylenes are not expected to participate significantly in food-chain pathways (ATSDR, 1995; HSDB, 2004); therefore, biotransfer factors are not provided.

3.0 Toxicokinetics

Xylenes are rapidly and extensively absorbed during inhalation and following oral exposure (ATSDR, 1995). In humans, approximately 50 to 73 percent of the inhaled concentration is retained. In laboratory animals, approximately 90 percent of an ingested dose is absorbed. Liquid xylene is absorbed through the skin of humans, but dermal uptake of xylene vapors approximates only 1 percent of inhalation uptake. A study in rats showed that dermal uptake of xylene adsorbed to soil is much slower than dermal uptake of the neat liquid.

Absorbed xylene is largely bound to serum protein in the blood and is distributed rapidly and widely throughout the body, but particularly to highly vascular tissues and those high in lipid content (e.g., blood, brain, liver) (ATSDR, 1995). Levels in fetal tissues approximate 2 percent of those measured in maternal brain.

The predominant metabolic pathway in humans and animals for all xylene isomers is oxidation of one of the methyl groups to the corresponding alcohol, with further oxidation to the corresponding methylbenzoic acid (ATSDR, 1995). The methylbenzoic acids conjugate with glycine to form the corresponding methylhippuric acids, which are the major urinary metabolites. Much lesser quantities of the alcohols and o-methylbenzoic acid are also excreted in the urine. Methylbenzaldehyde, proposed as the ultimate toxicant because it inactivates enzymes involved in

electron transport, has been identified in laboratory animals but not in humans. Metabolism in laboratory animals differs from that in humans largely in the nature of the conjugates that are formed. Ring hydroxylation to form phenolic compounds represents a minor metabolic pathway is both humans and animals.

The xylenes are rapidly excreted from the body, largely in the form of urinary metabolites (ATSDR, 1955) as described above. Approximately 5 percent of an oral dose is eliminated in the breath as unchanged compound. Residues are slightly more persistent in adiposa and muscle tissue than other tissues of the body, but no organ or tissue accumulates xylene residues.

4.0 Dermal Exposure

EPA (2003) recommends that oral toxicity values should not be adjusted when used for dermal exposure unless empirical data demonstrate that GI absorption is significantly less than complete. Xylenes are nearly completely absorbed from the GI tract; therefore, no GAF is developed for the xylenes and the oral toxicity values described below should be used for dermal exposure without adjustment for GI absorption.

Xylene in soil is absorbed by the skin, albeit very slowly, but quantitative data were not located. VOCs tend to volatilize from soil when applied to the skin, reducing dermal uptake to toxicologically insignificant levels (EPA, 2003). Therefore, dermal uptake of xylenes from soil is not evaluated. Values for t*, K_p, τ, FA and B are provided by EPA (2003) for m-xylene as follows:

Chemical	t*	K_p	τ	FA	B
m-Xylene	1.01	5.3E-2	0.42	1.0	0.2

t* = time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); □ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).

The dermal uptake parameters presented by EPA (2003) for m-xylene are applied to all the xylene isomers as well as to total xylenes.

5.0 Noncancer Effects Evaluation

Oral LD_{50} values for xylenes include 3.5 to 8.6 g/kg in rats and 1.6 to 5.6 g/kg in mice (HSDB, 2004), suggesting that the acute toxicity is low, but that mice may be slightly more sensitive than rats to the acute effects of ingested xylenes. Prolonged oral exposure of animals to xylenes is associated with reduced body weight and survival without histopathological alterations in the internal organs (EPA, 2004). EPA (2004) confirmed a previously verified chronic oral RfD for total xylenes of 2E-1 mg/kg-day based on a NOAEL of 250 mg/kg, equivalent to a continuous dose rate of 179 mg/kg-day, for decreased body weight and survival in male rats in chronic gavage studies with mixed xylenes. The LOAEL was 500 mg/kg, equivalent to 357 mg/kg-day. Mice were also included in the study. The LOAEL in mice was 1000 mg/kg, equivalent to 714 mg/kg-day, associated with hyperactivity, which was consistently observed at 5 to 30 minutes after treatment. The mice did not exhibit the effects on body weight or survival that was observed with the rats, establishing the rat as the more sensitive species to prolonged oral exposure. An uncertainty factor of 1000 was applied to the rat NOAEL to derive the verified chronic oral RfD. Confidence in the chronic oral RfD is medium.

EPA (1997) presented provisional chronic oral RfDs for o-xylene and m-xylene of 2E+0 mg/kg-day based on an earlier IRIS evaluation of the same rat and mouse gavage study. Given the EPA (2004) re-evaluation of this study and the lowering of the chronic oral RfD by an order of magnitude, it seems prudent to adopt the verified chronic oral RfD of 2E-1 mg/kg-day for use with mixed xylenes and all xylene isomers. The critical effects of prolonged oral exposure to xylenes are reduced body weight and reduced survival. The verified chronic oral RfD is adopted as sufficiently protective for subchronic oral exposure to mixed xylenes and all xylene isomers.

Occupational exposure to xylenes induces CNS effects and GI disturbances (ACGIH, 1991). Other effects attributed to occupational exposure to xylene (blood dyscrasias, and heart, liver and kidney damage) may arise from concurrent exposure to other chemicals. EPA (2004) verified a chronic inhalation RfC of 1E-1 mg/m^3 based on CNS effects. In the key study, male rats were intermittently exposed to m-xylene at airborne concentrations of 0, 50 or 100 ppm for three months. Endpoints evaluated included spontaneous motor activity and motor coordination as measured by performance on a rotorod. Body and organ weights and limited blood chemistry and hematological parameters were also evaluated, but minor alterations in these endpoints were not attributed to exposure to m-xylene. The study identified 50 ppm as the NOAEL and 100 ppm as the LOAEL for impaired rotorod performance. The NOAEL is equivalent to an adjusted human equivalent concentration of 39 mg/m^3. Application of an uncertainty factor of 300 to the NOAEL yields the verified chronic inhalation RfC of 1E-1 mg/m^3, which is equivalent to a chronic inhalation RfD of 2.9E-2 mg/kg-day. The uncertainty factor consists of a factor of 10 to provide greater protection for more sensitive individuals, and factors of 3 each to extrapolate from animals to humans, to expand from subchronic to chronic exposure, and to account for deficiencies in the data base. The CNS is considered to be the target organ for prolonged inhalation exposure to xylenes. Confidence in the chronic inhalation RfC is medium.

No EPA-derived subchronic inhalation RfC is available for exposure to xylene. However, a preliminary subchronic inhalation RfC can be derived by applying an uncertainty factor of 100 to the NOAEL of 39 mg/m^3 in the subchronic rotorod study in rats described above. The uncertainty factor of 100 reflects the chronic uncertainty factor of 300 without the factor of 3 to expand from subchronic to chronic exposure. The preliminary subchronic inhalation RfC so derived is 4E-1 mg/m^3, which is equivalent to a subchronic inhalation RfD of 1.1E-1 mg/kg-day.

6.0 Carcinogenicity Evaluation

Xylene was previously characterized as a cancer weight-of-evidence Group D compound (not classifiable as to carcinogenicity to humans). Using a more descriptive characterization, EPA (2004) concluded that the cancer *data are inadequate for an assessment of the carcinogenic potential of xylenes*. Adequate human data on the carcinogenicity of the xylenes are not available, and the available animal data are inconclusive as to the ability of xylenes to cause a carcinogenic response. Evaluations of the genotoxic effects of xylenes have consistently given negative results. Potency factors are not available.

7.0 Toxicity Summary

Toxicity values for the xylenes are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
2E-1	2E-1	BW, Su	4E-1/ 1.1E-1	1E-1/ 2.9E-2	CNS	D	NA	D	NA	NA

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); NA = not applicable.
Target organ or critical effect abbreviations: BW = reduced body weight; Su = reduced survival; CNS = central nervous system.
[a]sRfDo and cRfDo should be used for dermal exposure without adjustment for GI absorption.

8.0 Preliminary Remediation Goals

PRGs are available for xylene (EPA, 2002). It appears, however, that the PRGs for xylenes are based on a chronic oral RfD of 7E-1 mg/kg-day rather than the verified value of 2E-1 mg/kg-day documented above. The differences are not large; however, the reason for this discrepancy is not clear. It was deemed advisable to re-calculate the PRGs using the verified oral RfD. The PRGs so calculated are presented below:

Chemical	Oral RfD (mg/kg-day)	Inhalation RfD (mg/kg-day)	VF_s[a] (m^3/kg)	Preliminary Remediation Goal			
				Residential Soil (mg/kg)	Industrial Soil (mg/kg)	Ambient Air (µg/m^3)	Tap Water (µg/L)
Xylenes	2E-1	2.9E-2	6.11E+3	2.7E+2	9.0E+2	1.1E+2	2.1E+2

RfD = reference dose; VF_s = soil-to-air volatilization factor.
[a]Based on physical properties of m-xylene.

The recalculated PRGs do not differ from those provided by EPA (2002) because of the greater importance of inhalation exposure compared with oral exposure.

9.0 References

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Miscellaneous

CYANIDE ANION (57-12-5), FREE CYANIDE, HYDROGEN CYANIDE (74-90-8)

$C^- \equiv N$

Cyanide Anion

1.0 Introduction and Physical Properties

The term cyanide is properly used to mean the cyanide anion illustrated above. The term is also used herein to represent any form of cyanide, particularly if the form was not specified in the literature cited. The term free cyanide generally means the cyanide anion, hydrogen cyanide and some cyanide salts (e.g., sodium cyanide, potassium cyanide) that readily dissociate and release cyanide in water solutions within the biological pH range (ATSDR, 1997). Chlorine-amenable cyanide includes free cyanide as well as most organic complexes and most simple metal complexes. The chlorine-amenable fraction excludes iron cyanides, which resist degradation with release of cyanide. Total cyanide includes all of the above.

Concentrations of cyanide reported by various analytical procedures do not necessarily reflect the amount that is bioavailable, and data are not available with which to quantify bioavailability (ATSDR, 1997). Free cyanide and simple water soluble complexes (part of the chlorine-amenable fraction) are expected to be highly bioavailable. More complicated organic complexes and many metal complexes are expected to be somewhat less bioavailable, but the nature of the specific compound and pH of the matrix will greatly influence bioavailability. A reasonably conservative approach (adopted herein) is to evaluate total cyanide in the RA. A more reasonable approach, including only chlorine-amenable cyanide in the RA, might be justified if there were large differences between concentrations of chlorine-amenable and total cyanide. Large differences (upwards of an order of magnitude) might be expected in mining situations where metal complexes are expected to predominate.

Hydrogen cyanide is used in the synthesis of a wide range of organic chemicals (ATSDR, 1997; HSDB, 2004). Cyanide salts are used in metal treatment, ore extraction, as anticaking agents in road salt, and in a wide variety of other uses. Hydrogen cyanide has been used formerly to fumigate grain to control insects and rodents, and to exterminate rodents in their burrows. The cyanide anion is an **inorganic** substance. Hydrogen cyanide is a liquid, or gas above 26.5 °C (HSDB, 2004), and behaves very much like a **VOC** in the environment. Relevant physical properties of inorganic cyanide and hydrogen cyanide are compiled below:

Cyanide Anion (57-12-5)							
MW	log K_{ow}	H	K_d	D_a	D_w	VP	S
26.02[a]	NA	NA	NA	NA	NA	NA	Note 1[b]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; K_d = soil/water partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; NA = not applicable.

Note 1: Several simple complexes or salts (e.g., hydrogen cyanide, sodium cyanide, potassium cyanide) are highly soluble in water, while other salts and organic complexes are sparingly soluble or practically insoluble in water.

[a]Howard, P.H. and M. Neal, 1992, ***Dictionary of Chemical Names and Synonyms***, Lewis Publishers, Ann Arbor.

[b]Agency for Toxic Substances and Disease Registry (ATSDR), 1997, ***Update Toxicological Profile for Cyanide***, U.S. Department of Health and Human Services, Atlanta, GA, on line, September.

Hydrogen Cyanide (74-90-8)										
MW	log K_{ow}	H	log K_{oc}	D_a	D_w	VP	S	T_b	T_c	$\Delta H_{v,b}$
27.03[a]	-0.25[a]	1.33E-4[a] (25°C)[b]	-0.044[c]	2.11E-1[c] (25°C)[b]	2.44E-5[c] (25°C)[b]	9.76E-1[a] (25°C)	1E+6[a] (25°C)	298.8[a]	456.7[a]	6.02E+3[a]

MW = molecular weight (g/mole); log K_{ow} = base 10 logarithm of the octanol/water partition coefficient (unitless); H = Henry's Law constant (atm-m^3/mole) at the reference temperature; log K_{oc} = base 10 logarithm of the soil/organic carbon partition coefficient (L/kg); D_a = diffusivity in air (cm^2/second); D_w = diffusivity in water (cm^2/second); VP = vapor pressure (atm) at the reference temperature; S = solubility in water (mg/L) at the reference temperature; T_b = normal boiling point (at 1 atm) of pure liquid compound (°K); T_c = critical temperature (°K); $H_{v,b}$ = enthalpy of vaporization at the boiling point (cal/mole).
[a]Hazardous Substance Data Bank (HSDB), 2004, National Library of Medicine, on line, accessed 22 April.
[b]Assumed.
[c]Calculated as described in Introduction to Toxicity Profiles.

2.0 Environmental Fate and Transport

Cyanide is a naturally occurring substance (ATSDR, 1997; HSDB, 2004). Hydrogen cyanide may be produced naturally by microorganisms as well as from the degradation of cyanogenic glycosides, which are produced naturally by many plants. Several species of blue-green algae liberate hydrogen cyanide in the process of nitrate metabolism. Laetrile and amygdalin, which occur in substantial concentrations in several fruit pits (e.g., cherries, peaches, apricots, apples, pears) liberate cyanide following ingestion.

Major releases to the environment occur from metal treatment and ore extraction (primarily to water) and in automobile exhaust (primarily to the atmosphere) (ATSDR, 1997). The production of hydrogen cyanide and its use as a starting material in the manufacture of acrylates, cyanide salts, herbicides and dyes as well as its former use as a fumigant may result in its release to the environment through various waste streams (HSDB, 2004). It also may be liberated from blast furnaces, gas works, coke ovens and oil shale retorting operations. Most hydrogen cyanide is emitted primarily to the atmosphere or waste water. Various cyanide salts may be released during their use in ore extraction and other metallurgic operations. Materials containing cyanide compounds disposed on land may cause elevated levels of cyanide in underlying strata and in groundwater. Cigarette smoke contains low levels of hydrogen cyanide.

Hydrogen cyanide released to the atmosphere is expected to remain solely in the vapor phase and to react slowly with photochemically generated hydroxyl radicals (HSDB, 2004). A half-life of approximately 300 to 550 days has been estimated for this reaction. Hydrogen cyanide is expected to be resistant to direct photolysis. The relatively slow rate of degradation suggests that hydrogen cyanide has the potential for transport over long distances before being removed by physical or chemical processes. Since hydrogen cyanide is miscible in water, wet deposition may be the most important removal process. Metal cyanide particles released to the air in dust are expected to be removed by both wet and dry deposition.

Cyanide may occur in the form of hydrogen cyanide, metal salts, or immobile metallocyanide complexes in soil (ATSDR, 1997; HSDB, 2004). It is expected that volatilization of hydrogen cyanide would be an important mechanism for cyanide removal from dry soil surfaces and from moist soil surfaces with pH less than 9.2. Hydrogen cyanide and many cyanide salts are very water soluble and are expected to be highly mobile in soil, readily leaching to deeper levels and to groundwater. Concentrations sufficiently low so as not to be toxic to microorganisms may undergo biodegradation in subsurface soil. Microbial degradation may yield formamide, or complete mineralization may yield carbon dioxide and ammonia. Degradation of low concentrations in soil may substantially reduce the potential for leaching to groundwater.

Hydrogen cyanide is not expected to adsorb to suspended solids and sediment in water (HSDB, 2004). Volatilization from water surfaces is expected to be the most important removal mechanism. Biodegradation may be an important removal mechanism for low concentrations that are not toxic to microorganisms as explained for soil.

Hydrogen cyanide is volatile and labile at low concentrations. Its low log K_{ow} suggests that bioconcentration is unlikely to be significant. Some metal complexes have been shown to biotransfer, but the toxicity of these complexes is much less than that of hydrogen cyanide because of their very low solubility (ATSDR, 1997). There is no evidence of biomagnification in the food chain (ATSDR, 1997), and EPA (1995) has determined that cyanide is not a threat to human health through fish consumption. Biotransfer factors are not estimated for cyanide for these reasons.

3.0 Toxicokinetics

Inhalation exposure of humans to hydrogen cyanide results in very rapid absorption and high systemic retention (approximately 58 percent retention) (ATSDR, 1997). Absorption is similarly rapid following oral exposure. Excretion data from orally treated animals suggest a minimum absorption factor of approximately 50 percent, but the extent of absorption is probably much higher. Dermal absorption of hydrogen cyanide by humans is inferred from toxicity data and supported by data from experimental animals. It is likely that some cyanide salts may also be absorbed but the extent has not been quantified.

Cyanide is rapidly and widely distributed throughout the body following absorption (ATSDR, 1997).

The primary detoxication pathway involves the action of the enzyme rhodanese to combine cyanide with sulfane sulfur to yield thiocyanate, which is rapidly excreted through the urine (ATSDR, 1997). Rhodanese activity is located in most tissues of the body; the relative activity largely dependent on species. Highest levels are not generally found in the liver, which is often the primary site of metabolism for environmental contaminants. Minor detoxication pathways include pulmonary excretion of hydrogen cyanide, conversion of cyanide to carbon dioxide or other constituents that enter the single-carbon pool, and incorporation into cyanocobalamin (vitamin B_{12}). Elimination occurs rapidly, resulting in a half-life for cyanide of approximately 6 hours in humans. The incorporation of carbon into the single-carbon pool may account for the low estimate of extent of GI absorption from excretion data.

Hydrogen cyanide is the toxic moiety, complexing with ferric iron in various metalloenzymes, inhibiting mitochondrial cytochrome c oxidase and resulting in histotoxic anoxia (ATSDR, 1997). Several changes follow that exacerbate the original biochemical lesion.

4.0 Dermal Exposure

GI absorption of cyanide almost certainly exceeds 50 percent as noted in Section 3.0. EPA (2004) suggests that oral toxicity values should not be adjusted when used for dermal exposure unless GI absorption is less than 50 percent. Therefore, the oral toxicity values described below are adopted without modification for use for dermal exposure

EPA (1991) stated that, "performing an oral-to-dermal extrapolation would not be appropriate because of the uncertainty that the oral RfD for cyanide would provide protection for the effects caused by dermal exposure." The available data, however, suggest that the effects following oral

and dermal exposure are similar (ATSDR, 1997). Furthermore, nothing in the toxicokinetic data suggest that detoxication would occur more efficiently following oral exposure so that the oral RfD may not be sufficiently protective for dermal exposure. Therefore, it is judged that the oral RfD is an appropriate value with which to evaluate the toxicity of dermal exposure to cyanide.

Two scenarios are relevant to dermal exposure to cyanide. The first scenario is exposure to cyanide in soil. Cyanide present in soil as hydrogen cyanide would be likely to volatilize so that dermal exposure is expected to be insignificant, as noted by EPA (2004) for other VOCs. Therefore, dermal exposure to hydrogen cyanide in soil is not quantified. It is possible that cyanide may exist as various salts or complexes in soil. Although these compounds may be dermally absorbed, the extent has not been quantified, so no ABS is available with which to quantify dermal uptake. Therefore, dermal uptake of cyanide from soil is not quantified, as recommended by EPA (2004).

The second scenario is exposure to cyanide in water, which may occur as hydrogen cyanide or soluble salts. Cyanide in water will be assumed to be present entirely as hydrogen cyanide to simplify the evaluation. Values for t*, K_p, τ, B and FA estimated by the EPA (2004) methodology follow:

Chemical	t*	K_p	τ	FA	B
Hydrogen Cyanide	0.36	7.65E-4	0.15	1	0.0
t* = time for dermal uptake to reach steady state (hours); K_p = permeability coefficient (cm/hour); □ = lag time for chemical to cross stratum corneum (hours); FA = fraction absorbed (unitless); B = ratio of the permeability coefficient for passage across the stratum corneum relative to the permeability coefficient for passage across the viable epidermis (unitless).					

5.0 Noncancer Effects Evaluation

Oral LD_{50} values in laboratory animals range from 8 to 22 mg/kg, depending on the particular cyanide compound and laboratory species (ATSDR, 1997; HSDB, 2004), indicating that the acute oral toxicity of cyanide is high. Prolonged oral exposure is associated with weight loss, thyroid effects and nervous system effects, particularly myelin degeneration (EPA, 2005). A verified chronic oral RfD of 2E-2 mg/kg-day for free cyanide and hydrogen cyanide was derived from a NOAEL of 10.8 mg/kg-day in a 2-year study in which rats were fed diets fumigated with hydrogen cyanide. The LOAEL of 30 mg/kg-day in another rat feeding study is associated with the effects described above. An uncertainty factor of 500 was applied. Confidence in the oral RfD is medium. Loss of body weight, thyroid effects and nervous system effects are considered the critical effects for prolonged oral exposure to cyanide. EPA (1997) adopted the verified chronic oral RfD as sufficiently protective for subchronic oral exposure.

EPA (2005) verified a chronic inhalation RfC of 3E-3 mg/m^3 for hydrogen cyanide based on nervous symptoms and thyroid effects in occupationally exposed humans. The key study involved 36 non-smoking male workers employed in the electroplating sections of three factories in Egypt exposed for 5 to 10 years (1 man exposed for 15 years). Twenty non-smoking unexposed male volunteers served as controls. Breathing-zone cyanide concentrations ranged from 4.63 to 13.69 mg/m^3, with a mean of 7.07 to 11.45 mg/m^3. Symptoms reported more frequently in the exposed workers included (in decreasing order of frequency) headache, weakness, and changes in the senses of taste and smell. Lacrimation, abdominal colic, and precordial (lower stomach) pain, salivation, and nervous instability occurred less frequently. Twenty of the exposed workers had thyroid enlargement to a mild or moderate degree, and thyroid function (iodine uptake) was altered. The lowest mean

concentration recorded in the three factories, 7.07 mg/m^3, corresponding to an exposure-adjusted concentration of 2.5 mg/m^3, was designated a LOAEL. Application of an uncertainty factor of 1000 (factors of 10 each to estimate a NOAEL from a LOAEL and to provide additional protection for unusually sensitive individuals, and factors of 3 each for deficiencies in the database [lack of chronic and multigenerational reproduction studies] and for less than chronic duration) yields the verified chronic inhalation RfC of 3E-3 mg/m^3. The chronic RfC is equivalent to a chronic inhalation RfD of 8.6E-4 mg/kg-day. The thyroid and CNS are the targets for prolonged inhalation exposure. Confidence in the verified RfC is low.

A subchronic inhalation RfC of 8E-3 mg/m^3 equivalent to a subchronic inhalation RfD of 2.3E-3 mg/kg-day is derived by applying an uncertainty factor of 300 to the LOAEL of 2.5 mg/m^3 described above. The uncertainty factor of 300 reflects the chronic uncertainty factor of 1000 excluding the factor of 3 to expand from subchronic to chronic exposure.

The chronic and subchronic inhalation RfC and RfD values can be applied to any airborne form of cyanide.

6.0 Carcinogenicity Evaluation

EPA (2005) classified cyanide in EPA cancer weight-of-evidence Group D – not classifiable as to carcinogenicity to humans – because of a lack of data in humans or laboratory animals. Cancer potency factors are not derived for Group D chemicals.

7.0 Toxicity Summary

Toxicity values for cyanide/hydrogen cyanide are summarized below:

Noncancer Effects						Carcinogenicity				
Oral Exposure[a]			Inhalation Exposure			Oral Exposure		Inhalation Exposure		
sRfDo	cRfDo	TO	sRfC/ sRfDi	cRfC/ cRfDi	TO	WOE	SFo	WOE	URFi	SFi
2E-2	2E-2	BW, T, NS	8E-3/ 2.3E-3	3E-3/ 8.6E-4	T, CNS	D	NA	D	NA	NA

sRfDo = subchronic oral reference dose (milligrams per kilogram-day); cRfDo = chronic oral reference dose (milligrams per kilogram-day); TO = target organ(s) or critical effect(s); sRfC = subchronic inhalation reference concentration (milligrams per cubic meter); sRfDi = subchronic inhalation reference dose (milligrams per kilogram-day); cRfC = chronic inhalation reference concentration (milligrams per cubic meter); cRfDi = chronic inhalation reference dose (milligrams per kilogram-day); WOE = cancer weight-of-evidence evaluation; SFo = oral cancer slope factor (risk per milligram per kilogram-day); URFi = inhalation unit risk factor (risk per microgram per cubic meter); SFi = inhalation cancer slope factor (risk per milligram per kilogram-day); NA = not applicable.
Target organ or critical effect abbreviations: BW = reduced body weight; T = thyroid, NS = nervous system; CNS = central nervous system.
[a]sRfDo and cRfDo should be used for dermal exposure without adjustment for GI absorption.

8.0 References

Agency for Toxic Substances and Disease Registry (ATSDR), 1997, ***Update Toxicological Profile for Cyanide***, U.S. Department of Health and Human Services, Atlanta, GA, on line, September.

Hazardous Substance Data Bank (HSDB), 2004, National Library of Medicine, on line, accessed 22 April.

U.S. Environmental Protection Agency (EPA), 1991, ***Risk Assessment Issue Paper for: Dermal Absorption of Cyanide (CASRN 57-12-5)***, National Center for Environmental Assessment, Cincinnati, OH, 3 June.

U.S. Environmental Protection Agency (EPA), 1995, "Final Water Quality Guidance for the Great Lakes System; Final Rule," (40 CFR 9, 122, 123, 131, and 132), ***Federal Register***, 60(56): 15365-15425.

U.S. Environmental Protection Agency (EPA), 1997, ***Health Effects Assessment Summary Tables, FY 1997 Update***, Office of Solid Waste and Emergency Response, 9200.6-303 (97-1), EPA-540-R-97-036, PB97-921199, July.

U.S. Environmental Protection Agency (EPA), 2004, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final***, Office of Superfund Remediation and Technology Innovation, Washington, DC, EPA/540/R/99/005, OSWER 9285.7-02EP, NTIS No. PB99-963312, July.

U.S. Environmental Protection Agency (EPA), 2005, ***Integrated Risk Information System (IRIS)***, National Center for Environmental Assessment, Cincinnati, OH, on line, accessed 12 December.

NITRATE (14797-55-8) and NITRITE (14797-65-0)

Nitrate is a naturally occurring member of the nitrogen cycle, being formed and released by nitrogen-fixing bacteria (EPA, 1989; Kettrup and Huppe, 1988). Nitrates are used largely as fertilizers. Relevant physical properties are compiled below:

MW (g/mole)	log K_{ow} (unitless)	H (atm-m^3/mole)	K_d (L/kg)	D_a (cm^2/s)	D_w (cm^2/s)	VP (atm)	S (mg/L)
Nitrate							
62.00 (anion)	NA	NA	NA	NA	NA	NA	Note 1[a]
Nitrite							
46.01 (anion)	NA	NA	NA	NA	NA	NA	Note 1[a]

NA = not applicable.
Note 1: Variable; many nitrate and nitrate salts are very soluble.
[a]Budavari, S, Ed., 1989, ***The Merck Index, An Encyclopedia of Chemicals, Drugs, and Biologicals***, Eleventh Edition, Merck & Co., Rahway, NJ.

Agricultural application of synthetic fertilizer and animal waste is a major mechanism by which nitrates are released to the environment (EPA, 1989; HSDB, 2002). It is also possible that the degradation of nitroaromatic compounds could contribute nitrate to the environment. Data were not located regarding the fate of nitrate or nitrite in the atmosphere, but the high solubility of many nitrate/nitrite compounds suggests that wet deposition may be a major removal process. Nitrate and nitrite in soil and water will exist largely as the soluble anions (EPA, 1989). Chemical interconversion and microbial transformation to other nitrogenous species will occur in soil and water. Biotransfer factors for nitrogen are compiled below:

BCF (L/kg)	Bpr (unitless)	Bpv (unitless)	Bb (unitless)	Bm (unitless)
ND	3.0E+1[a]	3.0E+1[a]	NA (see below)	NA (see below)

ND = no data; NA = not applicable.
[a]Baes, C.F., R.D. Sharp, A.L. Sjoreen, R.W. Shor, 1984, ***A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture***, Health and Safety Division, Oak Ridge National Laboratory, ORNL-5786, September.

It is well established that certain plants grown in soil containing high levels of nitrates (e.g., highly fertilized) may accumulate high levels of nitrate (Menzer, 1991). This is of particular concern to the welfare of domestic ruminant species, which consume large quantities of heavily fertilized forages. Animals, however, do not tend to bioaccumulate nitrate or nitrate. Therefore, human ingestion of food products from animals that consumed feedstuffs obtained from soils with high levels of nitrate is not likely to be a matter for concern.

Data regarding the GI absorption of nitrate/nitrite nitrogen are of limited usefulness. Several competing processes may occur in the acidic and reducing milieu of the GI tract, including conversion of nitrite to N_2O_2, which is probably readily absorbed (EPA, 1989). *In vivo* and *in*

vitro studies indicate that GI absorption of nitrite (the first reduction product of nitrate) may approach 50 to 80 percent. The GAF of 0.5 is conservatively chosen for this evaluation.

Data regarding the dermal absorption of nitrate/nitrite nitrogen were not located; therefore, the EPA (1995) default ABS of 0.01 for inorganic chemicals is selected for this evaluation. Data were not located regarding the dermal uptake of nitrate/nitrite nitrogen from water. However, as noted above, most nitrate and nitrite salts are very soluble in water. Therefore, it is assumed that the nitrate and nitrite anion may be absorbed by the skin at the same rate as water. The PC for water of 1E-3 cm/hour (EPA, 1992) is adopted for nitrate/nitrite nitrogen.

The oral toxicity of nitrate is mediated by its reduction to nitrite by the microflora of the GI tract (EPA, 2002). Nitrite oxidizes hemoglobin to methemoglobin, which is incapable of transporting oxygen from the lungs to the tissues. Human toxicity is generally associated with high levels of nitrate or nitrite in drinking water. Infants are the most sensitive members of the population. EPA (2002) presents a verified chronic oral RfD for nitrate of 1.6E+0 mg nitrate nitrogen/kg-day, based on a NOAEL of 1.6 mg/kg-day for methemoglobinemia in infants and an uncertainty factor of 1. Confidence in the oral RfD is high. EPA (2002) also presents a verified chronic oral RfD for nitrite of 1E-1 mg nitrite nitrogen/kg-day, based on the same NOAEL and an uncertainty factor of 10. Confidence in the oral RfD is high. The target tissue for the toxicity of nitrate or nitrite is the erythrocyte. The chronic oral RfD of 1E-1 for nitrite nitrogen is adopted as the conservative estimate of a chronic oral RfD for nitrate/nitrite nitrogen.

Data regarding the toxicity of inhalation exposure to nitrate/nitrite nitrogen were not located; an inhalation RfC cannot be developed.

Data regarding the carcinogenicity of uncombined nitrate or nitrite were not located. Nitrite can combine with secondary amines in food or other nitrogenous compounds to form nitrosamines or other N-nitroso compounds, many of which are important animal carcinogens (Menzer, 1991).

References for Nitrate/Nitrite

Hazardous Substance Data Bank (HSDB), 2002, National Library of Medicine, on line.

Kettrup, A and U. Huppe, 1988, "Nitrogen," in Seiler, H.G. and H. Sigel, eds., ***Handbook on Toxicity of Inorganic Compounds***, Marcel Dekker, Inc., New York, pp. 475-489.

Menzer, R.E., 1991, "Water and Soil Pollutants." In: M.O. Amdur, J. Doull and C.D. Klaassen, eds., ***Casarett and Doull's Toxicology, the Basic Science of Poisons***, Fourth Edition, New York: Pergamon Press, p. 872-902.

U.S. Environmental Protection Agency (EPA), 1989, ***Health and Environmental Effects Document for Nitrite***, Final Draft, Prepared by the Environmental Criteria and Assessment Office, Cincinnati, OH, for the Office of Solid Waste, Washington, DC., ECAO-CIN-GO59.

U.S. Environmental Protection Agency (EPA), 1992, ***Dermal Exposure Assessment: Principles and Applications***, Interim Report, Office of Research and Development, Washington, DC, EPA/600/8-91/011B, January.

U.S. Environmental Protection Agency (EPA), 1995, ***Region III Technical Guidance Manual, Risk Assessment, Assessing Dermal Exposure from Soil***, EPA Region III, Philadelphia, PA, EPA/903-K-95-003, December.

U.S. Environmental Protection Agency (EPA), 2002, ***Integrated Risk Information System (IRIS)***, National Center for Environmental Assessment, Cincinnati, OH, on line.

APPENDIX G

RISK CHARACTERIZATION SPREADSHEETS

Table G-1

Summary of Risk for the On-Site Worker
TNT Area A, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Exposure Point Concentration (mg/L)	Incidental Ingestion Noncancer Dose (mg/kg-day)	Incidental Ingestion Cancer Dose (mg/kg-day)	Oral HQ	Oral ILCR	DA mg/cm2-day	Dermal Absorption Noncancer Dose (mg/kg-day)	Dermal Absorption Cancer Dose (mg/kg-day)	Dermal HQ	Dermal ILCR	**HI All Pathways**	**ILCR All Pathways**
Metals												
Aluminum	8.30E+00	8.12E-02	2.90E-02	8.12E-02	ND	8.30E-06	2.68E-04	9.57E-05	NA	ND	**8.12E-02**	**NA**
Arsenic	1.73E-02	1.69E-04	6.05E-05	5.64E-01	9.07E-05	1.73E-08	5.59E-07	2.00E-07	1.86E-03	2.99E-07	**5.66E-01**	**9.10E-05**
Chromium	3.72E-02	3.64E-04	1.30E-04	1.21E-01	ND	3.72E-08	1.20E-06	4.29E-07	1.60E-02	ND	**1.37E-01**	**NA**
Iron	3.34E+01	3.27E-01	1.17E-01	1.09E+00	ND	3.34E-05	1.08E-03	3.85E-04	3.59E-03	ND	**1.09E+00**	**NA**
Lead	1.84E-02	1.80E-04	6.43E-05	NA	ND	1.84E-09	5.94E-08	2.12E-08	NA	ND	**NA**	**NA**
Manganese	1.17E+01	1.14E-01	4.09E-02	4.77E+00	ND	1.17E-05	3.78E-04	1.35E-04	NA	ND	**4.77E+00**	**NA**
Nickel	7.57E-02	7.41E-04	2.65E-04	3.70E-02	ND	1.51E-08	4.89E-07	1.75E-07	6.11E-04	ND	**3.76E-02**	**NA**
Vanadium	3.69E-02	3.61E-04	1.29E-04	3.61E-01	ND	3.69E-08	1.19E-06	4.26E-07	3.97E-02	ND	**4.01E-01**	**NA**
Explosives												
1,3-Dinitrobenzene	1.00E-03	9.78E-06	3.49E-06	9.78E-03	ND	4.64E-09	1.50E-07	5.35E-08	1.50E-04	ND	**9.93E-03**	**NA**
2,4-Dinitrotoluene	4.90E-04	4.79E-06	1.71E-06	2.40E-03	1.16E-06	4.44E-09	1.44E-07	5.13E-08	7.18E-05	3.49E-08	**2.47E-03**	**1.20E-06**
2,6-Dinitrotoluene	3.60E-03	3.52E-05	1.26E-05	3.52E-02	8.55E-06	2.21E-08	7.14E-07	2.55E-07	7.14E-04	1.73E-07	**3.59E-02**	**8.73E-06**
2-Nitrotoluene	3.10E-04	3.03E-06	1.08E-06	3.03E-04	2.49E-07	6.01E-09	1.94E-07	6.93E-08	1.94E-05	1.59E-08	**3.23E-05**	**2.65E-07**
4-Amino-2,6-dinitrotoluene	1.30E-03	1.27E-05	4.54E-06	6.36E-02	ND	8.46E-09	2.73E-07	9.75E-08	1.37E-03	ND	**6.50E-02**	**NA**
Nitrobenzene	2.00E-03	1.96E-05	6.99E-06	3.91E-02	ND	2.14E-08	6.90E-07	2.46E-07	1.38E-03	ND	**4.05E-02**	**NA**
Semivolatile Organic Compounds												
2-Methylnaphthalene	4.70E-01	4.60E-03	1.64E-03	2.30E-01	ND	9.42E-05	3.04E-03	1.09E-03	1.52E-01	ND	**3.82E-01**	**NA**
Bis(2-ethylhexyl)phthalate	8.15E-03	7.98E-05	2.85E-05	3.99E-03	3.99E-07	1.84E-06	5.94E-05	2.12E-05	2.97E-03	2.97E-07	**6.96E-03**	**6.96E-07**
Chrysene	1.50E-02	1.47E-04	5.24E-05	NA	3.83E-07	2.78E-05	8.97E-04	3.20E-04	NA	2.34E-06	**NA**	**2.72E-06**
Dibenzofuran	1.20E-02	1.17E-04	4.19E-05	5.87E-02	ND	1.81E-06	5.84E-05	2.09E-05	2.92E-02	ND	**8.79E-02**	**NA**
Fluorene	2.80E-02	2.74E-04	9.78E-05	6.85E-03	ND	7.84E-06	2.53E-04	9.04E-05	6.33E-03	ND	**1.32E-02**	**NA**
Naphthalene	1.70E-01	1.66E-03	5.94E-04	8.32E-02	ND	1.65E-05	5.34E-04	1.91E-04	2.67E-02	ND	**1.10E-01**	**NA**
Phenanthrene	7.40E-02	7.24E-04	2.59E-04	2.41E-02	ND	2.95E-05	9.52E-04	3.40E-04	3.17E-02	ND	**5.59E-02**	**NA**
Volatile Organic Compounds												
Benzene	7.00E-01	6.85E-03	2.45E-03	1.71E+00	1.35E-04	1.56E-05	5.05E-04	1.80E-04	1.26E-01	9.92E-06	**1.84E+00**	**1.44E-04**
Chloromethane	3.50E-02	3.42E-04	1.22E-04	NA	ND	1.43E-07	4.61E-06	1.65E-06	NA	ND	**NA**	**NA**
Ethylbenzene	2.40E-01	2.35E-03	8.39E-04	2.35E-02	ND	2.11E-05	6.80E-04	2.43E-04	6.80E-03	ND	**3.03E-02**	**NA**
Methylene chloride	3.30E-01	3.23E-03	1.15E-03	5.38E-02	8.65E-06	1.81E-06	5.83E-05	2.08E-05	9.72E-04	1.56E-07	**5.48E-02**	**8.81E-06**
Toluene	7.30E-01	7.14E-03	2.55E-03	3.57E-02	ND	3.70E-05	1.20E-03	4.27E-04	5.98E-03	ND	**4.17E-02**	**NA**
Xylenes, total	1.40E+00	1.37E-02	4.89E-03	6.85E-02	ND	1.33E-04	4.29E-03	1.53E-03	2.15E-02	ND	**9.00E-02**	**NA**
Total HI				**9.48**					**0.48**		**10**	
Total ILCR					**2.45E-04**					**1.32E-05**		**3.E-04**

HQ - Hazard quotient; HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
NA - Not applicable.

Table G-2

Separation of Noncancer Hazard by Target Organ
On-Site Worker Exposure to Groundwater
TNT Area A, Former Plum Brook Ordnance Works
Sandusky, Ohio

	Target Organs												
COPC	NS/CNS	Skin	PVS	GI	Fetus & Repro	Iron Overload	Kidney	Erythrocyte	Eye	Reduced BW/OW	Blood/ Blood cells	Liver	Spleen
Metals													
Aluminum	0.08												
Arsenic		0.57	0.57										
Chromium				0.14	0.14								
Iron						1.09							
Manganese	4.77												
Nickel										0.04			
Vanadium							0.40						
Explosives													
1,3-Dinitrobenzene								0.01					
2,4-Dinitrotoluene	0.002							0.002				0.002	
2,6-Dinitrotoluene	0.04						0.04	0.04				0.04	
2-Nitrotoluene													0.00003
4-Amino-2,6-dinitrotoluene								0.06				0.06	
Nitrobenzene							0.04	0.04				0.04	
Semivolatile Organic Compounds													
2-Methylnaphthalene								0.38	0.38	0.38			
Bis(2-ethylhexyl)phthalate												0.01	
Dibenzofuran							0.09						
Fluorene								0.01					
Naphthalene								0.11	0.11	0.11			
Phenanthrene							0.06						
Volatile Organic Compounds													
Benzene											1.84		
Ethylbenzene							0.03					0.03	
Methylene chloride								0.05				0.05	
Toluene	0.04						0.04					0.04	
Xylenes, total										0.09			
Total HI	**5**	**0.6**	**0.6**	**0.1**	**0.1**	**1**	**0.7**	**0.7**	**0.5**	**0.6**	**2**	**0.3**	**0**

COPC - Chemical of potential concern.
HI - Hazard index.
Target Organs: NS/CNS - nervous system/central nervous system; BW - body weight; N & O - nasal and olfactory; PVS - pulmonary vascular system; GI - gastrointestinal; OW - organ weight.

Table G-3

Summary of Noncancer Risk for the Child Resident
TNT Area A, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Exposure Point Concentration (mg/L)	Incidental Ingestion Child Noncancer Dose (mg/kg-day)	Oral HQ	Cd (mg/L)	DA (mg/cm^2-day)	Dermal Absorption Child Noncancer Dose (mg/kg-day)	Dermal HQ	Concentration in Air (mg/m^3)	Inhalation Child Noncancer Dose (mg/kg-day)	Inhalation HQ	HI All Pathways
Metals											
Aluminum	8.30E+00	5.31E-01	5.31E-01	8.30E+00	2.76E-06	1.17E-03	NA	NA	NA	NA	**5.31E-01**
Arsenic	1.73E-02	1.11E-03	3.69E+00	1.73E-02	5.76E-09	2.43E-06	8.10E-03	NA	NA	NA	**3.69E+00**
Chromium	3.72E-02	2.38E-03	7.93E-01	3.72E-02	1.24E-08	5.23E-06	6.97E-02	NA	NA	NA	**8.62E-01**
Iron	3.34E+01	2.14E+00	7.12E+00	3.34E+01	1.11E-05	4.69E-03	1.56E-02	NA	NA	NA	**7.13E+00**
Lead	1.84E-02	1.18E-03	NA	1.84E-02	6.13E-10	2.59E-07	NA	NA	NA	NA	**NA**
Manganese	1.17E+01	7.48E-01	3.12E+01	1.17E+01	3.90E-06	1.64E-03	NA	NA	NA	NA	**3.12E+01**
Nickel	7.57E-02	4.84E-03	2.42E-01	7.57E-02	5.04E-09	2.13E-06	2.66E-03	NA	NA	NA	**2.45E-01**
Vanadium	3.69E-02	2.36E-03	2.36E+00	3.69E-02	1.23E-08	5.18E-06	1.73E-01	NA	NA	NA	**2.53E+00**
Explosives											
1,3-Dinitrobenzene	1.00E-03	6.39E-05	6.39E-02	1.00E-03	2.68E-09	1.13E-06	1.13E-03	NA	NA	NA	**6.51E-02**
2,4-Dinitrotoluene	4.90E-04	3.13E-05	1.57E-02	4.90E-04	2.56E-09	1.08E-06	5.41E-04	NA	NA	NA	**1.62E-02**
2,6-Dinitrotoluene	3.60E-03	2.30E-04	2.30E-01	3.60E-03	1.28E-08	5.39E-06	5.39E-03	NA	NA	NA	**2.36E-01**
2-Nitrotoluene	3.10E-04	1.98E-05	1.98E-03	1.55E-04	1.73E-09	7.32E-07	7.32E-05	1.55E-04	9.89E-05	NA	**2.05E-03**
4-Amino-2,6-dinitrotoluene	1.30E-03	8.31E-05	4.16E-01	1.30E-03	4.88E-09	2.06E-06	1.03E-02	NA	NA	NA	**4.26E-01**
Nitrobenzene	2.00E-03	1.28E-04	2.56E-01	1.00E-03	6.17E-09	2.60E-06	5.20E-03	1.00E-03	6.38E-04	1.12E+00	**1.38E+00**
Semivolatile Organic Compounds											
2-Methylnaphthalene	4.70E-01	3.00E-02	1.50E+00	2.35E-01	2.72E-05	1.15E-02	5.73E-01	2.35E-01	1.50E-01	1.74E+02	**1.76E+02**
Bis(2-ethylhexyl)phthalate	8.15E-03	5.21E-04	2.61E-02	8.15E-03	1.06E-06	4.48E-04	2.24E-02	NA	NA	NA	**4.84E-02**
Chrysene	1.50E-02	9.59E-04	NA	1.50E-02	1.60E-05	6.76E-03	NA	NA	NA	NA	**NA**
Dibenzofuran	1.20E-02	7.67E-04	3.84E-01	6.00E-03	5.22E-07	2.20E-04	1.10E-01	6.00E-03	3.83E-03	NA	**4.94E-01**
Fluorene	2.80E-02	1.79E-03	4.47E-02	1.40E-02	2.26E-06	9.54E-04	2.38E-02	1.40E-02	8.94E-03	NA	**6.86E-02**
Naphthalene	1.70E-01	1.09E-02	5.43E-01	8.50E-02	4.77E-06	2.01E-03	1.01E-01	8.50E-02	5.43E-02	6.31E+01	**6.37E+01**
Phenanthrene	7.40E-02	4.73E-03	1.58E-01	3.70E-02	8.51E-06	3.59E-03	1.20E-01	3.70E-02	2.36E-02	NA	**2.77E-01**
Volatile Organic Compounds											
Benzene	7.00E-01	4.47E-02	1.12E+01	3.50E-01	4.51E-06	1.90E-03	4.76E-01	3.50E-01	2.23E-01	2.60E+01	**3.76E+01**
Chloromethane	3.50E-02	2.24E-03	NA	1.75E-02	4.12E-08	1.74E-05	NA	1.75E-02	1.12E-02	4.30E-01	**4.30E-01**
Ethylbenzene	2.40E-01	1.53E-02	1.53E-01	1.20E-01	6.08E-06	2.57E-03	2.57E-02	1.20E-01	7.66E-02	2.64E-01	**4.43E-01**
Methylene chloride	3.30E-01	2.11E-02	3.52E-01	1.65E-01	5.21E-07	2.20E-04	3.66E-03	1.65E-01	1.05E-01	1.22E-01	**4.78E-01**
Toluene	7.30E-01	4.67E-02	2.33E-01	3.65E-01	1.07E-05	4.51E-03	2.25E-02	3.65E-01	2.33E-01	2.12E+00	**2.37E+00**
Xylenes, total	1.40E+00	8.95E-02	4.47E-01	7.00E-01	3.84E-05	1.62E-02	8.09E-02	7.00E-01	4.47E-01	1.54E+01	**1.59E+01**
Total HI			**61.9**				**1.85**			**283**	**347**

HQ - Hazard quotient; HI - Hazard index.
NA - Not applicable.

Table G-4

Separation of Noncancer Hazard by Target Organ
Child Resident Exposure to Groundwater
TNT Area A, Former Plum Brook Ordnance Works
Sandusky, Ohio

	Target Organs														
COPC	NS/CNS	Skin	PVS	GI	Fetus & Repro	URT/ Lung	Iron Overload	Kidney	Erythrocyte	Eye	Reduced BW/OW	N & O epithelia	Blood/ Blood cells	Liver	Spleen
Metals															
Aluminum	0.53														
Arsenic		3.69	3.69												
Chromium				0.86	0.86										
Iron							7.13								
Manganese	31.16														
Nickel											0.24				
Vanadium								2.53							
Explosives															
1,3-Dinitrobenzene									0.07						
2,4-Dinitrotoluene	0.02								0.02					0.02	
2,6-Dinitrotoluene	0.24							0.24	0.24					0.24	
2-Nitrotoluene															0.0002
4-Amino-2,6-dinitrotoluene									0.43					0.43	
Nitrobenzene								1.38	1.38					1.38	
Semivolatile Organic Compounds															
2-Methylnaphthalene									2.08	2.08	2.08	174.40			
Bis(2-ethylhexyl)phthalate														0.05	
Dibenzofuran								0.49							
Fluorene									0.07						
Naphthalene									0.64	0.64	0.64	63.08			
Phenanthrene								0.28							
Volatile Organic Compounds															
Benzene													37.64		
Chloromethane	0.43														
Ethylbenzene					0.26			0.44						0.44	
Methylene chloride									0.48					0.48	
Toluene	0.26			2.12		2.12		0.26						0.26	
Xylenes, total	15.41										0.53				
Total HI	**48**	**4**	**4**	**3**	**1**	**2**	**7**	**6**	**5**	**3**	**3**	**237**	**38**	**3**	**0**

COPC - Chemical of potential concern.
HI - Hazard index.
Target Organs: NS/CNS - nervous system/central nervous system; BW - body weight; N & O - nasal and olfactory; PVS - pulmonary vascular system; GI - gastrointestinal; OW - organ weight.

Table G-5

Risk Evaluation for the Adult Resident
TNT Area A, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Exposure Point Concentration (mg/L)	Incidental Ingestion Adult Noncancer Dose (mg/kg-day)	Oral HQ	Cd (mg/L)	DA (mg/cm^2-day)	Dermal Absorption Adult Noncancer Dose (mg/kg-day)	Dermal HQ	Concentration in Air (mg/m^3)	Inhalation Adult Noncancer Dose (mg/kg-day)	Inhalation HQ	HI All Pathways
Metals											
Aluminum	8.30E+00	2.27E-01	2.27E-01	8.30E+00	1.66E-06	4.55E-04	NA	NA	NA	NA	**2.27E-01**
Arsenic	1.73E-02	4.74E-04	1.58E+00	1.73E-02	3.46E-09	9.48E-07	3.16E-03	NA	NA	NA	**1.58E+00**
Chromium	3.72E-02	1.02E-03	3.40E-01	3.72E-02	7.44E-09	2.04E-06	2.72E-02	NA	NA	NA	**3.67E-01**
Iron	3.34E+01	9.15E-01	3.05E+00	3.34E+01	6.68E-06	1.83E-03	6.10E-03	NA	NA	NA	**3.06E+00**
Lead	1.84E-02	5.04E-04	NA	1.84E-02	3.68E-10	1.01E-07	NA	NA	NA	NA	**NA**
Manganese	1.17E+01	3.21E-01	1.34E+01	1.17E+01	2.34E-06	6.41E-04	NA	NA	NA	NA	**1.34E+01**
Nickel	7.57E-02	2.07E-03	1.04E-01	7.57E-02	3.03E-09	8.30E-07	1.04E-03	NA	NA	NA	**1.05E-01**
Vanadium	3.69E-02	1.01E-03	1.01E+00	3.69E-02	7.38E-09	2.02E-06	6.74E-02	NA	NA	NA	**1.08E+00**
Explosives											
1,3-Dinitrobenzene	1.00E-03	2.74E-05	2.74E-02	1.00E-03	2.08E-09	5.69E-07	5.69E-04	NA	NA	NA	**2.80E-02**
2,4-Dinitrotoluene	4.90E-04	1.34E-05	6.71E-03	4.90E-04	1.99E-09	5.45E-07	2.72E-04	NA	NA	NA	**6.98E-03**
2,6-Dinitrotoluene	3.60E-03	9.86E-05	9.86E-02	3.60E-03	9.89E-09	2.71E-06	2.71E-03	NA	NA	NA	**1.01E-01**
2-Nitrotoluene	3.10E-04	8.49E-06	8.49E-04	1.55E-04	1.34E-09	3.68E-07	3.68E-05	1.55E-04	4.24E-05	NA	**8.86E-04**
4-Amino-2,6-dinitrotoluene	1.30E-03	3.56E-05	1.78E-01	1.30E-03	3.78E-09	1.04E-06	5.18E-03	NA	NA	NA	**1.83E-01**
Nitrobenzene	2.00E-03	5.48E-05	1.10E-01	1.00E-03	4.78E-09	1.31E-06	2.62E-03	1.00E-03	2.74E-04	4.80E-01	**5.93E-01**
Semivolatile Organic Compounds											
2-Methylnaphthalene	4.70E-01	1.29E-02	6.44E-01	2.35E-01	2.11E-05	5.77E-03	2.88E-01	2.35E-01	6.44E-02	7.48E+01	**7.58E+01**
Bis(2-ethylhexyl)phthalate	8.15E-03	2.23E-04	1.12E-02	8.15E-03	8.22E-07	2.25E-04	1.13E-02	NA	NA	NA	**2.24E-02**
Chrysene	1.50E-02	4.11E-04	NA	1.50E-02	1.24E-05	3.40E-03	NA	NA	NA	NA	**NA**
Dibenzofuran	1.20E-02	3.29E-04	1.64E-01	6.00E-03	4.05E-07	1.11E-04	5.54E-02	6.00E-03	1.64E-03	NA	**2.20E-01**
Fluorene	2.80E-02	7.67E-04	1.92E-02	1.40E-02	1.75E-06	4.80E-04	1.20E-02	1.40E-02	3.83E-03	NA	**3.12E-02**
Naphthalene	1.70E-01	4.66E-03	2.33E-01	8.50E-02	3.70E-06	1.01E-03	5.06E-02	8.50E-02	2.33E-02	2.71E+01	**2.74E+01**
Phenanthrene	7.40E-02	2.03E-03	6.76E-02	3.70E-02	6.59E-06	1.81E-03	6.02E-02	3.70E-02	1.01E-02	NA	**1.28E-01**
Volatile Organic Compounds											
Benzene	7.00E-01	1.92E-02	4.79E+00	3.50E-01	3.50E-06	9.58E-04	2.39E-01	3.50E-01	9.59E-02	1.11E+01	**1.62E+01**
Chloromethane	3.50E-02	9.59E-04	NA	1.75E-02	3.19E-08	8.75E-06	NA	1.75E-02	4.79E-03	1.84E-01	**1.84E-01**
Ethylbenzene	2.40E-01	6.58E-03	6.58E-02	1.20E-01	4.71E-06	1.29E-03	1.29E-02	1.20E-01	3.29E-02	1.13E-01	**1.92E-01**
Methylene chloride	3.30E-01	9.04E-03	1.51E-01	1.65E-01	4.04E-07	1.11E-04	1.84E-03	1.65E-01	4.52E-02	5.25E-02	**2.05E-01**
Toluene	7.30E-01	2.00E-02	1.00E-01	3.65E-01	8.28E-06	2.27E-03	1.13E-02	3.65E-01	1.00E-01	9.09E-01	**1.02E+00**
Xylenes, total	1.40E+00	3.84E-02	1.92E-01	7.00E-01	2.97E-05	8.14E-03	4.07E-02	7.00E-01	1.92E-01	6.61E+00	**6.84E+00**
Total HI			**26.5**				**0.90**			**121**	**149**

HQ - Hazard quotient; HI - Hazard index.
NA - Not applicable.

Table G-6

Separation of Noncancer Hazard by Target Organ
Adult Resident Exposure to Groundwater
TNT Area A, Former Plum Brook Ordnance Works
Sandusky, Ohio

	Target Organs														
COPC	NS/CNS	Skin	PVS	GI	Fetus & Repro	URT/ Lung	Iron Overload	Kidney	Erythrocyte	Eye	Reduced BW/OW	N & O epithelia	Blood/ Blood cells	Liver	Spleen
Metals															
Aluminum	0.23														
Arsenic		1.58	1.58												
Chromium				0.37	0.37										
Iron							3.06								
Manganese	13.36														
Nickel											0.10				
Vanadium								1.08							
Explosives															
1,3-Dinitrobenzene									0.03						
2,4-Dinitrotoluene	0.01								0.01					0.01	
2,6-Dinitrotoluene	0.10							0.10	0.10					0.10	
2-Nitrotoluene															0.0001
4-Amino-2,6-dinitrotoluene									0.18					0.18	
Nitrobenzene								0.59	0.59					0.59	
Semivolatile Organic Compounds															
2-Methylnaphthalene									0.93	0.93	0.93	74.83			
Bis(2-ethylhexyl)phthalate														0.02	
Dibenzofuran								0.22							
Fluorene									0.03						
Naphthalene									0.28	0.28	0.28	27.07			
Phenanthrene								0.13							
Volatile Organic Compounds															
Benzene													16.18		
Chloromethane	0.18														
Ethylbenzene					0.11			0.19						0.19	
Methylene chloride									0.21					0.21	
Toluene	0.11			0.91		0.91		0.11						0.11	
Xylenes, total	6.61										0.23				
Total HI	**21**	**2**	**2**	**1**	**0.5**	**0.9**	**3**	**2**	**2**	**1**	**2**	**102**	**16**	**1**	**0**

COPC - Chemical of potential concern.
HI - Hazard index.
Target Organs: NS/CNS - nervous system/central nervous system; BW - body weight; N & O - nasal and olfactory; PVS - pulmonary vascular system; GI - gastrointestinal; OW - organ weight; URT - upper respiratory tract.

Table G-7

Summary of Cancer Risk for the Resident
TNT Area A, Plum Brook Ordnance Works
Sandusky, Ohio

		Incidental Ingestion						Dermal Absorption						
Chemical	Exposure Point Concentration (mg/L)	Adult Cancer Dose (mg/kg-day)	Child Cancer Dose (mg/kg-day)	Adult Oral ILCR	Child Oral ILCR	Total Oral ILCR	Cd mg/L	Adult DA (mg/cm^2-day)	Adult Cancer Dose (mg/kg-day)	Child DA (mg/cm^2-day)	Child Cancer Dose (mg/kg-day)	Adult Dermal ILCR	Child Dermal ILCR	Total Dermal ILCR
Metals														
Aluminum	8.30E+00	7.80E-02	4.55E-02	NA	NA	NA	8.30E+00	1.66E-06	1.56E-04	2.76E-06	1.00E-04	NA	NA	NA
Arsenic	1.73E-02	1.63E-04	9.48E-05	2.44E-04	1.42E-04	3.86E-04	1.73E-02	3.46E-09	3.25E-07	5.76E-09	2.08E-07	4.88E-07	3.13E-07	8.00E-07
Chromium	3.72E-02	3.49E-04	2.04E-04	NA	NA	NA	3.72E-02	7.44E-09	6.99E-07	1.24E-08	4.48E-07	NA	NA	NA
Iron	3.34E+01	3.14E-01	1.83E-01	NA	NA	NA	3.34E+01	6.68E-06	6.27E-04	1.11E-05	4.02E-04	NA	NA	NA
Lead	1.84E-02	1.73E-04	1.01E-04	NA	NA	NA	1.84E-02	3.68E-10	3.46E-08	6.13E-10	2.22E-08	NA	NA	NA
Manganese	1.17E+01	1.10E-01	6.41E-02	NA	NA	NA	1.17E+01	2.34E-06	2.20E-04	3.90E-06	1.41E-04	NA	NA	NA
Nickel	7.57E-02	7.11E-04	4.15E-04	NA	NA	NA	7.57E-02	3.03E-09	2.84E-07	5.04E-09	1.82E-07	NA	NA	NA
Vanadium	3.69E-02	3.47E-04	2.02E-04	NA	NA	NA	3.69E-02	7.38E-09	6.93E-07	1.23E-08	4.44E-07	NA	NA	NA
Explosives														
1,3-Dinitrobenzene	1.00E-03	9.39E-06	5.48E-06	NA	NA	NA	1.00E-03	2.08E-09	1.95E-07	2.68E-09	9.68E-08	NA	NA	NA
2,4-Dinitrotoluene	4.90E-04	4.60E-06	2.68E-06	3.13E-06	1.83E-06	4.96E-06	4.90E-04	1.99E-09	1.87E-07	2.56E-09	9.27E-08	1.27E-07	6.31E-08	1.90E-07
2,6-Dinitrotoluene	3.60E-03	3.38E-05	1.97E-05	2.30E-05	1.34E-05	3.64E-05	3.60E-03	9.89E-09	9.29E-07	1.28E-08	4.62E-07	6.32E-07	3.14E-07	9.46E-07
2-Nitrotoluene	3.10E-04	2.91E-06	1.70E-06	6.70E-07	3.91E-07	1.06E-06	1.55E-04	1.34E-09	1.26E-07	1.73E-09	6.27E-08	2.90E-08	1.44E-08	4.35E-08
4-Amino-2,6-dinitrotoluene	1.30E-03	1.22E-05	7.12E-06	NA	NA	NA	1.30E-03	3.78E-09	3.55E-07	4.88E-09	1.76E-07	NA	NA	NA
Nitrobenzene	2.00E-03	1.88E-05	1.10E-05	NA	NA	NA	1.00E-03	4.78E-09	4.49E-07	6.17E-09	2.23E-07	NA	NA	NA
Semivolatile Organic Compounds														
2-Methylnaphthalene	4.70E-01	4.41E-03	2.58E-03	NA	NA	NA	2.35E-01	2.11E-05	1.98E-03	2.72E-05	9.82E-04	NA	NA	NA
Bis(2-ethylhexyl)phthalate	8.15E-03	7.66E-05	4.47E-05	1.07E-06	6.25E-07	1.70E-06	8.15E-03	8.22E-07	7.72E-05	1.06E-06	3.84E-05	1.08E-06	5.37E-07	1.62E-06
Chrysene	1.50E-02	1.41E-04	8.22E-05	1.03E-06	6.00E-07	1.63E-06	1.50E-02	1.24E-05	1.17E-03	1.60E-05	5.80E-04	8.52E-06	4.23E-06	1.27E-05
Dibenzofuran	1.20E-02	1.13E-04	6.58E-05	NA	NA	NA	6.00E-03	4.05E-07	3.80E-05	5.22E-07	1.89E-05	NA	NA	NA
Fluorene	2.80E-02	2.63E-04	1.53E-04	NA	NA	NA	1.40E-02	1.75E-06	1.65E-04	2.26E-06	8.18E-05	NA	NA	NA
Naphthalene	1.70E-01	1.60E-03	9.32E-04	NA	NA	NA	8.50E-02	3.70E-06	3.47E-04	4.77E-06	1.72E-04	NA	NA	NA
Phenanthrene	7.40E-02	6.95E-04	4.05E-04	NA	NA	NA	3.70E-02	6.59E-06	6.19E-04	8.51E-06	3.08E-04	NA	NA	NA
Volatile Organic Compounds														
Benzene	7.00E-01	6.58E-03	3.84E-03	3.62E-04	2.11E-04	5.73E-04	3.50E-01	3.50E-06	3.28E-04	4.51E-06	1.63E-04	1.81E-05	8.97E-06	2.70E-05
Chloromethane	3.50E-02	3.29E-04	1.92E-04	NA	NA	NA	1.75E-02	3.19E-08	3.00E-06	4.12E-08	1.49E-06	NA	NA	NA
Ethylbenzene	2.40E-01	2.25E-03	1.32E-03	NA	NA	NA	1.20E-01	4.71E-06	4.43E-04	6.08E-06	2.20E-04	NA	NA	NA
Methylene chloride	3.30E-01	3.10E-03	1.81E-03	2.32E-05	1.36E-05	3.68E-05	1.65E-01	4.04E-07	3.79E-05	5.21E-07	1.88E-05	2.85E-07	1.41E-07	4.26E-07
Toluene	7.30E-01	6.86E-03	4.00E-03	NA	NA	NA	3.65E-01	8.28E-06	7.77E-04	1.07E-05	3.86E-04	NA	NA	NA
Xylenes, total	1.40E+00	1.32E-02	7.67E-03	NA	NA	NA	7.00E-01	2.97E-05	2.79E-03	3.84E-05	1.39E-03	NA	NA	NA
Total ILCR				**6.58E-04**	**3.84E-04**	**1.04E-03**						**2.92E-05**	**1.46E-05**	**4.38E-05**

ILCR - Incremental lifetime cancer risk.
NA - Not applicable.

Table G-7

Summary of Cancer Risk for the Resident
TNT Area A, Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Exposure Point Concentration (mg/L)	Concentration in Air (mg/m^3)	Inhalation: Adult Cancer Dose (mg/kg-day)	Inhalation: Child Cancer Dose (mg/kg-day)	Adult Inhalation ILCR	Child Inhalation ILCR	Total Inhalation ILCR	ILCR All Pathways
Metals								
Aluminum	8.30E+00	NA	NA	NA	NA	NA	NA	NA
Arsenic	1.73E-02	NA	NA	NA	NA	NA	NA	**3.87E-04**
Chromium	3.72E-02	NA	NA	NA	NA	NA	NA	NA
Iron	3.34E+01	NA	NA	NA	NA	NA	NA	NA
Lead	1.84E-02	NA	NA	NA	NA	NA	NA	NA
Manganese	1.17E+01	NA	NA	NA	NA	NA	NA	NA
Nickel	7.57E-02	NA	NA	NA	NA	NA	NA	NA
Vanadium	3.69E-02	NA	NA	NA	NA	NA	NA	NA
Explosives								
1,3-Dinitrobenzene	1.00E-03	NA	NA	NA	NA	NA	NA	NA
2,4-Dinitrotoluene	4.90E-04	NA	NA	NA	NA	NA	NA	**5.15E-06**
2,6-Dinitrotoluene	3.60E-03	NA	NA	NA	NA	NA	NA	**3.74E-05**
2-Nitrotoluene	3.10E-04	1.55E-04	1.46E-05	8.48E-06	NA	NA	NA	**1.10E-06**
4-Amino-2,6-dinitrotoluene	1.30E-03	NA	NA	NA	NA	NA	NA	NA
Nitrobenzene	2.00E-03	1.00E-03	9.39E-05	5.47E-05	NA	NA	NA	NA
Semivolatile Organic Compounds								
2-Methylnaphthalene	4.70E-01	2.35E-01	2.21E-02	1.29E-02	NA	NA	NA	NA
Bis(2-ethylhexyl)phthalate	8.15E-03	NA	NA	NA	NA	NA	NA	**3.32E-06**
Chrysene	1.50E-02	NA	NA	NA	NA	NA	NA	**1.44E-05**
Dibenzofuran	1.20E-02	6.00E-03	5.63E-04	3.28E-04	NA	NA	NA	NA
Fluorene	2.80E-02	1.40E-02	1.31E-03	7.66E-04	NA	NA	NA	NA
Naphthalene	1.70E-01	8.50E-02	7.98E-03	4.65E-03	NA	NA	NA	NA
Phenanthrene	7.40E-02	3.70E-02	3.47E-03	2.02E-03	NA	NA	NA	NA
Volatile Organic Compounds								
Benzene	7.00E-01	3.50E-01	3.29E-02	1.91E-02	8.87E-04	5.17E-04	1.40E-03	**2.00E-03**
Chloromethane	3.50E-02	1.75E-02	1.64E-03	9.57E-04	NA	NA	NA	NA
Ethylbenzene	2.40E-01	1.20E-01	1.13E-02	6.56E-03	NA	NA	NA	NA
Methylene chloride	3.30E-01	1.65E-01	1.55E-02	9.03E-03	2.48E-05	1.44E-05	3.92E-05	**7.65E-05**
Toluene	7.30E-01	3.65E-01	3.43E-02	2.00E-02	NA	NA	NA	NA
Xylenes, total	1.40E+00	7.00E-01	6.57E-02	3.83E-02	NA	NA	NA	NA
Total ILCR					**9.12E-04**	**5.31E-04**	**1.44E-03**	**3.E-03**

ILCR - Incremental lifetime cancer risk.
NA - Not applicable.

Table G-8

Summary of Risk for the On-Site Worker
TNT B, Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Exposure Point Concentration (mg/L)	Incidental Ingestion Noncancer Dose (mg/kg-day)	Incidental Ingestion Cancer Dose (mg/kg-day)	Oral HQ	Oral ILCR	DA mg/cm2-day	Dermal Absorption Noncancer Dose (mg/kg-day)	Dermal Absorption Cancer Dose (mg/kg-day)	Dermal HQ	Dermal ILCR	**HI All Pathways**	**ILCR All Pathways**
Metals												
Aluminum	1.69E+01	1.65E-01	5.91E-02	1.65E-01	ND	1.69E-05	5.46E-04	1.95E-04	NA	ND	**1.65E-01**	**NA**
Arsenic	1.29E-02	1.26E-04	4.51E-05	4.21E-01	6.76E-05	1.29E-08	4.17E-07	1.49E-07	1.39E-03	2.23E-07	**4.22E-01**	**6.78E-05**
Chromium	3.03E-02	2.97E-04	1.06E-04	9.90E-02	ND	3.03E-08	9.80E-07	3.50E-07	1.31E-02	ND	**1.12E-01**	**NA**
Iron	2.56E+01	2.50E-01	8.94E-02	8.35E-01	ND	2.56E-05	8.26E-04	2.95E-04	2.75E-03	ND	**8.37E-01**	**NA**
Lead	1.54E-02	1.51E-04	5.38E-05	NA	ND	1.54E-09	4.97E-08	1.78E-08	NA	ND	**NA**	**NA**
Manganese	7.91E-01	7.74E-03	2.77E-03	3.23E-01	ND	7.91E-07	2.56E-05	9.13E-06	NA	ND	**3.23E-01**	**NA**
Vanadium	2.50E-02	2.45E-04	8.74E-05	2.45E-01	ND	2.50E-08	8.07E-07	2.88E-07	2.69E-02	ND	**2.72E-01**	**NA**
Semivolatile Organic Compounds												
2-Methylnaphthalene	4.80E-03	4.70E-05	1.68E-05	2.35E-03	ND	9.62E-07	3.11E-05	1.11E-05	1.55E-03	ND	**3.90E-03**	**NA**
Naphthalene	2.80E-03	2.74E-05	9.78E-06	1.37E-03	ND	2.72E-07	8.79E-06	3.14E-06	4.40E-04	ND	**1.81E-03**	**NA**
Volatile Organic Compounds												
Benzene	1.70E-02	1.66E-04	5.94E-05	4.16E-02	3.27E-06	3.80E-07	1.23E-05	4.38E-06	3.06E-03	2.41E-07	**4.46E-02**	**3.51E-06**
Total HI				**2.13**					**0.05**		**2**	
Total ILCR					**7.09E-05**					**4.64E-07**		**7.E-05**

HQ - Hazard quotient; HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
NA - Not applicable.
mg/L - Milligrams per liter.

Table G-9

Separation of Noncancer Hazard by Target Organ
On-Site Worker Exposure to Groundwater
TNT B, Former Plum Brook Ordnance Works
Sandusky, Ohio

	Target Organs										
COPC	NS/CNS	Skin	PVS	GI	Fetus & Repro	Iron Overload	Kidney	Erythrocyte	Eye	Reduced BW	Blood/ Blood cells
Metals											
Aluminum	0.17										
Arsenic		0.42	0.42								
Chromium				0.11	0.11						
Iron						0.84					
Manganese	0.32										
Vanadium							0.27				
Semivolatile Organic Compounds											
2-Methylnaphthalene								0.004	0.004	0.004	
Naphthalene								0.002	0.002	0.002	
Volatile Organic Compounds											
Benzene											0.04
Total HI	**0.5**	**0.4**	**0.4**	**0.1**	**0.1**	**0.8**	**0.3**	**0**	**0**	**0**	**0.04**

COPC - Chemical of potential concern.
HI - Hazard index.
Target Organs: NS/CNS - nervous system/central nervous system; BW - body weight; PVS - pulmonary vascular system; GI - gastrointestinal

Table G-10

Risk Evaluation for the Child Resident
TNT B, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Exposure Point Concentration (mg/L)	Incidental Ingestion Child Noncancer Dose (mg/kg-day)	Oral HQ	Dermal Absorption Child Noncancer Dose (mg/kg-day)	Dermal HQ	Concentration in Air (mg/m^3)	Inhalation Child Noncancer Dose (mg/kg-day)	Inhalation HQ	**Total HI All Pathways**
Metals									
Aluminum	1.69E+01	1.08E+00	1.08E+00	2.37E-03	NA	NA	NA	NA	**1.08E+00**
Arsenic	1.29E-02	8.25E-04	2.75E+00	1.81E-06	6.04E-03	NA	NA	NA	**2.75E+00**
Chromium	3.03E-02	1.94E-03	6.47E-01	4.26E-06	5.68E-02	NA	NA	NA	**7.03E-01**
Iron	2.56E+01	1.64E+00	5.45E+00	3.60E-03	1.20E-02	NA	NA	NA	**5.47E+00**
Lead	1.54E-02	9.84E-04	NA	2.16E-07	NA	NA	NA	NA	**NA**
Manganese	7.91E-01	5.06E-02	2.11E+00	1.11E-04	NA	NA	NA	NA	**2.11E+00**
Vanadium	2.50E-02	1.60E-03	1.60E+00	3.51E-06	1.17E-01	NA	NA	NA	**1.72E+00**
Semivolatile Organic Compounds									
2-Methylnaphthalene	4.80E-03	3.07E-04	1.53E-02	1.17E-04	5.85E-03	2.40E-03	1.53E-03	1.78E+00	**1.80E+00**
Naphthalene	2.80E-03	1.79E-04	8.95E-03	3.31E-05	1.66E-03	1.40E-03	8.94E-04	1.04E+00	**1.05E+00**
Volatile Organic Compounds									
Benzene	1.70E-02	1.09E-03	2.72E-01	4.62E-05	1.16E-02	8.50E-03	5.43E-03	6.31E-01	**9.14E-01**
Total HI			**1.39E+01**		**2.11E-01**			**3.45E+00**	**18**

HQ - Hazard quotient; HI - Hazard index.
NA - Not applicable.
mg/L - Milligrams per liter.

Table G-11

Separation of Noncancer Hazard by Target Organ
Child Resident Exposure to Groundwater
TNT B, Former Plum Brook Ordnance Works
Sandusky, Ohio

	Target Organs											
COPC	NS/CNS	Skin	PVS	GI	Fetus & Repro	Iron Overload	Kidney	Erythrocyte	Eye	Reduced BW	N & O epithelia	Blood/ Blood cells
Metals												
Aluminum	1.08											
Arsenic		2.75	2.75									
Chromium				0.70	0.70							
Iron						5.47						
Manganese	2.11											
Vanadium							1.72					
Semivolatile Organic Compounds												
2-Methylnaphthalene								0.02	0.02	0.02	1.78	
Naphthalene								0.01	0.01	0.01	1.04	
Volatile Organic Compounds												
Benzene												0.91
Total HI	**3**	**3**	**3**	**0.7**	**0.7**	**5**	**2**	**0.03**	**0.03**	**0.03**	**3**	**0.9**

COPC - Chemical of potential concern.
HI - Hazard index.
Target Organs: NS/CNS - nervous system/central nervous system; BW - body weight; N & O - nasal and olfactory; PVS - pulmonary vascular system; GI - gastrointestinal.

Table G-12

Risk Evaluation for the Adult Resident
TNT B, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Exposure Point Concentration (mg/L)	Incidental Ingestion Adult Noncancer Dose (mg/kg-day)	Oral HQ	Dermal Absorption Adult Noncancer Dose (mg/kg-day)	Dermal HQ	Concentration in Air (mg/m^3)	Inhalation Adult Noncancer Dose (mg/kg-day)	Inhalation HQ	**HI All Pathways**
Metals									
Aluminum	1.69E+01	4.63E-01	4.63E-01	9.26E-04	NA	NA	NA	NA	**4.63E-01**
Arsenic	1.29E-02	3.53E-04	1.18E+00	7.07E-07	2.36E-03	NA	NA	NA	**1.18E+00**
Chromium	3.03E-02	8.31E-04	2.77E-01	1.66E-06	2.22E-02	NA	NA	NA	**2.99E-01**
Iron	2.56E+01	7.01E-01	2.34E+00	1.40E-03	4.67E-03	NA	NA	NA	**2.34E+00**
Lead	1.54E-02	4.22E-04	NA	8.44E-08	NA	NA	NA	NA	**NA**
Manganese	7.91E-01	2.17E-02	9.03E-01	4.34E-05	NA	NA	NA	NA	**9.03E-01**
Vanadium	2.50E-02	6.85E-04	6.85E-01	1.37E-06	4.57E-02	NA	NA	NA	**7.31E-01**
Semivolatile Organic Compounds									
2-Methylnaphthalene	4.80E-03	1.32E-04	6.58E-03	5.89E-05	2.95E-03	2.40E-03	6.57E-04	7.64E-01	**7.74E-01**
Naphthalene	2.80E-03	7.67E-05	3.84E-03	1.67E-05	8.34E-04	1.40E-03	3.83E-04	4.46E-01	**4.50E-01**
Volatile Organic Compounds									
Benzene	1.70E-02	4.66E-04	1.16E-01	2.33E-05	5.81E-03	8.50E-03	2.33E-03	2.71E-01	**3.93E-01**
Total HI			**5.97**		**0.08**			**1.48**	**8**

HQ - Hazard quotient; HI - Hazard index.
NA - Not applicable.
mg/L - Milligrams per liter.

Table G-13

Separation of Noncancer Hazard by Target Organ
Adult Resident Exposure to Groundwater
TNT B, Former Plum Brook Ordnance Works
Sandusky, Ohio

	Target Organs											
COPC	NS/CNS	Skin	PVS	GI	Fetus & Repro	Iron Overload	Kidney	Erythrocyte	Eye	Reduced BW	N & O epithelia	Blood/ Blood cells
Metals												
Aluminum	0.46											
Arsenic		1.18	1.18									
Chromium				0.30	0.30							
Iron						2.34						
Manganese	0.90											
Vanadium							0.73					
Semivolatile Organic Compounds												
2-Methylnaphthalene								0.01	0.01	0.01	0.76	
Naphthalene								0.005	0.005	0.005	0.45	
Volatile Organic Compounds												
Benzene												0.39
Total HI	**1**	**1**	**1**	**0.3**	**0.3**	**2**	**1**	**0.01**	**0.01**	**0.01**	**1**	**0.4**

COPC - Chemical of potential concern.
HI - Hazard index.
Target Organs: NS/CNS - nervous system/central nervous system; BW - body weight; N & O - nasal and olfactory; PVS - pulmonary vascular system; GI - gastrointestinal.

Table G-14

Summary of Cancer Risk for the Resident
TNT B, Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Exposure Point Concentration (mg/L)	Incidental Ingestion: Adult Cancer Dose (mg/kg-day)	Incidental Ingestion: Child Cancer Dose (mg/kg-day)	Adult Oral ILCR	Child Oral ILCR	Total Oral ILCR	Cd mg/L	Dermal Absorption: Adult DA (mg/cm^2-day)	Dermal Absorption: Adult Cancer Dose (mg/kg-day)	Dermal Absorption: Child DA (mg/cm^2-day)	Dermal Absorption: Child Cancer Dose (mg/kg-day)	Adult Dermal ILCR	Child Dermal ILCR	Total Dermal ILCR
Metals														
Aluminum	1.69E+01	1.59E-01	9.26E-02	NA	NA	NA	1.69E+01	3.38E-06	3.17E-04	5.63E-06	2.04E-04	NA	NA	NA
Arsenic	1.29E-02	1.21E-04	7.07E-05	1.82E-04	1.06E-04	2.88E-04	1.29E-02	2.58E-09	2.42E-07	4.30E-09	1.55E-07	3.64E-07	2.33E-07	5.97E-07
Chromium	3.03E-02	2.85E-04	1.66E-04	NA	NA	NA	3.03E-02	6.07E-09	5.70E-07	1.01E-08	3.65E-07	NA	NA	NA
Iron	2.56E+01	2.40E-01	1.40E-01	NA	NA	NA	2.56E+01	5.12E-06	4.81E-04	8.52E-06	3.08E-04	NA	NA	NA
Lead	1.54E-02	1.45E-04	8.44E-05	NA	NA	NA	1.54E-02	3.08E-10	2.89E-08	5.13E-10	1.85E-08	NA	NA	NA
Manganese	7.91E-01	7.43E-03	4.34E-03	NA	NA	NA	7.91E-01	1.58E-07	1.49E-05	2.63E-07	9.53E-06	NA	NA	NA
Vanadium	2.50E-02	2.35E-04	1.37E-04	NA	NA	NA	2.50E-02	5.00E-09	4.70E-07	8.33E-09	3.01E-07	NA	NA	NA
Semivolatile Organic Compounds														
2-Methylnaphthalene	4.80E-03	4.51E-05	2.63E-05	NA	NA	NA	2.40E-03	2.15E-07	2.02E-05	2.77E-07	1.00E-05	NA	NA	NA
Naphthalene	2.80E-03	2.63E-05	1.53E-05	NA	NA	NA	1.40E-03	6.09E-08	5.72E-06	7.86E-08	2.84E-06	NA	NA	NA
Volatile Organic Compounds														
Benzene	1.70E-02	1.60E-04	9.32E-05	8.78E-06	5.12E-06	1.39E-05	8.50E-03	8.49E-08	7.97E-06	1.10E-07	3.96E-06	4.39E-07	2.18E-07	6.56E-07
Total ILCR				**1.91E-04**	**1.11E-04**	**3.02E-04**						**8.02E-07**	**4.51E-07**	**1.25E-06**

ILCR - Incremental lifetime cancer risk.
NA - Not applicable.
mg/L - Milligrams per liter.

Table G-14

Summary of Cancer Risk for the Resident
TNT B, Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Exposure Point Concentration (mg/L)	Concentration in Air (mg/m^3)	Inhalation: Adult Cancer Dose (mg/kg-day)	Inhalation: Child Cancer Dose (mg/kg-day)	Adult Inhalation ILCR	Child Inhalation ILCR	Total Inhalation ILCR	ILCR All Pathways
Metals								
Aluminum	1.69E+01	NA	NA	NA	NA	NA	NA	**NA**
Arsenic	1.29E-02	NA	NA	NA	NA	NA	NA	**2.88E-04**
Chromium	3.03E-02	NA	NA	NA	NA	NA	NA	**NA**
Iron	2.56E+01	NA	NA	NA	NA	NA	NA	**NA**
Lead	1.54E-02	NA	NA	NA	NA	NA	NA	**NA**
Manganese	7.91E-01	NA	NA	NA	NA	NA	NA	**NA**
Vanadium	2.50E-02	NA	NA	NA	NA	NA	NA	**NA**
Semivolatile Organic Compounds								
2-Methylnaphthalene	4.80E-03	2.40E-03	2.25E-04	1.31E-04	NA	NA	NA	**NA**
Naphthalene	2.80E-03	1.40E-03	1.31E-04	7.66E-05	NA	NA	NA	**NA**
Volatile Organic Compounds								
Benzene	1.70E-02	8.50E-03	7.98E-04	4.65E-04	2.15E-05	1.26E-05	3.41E-05	**4.87E-05**
Total ILCR					**2.15E-05**	**1.26E-05**	**3.41E-05**	**3.E-04**

ILCR - Incremental lifetime cancer risk.
NA - Not applicable.
mg/L - Milligrams per liter.

Table G-15

Summary of Risk for the On-Site Worker
TNT C, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Exposure Point Concentration (mg/L)	Incidental Ingestion					Dermal Absorption					
		Noncancer Dose (mg/kg-day)	Cancer Dose (mg/kg-day)	Oral HQ	Oral ILCR	DA mg/cm2-day	Noncancer Dose (mg/kg-day)	Cancer Dose (mg/kg-day)	Dermal HQ	Dermal ILCR	**Total HI All Pathways**	**Total ILCR All Pathways**
Semivolatile Organic Compounds												
2-Methylnaphthalene	2.66E-02	2.61E-04	9.31E-05	1.30E-02	NA	5.34E-06	1.72E-04	6.15E-05	8.62E-03	ND	**2.17E-02**	**NA**
Bis(2-ethylhexyl)phthalate	5.50E-02	5.38E-04	1.92E-04	2.69E-02	2.69E-06	1.24E-05	4.01E-04	1.43E-04	2.00E-02	2.00E-06	**4.69E-02**	**4.69E-06**
Naphthalene	3.40E-02	3.33E-04	1.19E-04	1.66E-02	NA	3.31E-06	1.07E-04	3.81E-05	5.34E-03	ND	**2.20E-02**	**NA**
Volatile Organic Compounds												
Benzene	4.10E-01	4.01E-03	1.43E-03	1.00E+00	7.88E-05	9.16E-06	2.96E-04	1.06E-04	7.39E-02	5.81E-06	**1.08E+00**	**8.46E-05**
Bromomethane	1.30E-02	1.27E-04	4.54E-05	9.09E-02	NA	6.04E-08	1.95E-06	6.96E-07	1.39E-03	ND	**9.23E-02**	**NA**
Methylene chloride	1.60E-01	1.57E-03	5.59E-04	2.61E-02	4.19E-06	8.76E-07	2.83E-05	1.01E-05	4.71E-04	7.57E-08	**2.66E-02**	**4.27E-06**
Toluene	3.00E-01	2.94E-03	1.05E-03	1.47E-02	NA	1.52E-05	4.91E-04	1.75E-04	2.46E-03	ND	**1.71E-02**	**NA**
Xylenes, total	1.30E+00	1.27E-02	4.54E-03	6.36E-02	NA	1.23E-04	3.99E-03	1.42E-03	1.99E-02	ND	**8.35E-02**	**NA**
Miscellaneous												
Sulfate	1.34E+03	1.31E+01	4.68E+00	NA	NA	NA	NA	NA	NA	ND	**NA**	**NA**
Total HI				**1.25E+00**					**1.32E-01**		**1.39E+00**	
Total ILCR					**8.57E-05**					**7.89E-06**		**9.E-05**

HQ - Hazard quotient; HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
NA - Not applicable.

Table G-16

Separation of Noncancer Hazard by Target Organ
On-Site Worker Exposure to Groundwater
TNT C, Former Plum Brook Ordnance Works
Sandusky, Ohio

	Target Organs						
COPC	NS/CNS	Kidney	Erythrocyte	Eye	Reduced BW/OW	Blood/ Blood cells	Liver
Semivolatile Organic Compounds							
2-Methylnaphthalene			0.02	0.02	0.02		
Bis(2-ethylhexyl)phthalate							0.05
Naphthalene			0.02	0.02	0.02		
Volatile Organic Compounds							
Benzene						1.08	
Bromomethane		0.09	0.09				
Methylene chloride			0.03				0.03
Toluene	0.02	0.02					0.02
Xylenes, total					0.08		
Total HI	**0.02**	**0.1**	**0.2**	**0.04**	**0.1**	**1**	**0.1**

COPC - Chemical of potential concern.
HI - Hazard index.
Target Organs: NS/CNS - nervous system/central nervous system; BW - body weight; N & O - nasal and olfactory; OW - organ weight.

Table G-17

Summary of Noncancer Risk for the Child Resident
TNT C, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Exposure Point Concentration (mg/L)	Incidental Ingestion Child Noncancer Dose (mg/kg-day)	Oral HQ	Cd (mg/L)	DA (mg/cm^2-day)	Dermal Absorption Child Noncancer Dose (mg/kg-day)	Dermal HQ	Concentration in Air (mg/m^3)	Inhalation Child Noncancer Dose (mg/kg-day)	Inhalation HQ	**Total HI All Pathways**
Semivolatile Organic Compounds											
2-Methylnaphthalene	2.66E-02	1.70E-03	8.52E-02	1.33E-02	1.54E-06	6.50E-04	3.25E-02	1.33E-02	8.50E-03	9.89E+00	**1.00E+01**
Bis(2-ethylhexyl)phthalate	5.50E-02	3.52E-03	1.76E-01	5.50E-02	7.16E-06	3.02E-03	1.51E-01	NA	NA	NA	**3.27E-01**
Naphthalene	3.40E-02	2.17E-03	1.09E-01	1.70E-02	9.54E-07	4.02E-04	2.01E-02	1.70E-02	1.09E-02	1.26E+01	**1.27E+01**
Volatile Organic Compounds											
Benzene	4.10E-01	2.62E-02	6.55E+00	2.05E-01	2.64E-06	1.11E-03	2.79E-01	2.05E-01	1.31E-01	1.52E+01	**2.20E+01**
Bromomethane	1.30E-02	8.31E-04	5.94E-01	6.50E-03	1.74E-08	7.35E-06	5.25E-03	6.50E-03	4.15E-03	2.96E+00	**3.56E+00**
Methylene chloride	1.60E-01	1.02E-02	1.70E-01	8.00E-02	2.53E-07	1.07E-04	1.78E-03	8.00E-02	5.11E-02	5.94E-02	**2.32E-01**
Toluene	3.00E-01	1.92E-02	9.59E-02	1.50E-01	4.39E-06	1.85E-03	9.26E-03	1.50E-01	9.57E-02	8.70E-01	**9.75E-01**
Xylenes, total	1.30E+00	8.31E-02	4.16E-01	6.50E-01	3.56E-05	1.50E-02	7.51E-02	6.50E-01	4.15E-01	1.43E+01	**1.48E+01**
Miscellaneous											
Sulfate	1.34E+03	8.57E+01	NA	1.34E+03	ND	NA	NA	NA	NA	NA	**NA**
Total HI			**8.20E+00**				**5.74E-01**			**5.59E+01**	**65**

HQ - Hazard quotient; HI - Hazard index.
NA - Not applicable.

Table G-18

Separation of Noncancer Hazard by Target Organ
Child Resident Exposure to Groundwater
TNT C, Former Plum Brook Ordnance Works
Sandusky, Ohio

	Target Organs									
COPC	NS/CNS	Erythrocyte	Eye	Reduced BW	Liver	N & O epithelia	Kidney	GI	URT	Blood/ Blood cells
Semivolatile Organic Compounds										
2-Methylnaphthalene		0.12	0.12	0.12		9.89				
Bis(2-ethylhexyl)phthalate					0.33					
Naphthalene		0.13	0.13	0.13		12.62				
Volatile Organic Compounds										
Benzene										22.05
Bromomethane		0.60				2.96	0.60			
Methylene chloride		0.17			0.17					
Toluene	0.11				0.11		0.11	0.87	0.87	
Xylenes, total	14.31			0.49						
Total HI	**14**	**1**	**0.2**	**0.7**	**0.6**	**25**	**0.7**	**0.9**	**0.9**	**22**

COPC - Chemical of potential concern.
HI - Hazard index.
Target Organs: NS/CNS - nervous system/central nervous system; BW - body weight; N & O - nasal and olfactory; OW - organ weight.

Table G-19

Risk Evaluation for the Adult Resident
TNT C, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Exposure Point Concentration (mg/L)	Incidental Ingestion Adult Noncancer Dose (mg/kg-day)	Oral HQ	Cd mg/L	DA mg/cm2-day	Dermal Absorption Adult Noncancer Dose (mg/kg-day)	Dermal HQ	Concentration in Air (mg/m^3)	Inhalation Adult Noncancer Dose (mg/kg-day)	Inhalation HQ	**Total HI All Pathways**
Semivolatile Organic Compounds											
2-Methylnaphthalene	2.66E-02	7.30E-04	3.65E-02	1.33E-02	1.19E-06	3.27E-04	1.63E-02	1.33E-02	3.65E-03	4.24E+00	**4.29E+00**
Bis(2-ethylhexyl)phthalate	5.50E-02	1.51E-03	7.53E-02	5.50E-02	5.55E-06	1.52E-03	7.60E-02	NA	NA	NA	**1.51E-01**
Naphthalene	3.40E-02	9.32E-04	4.66E-02	1.70E-02	7.39E-07	2.03E-04	1.01E-02	1.70E-02	4.66E-03	5.41E+00	**5.47E+00**
Volatile Organic Compounds											
Benzene	4.10E-01	1.12E-02	2.81E+00	2.05E-01	2.05E-06	5.61E-04	1.40E-01	2.05E-01	5.61E-02	6.53E+00	**9.48E+00**
Bromomethane	1.30E-02	3.56E-04	2.54E-01	6.50E-03	1.35E-08	3.70E-06	2.64E-03	6.50E-03	1.78E-03	1.27E+00	**1.53E+00**
Methylene chloride	1.60E-01	4.38E-03	7.31E-02	8.00E-02	1.96E-07	5.37E-05	8.94E-04	8.00E-02	2.19E-02	2.55E-02	**9.94E-02**
Toluene	3.00E-01	8.22E-03	4.11E-02	1.50E-01	3.40E-06	9.32E-04	4.66E-03	1.50E-01	4.11E-02	3.73E-01	**4.19E-01**
Xylenes, total	1.30E+00	3.56E-02	1.78E-01	6.50E-01	2.76E-05	7.56E-03	3.78E-02	6.50E-01	1.78E-01	6.14E+00	**6.35E+00**
Miscellaneous											
Sulfate	1.34E+03	3.67E+01	NA	1.34E+03	NA	NA	NA	NA	NA	NA	**NA**
Total HI			**3.51E+00**				**2.89E-01**			**2.40E+01**	**28**

HQ - Hazard quotient; HI - Hazard index.
NA - Not applicable.

Table G-20

Separation of Noncancer Hazard by Target Organ
Adult Resident Exposure to Groundwater
TNT C, Former Plum Brook Ordnance Works
Sandusky, Ohio

	Target Organs									
COPC	NS/CNS	Kidney	Erythrocyte	Eye	Reduced BW/OW	N & O epithelia	URT/ Lung	GI	Blood/ Blood cells	Liver
Semivolatile Organic Compounds										
2-Methylnaphthalene			0.05	0.05	0.05	4.24				
Bis(2-ethylhexyl)phthalate										0.15
Naphthalene			0.06	0.06	0.06	5.41				
Volatile Organic Compounds										
Benzene									9.48	
Bromomethane		0.26	0.26			1.27				
Methylene chloride			0.10							0.10
Toluene	0.05	0.05					0.37	0.37		0.05
Xylenes, total	6.14				0.22					
Total HI	**6**	**0.3**	**0.5**	**0.1**	**0.3**	**11**	**0.4**	**0.4**	**9**	**0.3**

COPC - Chemical of potential concern.
HI - Hazard index.
Target Organs: NS/CNS - nervous system/central nervous system; BW - body weight; N & O - nasal and olfactory; OW - organ weight.

Table G-21

Summary of Cancer Risk for the Resident
TNT C, Plum Brook Ordnance Works
Sandusky, Ohio

		Incidental Ingestion							Dermal Absorption					
Chemical	Exposure Point Concentration (mg/L)	Adult Cancer Dose (mg/kg-day)	Child Cancer Dose (mg/kg-day)	Adult Oral ILCR	Child Oral ILCR	Total Oral ILCR	Cd mg/L	Adult DA (mg/cm^2-day)	Adult Cancer Dose (mg/kg-day)	Child DA (mg/cm^2-day)	Child Cancer Dose (mg/kg-day)	Adult Dermal ILCR	Child Dermal ILCR	Total Dermal ILCR
Semivolatile Organic Compounds														
2-Methylnaphthalene	2.66E-02	2.50E-04	1.46E-04	NA	NA	NA	1.33E-02	1.19E-06	1.12E-04	1.54E-06	5.57E-05	NA	NA	NA
Bis(2-ethylhexyl)phthalate	5.50E-02	5.17E-04	3.01E-04	7.23E-06	4.22E-06	1.15E-05	5.50E-02	5.55E-06	5.21E-04	7.16E-06	2.59E-04	7.30E-06	3.62E-06	1.09E-05
Naphthalene	3.40E-02	3.19E-04	1.86E-04	NA	NA	NA	1.70E-02	7.39E-07	6.94E-05	9.54E-07	3.45E-05	NA	NA	NA
Volatile Organic Compounds														
Benzene	4.10E-01	3.85E-03	2.25E-03	2.12E-04	1.24E-04	3.35E-04	2.05E-01	2.05E-06	1.92E-04	2.64E-06	9.55E-05	1.06E-05	5.25E-06	1.58E-05
Bromomethane	1.30E-02	1.22E-04	7.12E-05	NA	NA	NA	6.50E-03	1.35E-08	1.27E-06	1.74E-08	6.30E-07	NA	NA	NA
Methylene chloride	1.60E-01	1.50E-03	8.77E-04	1.13E-05	6.58E-06	1.78E-05	8.00E-02	1.96E-07	1.84E-05	2.53E-07	9.14E-06	1.38E-07	6.85E-08	2.07E-07
Toluene	3.00E-01	2.82E-03	1.64E-03	NA	NA	NA	1.50E-01	3.40E-06	3.19E-04	4.39E-06	1.59E-04	NA	NA	NA
Xylenes, total	1.30E+00	1.22E-02	7.12E-03	NA	NA	NA	6.50E-01	2.76E-05	2.59E-03	3.56E-05	1.29E-03	NA	NA	NA
Miscellaneous														
Sulfate	1.34E+03	1.26E+01	7.34E+00	NA	NA	NA	1.34E+03	NA	NA	ND	NA	NA	NA	NA
Total ILCR				**2.30E-04**	**1.34E-04**	**3.65E-04**						**1.80E-05**	**8.95E-06**	**2.70E-05**

ILCR - Incremental lifetime cancer risk.
NA - Not applicable.

Table G-21

Summary of Cancer Risk for the Resident
TNT C, Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Exposure Point Concentration (mg/L)	Concentration in Air (mg/m^3)	Inhalation: Adult Cancer Dose (mg/kg-day)	Inhalation: Child Cancer Dose (mg/kg-day)	Adult Inhalation ILCR	Child Inhalation ILCR	Total Inhalation ILCR	**Total ILCR All Pathways**
Semivolatile Organic Compounds								
2-Methylnaphthalene	2.66E-02	1.33E-02	1.25E-03	7.29E-04	NA	NA	NA	**NA**
Bis(2-ethylhexyl)phthalate	5.50E-02	NA	NA	NA	NA	NA	NA	**2.24E-05**
Naphthalene	3.40E-02	1.70E-02	1.60E-03	9.30E-04	NA	NA	NA	**NA**
Volatile Organic Compounds								
Benzene	4.10E-01	2.05E-01	1.92E-02	1.12E-02	5.20E-04	3.03E-04	8.23E-04	**1.17E-03**
Bromomethane	1.30E-02	6.50E-03	6.10E-04	3.56E-04	NA	NA	NA	**NA**
Methylene chloride	1.60E-01	8.00E-02	7.51E-03	4.38E-03	1.20E-05	7.00E-06	1.90E-05	**3.71E-05**
Toluene	3.00E-01	1.50E-01	1.41E-02	8.21E-03	NA	NA	NA	**NA**
Xylenes, total	1.30E+00	6.50E-01	6.10E-02	3.56E-02	NA	NA	NA	**NA**
Miscellaneous								
Sulfate	1.34E+03	NA	NA	NA	NA	NA	NA	**NA**
Total ILCR					**5.32E-04**	**3.10E-04**	**8.42E-04**	**1.E-03**

ILCR - Incremental lifetime cancer risk.
NA - Not applicable.

Table G-22

Summary of Risk for the On-Site Worker
Pentolite Road Red Water Pond Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Exposure Point Concentration (mg/L)	Incidental Ingestion Noncancer Dose (mg/kg-day)	Incidental Ingestion Cancer Dose (mg/kg-day)	Oral HQ	Oral ILCR	Dermal Absorption Noncancer Dose (mg/kg-day)	Dermal Absorption Cancer Dose (mg/kg-day)	Dermal HQ	Dermal ILCR	**Total HI All Pathways**	**Total ILCR All Pathways**
Metals											
Chromium	2.06E-02	2.02E-04	7.20E-05	6.72E-02	ND	6.65E-07	2.38E-07	8.87E-03	ND	**7.61E-02**	**NA**
Iron	7.28E+00	7.12E-02	2.54E-02	2.37E-01	ND	2.35E-04	8.40E-05	7.84E-04	ND	**2.38E-01**	**NA**
Manganese	1.17E+00	1.14E-02	4.09E-03	4.77E-01	ND	3.78E-05	1.35E-05	NA	ND	**4.77E-01**	**NA**
Thallium	5.08E-02	4.97E-04	1.78E-04	7.65E+00	ND	1.64E-06	5.86E-07	2.52E-02	ND	**7.67E+00**	**NA**
Explosives											
2,4,6-Trinitrotoluene (TNT)	1.30E-03	1.27E-05	4.54E-06	2.54E-02	1.36E-07	1.57E-07	5.59E-08	3.13E-04	1.68E-09	**2.58E-02**	**1.38E-07**
2,4-Dinitrotoluene	8.90E-04	8.71E-06	3.11E-06	4.35E-03	2.11E-06	2.61E-07	9.31E-08	1.30E-04	6.33E-08	**4.48E-03**	**2.18E-06**
2,6-Dinitrotoluene	8.90E-04	8.71E-06	3.11E-06	8.71E-03	2.11E-06	1.77E-07	6.31E-08	1.77E-04	4.29E-08	**8.88E-03**	**2.16E-06**
4-Amino-2,6-dinitrotoluene	9.70E-04	9.49E-06	3.39E-06	4.75E-02	ND	2.04E-07	7.28E-08	1.02E-03	ND	**4.85E-02**	**NA**
Nitrobenzene	3.50E-04	3.42E-06	1.22E-06	6.85E-03	ND	1.21E-07	4.31E-08	2.41E-04	ND	**7.09E-03**	**NA**
Semivolatile Organic Compounds											
2-Methylnaphthalene	3.45E-02	3.38E-04	1.21E-04	1.69E-02	ND	2.23E-04	7.98E-05	1.12E-02	ND	**2.81E-02**	**NA**
4-Methylphenol	4.30E-02	4.21E-04	1.50E-04	8.41E-02	ND	1.94E-05	6.92E-06	3.88E-03	ND	**8.80E-02**	**NA**
Bis(2-ethylhexyl)phthalate	3.70E-02	3.62E-04	1.29E-04	1.81E-02	1.81E-06	2.69E-04	9.62E-05	1.35E-02	1.35E-06	**3.16E-02**	**3.16E-06**
Naphthalene	2.99E-02	2.93E-04	1.05E-04	1.46E-02	ND	9.39E-05	3.35E-05	4.70E-03	ND	**1.93E-02**	**NA**
Volatile Organic Compounds											
1,1,2-Trichloroethane	4.90E-03	4.79E-05	1.71E-05	1.20E-02	9.76E-07	2.17E-06	7.74E-07	5.42E-04	4.41E-08	**1.25E-02**	**1.02E-06**
Acetone	1.60E+00	1.57E-02	5.59E-03	1.74E-02	ND	3.48E-05	1.24E-05	3.87E-05	ND	**1.74E-02**	**NA**
Benzene	2.50E+00	2.45E-02	8.74E-03	6.12E+00	4.81E-04	1.80E-03	6.44E-04	4.51E-01	3.54E-05	**6.57E+00**	**5.16E-04**
Ethylbenzene	2.02E-01	1.98E-03	7.08E-04	1.98E-02	ND	5.74E-04	2.05E-04	5.74E-03	ND	**2.56E-02**	**NA**
Methylene chloride	1.60E-01	1.57E-03	5.59E-04	2.61E-02	4.19E-06	2.83E-05	1.01E-05	4.71E-04	7.57E-08	**2.66E-02**	**4.27E-06**
Toluene	9.46E-01	9.26E-03	3.31E-03	4.63E-02	ND	1.55E-03	5.53E-04	7.75E-03	ND	**5.40E-02**	**NA**
Xylenes, total	1.40E+00	1.37E-02	4.88E-03	6.84E-02	ND	4.28E-03	1.53E-03	2.14E-02	ND	**8.98E-02**	**NA**
Total HI				**1.49E+01**				**5.56E-01**		**15**	
Total ILCR					**4.92E-04**				**3.70E-05**		**5.E-04**

HQ - Hazard quotient; HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
NA - Not applicable.

Note: TNT was not selected as a COPC but is included on this table for the purpose of calculating modeled future risks (refer to Section 6.3 of the text).

Table G-23

Separation of Noncancer Hazard by Target Organ
On-Site Worker Exposure to Groundwater
Pentolite Road Red Water Pond Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

	Target Organs											
COPC	NS/CNS	Skin	GI	Fetus & Repro	Iron Overload	Kidney	Erythrocyte	Eye	Reduced BW/OW	Blood/ Blood cells	Immune System	Liver
Metals												
Chromium			7.61E-02	7.61E-02								
Iron					2.38E-01							
Manganese	4.77E-01											
Thallium		7.67E+00										7.67E+00
Explosives												
2,4-Dinitrotoluene	4.48E-03						4.48E-03					4.48E-03
2,6-Dinitrotoluene	8.88E-03					8.88E-03	8.88E-03					8.88E-03
4-Amino-2,6-dinitrotoluene							4.85E-02					4.85E-02
Nitrobenzene						7.09E-03	7.09E-03					7.09E-03
Semivolatile Organic Compounds												
2-Methylnaphthalene							2.81E-02	2.81E-02	2.81E-02			
4-Methylphenol	8.80E-02											
Bis(2-ethylhexyl)phthalate												3.16E-02
Naphthalene							1.93E-02	1.93E-02	1.93E-02			
Volatile Organic Compounds												
1,1,2-Trichloroethane											1.25E-02	
Acetone						1.74E-02						
Benzene										6.57E+00		
Ethylbenzene						2.56E-02						2.56E-02
Methylene chloride							2.66E-02					2.66E-02
Toluene	5.40E-02					5.40E-02						5.40E-02
Xylenes, total									8.98E-02			
Total HI	**0.6**	**8**	**0.08**	**0.08**	**0.2**	**0.1**	**0.1**	**0.05**	**0.1**	**7**	**0.01**	**8**

COPC - Chemical of potential concern.
HI - Hazard index.
Target Organs: NS/CNS - nervous system/central nervous system; BW - body weight; GI - gastrointestinal; OW - organ weight.

Table G-24

Summary of Noncancer Risk for the Child Resident
Pentolite Road Red Water Pond Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Exposure Point Concentration (mg/L)	Incidental Ingestion Child Noncancer Dose (mg/kg-day)	Oral HQ	Dermal Absorption Child Noncancer Dose (mg/kg-day)	Dermal HQ	Concentration in Air (mg/m3)	Inhalation Child Noncancer Dose (mg/kg-day)	Inhalation HQ	**Total HI All Pathways**
Metals									
Chromium	2.06E-02	1.32E-03	4.39E-01	2.89E-06	3.86E-02	NA	NA	NA	**4.78E-01**
Iron	7.28E+00	4.65E-01	1.55E+00	1.02E-03	3.41E-03	NA	NA	NA	**1.55E+00**
Manganese	1.17E+00	7.48E-02	3.12E+00	1.64E-04	NA	NA	NA	NA	**3.12E+00**
Thallium	5.08E-02	3.25E-03	5.00E+01	7.14E-06	1.10E-01	NA	NA	NA	**5.01E+01**
Explosives									
2,4,6-Trinitrotoluene (TNT)	1.30E-03	8.31E-05	1.66E-01	1.18E-06	2.36E-03	NA	NA	NA	**1.69E-01**
2,4-Dinitrotoluene	8.90E-04	5.69E-05	2.84E-02	1.97E-06	9.83E-04	NA	NA	NA	**2.94E-02**
2,6-Dinitrotoluene	8.90E-04	5.69E-05	5.69E-02	1.33E-06	1.33E-03	NA	NA	NA	**5.82E-02**
4-Amino-2,6-dinitrotoluene	9.70E-04	6.20E-05	3.10E-01	1.54E-06	7.68E-03	NA	NA	NA	**3.18E-01**
Nitrobenzene	3.50E-04	2.24E-05	4.47E-02	4.55E-07	9.10E-04	1.75E-04	1.12E-04	1.96E-01	**2.42E-01**
Semivolatile Organic Compounds									
2-Methylnaphthalene	3.45E-02	2.21E-03	1.10E-01	8.42E-04	4.21E-02	1.73E-02	1.10E-02	1.28E+01	**1.30E+01**
4-Methylphenol	4.30E-02	2.75E-03	5.50E-01	1.46E-04	2.92E-02	NA	NA	NA	**5.79E-01**
Bis(2-ethylhexyl)phthalate	3.70E-02	2.37E-03	1.18E-01	2.03E-03	1.02E-01	NA	NA	NA	**2.20E-01**
Naphthalene	2.99E-02	1.91E-03	9.56E-02	3.54E-04	1.77E-02	1.50E-02	9.54E-03	1.11E+01	**1.12E+01**
Volatile Organic Compounds									
1,1,2-Trichloroethane	4.90E-03	3.13E-04	7.83E-02	8.18E-06	2.04E-03	2.45E-03	1.56E-03	NA	**8.04E-02**
Acetone	1.60E+00	1.02E-01	1.14E-01	1.31E-04	1.46E-04	8.00E-01	5.11E-01	NA	**1.14E-01**
Benzene	2.50E+00	1.60E-01	4.00E+01	6.80E-03	1.70E+00	1.25E+00	7.98E-01	9.28E+01	**1.34E+02**
Ethylbenzene	2.02E-01	1.29E-02	1.29E-01	2.16E-03	2.16E-02	1.01E-01	6.46E-02	2.23E-01	**3.74E-01**
Methylene chloride	1.60E-01	1.02E-02	1.70E-01	1.07E-04	1.78E-03	8.00E-02	5.11E-02	5.94E-02	**2.32E-01**
Toluene	9.46E-01	6.05E-02	3.02E-01	5.84E-03	2.92E-02	4.73E-01	3.02E-01	2.74E+00	**3.08E+00**
Xylenes, total	1.40E+00	8.93E-02	4.47E-01	1.62E-02	8.08E-02	6.99E-01	4.46E-01	1.54E+01	**1.59E+01**
Total HI			**9.76E+01**		**2.19E+00**			**1.35E+02**	**235**

HQ - Hazard quotient; HI - Hazard index.

Table G-25

Separation of Noncancer Hazard by Target Organ
Child Resident Exposure to Groundwater
Pentolite Road Red Water Pond Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

	Target Organs												
COPC	NS/CNS	Skin	GI	Fetus & Repro	URT/ Lung	Iron Overload	Kidney	Erythrocyte	Eye	Reduced BW/OW	N & O epithelia	Blood/ Blood cells	Liver
Metals													
Chromium			0.48	0.48									
Iron						1.55							
Manganese	3.12												
Thallium		50.07											50.07
Explosives													
2,4-Dinitrotoluene	0.03							0.03					0.03
2,6-Dinitrotoluene	0.06							0.06					0.06
4-Amino-2,6-dinitrotoluene								0.32					0.32
Nitrobenzene							0.24	0.24					0.24
Semivolatile Organic Compounds													
2-Methylnaphthalene								0.15	0.15	0.15	12.82		
4-Methylphenol	0.58												
Bis(2-ethylhexyl)phthalate													0.22
Naphthalene								0.11	0.11	0.11	11.10		
Volatile Organic Compounds													
1,1,2-Trichloroethane													
Acetone							0.11						
Benzene												134.42	
Ethylbenzene				0.22			0.37						0.37
Methylene chloride								0.23					0.23
Toluene	0.33		2.74		2.74								0.33
Xylenes, total	15.38									0.53			
Total HI	**19**	**50**	**3**	**0.7**	**3**	**2**	**0.7**	**1**	**0.3**	**0.8**	**24**	**134**	**52**

COPC - Chemical of potential concern.
HI - Hazard index.
Target Organs: NS/CNS - nervous system/central nervous system; BW - body weight; N & O - nasal and olfactory; GI - gastrointestinal; OW - organ weight.

Table G-26

Risk Evaluation for the Adult Resident
Pentolite Road Red Water Pond Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Exposure Point Concentration (mg/L)	Incidental Ingestion Adult Noncancer Dose (mg/kg-day)	Oral HQ	Dermal Absorption Adult Noncancer Dose (mg/kg-day)	Dermal HQ	Concentration in Air (mg/m3)	Inhalation Adult Noncancer Dose (mg/kg-day)	Inhalation HQ	**Total HI All Pathways**
Metals									
Chromium	2.06E-02	5.64E-04	1.88E-01	1.13E-06	1.51E-02	NA	NA	NA	**2.03E-01**
Iron	7.28E+00	1.99E-01	6.65E-01	3.99E-04	1.33E-03	NA	NA	NA	**6.66E-01**
Manganese	1.17E+00	3.21E-02	1.34E+00	6.41E-05	NA	NA	NA	NA	**1.34E+00**
Thallium	5.08E-02	1.39E-03	2.14E+01	2.78E-06	4.28E-02	NA	NA	NA	**2.15E+01**
Explosives									
2,4,6-Trinitrotoluene (TNT)	1.30E-03	3.56E-05	7.12E-02	5.94E-07	1.19E-03	NA	NA	NA	**7.24E-02**
2,4-Dinitrotoluene	8.90E-04	2.44E-05	1.22E-02	9.89E-07	4.95E-04	NA	NA	NA	**1.27E-02**
2,6-Dinitrotoluene	8.90E-04	2.44E-05	2.44E-02	6.70E-07	6.70E-04	NA	NA	NA	**2.51E-02**
4-Amino-2,6-dinitrotoluene	9.70E-04	2.66E-05	1.33E-01	7.73E-07	3.87E-03	NA	NA	NA	**1.37E-01**
Nitrobenzene	3.50E-04	9.59E-06	1.92E-02	2.29E-07	4.58E-04	1.75E-04	4.79E-05	8.41E-02	**1.04E-01**
Semivolatile Organic Compounds									
2-Methylnaphthalene	3.45E-02	9.46E-04	4.73E-02	4.24E-04	2.12E-02	1.73E-02	4.73E-03	5.50E+00	**5.57E+00**
4-Methylphenol	4.30E-02	1.18E-03	2.36E-01	7.35E-05	1.47E-02	NA	NA	NA	**2.50E-01**
Bis(2-ethylhexyl)phthalate	3.70E-02	1.01E-03	5.07E-02	1.02E-03	5.11E-02	NA	NA	NA	**1.02E-01**
Naphthalene	2.99E-02	8.19E-04	4.10E-02	1.78E-04	8.91E-03	1.50E-02	4.10E-03	4.76E+00	**4.81E+00**
Volatile Organic Compounds									
1,1,2-Trichloroethane	4.90E-03	1.34E-04	3.36E-02	4.11E-06	1.03E-03	2.45E-03	6.71E-04	NA	**3.46E-02**
Acetone	1.60E+00	4.38E-02	4.87E-02	6.61E-05	7.34E-05	8.00E-01	2.19E-01	NA	**4.88E-02**
Benzene	2.50E+00	6.85E-02	1.71E+01	3.42E-03	8.55E-01	1.25E+00	3.42E-01	3.98E+01	**5.78E+01**
Ethylbenzene	2.02E-01	5.55E-03	5.55E-02	1.09E-03	1.09E-02	1.01E-01	2.77E-02	9.56E-02	**1.62E-01**
Methylene chloride	1.60E-01	4.38E-03	7.31E-02	5.37E-05	8.94E-04	8.00E-02	2.19E-02	2.55E-02	**9.94E-02**
Toluene	9.46E-01	2.59E-02	1.30E-01	2.94E-03	1.47E-02	4.73E-01	1.30E-01	1.18E+00	**1.32E+00**
Xylenes, total	1.40E+00	3.83E-02	1.91E-01	8.13E-03	4.06E-02	6.99E-01	1.91E-01	6.60E+00	**6.83E+00**
Total HI			**4.18E+01**		**1.08E+00**			**5.80E+01**	**101**

HQ - Hazard quotient; HI - Hazard index.
NA - Not applicable.

Note: TNT was not selected as a COPC but is included on this table for the purpose of calculating modeled future risks (refer to Section 6.3 of the text).

Table G-27

Separation of Noncancer Hazard by Target Organ
Adult Resident Exposure to Groundwater
Pentolite Road Red Water Pond Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

	Target Organs													
COPC	NS/CNS	Skin	GI	Fetus & Repro	URT/ Lung	Iron Overload	Kidney	Erythrocyte	Eye	Reduced BW/OW	N & O epithelia	Blood/ Blood cells	Immune System	Liver
Metals														
Chromium			2.03E-01	2.03E-01										
Iron						6.66E-01								
Manganese	1.34E+00													
Thallium		2.15E+01												2.15E+01
Explosives														
2,4-Dinitrotoluene	1.27E-02							1.27E-02						1.27E-02
2,6-Dinitrotoluene	2.51E-02						2.51E-02	2.51E-02						2.51E-02
4-Amino-2,6-dinitrotoluene								1.37E-01						1.37E-01
Nitrobenzene							1.04E-01	1.04E-01						1.04E-01
Semivolatile Organic Compounds														
2-Methylnaphthalene								6.85E-02	6.85E-02	6.85E-02	5.50E+00			
4-Methylphenol	2.50E-01													
Bis(2-ethylhexyl)phthalate														1.02E-01
Naphthalene								4.99E-02	4.99E-02	4.99E-02	4.76E+00			
Volatile Organic Compounds														
1,1,2-Trichloroethane													3.46E-02	
Acetone							4.88E-02							
Benzene												5.78E+01		
Ethylbenzene				9.56E-02			6.64E-02							6.64E-02
Methylene chloride								9.94E-02						9.94E-02
Toluene	1.44E-01		1.18E+00		1.18E+00		1.44E-01							1.44E-01
Xylenes, total	6.60E+00									2.32E-01				
Total HI	**8**	**21**	**1**	**0.3**	**1**	**0.7**	**0.4**	**0.5**	**0.1**	**0.4**	**10**	**58**	**0.03**	**22**

COPC - Chemical of potential concern.
HI - Hazard index.
Target Organs: NS/CNS - nervous system/central nervous system; BW - body weight; N & O - nasal and olfactory; GI - gastrointestinal; OW - organ weight.

Table G-28

Summary of Cancer Risk for the Resident
Pentolite Road Red Water Pond Area, Plum Brook Ordnance Works
Sandusky, Ohio

		Incidental Ingestion						Dermal Absorption						
Chemical	Exposure Point Concentration (mg/L)	Adult Cancer Dose (mg/kg-day)	Child Cancer Dose (mg/kg-day)	Adult Oral ILCR	Child Oral ILCR	Total Oral ILCR	Cd mg/L	Adult DA (mg/cm^2-day)	Adult Cancer Dose (mg/kg-day)	Child DA (mg/cm^2-day)	Child Cancer Dose (mg/kg-day)	Adult Dermal ILCR	Child Dermal ILCR	Total Dermal ILCR
Metals														
Chromium	2.06E-02	1.94E-04	1.13E-04	NA	NA	NA	2.06E-02	4.12E-09	3.87E-07	6.86E-09	2.48E-07	NA	NA	NA
Iron	7.28E+00	6.84E-02	3.99E-02	NA	NA	NA	7.28E+00	1.46E-06	1.37E-04	2.42E-06	8.77E-05	NA	NA	NA
Manganese	1.17E+00	1.10E-02	6.41E-03	NA	NA	NA	1.17E+00	2.34E-07	2.20E-05	3.90E-07	1.41E-05	NA	NA	NA
Thallium	5.08E-02	4.77E-04	2.78E-04	NA	NA	NA	5.08E-02	1.02E-08	9.54E-07	1.69E-08	6.12E-07	NA	NA	NA
Explosives														
2,4,6-Trinitrotoluene (TNT)	1.30E-03	1.22E-05	7.12E-06	3.66E-07	2.14E-07	5.80E-07	1.30E-03	2.17E-09	2.04E-07	2.80E-09	1.01E-07	6.11E-09	3.04E-09	9.15E-09
2,4-Dinitrotoluene	8.90E-04	8.36E-06	4.88E-06	5.68E-06	3.32E-06	9.00E-06	8.90E-04	3.61E-09	3.39E-07	4.66E-09	1.68E-07	2.31E-07	1.15E-07	3.45E-07
2,6-Dinitrotoluene	8.90E-04	8.36E-06	4.88E-06	5.68E-06	3.32E-06	9.00E-06	8.90E-04	2.45E-09	2.30E-07	3.16E-09	1.14E-07	1.56E-07	7.76E-08	2.34E-07
4-Amino-2,6-dinitrotoluene	9.70E-04	9.11E-06	5.32E-06	NA	NA	NA	9.70E-04	2.82E-09	2.65E-07	3.64E-09	1.32E-07	NA	NA	NA
Nitrobenzene	3.50E-04	3.29E-06	1.92E-06	NA	NA	NA	1.75E-04	8.36E-10	7.85E-08	1.08E-09	3.90E-08	NA	NA	NA
Semivolatile Organic Compounds														
2-Methylnaphthalene	3.45E-02	3.24E-04	1.89E-04	NA	NA	NA	1.73E-02	1.55E-06	1.45E-04	2.00E-06	7.22E-05	NA	NA	NA
4-Methylphenol	4.30E-02	4.04E-04	2.36E-04	NA	NA	NA	4.30E-02	2.68E-07	2.52E-05	3.46E-07	1.25E-05	NA	NA	NA
Bis(2-ethylhexyl)phthalate	3.70E-02	3.48E-04	2.03E-04	4.87E-06	2.84E-06	7.70E-06	3.70E-02	3.73E-06	3.51E-04	4.82E-06	1.74E-04	4.91E-06	2.44E-06	7.35E-06
Naphthalene	2.99E-02	2.81E-04	1.64E-04	NA	NA	NA	1.50E-02	6.50E-07	6.11E-05	8.39E-07	3.03E-05	NA	NA	NA
Volatile Organic Compounds														
1,1,2-Trichloroethane	4.90E-03	4.60E-05	2.68E-05	2.62E-06	1.53E-06	4.15E-06	2.45E-03	1.50E-08	1.41E-06	1.94E-08	7.01E-07	8.04E-08	3.99E-08	1.20E-07
Acetone	1.60E+00	1.50E-02	8.77E-03	NA	NA	NA	8.00E-01	2.41E-07	2.27E-05	3.11E-07	1.13E-05	NA	NA	NA
Benzene	2.50E+00	2.35E-02	1.37E-02	1.29E-03	7.53E-04	2.05E-03	1.25E+00	1.25E-05	1.17E-03	1.61E-05	5.83E-04	6.45E-05	3.20E-05	9.65E-05
Ethylbenzene	2.02E-01	1.90E-03	1.11E-03	NA	NA	NA	1.01E-01	3.97E-06	3.73E-04	5.13E-06	1.85E-04	NA	NA	NA
Methylene chloride	1.60E-01	1.50E-03	8.77E-04	1.13E-05	6.58E-06	1.78E-05	8.00E-02	1.96E-07	1.84E-05	2.53E-07	9.14E-06	1.38E-07	6.85E-08	2.07E-07
Toluene	9.46E-01	8.89E-03	5.18E-03	NA	NA	NA	4.73E-01	1.07E-05	1.01E-03	1.38E-05	5.01E-04	NA	NA	NA
Xylenes, total	1.40E+00	1.31E-02	7.66E-03	NA	NA	NA	6.99E-01	2.97E-05	2.79E-03	3.83E-05	1.38E-03	NA	NA	NA
Total ILCR				**1.32E-03**	**7.71E-04**	**2.09E-03**						**7.00E-05**	**3.48E-05**	**1.05E-04**

Table G-28

Summary of Cancer Risk for the Resident
Pentolite Road Red Water Pond Area, Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Exposure Point Concentration (mg/L)	Concentration in Air (mg/m^3)	Inhalation: Adult Cancer Dose (mg/kg-day)	Inhalation: Child Cancer Dose (mg/kg-day)	Adult Inhalation ILCR	Child Inhalation ILCR	Total Inhalation ILCR	**Total ILCR All Pathways**
Metals								
Chromium	2.06E-02	NA	NA	NA	NA	NA	NA	**NA**
Iron	7.28E+00	NA	NA	NA	NA	NA	NA	**NA**
Manganese	1.17E+00	NA	NA	NA	NA	NA	NA	**NA**
Thallium	5.08E-02	NA	NA	NA	NA	NA	NA	**NA**
Explosives								
2,4,6-Trinitrotoluene (TNT)	1.30E-03	NA	NA	NA	NA	NA	NA	**5.89E-07**
2,4-Dinitrotoluene	8.90E-04	NA	NA	NA	NA	NA	NA	**9.35E-06**
2,6-Dinitrotoluene	8.90E-04	NA	NA	NA	NA	NA	NA	**9.23E-06**
4-Amino-2,6-dinitrotoluene	9.70E-04	NA	NA	NA	NA	NA	NA	**NA**
Nitrobenzene	3.50E-04	1.75E-04	1.64E-05	9.57E-06	NA	NA	NA	**NA**
Semivolatile Organic Compounds								
2-Methylnaphthalene	3.45E-02	1.73E-02	1.62E-03	9.45E-04	NA	NA	NA	**NA**
4-Methylphenol	4.30E-02	NA	NA	NA	NA	NA	NA	**NA**
Bis(2-ethylhexyl)phthalate	3.70E-02	NA	NA	NA	NA	NA	NA	**1.51E-05**
Naphthalene	2.99E-02	1.50E-02	1.40E-03	8.18E-04	NA	NA	NA	**NA**
Volatile Organic Compounds								
1,1,2-Trichloroethane	4.90E-03	2.45E-03	2.30E-04	1.34E-04	1.31E-05	7.64E-06	2.08E-05	**2.50E-05**
Acetone	1.60E+00	8.00E-01	7.51E-02	4.38E-02	NA	NA	NA	**NA**
Benzene	2.50E+00	1.25E+00	1.17E-01	6.84E-02	3.17E-03	1.85E-03	5.02E-03	**7.16E-03**
Ethylbenzene	2.02E-01	1.01E-01	9.51E-03	5.54E-03	NA	NA	NA	**NA**
Methylene chloride	1.60E-01	8.00E-02	7.51E-03	4.38E-03	1.20E-05	7.00E-06	1.90E-05	**3.71E-05**
Toluene	9.46E-01	4.73E-01	4.44E-02	2.59E-02	NA	NA	NA	**NA**
Xylenes, total	1.40E+00	6.99E-01	6.56E-02	3.82E-02	NA	NA	NA	**NA**
Total ILCR					**3.19E-03**	**1.86E-03**	**5.06E-03**	**7.E-03**

ILCR - Incremental lifetime cancer risk.
NA - Not applicable.

Note: TNT was not selected as a COPC but is included on this table for the purpose of calculating modeled future risks (refer to Section 6.3 of the text).

Table G-29

Summary of Risk for the On-Site Worker
West Area Red Water Ponds Area, Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Exposure Point Concentration (mg/L)	Incidental Ingestion Noncancer Dose (mg/kg-day)	Incidental Ingestion Cancer Dose (mg/kg-day)	Oral HQ	Oral ILCR	DA mg/cm2-day	Dermal Absorption Noncancer Dose (mg/kg-day)	Dermal Absorption Cancer Dose (mg/kg-day)	Dermal HQ	Dermal ILCR	**HI All Pathways**	**ILCR All Pathways**
Metals												
Arsenic	9.50E-03	9.30E-05	3.32E-05	3.10E-01	4.98E-05	9.50E-09	3.07E-07	1.10E-07	1.02E-03	1.64E-07	**3.11E-01**	**5.00E-05**
Cobalt	2.67E-01	2.61E-03	9.33E-04	1.31E-01	ND	2.67E-07	8.62E-06	3.08E-06	2.16E-03	ND	**1.33E-01**	**NA**
Nickel	2.78E-01	2.72E-03	9.71E-04	1.36E-01	ND	5.56E-08	1.80E-06	6.41E-07	2.24E-03	ND	**1.38E-01**	**NA**
Vanadium	5.50E-03	5.38E-05	1.92E-05	5.38E-02	ND	5.50E-09	1.78E-07	6.34E-08	5.92E-03	ND	**5.97E-02**	**NA**
Semivolatile Organic Compounds												
2,4-Dinitrotoluene	1.90E-02	1.86E-04	6.64E-05	9.30E-02	4.51E-05	1.72E-07	5.56E-06	1.99E-06	2.78E-03	1.35E-06	**9.57E-02**	**4.65E-05**
4,6-Dinitro-2-methylphenol	2.80E-02	2.74E-04	9.78E-05	2.74E+00	ND	2.82E-07	9.12E-06	3.26E-06	9.12E-02	ND	**2.83E+00**	**NA**
2,4-Dinitrophenol	1.40E-02	1.37E-04	4.89E-05	6.85E-02	ND	6.23E-08	2.01E-06	7.18E-07	1.01E-03	ND	**6.95E-02**	**NA**
3-Nitroaniline	1.50E-01	1.47E-03	5.24E-04	4.89E+00	1.10E-05	7.00E-07	2.26E-05	8.08E-06	7.54E-02	1.70E-07	**4.97E+00**	**1.12E-05**
Nitrobenzene	5.80E-03	5.68E-05	2.03E-05	1.14E-01	ND	6.20E-08	2.00E-06	7.15E-07	4.00E-03	ND	**1.18E-01**	**NA**
Volatile Organic Compounds												
Benzene	1.10E-03	1.08E-05	3.84E-06	2.69E-03	2.11E-07	2.46E-08	7.93E-07	2.83E-07	1.98E-04	1.56E-08	**2.89E-03**	**2.27E-07**
Miscellaneous												
Nitrate	7.93E+01	7.76E-01	2.77E-01	4.85E-01	ND	7.93E-05	2.56E-03	9.14E-04	3.20E-03	ND	**4.88E-01**	**NA**
Nitrate-Nitrite	3.00E-01	2.94E-03	1.05E-03	2.94E-02	ND	3.00E-07	9.69E-06	3.46E-06	1.94E-04	ND	**2.95E-02**	**NA**
Sulfate	2.66E+03	2.60E+01	9.30E+00	NA	ND	NA	NA	NA	NA	ND	**NA**	**NA**
Total HI				**9.05**					**0.189**		**9**	
Total ILCR					**1.06E-04**					**1.70E-06**		**1.E-04**

HQ - Hazard quotient; HI - Hazard index.
ILCR - Incremental lifetime cancer risk.
NA - Not applicable.

Table G-30

Separation of Noncancer Hazard by Target Organ
On-Site Worker Exposure to Groundwater
West Area Red Water Ponds Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

	Target Organs										
COPC	NS/CNS	Skin	PVS	Kidney	Erthropoiesis /Erythrocyte	Eye	Reduced BW/OW	Blood/ Blood cells	Cellular Respiration	Liver	Increased Basal MR
Metals											
Arsenic		0.31	0.31								
Cobalt					0.13						
Nickel							0.14				
Vanadium				0.06							
Semivolatile Organic Compounds											
2,4-Dinitrotoluene	0.10				0.10					0.10	
4,6-Dinitro-2-methylphenol									2.83		
2,4-Dinitrophenol						0.07					0.07
3-Nitroaniline					4.97						
Nitrobenzene				0.12	0.12					0.12	
Volatile Organic Compounds											
Benzene								0.00			
Miscellaneous											
Nitrate					0.49						
Nitrate-Nitrite					0.03						
Total HI	**0.1**	**0.3**	**0.3**	**0.2**	**6**	**0.07**	**0.1**	**0**	**3**	**0.2**	**0.07**

COPC - Chemical of potential concern.
HI - Hazard index.
Target Organs: NS/CNS - nervous system/central nervous system; BW - body weight; PVS - pulmonary vascular system; OW - organ weight; MR - metalbolic rate.

Table G-31

Summary of Noncancer Risk for the Child Resident
West Area Red Water Pond Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Incidental Ingestion Child Noncancer Exposure Point Concentration (mg/L)	Incidental Ingestion Child Noncancer Dose (mg/kg-day)	Oral HQ	Dermal Absorption Child Noncancer Cd (mg/L)	Dermal Absorption Child Noncancer DA (mg/cm^2-day)	Dermal Absorption Child Noncancer Dose (mg/kg-day)	Dermal HQ	Inhalation Child Noncancer Concentration in Air (mg/m^3)	Inhalation Child Noncancer Dose (mg/kg-day)	Inhalation HQ	HI All Pathways
Metals											
Arsenic	9.50E-03	6.07E-04	2.02E+00	9.50E-03	3.16E-09	1.33E-06	4.45E-03	NA	NA	NA	**2.03E+00**
Cobalt	2.67E-01	1.71E-02	8.53E-01	2.67E-01	8.89E-08	3.75E-05	9.38E-03	NA	NA	NA	**8.63E-01**
Nickel	2.78E-01	1.78E-02	8.89E-01	2.78E-01	1.85E-08	7.81E-06	9.76E-03	NA	NA	NA	**8.98E-01**
Vanadium	5.50E-03	3.52E-04	3.52E-01	5.50E-03	1.83E-09	7.73E-07	2.58E-02	NA	NA	NA	**3.77E-01**
Semivolatile Organic Compounds											
2,4-Dinitrotoluene	1.90E-02	1.21E-03	6.07E-01	1.90E-02	9.94E-08	4.20E-05	2.10E-02	NA	NA	NA	**6.28E-01**
4,6-Dinitro-2-methylphenol	2.80E-02	1.79E-03	1.79E+01	1.40E-02	8.15E-08	3.44E-05	3.44E-01	1.40E-02	8.94E-03	NA	**1.82E+01**
2,4-Dinitrophenol	1.40E-02	8.95E-04	4.47E-01	1.40E-02	3.59E-08	1.52E-05	7.58E-03	NA	NA	NA	**4.55E-01**
3-Nitroaniline	1.50E-01	9.59E-03	3.20E+01	1.50E-01	4.04E-07	1.71E-04	5.68E-01	NA	NA	NA	**3.25E+01**
Nitrobenzene	5.80E-03	3.71E-04	7.42E-01	2.90E-03	1.79E-08	7.54E-06	1.51E-02	2.90E-03	1.85E-03	3.25E+00	**4.00E+00**
Volatile Organic Compounds											
Benzene	1.10E-03	7.03E-05	1.76E-02	5.50E-04	7.09E-09	2.99E-06	7.48E-04	5.50E-04	3.51E-04	4.08E-02	**5.91E-02**
Miscellaneous											
Nitrate	7.93E+01	5.07E+00	3.17E+00	7.93E+01	2.64E-05	1.11E-02	1.39E-02	NA	NA	NA	**3.18E+00**
Nitrate-Nitrite	3.00E-01	1.92E-02	1.92E-01	3.00E-01	9.99E-08	4.21E-05	8.43E-04	NA	NA	NA	**1.93E-01**
Sulfate	2.66E+03	1.70E+02	NA	2.66E+03	ND	NA	NA	NA	NA	NA	**NA**
Total HI			**59.16**				**1.02**			**3.29**	**63**

HQ - Hazard quotient; HI - Hazard index.
NA - Not applicable.

Table G-32

Separation of Noncancer Hazard by Target Organ
Child Resident Exposure to Groundwater
West Area Red Water Ponds Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

	Target Organs										
COPC	NS/CNS	Skin	PVS	Kidney	Erythropoiesis /Erythrocyte	Eye	Reduced BW/OW	Cellular Respiration	Blood/ Blood cells	Liver	Increased Basal MR
Metals											
Arsenic		2.03	2.03								
Cobalt					0.86						
Nickel							0.90				
Vanadium				0.38							
Explosives											
2,4-Dinitrotoluene	0.63				0.63					0.63	
4,6-Dinitro-2-methylphenol								18.24			
2,4-Dinitrophenol						0.46					0.46
3-Nitroaniline					32.53						
Nitrobenzene				4.00	4.00					4.00	
Volatile Organic Compounds											
Benzene									0.06		
Miscellaneous											
Nitrate					3.18						
Nitrate-Nitrite					0.19						
Total HI	**0.6**	**2**	**2**	**4**	**41**	**0.5**	**0.9**	**18**	**0.06**	**5**	**0.5**

COPC - Chemical of potential concern.
HI - Hazard index.
Target Organs: NS/CNS - nervous system/central nervous system; BW - body weight; PVS - pulmonary vascular system; RT - respiratory tract; OW - organ weight; MR - metabolic rate.

Table G-33

Risk Evaluation for the Adult Resident
West Area Red Water Ponds Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Exposure Point Concentration (mg/L)	Incidental Ingestion Adult Noncancer Dose (mg/kg-day)	Oral HQ	Cd mg/L	DA mg/cm2-day	Dermal Absorption Adult Noncancer Dose (mg/kg-day)	Dermal HQ	Concentration in Air (mg/m^3)	Inhalation Adult Noncancer Dose (mg/kg-day)	Inhalation HQ	HI All Pathways
Metals											
Arsenic	9.50E-03	2.60E-04	8.68E-01	9.50E-03	1.90E-09	5.21E-07	1.74E-03	NA	NA	NA	**8.69E-01**
Cobalt	2.67E-01	7.32E-03	3.66E-01	2.67E-01	5.34E-08	1.46E-05	3.66E-03	NA	NA	NA	**3.69E-01**
Nickel	2.78E-01	7.62E-03	3.81E-01	2.78E-01	1.11E-08	3.05E-06	3.81E-03	NA	NA	NA	**3.85E-01**
Vanadium	5.50E-03	1.51E-04	1.51E-01	5.50E-03	1.10E-09	3.01E-07	1.00E-02	NA	NA	NA	**1.61E-01**
Semivolatile Organic Compounds											
2,4-Dinitrotoluene	1.90E-02	5.21E-04	2.60E-01	1.90E-02	7.71E-08	2.11E-05	1.06E-02	NA	NA	NA	**2.71E-01**
4,6-Dinitro-2-methylphenol	2.80E-02	7.67E-04	7.67E+00	1.40E-02	6.32E-08	1.73E-05	1.73E-01	1.40E-02	3.83E-03	NA	**7.84E+00**
2,4-Dinitrophenol	1.40E-02	3.84E-04	1.92E-01	1.40E-02	2.78E-08	7.63E-06	3.81E-03	NA	NA	NA	**1.96E-01**
3-Nitroaniline	1.50E-01	4.11E-03	1.37E+01	1.50E-01	3.13E-07	8.58E-05	2.86E-01	NA	NA	NA	**1.40E+01**
Nitrobenzene	5.80E-03	1.59E-04	3.18E-01	2.90E-03	1.39E-08	3.80E-06	7.59E-03	2.90E-03	7.94E-04	1.39E+00	**1.72E+00**
Volatile Organic Compounds											
Benzene	1.10E-03	3.01E-05	7.53E-03	5.50E-04	5.49E-09	1.50E-06	3.76E-04	5.50E-04	1.51E-04	1.75E-02	**2.54E-02**
Miscellaneous											
Nitrate	7.93E+01	2.17E+00	1.36E+00	7.93E+01	1.59E-05	4.35E-03	5.43E-03	NA	NA	NA	**1.36E+00**
Nitrate-Nitrite	3.00E-01	8.22E-03	8.22E-02	3.00E-01	6.00E-08	1.64E-05	3.29E-04	NA	NA	NA	**8.25E-02**
Sulfate	2.66E+03	7.29E+01	NA	2.66E+03	ND	NA	NA	NA	NA	NA	**NA**
Total HI			**25.4**				**0.506**			**1.41**	**27**

HQ - Hazard quotient; HI - Hazard index.
NA - Not applicable.

Table G-34

Separation of Noncancer Hazard by Target Organ
Adult Resident Exposure to Groundwater
West Area Red Water Ponds Area, Former Plum Brook Ordnance Works
Sandusky, Ohio

	Target Organs										
COPC	NS/CNS	Skin	PVS	Kidney	Erythropoiesis /Erythrocyte	Eye	Reduced BW/OW	Cellular Respiration	Blood/ Blood cells	Liver	Increased Basal MR
Metals											
Arsenic		0.87	0.87								
Cobalt					0.37						
Nickel							0.38				
Vanadium				0.16							
Semivolatile Organic Compounds											
2,4-Dinitrotoluene	0.27				0.27					0.27	
4,6-Dinitro-2-methylphenol								7.84			
2,4-Dinitrophenol						0.20					0.20
3-Nitroaniline					13.98						
Nitrobenzene				1.72	1.72					1.72	
Volatile Organic Compounds											
Benzene									0.03		
Miscellaneous											
Nitrate					1.36						
Nitrate-Nitrite					0.08						
Total HI	**0.3**	**0.9**	**0.9**	**2**	**18**	**0.2**	**0.4**	**8**	**0.03**	**2**	**0.2**

COPC - Chemical of potential concern.
HI - Hazard index.
Target Organs: NS/CNS - nervous system/central nervous system; BW - body weight; PVS - pulmonary vascular system; RT - respiratory tract; OW - organ weight; MR - metabolic rate.

Table G-35

Summary of Cancer Risk for the Resident
West Area Red Water Ponds Area, Plum Brook Ordnance Works
Sandusky, Ohio

		Incidental Ingestion						Dermal Absorption					
Chemical	Exposure Point Concentration (mg/L)	Adult Cancer Dose (mg/kg-day)	Child Cancer Dose (mg/kg-day)	Adult Oral ILCR	Child Oral ILCR	Total Oral ILCR	Cd mg/L	Adult DA (mg/cm^2-day)	Adult Cancer Dose (mg/kg-day)	Child DA (mg/cm^2-day)	Child Cancer Dose (mg/kg-day)	Adult Dermal ILCR	Child Dermal ILCR	Total Dermal ILCR
Metals														
Arsenic	9.50E-03	8.92E-05	5.21E-05	1.34E-04	7.81E-05	2.12E-04	9.50E-03	1.90E-09	1.78E-07	3.16E-09	1.14E-07	2.68E-07	1.72E-07	4.39E-07
Cobalt	2.67E-01	2.51E-03	1.46E-03	NA	NA	NA	2.67E-01	5.34E-08	5.02E-06	8.89E-08	3.22E-06	NA	NA	NA
Nickel	2.78E-01	2.61E-03	1.52E-03	NA	NA	NA	2.78E-01	1.11E-08	1.04E-06	1.85E-08	6.70E-07	NA	NA	NA
Vanadium	5.50E-03	5.17E-05	3.01E-05	NA	NA	NA	5.50E-03	1.10E-09	1.03E-07	1.83E-09	6.62E-08	NA	NA	NA
Semivolatile Organic Compounds														
2,4-Dinitrotoluene	1.90E-02	1.78E-04	1.04E-04	1.21E-04	7.08E-05	1.92E-04	1.90E-02	7.71E-08	7.24E-06	9.94E-08	3.60E-06	4.92E-06	2.45E-06	7.37E-06
4,6-Dinitro-2-methylphenol	2.80E-02	2.63E-04	1.53E-04	NA	NA	NA	1.40E-02	6.32E-08	5.93E-06	8.15E-08	2.95E-06	NA	NA	NA
2,4-Dinitrophenol	1.40E-02	1.32E-04	7.67E-05	NA	NA	NA	1.40E-02	2.78E-08	2.62E-06	3.59E-08	1.30E-06	NA	NA	NA
3-Nitroaniline	1.50E-01	1.41E-03	8.22E-04	2.96E-05	1.73E-05	4.68E-05	1.50E-01	3.13E-07	2.94E-05	4.04E-07	1.46E-05	6.18E-07	3.07E-07	9.25E-07
Nitrobenzene	5.80E-03	5.45E-05	3.18E-05	NA	NA	NA	2.90E-03	1.39E-08	1.30E-06	1.79E-08	6.47E-07	NA	NA	NA
Volatile Organic Compounds														
Benzene	1.10E-03	1.03E-05	6.03E-06	5.68E-07	3.32E-07	9.00E-07	5.50E-04	5.49E-09	5.16E-07	7.09E-09	2.56E-07	2.84E-08	1.41E-08	4.25E-08
Miscellaneous														
Nitrate	7.93E+01	7.45E-01	4.35E-01	NA	NA	NA	7.93E+01	1.59E-05	1.49E-03	2.64E-05	9.55E-04	NA	NA	NA
Nitrate-Nitrite	3.00E-01	2.82E-03	1.64E-03	NA	NA	NA	3.00E-01	6.00E-08	5.64E-06	9.99E-08	3.61E-06	NA	NA	NA
Sulfate	2.66E+03	2.50E+01	1.46E+01	NA	NA	NA	2.66E+03	ND	NA	ND	NA	NA	NA	NA
Total ILCR				**2.85E-04**	**1.66E-04**	**4.52E-04**						**5.84E-06**	**2.94E-06**	**8.78E-06**

ILCR - Incremental lifetime cancer risk.
NA - Not applicable.

Table G-35

Summary of Cancer Risk for the Resident
West Area Red Water Ponds Area, Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Exposure Point Concentration (mg/L)	Concentration in Air (mg/m^3)	Inhalation: Adult Cancer Dose (mg/kg-day)	Inhalation: Child Cancer Dose (mg/kg-day)	Adult Inhalation ILCR	Child Inhalation ILCR	Total Inhalation ILCR	ILCR All Pathways
Metals								
Arsenic	9.50E-03	NA	NA	NA	NA	NA	NA	**2.12E-04**
Cobalt	2.67E-01	NA	NA	NA	NA	NA	NA	**NA**
Nickel	2.78E-01	NA	NA	NA	NA	NA	NA	**NA**
Vanadium	5.50E-03	NA	NA	NA	NA	NA	NA	**NA**
Semivolatile Organic Compounds								
2,4-Dinitrotoluene	1.90E-02	NA	NA	NA	NA	NA	NA	**2.00E-04**
4,6-Dinitro-2-methylphenol	2.80E-02	1.40E-02	1.31E-03	7.66E-04	NA	NA	NA	**NA**
2,4-Dinitrophenol	1.40E-02	NA	NA	NA	NA	NA	NA	**NA**
3-Nitroaniline	1.50E-01	NA	NA	NA	NA	NA	NA	**4.78E-05**
Nitrobenzene	5.80E-03	2.90E-03	2.72E-04	1.59E-04	NA	NA	NA	**NA**
Volatile Organic Compounds								
Benzene	1.10E-03	5.50E-04	5.16E-05	3.01E-05	1.39E-06	8.12E-07	2.21E-06	**3.15E-06**
Miscellaneous								
Nitrate	7.93E+01	NA	NA	NA	NA	NA	NA	**NA**
Nitrate-Nitrite	3.00E-01	NA	NA	NA	NA	NA	NA	**NA**
Sulfate	2.66E+03	NA	NA	NA	NA	NA	NA	**NA**
Total ILCR					**1.39E-06**	**8.12E-07**	**2.21E-06**	**5.E-04**

ILCR - Incremental lifetime cancer risk.
NA - Not applicable.

Table G-36

Summary of Noncancer Risk for the Child Resident
Downgradient Areas at the Facility Boundary, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Exposure Point Concentration (mg/L)	Incidental Ingestion Child Noncancer Dose (mg/kg-day)	Oral HQ	Cd (mg/L)	DA (mg/cm^2-day)	Dermal Absorption Child Noncancer Dose (mg/kg-day)	Dermal HQ	Concentration in Air (mg/m^3)	Inhalation Child Noncancer Dose (mg/kg-day)	Inhalation HQ	**Total HI All Pathways**
Metals											
Chromium	2.44E-02	1.56E-03	5.20E-01	2.44E-02	8.13E-09	3.43E-06	4.57E-02	NA	NA	NA	**5.66E-01**
Iron	2.57E+02	1.64E+01	5.48E+01	2.57E+02	8.56E-05	3.61E-02	1.20E-01	NA	NA	NA	**5.49E+01**
Manganese	4.66E+00	2.98E-01	1.24E+01	4.66E+00	1.55E-06	6.55E-04	NA	NA	NA	NA	**1.24E+01**
Explosives											
2,4-Dinitrotoluene	1.50E-03	9.59E-05	4.79E-02	1.50E-03	7.85E-09	3.31E-06	1.66E-03	NA	NA	NA	**4.96E-02**
2,6-Dinitrotoluene	1.40E-03	8.95E-05	8.95E-02	1.40E-03	4.96E-09	2.09E-06	2.09E-03	NA	NA	NA	**9.16E-02**
2-Nitrotoluene	5.50E-04	3.52E-05	3.52E-04	2.75E-04	3.08E-09	1.30E-06	1.30E-05	2.75E-04	1.76E-04	NA	**3.65E-04**
Nitrobenzene	3.40E-04	2.17E-05	4.35E-02	1.70E-04	1.05E-09	4.42E-07	8.84E-04	1.70E-04	1.09E-04	1.90E-01	**2.35E-01**
Semivolatile Organic Compounds											
2-Methylnaphthalene	2.40E-02	1.53E-03	7.67E-02	1.20E-02	1.39E-06	5.85E-04	2.93E-02	1.20E-02	7.66E-03	8.91E+00	**9.01E+00**
Bis(2-ethylhexyl)phthalate	9.70E-03	6.20E-04	3.10E-02	9.70E-03	1.26E-06	5.33E-04	2.66E-02	NA	NA	NA	**5.76E-02**
Naphthalene	1.80E-02	1.15E-03	5.75E-02	9.00E-03	5.05E-07	2.13E-04	1.07E-02	9.00E-03	5.74E-03	6.68E+00	**6.75E+00**
Volatile Organic Compounds											
Benzene	1.30E-01	8.31E-03	2.08E+00	6.50E-02	8.38E-07	3.53E-04	8.84E-02	6.50E-02	4.15E-02	4.82E+00	**6.99E+00**
Chlorobenzene	1.10E-02	7.03E-04	3.52E-02	5.50E-03	1.67E-07	7.03E-05	3.52E-03	5.50E-03	3.51E-03	6.16E-01	**6.55E-01**
Methylene chloride	9.80E-02	6.26E-03	1.04E-01	4.90E-02	1.55E-07	6.53E-05	1.09E-03	4.90E-02	3.13E-02	3.64E-02	**1.42E-01**
Toluene	1.80E-01	1.15E-02	5.75E-02	9.00E-02	2.63E-06	1.11E-03	5.56E-03	9.00E-02	5.74E-02	5.22E-01	**5.85E-01**
Xylenes, total	5.60E-01	3.58E-02	1.79E-01	2.80E-01	1.53E-05	6.47E-03	3.24E-02	2.80E-01	1.79E-01	6.16E+00	**6.37E+00**
Miscellaneous											
Cyanide, total	3.20E-01	2.05E-02	1.02E+00	3.20E-01	8.15E-08	3.44E-05	1.72E-03	NA	NA	NA	**1.02E+00**
Sulfate	1.28E+03	8.18E+01	NA	1.28E+03	ND	NA	NA	NA	NA	NA	**NA**
Total HI			**7.15E+01**				**3.70E-01**			**2.79E+01**	**100**

HQ - Hazard quotient; HI - Hazard index.
NA - Not applicable.

Table G-37

Separation of Noncancer Hazard by Target Organ
Child Resident Exposure to Groundwater
Downgradient Areas at the Facility Boundary, Former Plum Brook Ordnance Works
Sandusky, Ohio

	Target Organs													
COPC	NS/CNS	GI	Fetus & Repro	URT/ Lung	Iron Overload	Kidney	Erythrocyte	Eye	Reduced BW/OW	N & O epithelia	Blood/ Blood cells	Liver	Spleen	Thyroid
Metals														
Chromium		5.66E-01	5.66E-01											
Iron					5.49E+01									
Manganese	1.24E+01													
Explosives														
2,4-Dinitrotoluene	4.96E-02						4.96E-02					4.96E-02		
2,6-Dinitrotoluene	9.16E-02					9.16E-02	9.16E-02					9.16E-02		
2-Nitrotoluene													3.65E-04	
Nitrobenzene						2.35E-01	2.35E-01					2.35E-01		
Semivolatile Organic Compounds														
2-Methylnaphthalene							1.06E-01	1.06E-01	1.06E-01	8.91E+00				
Bis(2-ethylhexyl)phthalate	5.76E-02											5.76E-02		
Naphthalene							6.82E-02	6.82E-02	6.82E-02	6.68E+00				
Volatile Organic Compounds														
Benzene											6.99E+00			
Chlorobenzene						6.16E-01						6.55E-01		
Methylene chloride							1.42E-01					1.42E-01		
Toluene	2.11E-01	5.22E-01		5.22E-01		2.11E-01						2.11E-01		
Xylenes, total	6.16E+00								2.11E-01					
Miscellaneous														
Cyanide, total	1.02E+00								1.02E+00					1.02E+00
Total HI	**20**	**1**	**0.6**	**0.5**	**55**	**1**	**0.7**	**0.2**	**1**	**16**	**7**	**1**	**0**	**1**

COPC - Chemical of potential concern.
HI - Hazard Index.
Target Organs: NS/CNS - nervous system/central nervous system; BW - body weight; N & O - nasal and olfactory; PVS - pulmonary vascular system; GI - gastrointestinal; OW - organ weight; URT - upper respiratory tract.

Table G-38

Risk Evaluation for the Adult Resident
Downgradient Areas at the Facility Boundary, Former Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Exposure Point Concentration (mg/L)	Incidental Ingestion Adult Noncancer Dose (mg/kg-day)	Oral HQ	Cd mg/L	DA mg/cm2-day	Dermal Absorption Adult Noncancer Dose (mg/kg-day)	Dermal HQ	Concentration in Air (mg/m^3)	Inhalation Adult Noncancer Dose (mg/kg-day)	Inhalation HQ	**Total HI All Pathways**
Metals											
Chromium	2.44E-02	6.68E-04	2.23E-01	2.44E-02	4.88E-09	1.34E-06	1.78E-02	NA	NA	NA	**2.41E-01**
Iron	2.57E+02	7.04E+00	2.35E+01	2.57E+02	5.14E-05	1.41E-02	4.69E-02	NA	NA	NA	**2.35E+01**
Manganese	4.66E+00	1.28E-01	5.32E+00	4.66E+00	9.32E-07	2.55E-04	NA	NA	NA	NA	**5.32E+00**
Explosives											
2,4-Dinitrotoluene	1.50E-03	4.11E-05	2.05E-02	1.50E-03	6.08E-09	1.67E-06	8.33E-04	NA	NA	NA	**2.14E-02**
2,6-Dinitrotoluene	1.40E-03	3.84E-05	3.84E-02	1.40E-03	3.85E-09	1.05E-06	1.05E-03	NA	NA	NA	**3.94E-02**
2-Nitrotoluene	5.50E-04	1.51E-05	1.51E-04	2.75E-04	2.39E-09	6.54E-07	6.54E-06	2.75E-04	7.53E-05	NA	**1.57E-04**
Nitrobenzene	3.40E-04	9.32E-06	1.86E-02	1.70E-04	8.12E-10	2.23E-07	4.45E-04	1.70E-04	4.66E-05	8.17E-02	**1.01E-01**
Semivolatile Organic Compounds											
2-Methylnaphthalene	2.40E-02	6.58E-04	3.29E-02	1.20E-02	1.08E-06	2.95E-04	1.47E-02	1.20E-02	3.29E-03	3.82E+00	**3.87E+00**
Bis(2-ethylhexyl)phthalate	9.70E-03	2.66E-04	1.33E-02	9.70E-03	9.78E-07	2.68E-04	1.34E-02	NA	NA	NA	**2.67E-02**
Naphthalene	1.80E-02	4.93E-04	2.47E-02	9.00E-03	3.91E-07	1.07E-04	5.36E-03	9.00E-03	2.46E-03	2.87E+00	**2.90E+00**
Volatile Organic Compounds											
Benzene	1.30E-01	3.56E-03	8.90E-01	6.50E-02	6.49E-07	1.78E-04	4.45E-02	6.50E-02	1.78E-02	2.07E+00	**3.00E+00**
Chlorobenzene	1.10E-02	3.01E-04	1.51E-02	5.50E-03	1.29E-07	3.54E-05	1.77E-03	5.50E-03	1.51E-03	2.64E-01	**2.81E-01**
Methylene chloride	9.80E-02	2.68E-03	4.47E-02	4.90E-02	1.20E-07	3.29E-05	5.48E-04	4.90E-02	1.34E-02	1.56E-02	**6.09E-02**
Toluene	1.80E-01	4.93E-03	2.47E-02	9.00E-02	2.04E-06	5.59E-04	2.80E-03	9.00E-02	2.46E-02	2.24E-01	**2.52E-01**
Xylenes, total	5.60E-01	1.53E-02	7.67E-02	2.80E-01	1.19E-05	3.26E-03	1.63E-02	2.80E-01	7.67E-02	2.64E+00	**2.74E+00**
Miscellaneous											
Cyanide, total	3.20E-01	8.77E-03	4.38E-01	3.20E-01	4.90E-08	1.34E-05	6.71E-04	NA	NA	NA	**4.39E-01**
Sulfate	1.28E+03	3.51E+01	NA	1.28E+03	ND	NA	NA	NA	NA	NA	**NA**
Total HI			**3.07E+01**				**1.67E-01**			**1.20E+01**	**43**

HQ - Hazard quotient; HI - Hazard index.
NA - Not applicable.

Table G-39

Separation of Noncancer Hazard by Target Organ
Adult Resident Exposure to Groundwater
Downgradient Areas at the Facility Boundary, Former Plum Brook Ordnance Works
Sandusky, Ohio

	Target Organs													
COPC	NS/CNS	GI	Fetus & Repro	URT/ Lung	Iron Overload	Kidney	Erythrocyte	Eye	Reduced BW/OW	N & O epithelia	Blood/ Blood cells	Liver	Spleen	Thyroid
Metals														
Chromium		0.24	0.24											
Iron					23.52									
Manganese	5.32													
Explosives														
2,4-Dinitrotoluene	0.02						0.02					0.02		
2,6-Dinitrotoluene	0.04					0.04	0.04					0.04		
2-Nitrotoluene													0.00	
Nitrobenzene						0.10	0.10					0.10		
Semivolatile Organic Compounds														
2-Methylnaphthalene							0.05	0.05	0.05	3.82				
Bis(2-ethylhexyl)phthalate												0.03		
Naphthalene							0.03	0.03	0.03	2.87				
Volatile Organic Compounds														
Benzene											3.00			
Chlorobenzene						0.26						0.28		
Methylene chloride							0.06					0.06		
Toluene	0.03	0.22		0.22		0.03						0.03		
Xylenes, total	2.64								0.09					
Miscellaneous														
Cyanide, total	0.44								0.44					0.44
Total HI	**8**	**0.5**	**0.2**	**0.2**	**24**	**0.4**	**0.3**	**0.08**	**0.6**	**7**	**3**	**0.6**	**0**	**0.4**

COPC - Chemical of potential concern.
HI - Hazard index.
Target Organs: NS/CNS - nervous system/central nervous system; BW - body weight; N & O - nasal and olfactory; PVS - pulmonary vascular system; GI - gastrointestinal; OW - organ weight; URT - upper respiratory tract.

Table G-40

Summary of Cancer Risk for the Resident
Downgradient Areas at the Facility Boundary, Plum Brook Ordnance Works
Sandusky, Ohio

		Incidental Ingestion						Dermal Absorption						
Chemical	Exposure Point Concentration (mg/L)	Adult Cancer Dose (mg/kg-day)	Child Cancer Dose (mg/kg-day)	Adult Oral ILCR	Child Oral ILCR	Total Oral ILCR	Cd mg/L	Adult DA (mg/cm^2-day)	Adult Cancer Dose (mg/kg-day)	Child DA (mg/cm^2-day)	Child Cancer Dose (mg/kg-day)	Adult Dermal ILCR	Child Dermal ILCR	Total Dermal ILCR
Metals														
Chromium	2.44E-02	2.29E-04	1.34E-04	NA	NA	NA	2.44E-02	4.88E-09	4.58E-07	8.13E-09	2.94E-07	NA	NA	NA
Iron	2.57E+02	2.41E+00	1.41E+00	NA	NA	NA	2.57E+02	5.14E-05	4.83E-03	8.56E-05	3.09E-03	NA	NA	NA
Manganese	4.66E+00	4.38E-02	2.55E-02	NA	NA	NA	4.66E+00	9.32E-07	8.75E-05	1.55E-06	5.61E-05	NA	NA	NA
Explosives														
2,4-Dinitrotoluene	1.50E-03	1.41E-05	8.22E-06	9.58E-06	5.59E-06	1.52E-05	1.50E-03	6.08E-09	5.72E-07	7.85E-09	2.84E-07	3.89E-07	1.93E-07	5.82E-07
2,6-Dinitrotoluene	1.40E-03	1.32E-05	7.67E-06	8.94E-06	5.22E-06	1.42E-05	1.40E-03	3.85E-09	3.61E-07	4.96E-09	1.80E-07	2.46E-07	1.22E-07	3.68E-07
2-Nitrotoluene	5.50E-04	5.17E-06	3.01E-06	1.19E-06	6.93E-07	1.88E-06	2.75E-04	2.39E-09	2.24E-07	3.08E-09	1.11E-07	5.15E-08	2.56E-08	7.71E-08
Nitrobenzene	3.40E-04	3.19E-06	1.86E-06	NA	NA	NA	1.70E-04	8.12E-10	7.63E-08	1.05E-09	3.79E-08	NA	NA	NA
Semivolatile Organic Compounds														
2-Methylnaphthalene	2.40E-02	2.25E-04	1.32E-04	NA	NA	NA	1.20E-02	1.08E-06	1.01E-04	1.39E-06	5.02E-05	NA	NA	NA
Bis(2-ethylhexyl)phthalate	9.70E-03	9.11E-05	5.32E-05	1.28E-06	7.44E-07	2.02E-06	9.70E-03	9.78E-07	9.19E-05	1.26E-06	4.57E-05	1.29E-06	6.39E-07	1.93E-06
Naphthalene	1.80E-02	1.69E-04	9.86E-05	NA	NA	NA	9.00E-03	3.91E-07	3.68E-05	5.05E-07	1.83E-05	NA	NA	NA
Volatile Organic Compounds														
Benzene	1.30E-01	1.22E-03	7.12E-04	6.72E-05	3.92E-05	1.06E-04	6.50E-02	6.49E-07	6.10E-05	8.38E-07	3.03E-05	3.35E-06	1.67E-06	5.02E-06
Chlorobenzene	1.10E-02	1.03E-04	6.03E-05	NA	NA	NA	5.50E-03	1.29E-07	1.21E-05	1.67E-07	6.03E-06	NA	NA	NA
Methylene chloride	9.80E-02	9.21E-04	5.37E-04	6.90E-06	4.03E-06	1.09E-05	4.90E-02	1.20E-07	1.13E-05	1.55E-07	5.60E-06	8.45E-08	4.20E-08	1.26E-07
Toluene	1.80E-01	1.69E-03	9.86E-04	NA	NA	NA	9.00E-02	2.04E-06	1.92E-04	2.63E-06	9.52E-05	NA	NA	NA
Xylenes, total	5.60E-01	5.26E-03	3.07E-03	NA	NA	NA	2.80E-01	1.19E-05	1.12E-03	1.53E-05	5.55E-04	NA	NA	NA
Miscellaneous														
Cyanide, total	3.20E-01	3.01E-03	1.75E-03	NA	NA	NA	3.20E-01	4.90E-08	4.60E-06	8.15E-08	2.95E-06	NA	NA	NA
Sulfate	1.28E+03	1.20E+01	7.01E+00	NA	NA	NA	1.28E+03	ND	NA	ND	NA	NA	NA	NA
Total ILCR				**9.51E-05**	**5.54E-05**	**1.51E-04**						**5.41E-06**	**2.69E-06**	**8.10E-06**

ILCR - Incremental lifetime cancer risk.
NA - Not applicable.

Table G-40

Summary of Cancer Risk for the Resident
Downgradient Areas at the Facility Boundary, Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Exposure Point Concentration (mg/L)	Concentration in Air (mg/m^3)	Inhalation: Adult Cancer Dose (mg/kg-day)	Inhalation: Child Cancer Dose (mg/kg-day)	Adult Inhalation ILCR	Child Inhalation ILCR	Total Inhalation ILCR	**Total ILCR All Pathways**
Metals								
Chromium	2.44E-02	NA	NA	NA	NA	NA	NA	**NA**
Iron	2.57E+02	NA	NA	NA	NA	NA	NA	**NA**
Manganese	4.66E+00	NA	NA	NA	NA	NA	NA	**NA**
Explosives								
2,4-Dinitrotoluene	1.50E-03	NA	NA	NA	NA	NA	NA	**1.58E-05**
2,6-Dinitrotoluene	1.40E-03	NA	NA	NA	NA	NA	NA	**1.45E-05**
2-Nitrotoluene	5.50E-04	2.75E-04	2.58E-05	1.50E-05	NA	NA	NA	**1.96E-06**
Nitrobenzene	3.40E-04	1.70E-04	1.60E-05	9.30E-06	NA	NA	NA	**NA**
Semivolatile Organic Compounds								
2-Methylnaphthalene	2.40E-02	1.20E-02	1.13E-03	6.56E-04	NA	NA	NA	**NA**
Bis(2-ethylhexyl)phthalate	9.70E-03	NA	NA	NA	NA	NA	NA	**3.95E-06**
Naphthalene	1.80E-02	9.00E-03	8.45E-04	4.92E-04	NA	NA	NA	**NA**
Volatile Organic Compounds								
Benzene	1.30E-01	6.50E-02	6.10E-03	3.56E-03	1.65E-04	9.60E-05	2.61E-04	**3.72E-04**
Chlorobenzene	1.10E-02	5.50E-03	5.16E-04	3.01E-04	NA	NA	NA	**NA**
Methylene chloride	9.80E-02	4.90E-02	4.60E-03	2.68E-03	7.36E-06	4.29E-06	1.17E-05	**2.27E-05**
Toluene	1.80E-01	9.00E-02	8.45E-03	4.92E-03	NA	NA	NA	**NA**
Xylenes, total	5.60E-01	2.80E-01	2.63E-02	1.53E-02	NA	NA	NA	**NA**
Miscellaneous								
Cyanide, total	3.20E-01	NA	NA	NA	NA	NA	NA	**NA**
Sulfate	1.28E+03	NA	NA	NA	NA	NA	NA	**NA**
Total ILCR					**1.72E-04**	**1.00E-04**	**2.72E-04**	**4.E-04**

ILCR - Incremental lifetime cancer risk.
NA - Not applicable.

APPENDIX H

EVALUATION OF SITE RELATEDNESS

Appendix H

Evaluation of Site Relatedness

This appendix evaluates information concerning each chemical of potential concern (COPC) for bedrock groundwater identified in Chapter 2.0 of this groundwater baseline human health risk assessment (BHHRA) report and quantitatively evaluated for exposure and risk. It addresses issues such as elevated concentrations due to sampling methods and potential for laboratory artifacts. Elevated concentrations associated with sampling methods among inorganics may sometimes be identified by a review of the sample collection logs and comparisons made between unfiltered and filtered sample results. This evaluation considers the presence of petroleum at depth in boring logs and whether petroleum-related COPCs (or other COPCs) were detected in the overburden groundwater and soil samples. Other information includes the general prevalence of a COPC throughout the Plum Brook Ordnance Works (PBOW) facility and historical information.

Based on this information, a determination was made for each of the COPCs, not just those associated with unacceptable risks. Table H-1 provides a synopsis of this evaluation. The list of COPCs identified as site related is the product of data review and best professional judgment. It was recognized that a level of uncertainty would be associated with any selection of site-related chemicals, so care was taken not to remove a COPC as non-site related without logical cause. Thus, an effort was made to err on the side of inclusion as site related rather than exclusion. *COPCs identified as site related are shown in shaded italics.*

TNT Area A. Wilcoxon Rank Sum (WRS) statistical testing was performed to compare TNT Area A (TNTA) versus background concentrations of inorganic COPCs that were detected in the PBOW background groundwater data set (aluminum, arsenic, iron, manganese, and nickel). Refer to Appendix C of this groundwater BHHRA report for WRS results. Because only 6 samples (5 for aluminum) are in the TNTA data set, population testing results have considerable uncertainty.

All of the inorganics listed below were at their highest concentration in one of the two samples collected from TNTA-BEDGW-001. These could not be collected via low flow because of poor well yield. Petroleum was observed on rock cores at depth (68 to 85 feet below ground surface [bgs]) during well installation.

Also, during April 2002 sampling, 3 gallons of naturally occurring petroleum were removed from well TNTA-BEDGW-001. In October 2001, this well was sampled until dry and was described as "light nonaqueous-phase liquid sticky, oily".

- ***Aluminum.*** Only one sample (8,300 micrograms per liter [µg/L] in TNTA-BEDGW-001 in April 2002) exceeded the background screening concentration (BSC) (309 µg/L). The concentration in the filtered fraction of this sample was 74 µg/L. Another relatively high detection, 283 µg/L, found in a bailer-collected sample from BED-MW18 in 1997, has not been replicated in the samples collected from this well since then (nondetect [ND], 54.6 µg/L, and 79.2 µg/L). The WRS results suggested a difference between site and background data sets (p=0.039). Aluminum does not appear to be site related, and the single elevated detection appears to be associated with sampling method.

- ***Arsenic.*** The two samples from TNTA-BEDGW-001 (10.8J and 17.3J µg/L) in 2001 and 2002 exceeded the BSC/maximum detected concentration (MDC) (7.4 µg/L). The other four samples were ND. Arsenic was ND in the filtered fractions from TNTA-BEDGW-001 (reporting limit [RL] of 10 µg/L in 2001 and 2002). The WRS results indicate a difference between site and background data sets (p=0.002); but this is largely influenced by the high RLs of two of the site samples (200 and 100 µg/L) from well BED-MW18 that were ND.

- ***Chromium.*** Chromium was detected only in the sample from TNTA-BEDGW-001, at an estimated concentration of 37.2 J µg/L. It was detected in the filtered fraction from this sample at 6.8 J µg/L, which is less than the risk-based screening concentration (RBSC) (10.9 µg/L).

- ***Iron.*** Only one sample (33,400 µg/L in TNTA-BEDGW-001) exceeded the BSC (1,550 µg/L). The filtered fraction from this location had a concentration of only 152 µg/L. The WRS results do not suggest site relatedness (p=0.48), though considerable uncertainty is associated with the relatively small sample size.

- ***Lead.*** Lead was detected only in the sample from TNTA-BEDGW-001, at an estimated concentration of 18.4 J µg/L. It was not detected in the filtered fraction from this sample. Although lead was detected at elevated concentrations in soil, these concentrations were limited to upper 3 feet or so, and only immediately adjacent to certain buildings. The WRS results do not suggest site relatedness (p=0.13), though considerable uncertainty is associated with the relatively small sample size. The single detection of lead in bedrock groundwater appears to be associated with sampling technique.

- ***Manganese.*** The two samples from TNTA-BEDGW-001 (11,700 and 1,830 µg/L) exceeded the BSC (636 µg/L). Manganese was detected at concentrations of 54.4 and 26.7 µg/L in the filtered fractions from these samples, well below the

BSC. All other unfiltered samples have concentrations (36.8 to 109 µg/L) well below the BSC.

- ***Nickel.*** The two samples from TNTA-BEDGW-001 (75.7 and 48.8 µg/L) exceeded the BSC (8.6 µg/L). Nickel was not detected in the filtered fraction from these samples. The WRS results suggest possible site relatedness (p=0.09), though considerable uncertainty is associated with the relatively small sample size. The lack of detection in the filtered fractions indicates that the BSC exceedances were associated with sampling method.

- ***Vanadium.*** Chromium was detected only in the sample from TNTA-BEDGW-001, at an estimated concentration of 36.9 J µg/L. It was not detected in the filtered fraction from this sample.

- ***Nitrotoluenes (DNTs, 2NT, 4ADNT).*** *Assumed to be site related.*

- ***Nitrobenzene.*** *Assumed to be site-related.*

- ***1,3-Dinitrobenzene.*** *Assumed to be site-related.*

- ***Benzene.*** Highest concentrations are found in the TNTA-BEDGW-001 samples (700 J and 490 J µg/L), though 3 of the other 4 (5.7 to 14 J µg/L) samples had concentrations greater than the BSC (2.4 µg/L). Also, benzene was detected in only 2 of 27 TNTA overburden groundwater samples (including direct-push and monitoring wells), and these were at substantially lower concentrations (0.17 and 4.81 µg/L, respectively). Benzene was not identified as a soil COPC (MDC: 0.00601 milligrams per kilogram [mg/kg]). Three gallons of naturally occurring petroleum were removed from this well in April 2002. Based on these observations, benzene is likely associated with naturally occurring petroleum in the Delaware Limestone.

- ***Chloromethane.*** Was detected in only 1 of 6 samples, the sample collected from BED-MW18 in 2001 at an estimated concentration of 35 J µg/L. It was not detected in the other 3 samples collected from this well in 1997, 1998, or 2002. Also, chloromethane was not detected in any of the TNTA overburden samples, soil samples, nor was it detected in the bedrock groundwater from any of the other 4 sites evaluated as part of this groundwater BHHRA. Based on these observations, the presence of chloromethane in TNTA bedrock groundwater is questionable.

- ***Ethylbenzene.*** Highest concentrations are found in the TNTA-BEDGW-001 samples (240 J and 210 J µg/L), though each of the other 4 (32 to 100 J µg/L) samples had concentrations much greater than the BSC (0.87 µg/L). Also, ethylbenzene was not detected in any of the 15 TNTA overburden well samples and detected in only 1 of 12 overburden direct-push groundwater samples (2.33 µg/L). Benzene was not identified as a soil COPC (MDC: 0.00248 mg/kg).

Based on these observations, ethylbenzene is likely associated with naturally occurring petroleum in the Delaware Limestone.

- ***Methylene chloride.*** Was reported in 3 of the 6 TNTA bedrock groundwater samples, and in another sample it was shown to be present due to blank contamination. Methylene chloride is recognized as a common laboratory contaminant. The highest reported concentrations were in the TNTA-BEDGW-001 samples (330 J µg/L and 170 J µg/L). It was also reported in one of the BED MW-18 samples (47 J µg/L) at a lower concentration. These samples were diluted prior to analysis and the RLs are accordingly elevated. The J-qualified values for methylene chloride in these samples are not inconsistent with laboratory contamination (though it was not detected in the laboratory blanks associated with these samples). Methylene chloride was not detected in the overburden groundwater samples and was not identified as a soil COPC.

- ***Toluene.*** Highest concentrations are found in the TNTA-BEDGW-001 samples (730 J and 630 J µg/L), though 3 of the other 4 (21 to 74 J µg/L) samples had concentrations much greater than the BSC (1.7 µg/L). Toluene was detected in 2 of 12 overburden groundwater well samples (7.8 and 10 µg/L) and 3 of 12 direct-push samples. Toluene concentrations in two of the direct-push samples were low (1.11 and 5.25 µg/L), but the toluene concentration of one of the samples was elevated (1,350 µg/L). Toluene was present in 13 of 39 soil samples (12 of 31 subsurface soil samples) at concentrations ranging from 0.00196 to 0.013 mg/kg and was no identified as a soil COPC. Elevated toluene concentrations observed in the TNTA-BEDGW-001 well are likely associated with naturally occurring petroleum in the Delaware Limestone. However, the elevated direct-push concentration may be site related, though it is noted that toluene was not known to ever have been stored near this location.

- ***Xylenes.*** Highest concentrations are found in the TNTA-BEDGW-001 samples (1,400 and 1,200 µg/L), though all of the other 4 (150 to 420 µg/L) samples had concentrations much greater than the BSC (5.5 µg/L). Xylenes were not detected in any of the overburden groundwater well samples, and were detected in only 1 of 10 direct-push overburden groundwater samples (12.3 µg/L combined xylenes). Also, xylenes were detected in only 1 of the 39 TNTA soils samples (0.01 mg/kg combined xylenes). Xylenes are likely associated with naturally occurring petroleum in the Delaware Limestone.

- ***Naphthalene.*** Highest concentrations are found in the TNTA-BEDGW-001 samples (3.1 J and 10 µg/L), though it was detected in each of the other 4 samples (3.1 J to 10 µg/L). Naphthalene was not detected in TNTA overburden groundwater. It was detected in only 1 of 39 soil samples (0.652 mg/kg) and was not identified as a groundwater COPC. Naphthalene is likely associated with naturally occurring petroleum in the Delaware Limestone.

- ***2-Methylnaphthalene.*** Highest concentrations are found in the TNTA-BEDGW-001 samples (470 and 47 µg/L), though it was detected in each of the other 4 samples (1.6 J to 5.3 J µg/L). 2-Methylnaphthalene was not detected in TNTA overburden groundwater. It was detected in only 4 of 39 soil samples (0.0907 to 1.15 mg/kg) and was not identified as a soil COPC. 2-Methylnaphthalene is likely associated with naturally occurring petroleum in the Delaware Limestone.

- ***bis(2-Ethylhexyl)phthalate (BEHP).*** Common laboratory contaminant was reported as detected in 2 of 5 TNTA bedrock groundwater samples (3.5 to 8.6 µg/L). It was reported in another bedrock groundwater sample at 16 µg/L (from BEDGW-018 sample collected in 1998), this samples was qualified "B" as blank contaminated. BEHP was detected in only 1 of 27 overburden groundwater samples. It was reported in 5 of 39 TNTA soil samples at low concentrations (0.023 to 0.060 mg/kg), and was not a soil COPC. It is likely that BEHP in bedrock groundwater is associated with laboratory contamination rather than former site operations.

- ***Chrysene.*** The only detections were found in the TNTA-BEDGW-001 samples (15 J and 0.62 J µg/L). Chrysene was not detected in TNTA overburden groundwater. It was detected in only 4 of 39 soil samples (0.0733 to 0.202 mg/kg) and was not identified as a soil COPC. Chrysene is likely associated with naturally occurring petroleum in the Delaware Limestone.

- ***Dibenzofuran.*** Only detection (12 J µg/L) was in the TNTA-BEDGW-001 sample from which 3 gallons of naturally occurring petroleum were removed prior to sampling. Dibenzofuran was not detected in TNTA overburden groundwater nor TNTA soil. Dibenzofuran is likely associated with naturally occurring petroleum in the Delaware Limestone.

- ***Fluorene.*** Only detections were found in the TNTA-BEDGW-001 samples (1.9 J and 28 J µg/L). Fluorene was not detected in TNTA overburden groundwater. It was not detected in any TNTA soil samples. Fluorene is likely associated with naturally occurring petroleum in the Delaware Limestone.

- ***Phenanthrene.*** Only detections were found in the TNTA-BEDGW-001 samples (74 J and 3.4 J µg/L). Phenanthrene was not detected in TNTA overburden groundwater. It was detected in 5 of 39 soil samples (0.0516 to 0.45 mg/kg) and was not identified as a soil COPC. Phenanthrene is likely associated with naturally occurring petroleum in the Delaware Limestone.

TNT Area B. WRS statistical testing was performed to compare site versus background concentrations of inorganic chemicals of potential concern that were detected in the TNT Area B (TNTB) background groundwater data set (aluminum, arsenic, iron, and manganese). Refer to Appendix B of this BHHRA report for WRS results. In each case, the site TNTB data was

shown to be statistically different from PBOW background. However, sampling methods and other factors likely played a substantial role in these TNTB analytical results. Also, because only 8 samples are in the TNTB data set, population testing results have considerable uncertainty.

All inorganics, except iron and magnesium, were at their highest concentration in one of the two samples collected from TNTB-BEDGW-003. These could not be collected via low-flow because of poor well yield.

- ***Aluminun.*** Was detected in 7 of 7 samples (53.1 to 16.900 µg/L); it was also reported in an additional sample, which was qualified "B" as blank contaminated. Aluminum was reported as detected only in one unfiltered fraction (56.7 J µg/L in the 2002 sample from TNTB-BEDGW-003). All other filtered fractions were either ND or were qualified "B." Aluminum was identified as present at background concentrations in TNTB soil. WRS results indicate a statistical significance (p=0.003) that the site data set are truly different from the background data set, but these test results were run with the very bailer-collected samples which are in question. The presence of aluminum at relatively high concentrations in TNTB bedrock groundwater appears to be related to sampling method.

- ***Arsenic.*** Was detected in 3 of 8 samples (12.5 to 22.7 µg/L). Of these three detections, arsenic was detected in only one of the filtered fractions and at a concentration of only 4.9 µg/L (TNTB-BEDGW-003), which is less than the BSC of 7.4 µg/L. WRS results indicate a statistical significance (p=0.036) that the site data set are truly different from the background data set, but these test results were run with the questionable bailer-collected samples.

- ***Chromium.*** Chromium was detected in 3 of 8 samples (1.3 to 32.3 µg/L), 2 (both from TNTB-BEDGW-003) of which exceeded the RBSC (10.9 µg/L). Chromium was detected in only one filtered sample, at a concentration (1.2 J µg/L) substantially less than the RBSC. The occurrence of chromium at concentrations approaching or exceeding the RBSC in bedrock groundwater appears to be associated with sampling method rather than former site operations.

- ***Iron.*** Was detected in 7 of 8 samples. It was detected in the 1997 filtered fraction from TNTB-BEDGW-001 collected by bailer at concentrations as high as 16,300 µg/L and in the low-flow unfiltered samples at concentrations as 8,090 µg/L (filtered at 5,670 µg/L) in TNTB-BEDGW-004. Each of these concentrations is greater than the MDC of the background (1,550 µg/L). WRS results indicate that TNTB iron concentrations are significantly higher than those of background (p=0.008), though the uncertainties of the results are noted. Soil results indicate that iron was present at background concentrations. Field Eh measurements indicate strongly reducing conditions, ranging from -364 to -43 millivolts. Hydrogen was sulfide present in the only sample in which it was measured (87

parts per million); this likewise indicates reducing conditions. Under such reducing conditions, elevated dissolved iron (indicative of the ferrous form) is expected. Association of elevated manganese with reducing conditions is corroborated with the presence of elevated dissolved manganese.

- ***Lead.*** Lead was detected in 4 of 8 samples (3.9 to 15.7 µg/L). Only one of these (from TNTB-BEDGW-003 in 2001) was marginally above the RBSC (15 µg/L). It was not detected any of the filtered fractions, nor in any of the samples collected via low-flow.

- ***Manganese.*** Was detected in all 8 TNTB samples collected (32.7 to 1,140 µg/L). Three samples exceeded the BSC (636 µg/L) and two exceeded the MDC of the PBOW background data set (688 µg/L). Of the two that exceeded the background MDC, the higher was detected at only 1.6 µg/L in the filtered fraction (1997 sample from TNTB-BEDMW-003). The second-highest (923 µg/L) was a low-flow sample from TNTB-BEDGW-004; the filtered fraction from this sample was detected at 812 µg/L, indicating that the manganese at this location is likely not the result of sampling technique. WRS results indicate that TNTB bedrock groundwater manganese concentrations are significantly higher than those of background (p=0.012). Manganese in soils was determined to be present at background concentrations. WRS was run eliminating the highest sample, but the p value (0.035) still indicated significant difference from background. The uncertainties of the WRS tests, especially given the relatively small data sets, are duly noted. The BSC exceedances were relatively minor, and the apparent departure from the site data may largely reflect sampling method. Field Eh measurements indicate strongly reducing conditions, ranging from -364 to -43. Hydrogen was sulfide present in the only sample in which it was measured (87 parts per million); this likewise indicates reducing conditions. Under such reducing conditions, elevated dissolved manganese (indicative of the 2+ valence form) is expected. Association of elevated manganese with reducing conditions is corroborated with the presence of elevated dissolved iron.

- ***Vanadium.*** Was detected in 3 of 8 samples (2.3 J to 48.6 J µg/L), with the two highest concentrations found in TNTB-BEDGW-003. It was not detected in any of the background samples. Vanadium was detected in the filtered fractions of the two TNTB-BEDGW-003 samples, but at much lower concentrations (8.5 J and 6.3 J µg/L, respectively) which only moderately exceed the RBSC (3.65 µg/L). Vanadium was not detected in overburden groundwater. It was detected in only 5 of 32 soil samples, and at concentrations well within the range of PBOW background.

- ***2-Methylnapthalene and Naphthalene.*** Were detected in only 1 of 8 samples, at estimated concentrations of 4.8 J and 2.8 J, respectively. Each was detected in the sample from TNTB-BEDGW-003, which was bailed dry prior to sampling in April 2002. It is possible that these compounds are associated with naturally occurring petroleum in the shale bedrock, as benzene has also been

detected in this well. Neither compound was detected in overburden groundwater. 2-Methylnaphthalene was detected in 6 of 28 soil samples and at an MDC of 0.17 mg/kg. Naphthalene was detected in only 3 of 28 samples, and at an MDC of 0.073 mg/kg.

- ***Benzene.*** Detected in 5 of 8 samples (0.14 to 17 µg/L). The concentrations in only two of these samples, both collected by bailer from TNTB-BEDGW-003 (14 and 17 µg/L), exceed the RBSC (0.365 µg/L) by more than a moderate amount. It is possible that benzene is associated with petroleum in the shale bedrock. Benzene has not been detected in TNTB soil or overburden groundwater.

TNT Area C. Petroleum odor was noted at a depth of 31 feet bgs and hydrogen sulfide was also encountered during the drilling of BED MW13. An oily odor and/or oil spots were noted on rock cores at a depth range of 41 to 66 feet bgs. BED-MW13 was bailed dry during purging and is extremely slow to recover to normal water elevation after sampling. In April 2002, a 40-foot water column was bailed dry, and the water column recovery was less than 3 feet the next day.

- ***2-Methylnaphthalene.*** Detected in each of the 6 TNT Area C (TNTC) bedrock samples at concentrations ranging from 3.2 to 34 µg/L. 2-Methylnaphthalene was not detected in any of the 25 overburden groundwater samples. It was detected in 9 of 39 TNTC soil samples, but only at low concentrations (0.01 to 1.15 mg/kg). Benzene, toluene, ethylbenzene, and xylenes (BTEX) compounds were also detected in the TNTC wells, especially BED-MW13 which had the highest concentrations of BTEX and 2-methylnaphthalene. As mentioned above, BED-MW13 was bailed dry during purging and is extremely slow to recover to normal water elevation after sampling.

- ***bis(2-Ethylhexyl)phthalate.*** Detected in 4 of 6 samples, including all 4 collected from BED-MW13 (5.2 J µg/L to 55 J µg/L). It was detected in much lower concentrations in the 2001 (7.7 J µg/L) and 2002 (5.2 J µg/L) samples than in the earlier samples collected in 1997 (39 µg/L) and 1998 (55 J µg/L). It was detected in only 1 of 24 overburden groundwater samples (7.3 J µg/L) and in 5 of 39 TNTC soil samples at very low concentrations (0.023 J to 0.06 J mg/kg). The detected concentrations of this common laboratory contaminant are consistent with those of laboratory contamination.

- ***Naphthalene.*** Detected in each of the 6 TNTC bedrock samples at concentrations ranging from 2.5 to 34 µg/L. Naphthalene was not detected in any of the 25 overburden groundwater samples. It was detected in only 1 of 39 TNTC soil samples (0.65 mg/kg). BTEX compounds were also detected in the TNTC wells, especially BED-MW13, which had the highest concentrations of BTEX, naphthalene, and 2-methylnaphthalene. BED-MW13 was bailed dry during purging and is extremely slow to recover to normal water elevation after sampling.

In April 2002, a 40-foot water column was bailed dry, and the column the next day was less than 3 feet thick.

- ***Benzene.*** Detected in each of the 6 bedrock water samples (8.4 to 410 µg/L), including all four samples from BED-MW13 (47 to 410 µg/L). Benzene was detected in only 1 of 27 overburden samples (0.16 µg/L) and 2 of 39 soil samples (0.0024 to 0.0026 µg/L). Therefore, benzene would not seemingly originate from TNTC. Rather, it is likely that benzene (as well as other BTEX compounds, naphthalene, and 2-methylnphthalene) originate from the petroliferous limestone.

- ***Bromomethane.*** Detected (13 µg/L) in only 1 of 6 bedrock groundwater samples, but was not detected in the duplicate of this sample. Not detected in the overburden groundwater nor in 40 soil samples.

- ***Methylene chloride.*** Detected in 4 of 5 samples (19 to 160 µg/L). One sample was rejected because of blank contamination. It is noted that nearly all TNTC soil data were rejected because of blank contamination, and all overburden groundwater data wee rejected due to blank contamination. The concentrations of methylene chloride in the bedrock groundwater samples are not uncharacteristic of blank contamination levels.

- ***Toluene.*** Toluene was detected in each of the bedrock groundwater samples (8.8 J to 300 J µg/L). Toluene was detected in 5 of 27 overburden groundwater samples (0.83 J to 22 J µg/L) and in 18 of 40 TNTC soil samples, but at low concentrations (0.0018 J to 0.078 J mg/kg); toluene was not identified as a soil COPC. Toluene is known as a common laboratory contaminant, and the concentrations found in soils and overburden groundwater are consistent with laboratory contamination (though contamination was not identified in the associated blank samples). Petroleum product has been observed in wells installed in limestone at PBOW and on the rock cores during well installation. Given this information and the observations of only low and infrequent detections in soil and overburden groundwater, toluene is interpreted as related to the limestone bedrock.

- ***Xylenes.*** Xylenes were detected in each of the bedrock groundwater samples (90 to 1,300 µg/L). Xylenes were detected in only 1 of 27 overburden groundwater samples (3.3 µg/L) and in only 6 of 40 TNTC soil samples (0.0025 to 0.011 mg/kg). Petroleum product has been observed in wells installed in limestone at PBOW and on the rock cores during well installation. Given this information and the observations of only low and infrequent detections in soil and overburden groundwater, xylenes are interpreted as related to the limestone bedrock.

Pentolite Road Red Water Pond. WRS statistical testing was performed to compare site versus background concentrations of inorganic chemicals of potential concern that were detected in the Pentialite Road Red Water Pond (PRRWP) Area background groundwater data set (iron and manganese). Refer to Appendix B of this BHHRA report for WRS results. For each of

these, the site data was not shown to be significantly different from background. Because only 6 samples are in the PRRWP data set, population testing results have considerable uncertainty.

The presence of petroleum and hydrogen sulfide was encountered at depth (33 to 74 feet bgs) in well BED-MW23.

- ***Chromium.*** Detected in 3 of 6 PRRWP bedrock samples (6.1 to 20.6 µg/L). Each of these samples was collected by bailer, due to poor water production. Reported turbidities of these samples ranged from 140 to 6,500 nephelometric turbidity units. Chromium was detected in only 1 of these in the filtered fraction and at a concentration (1.5 µg/L) far less than the RBSC (10.9 µg/L). Chromium in PRRWP bedrock samples appears to be an artifact of the sampling method. Chromium was not detected in any of the PBOW background samples.

- **Iron.** Detected in 5 of 6 PRRWP bedrock groundwater samples (142 to 7,280 µg/L). Each of these samples had to be collected by bailer because of poor water yield. In the filtered fractions, iron was detected in both samples from BED-MW23 (3,060 and 4,050 µg/L), but not in the other samples. Both of these samples had higher concentrations than the highest detected among the background samples (1,550 µg/L) which were collected using low-flow sampling. The WRS results indicate with marginal significance (p=0.086) that PRRWP iron concentrations generally are not greater than PBOW background, but as mentioned, there is considerable uncertainty associated with these because of small sample size. Note also that this well recovered less than 0.23 feet (of a water column of more than 54 feet) in 24 hours during the April 2002 sampling event. Elevated iron concentrations were not observed in soil. Field Eh measurements of groundwater indicate strongly reducing conditions, ranging from -325 to -20 millivolts. Hydrogen sulfide was also present in 2 of 3 groundwater samples in which it was analyzed and a "strong PAH odor" was noted on a sampling log which suggests the presence of petroleum. The presence of hydrogen sulfide and petroleum both likewise indicate reducing conditions. Under such reducing conditions, elevated dissolved iron (indicative of ferrous iron) is expected. Association of elevated iron with reducing conditions is corroborated by the presence of relatively high dissolved manganese. Therefore, the presence of elevated dissolved iron is attributed to reducing conditions.

- ***Manganese.*** Detected in each of the 6 PRRWP groundwater samples (5.6 to 1,170 µg/L), though only one (from BED-MW23) exceeded the BSC (636 µg/L). The concentrations of manganese detected in filtered fractions of the two samples from BED-MW23 were nearly as high as those of the unfiltered fractions (988 and 212 µg/L). This well was reported in April 2002 as having a "strong polynuclear aromatic hydrocarbon (PAH) odor" and hydrogen sulfide, which is indicative of reducing conditions. It is possible that the presence of naturally occurring petroleum (see below) and reducing conditions have influenced the water chemistry, and not necessarily the sampling method. This is based on the

observation that most of the manganese in the sample with highest concentration was apparently in dissolved form. The WRS results (p=0.86) indicate no statistical difference between PRRWP and PBOW background samples, though there are considerable uncertainties associated with the small sample size of the site data.

- ***Thallium.*** Detected in only 1 of the 6 PRRWP bedrock groundwater samples (50.8 in BED-MW15 collected in May 1998). The filtered fraction of this same sample had an even slightly higher concentration (62 µg/L). Thallium was detected in no other filtered or unfiltered fraction. It was not detected in any of the 123 PRRWP soil samples nor any of the 31 overburden groundwater samples. Therefore, the lone detection of thallium does not appear to be related to conditions associated with former site activities and may be an unusual occurrence, regardless of the source.

- ***DNTs, 4-ADNT, Nitrobenzene.*** *Assumed to related to former site activities.*

- ***2-Methylnaphthalene.*** Detected in each of the 6 PRRWP groundwater samples (22 to 37 µg/L). BED-MW23 was reported to have a "strong PAH odor" and the other PRRWP bedrock well, BED-MW15 was reported in April 2002 as leaving "an oil sheen" on the water level tape after measuring. 2-Methylnaphthalene was not detected in any of the 31 overburden groundwater samples nor in any of the 19 soil samples in which it was analyzed for. Based on the lack of 2-methylnaph-thalene in the overburden groundwater or soil column at the PRRWP, and the reported evidence of apparently naturally occurring petroleum, it is likely that the presence of 2-methylnaphthalene is associated with naturally occurring petroleum.

- ***4-Methylphenol.*** Detected in each of the 6 PRRWP groundwater samples (3.9 to 43 µg/L). BED-MW23 was reported to have a "strong PAH odor" and the other PRRWP bedrock well, BED-MW15 was reported in April 2002 as leaving "an oil sheen" on the water level tape after measuring. 4-Methylphenol was not detected in any of the 31 overburden groundwater samples nor in any of the 19 soil samples in which it was analyzed for. Based on the lack of 4-methylphenol in the overburden groundwater or soil column at the PRRWP, and the reported evidence of apparently naturally occurring petroleum, it is likely that the presence of 4-methylphenol is associated with naturally occurring petroleum.

- ***bis(2-Ethylhexl)phthalate.*** Reported in each of the 6 PRRWP groundwater samples (1.8 to 37 µg/L), though it was eliminated as blank contaminated in one of the samples (28 µg/L in BED-MW15 in May 1998). It was not reported in any of the 19 soil samples in which it was analyzed, and was detected in only 2 of the 31 overburden groundwater samples (3.2 and 10 µg/L). Because BEHP was not found in site soils, is not known to have been used on site, was not prevalent in overburden groundwater, is a common laboratory contaminant, and was present in PRRWP groundwater at concentrations consistent with laboratory contamination, it is likely that BEHP is not truly present in PRRWP groundwater at detectable concentrations.

- ***Naphthalene.*** Detected in each of the 6 PRRWP groundwater samples (2 to 31 µg/L). BED-MW23 was reported to have a "strong PAH odor" and the other PRRWP bedrock well, BED-MW15, was reported in April 2002 as leaving "an oil sheen" on the water level tape after measuring. Naphthalene was detected in only 1 of the 31 overburden groundwater samples (1.9 µg/L) and was not detected in any of the 19 soil samples in which it was analyzed for. Based on the virtual lack of naphthalene in the overburden groundwater or soil column at the PRRWP, and the reported evidence of apparently naturally occurring petroleum, it is likely that the presence of naphthalene is associated with naturally occurring petroleum.

- ***1,1,2-Trichloroethane.*** 1,1,2-Trichloroethane was detected in 1 of the 6 PRRWP groundwater samples at 4.9 J µg/L in the 1998 sample from BED-MW15. It was not detected in either of two subsequent samples from this well, nor was it detected in any of the 31 overburden groundwater samples or any of the site soil samples.

- ***Acetone.*** This common laboratory contaminant was reported in 4 of 6 PRRWP bedrock groundwater samples (87 J to 1600 J µg/L). The highest detections (1,600 and 1400 J µg/L) were reported in BED-MW23, which also exhibited the highest BTEX concentrations (e.g., benzene at 2,100 and 2,500 µg/L). It was reported in 5 of 6 overburden groundwater samples at much lower concentration (20 J to 70 J µg/L), and was qualified "B" as blank contaminated or "R" rejected in 25 others. It was detected in 1 of 18 soil samples at a low concentration (0.0082 J mg/kg) and was qualified "B" as blank contaminated in one other. Its absence from soil, high frequency of blank contamination in overburden groundwater, lower concentrations in overburden groundwater, and possible apparent correlation with BTEX in bedrock groundwater indicate that acetone is not related to former site operations.

- ***Benzene.*** Detected in each of the 6 PRRWP groundwater samples (570 to 2,500 µg/L). BED-MW23 was reported to have a "strong PAH odor" and the other PRRWP bedrock well, BED-MW15, was reported in April 2002 as leaving "an oil sheen" on the water level tape after measuring. Ethylbenzene was detected at much lower concentrations (0.14 to 0.48 J µg/L) in 4 of the 31 overburden groundwater samples and was not detected in any of the 19 soil samples in which it was analyzed for. Based on the near lack of benzene in the overburden groundwater or soil column at the PRRWP, and the reported evidence of apparently naturally occurring petroleum, it is likely that the presence of benzene is associated with naturally occurring petroleum.

- ***Ethylbenzene.*** Detected in each of the 6 PRRWP groundwater samples (130 to 230 µg/L). BED-MW23 was reported to have a "strong PAH odor" and the other PRRWP bedrock well, BED-MW15, was reported in April 2002 as leaving "an oil sheen" on the water level tape after measuring. Ethylbenzene was detected at much lower concentrations (0.17 J to 1.5 µg/L) in 4 of the 31 overburden

groundwater samples and was not detected in any of the 19 soil samples in which it was analyzed for. Based on the near lack of ethylbenzene in the overburden groundwater or soil column at the PRRWP, and the reported evidence of apparently naturally occurring petroleum, it is likely that the presence of ethylbenzene is associated with naturally occurring petroleum.

- ***Methylene chloride.*** Detected in each of the 4 PRRWP groundwater samples (31 J to 160 µg/L). Methylene chloride, recognized as a common laboratory contaminant, was also reported in two other samples PRRWP bedrock groundwater samples (31 and 83 µg/L respectively), but was qualified as not significantly different from the blanks. Methylene chloride was also reported in several of the overburden groundwater samples, but in each of these was qualified "B" as blank contaminated. It was detected in 2 of the 19 soil samples (0.0018 J and 0.0021 J µg/L, respectively) in which it was analyzed for. Based on an almost total lack of methylene chloride in soils and overburden groundwater, as well as the observation that levels of methylene chloride reported in PRRWP bedrock groundwater are consistent with those found in laboratory blanks, it is concluded that reported methylene chloride levels are likely associated with blank contamination.

- ***Toluene.*** Detected in each of the 6 PRRWP groundwater samples (460 to 1,000 µg/L). BED-MW23 was reported to have a "strong PAH odor" and the other PRRWP bedrock well, BED-MW15, was reported in April 2002 as leaving "an oil sheen" on the water level tape after measuring. Toluene was detected at much lower concentrations (1.5 and 1.7 µg/L) in 2 of the 13 overburden groundwater samples; it was reported in several others which were associated with blank contamination. It was detected in only 1 of the 19 soil samples (0.0018 J µg/L) in which it was analyzed for. Based on the virtual lack of toluene in the overburden groundwater or soil column at the PRRWP, and the reported evidence of apparently naturally occurring petroleum, it is likely that the presence of toluene is associated with naturally occurring petroleum.

- ***Xylenes.*** Detected in each of the 6 PRRWP groundwater samples (880 to 1,600 µg/L). BED-MW23 was reported to have a "strong PAH odor" and the other PRRWP bedrock well, BED-MW15, was reported in April 2002 as leaving "an oil sheen" on the water level tape after measuring. Xylenes were detected at much lower concentrations (0.44 J to 8 µg/L) in 4 of the 30 overburden groundwater samples and was not detected in any of the 19 soil samples in which they were analyzed for. Based on the near lack of xylenes in soil, the relatively low concentrations in PRRWP overburden groundwater, and the reported evidence of apparently naturally occurring petroleum, it is likely that the presence of xylenes are associated with naturally occurring petroleum.

West Area Red Water Pond. A WRS test could not be run because too few bedrock groundwater samples were available from the site.

- ***Arsenic.*** Detected in 2 of the 3 samples (6.1 and 9.5 µg/L), one of which exceeded the BSC (7.4 mg/kg). Similar concentrations were also found in the filtered fractions of these samples. This exceedance is only marginal and the MDC in arsenic is still generally consistent with concentrations found in PBOW background. Thus, arsenic in West Area Red Water Ponds (WARWP) area groundwater is likely associated with background.

- ***Cobalt.*** *Detected in 2 of the 3 samples (102 and 267 µg/L), both of which are well above the BSC (12.1 µg/L). Similar concentrations were also found in the filtered fractions of these samples. Cobalt was also detected in 6 of 15 overburden groundwater samples (68.4 to 264 µg/L). Cobalt was also detected in 47 of 56 WARWP soil samples, but at concentrations well within the PBOW background range (background MDC=116 mg/kg).*

- ***Nickel.*** *Detected in each of the 3 WARWP bedrock groundwater samples (45.5 to 278 µg/L) at a concentration exceeding the BSC (8.6 µg/L), and 2 of which exceed the RBSC (73 µg/L). The concentration in each of the respective filtered fractions was similar. Soil concentrations were identified as within background levels. Based on the bedrock groundwater concentrations, nickel in groundwater appears to be site related.*

- ***Vanadium.*** Detected in 1 of 2 samples at 5.5 J µg/L. The filtered fraction of this sample had approximately the same concentration (5.8 J µg/L). Both of these values are an order of magnitude less than the RL of 50 µg/L, which casts considerable uncertainty upon the vanadium analytical results from this well. Vanadium was reported in another sample from this well at 2.4 µg/L, but was qualified "B" as blank contaminated. Vanadium was detected in 5 of 15 overburden direct-push groundwater samples at concentrations of 62 to 381 µg/L, but each of these was ND in the filtered fraction. This indicates that vanadium in overburden groundwater was associated with suspended particulates resulting from the sampling technique. Concentrations of vanadium in bedrock groundwater are consistent with blank contamination.

- ***2,4-Dinitrophenol, 4,6-Dinitro-2-methylphenol, 3-Nitroaniline, Nitrobenzene.*** *Assumed to be site related.*

- ***2,4-DNT.*** *Reported as detected in 2 of 4 bedrock groundwater samples in the semivolatile organic compound (SVOC) analysis (16 and 19 µg/L; RL of 10 µg/L) but was reported as a ND in the associated more-sensitive explosives analysis (RLs of 0.1 and 1.0 µg/L, respectively). It was detected in 9 of 23 overburden groundwater samples via nitroaromatics analysis at concentrations of 1.1 J to 660 µg/L. It was detected in 15 of 96 soil samples, at concentrations of 0.3 J to 6.3 mg/kg. 2,4-DNT is regarded as site related, but its concentration is considered highly uncertain because of the disparity between nitroaromatics and SVOC analyses.*

- ***Benzene.*** Detected in 1 of 4 WARWP bedrock groundwater samples at a concentration of 1.1 µg/L. It was detected in 2 of 23 overburden groundwater samples (0.13 to 0.15 J µg/L). Benzene was not detected in any of the 19 soil samples. Given the presence of petroleum in the limestone formation, it is likely that benzene in this sample is associated with naturally occurring petroleum.

- ***Nitrate.*** *Detected in 3 of 3 WARWP bedrock groundwater samples (22,000 to 79,300 µg/L). Also detected in 3 of 6 overburden groundwater samples at 200 to 62,000 µg/L. Nitrate was also detected in 7 of 28 background bedrock groundwater samples at concentrations ranging from 390 to 22,000 µg/L. Although nitrates are present at substantial concentrations in background groundwater, they appear to be at higher concentrations in WARWP groundwater. Also, it is noted that the site was formerly used for the manufacture of nitric acid as well as nitrogen-containing explosives.*

- ***Nitrate-Nitrite.*** *Detected in the lone bedrock groundwater sample in which it was analyzed (300 µg/L). Nitrate-nitrite was not analyzed for in the background groundwater data set. (Nitrate-nitrite was also detected in 2 of the 4 overburden groundwater samples [100 and 80,000 µg/L] in which it was analyzed for.) Also, it is noted that the site was formerly used for the manufacture of nitric acid as well as nitrogen-containing explosives.*

Downgradient Bedrock Wells. Because these wells were not limited to a geographic area, the MDCs were used for the BHHRA.

Hydrocarbons were found at depth on the cores during drilling of 4 of the 6 downgradient wells: BED-MW22; BED-MW24; BED-MW27; and BED-MW30. The boring logs of the other two wells indicated "black staining" at 61 to 63 feet bgs in BED-MW17 and at 36 to 39 feet bgs in BED-MW19, and hydrogen sulfide was evident in both of these wells during sampling. Well BED-MW27 was abandoned at the results of local residents due to it high hydrogen sulfide odor. Hydrogen sulfide at PBOW seems to be correlated with the presence of petroleum hydrocarbons.

- ***Chromium.*** Detected in 5 of 28 downgradient samples (1.6 J to 24.4 µg/L). Three of these samples were collected using low-flow technique, but the detected concentrations in these were less than 2 µg/L, except for one sample collected from BED-MW24 in July 2002 (9.4 µg/L). Chromium was not detected in the other 9 unfiltered fractions collected from this well, and it was not detected in the filtered fraction of the lone detect from this well. Neither was it detected in the filtered fraction of the bailer-collected sample with the MDC (BED-MW27 in April 2002). Note that well BED-MW27 never produced enough water to be properly developed. This coupled with the associated low well yield indicates that BED-MW27 is not representative of site groundwater in general. Chromium does

not appear to be site related. It has only appeared at very low concentrations which are less than the RLs.

- ***Iron.*** Detected in 16 of 27 bedrock groundwater samples (48.3 to 257,000 µg/L), 5 of which exceeded the BSC (1,550 µg/L). Of these 5 samples, 4 were collected using a bailer; the only sample among these 5 collected using low-flow technique had a concentration (1,225 µg/L, average of two duplicates [2,220 and 1,030 µg/L] collected in May 2004 at BED-MW22) not greatly exceeding the BSC. The highest concentrations, by far, were collected from well BED-MW27 (31,600, 43,100, and 257,000 µg/L). Among the filtered fractions, iron was detected at an MDC (1,460 µg/L) that is less than the BSC; the filtered fractions of 3 of these samples (with BSC exceedances in the corresponding unfiltered fraction) ranged from 144 to 189 µg/L, well below the BSC. The WRS results (p=0.41) do not suggest site relatedness. Iron does not appear to be truly elevated.

- ***Manganese.*** Detected in 25 of 27 downgradient samples (2.0 J to 4,660 µg/L). It was detected in three samples exceeding the BSC (636 mg/L); each of these was from BED-MW27 (660, 1,250, and 4,660 µg/L, respectively). The corresponding BED-MW27 filtered fractions had two samples (816 and 1,460 µg/L) with concentrations exceeding the BSC concentrations ranging from 141 to 1,460 µg/L. The WRS results indicate that downgradient and background data sets are not equivalent (p=0.01). However, if the results from BED-MW27 are removed from the downgradient data set, then the mean manganese concentration of the downgradient data (28.4 µg/L) is clearly less than that of the background data set (81.2 µg/L). This indicates that aside from BED-MW27, the downgradient wells are generally in the lower range of what would be expected in PBOW background. Only low concentrations (1.2 to 2.6 µg/L) of nitroaromatics were detected in BED-MW27. Thus, the apparently reducing conditions evidenced by the presence of hydrogen sulfide which may be responsible for the elevated manganese in BED-MW27, are not the result of site contamination. Therefore, manganese is not regarded as site related.

- ***DNTs, 2-Nitrotoluene, and Nitrobenzene.*** *Assumed to be site-related.*

- ***2-Methylnaphthalene.*** Detected in 25 of 30 downgradient groundwater samples (1.4 to 24 µg/L), 4 of which exceed the RBSC (12 µg/L). Three of these RBSC exceedances, including the MDC, are associated with BED-MW27. This well was abandoned because of high hydrogen sulfide emissions. The core was stained with naturally occurring hydrocarbons from 41 to 105 feet bgs. BTEX compounds were also found in this well at some of the highest concentrations among the downgradient wells. The other RBSC exceedance was associated with BED-MW17, which also had relatively high concentrations of BTEX. 2-MN in these wells appears to be the result of naturally occurring hydrocarbons.

- ***bis(2-Ethylhexyl)phthalate.*** Reported as detected in 6 of 27 samples (2.3 J to 9.7 J) used in the BHHRA. This common laboratory contaminant was also

reported in 3 additional samples, but at concentrations (4.6 to 24 µg/L) qualified "B" as not significantly greater than the blank. Detected concentrations of BEHP are well within the range of the "B"-qualified data. Thus, BEHP does not appear to be site related.

- ***Naphthalene.*** Detected in 31 of 30 downgradient groundwater samples (2.1 to 18 µg/L). Each of these are associated with BTEX compounds, with the highest naphthalene concentrations associated with well BED-MW17 and BED-MW27. The latter well was abandoned because of high hydrogen sulfide emissions, and the core was stained with naturally occurring hydrocarbons from 41 to 105 feet bgs. Naphthalene in these wells, and other downgradient wells, appears to be the result of naturally occurring hydrocarbons.

- ***Benzene.*** Detected in 26 of 30 samples (0.195 to 130 µg/L), with at least 1 benzene detection in each of the downgradient bedrock wells. As mentioned, petroleum hydrocarbons were found at depth in these wells located in the Limestone. Therefore, it is likely that the benzene in these wells is associated with naturally occurring petroleum.

- ***Chlorobenzene.*** Detected in 2 of 30 samples, at 2.2 J and 11 J µg/L in wells BED-MW17 and BED-MW19, respectively. It is noted that each of these was reported in the May 2004, but in none of the other 10 samples collected from these two wells. Also, each of the reported values is an order of magnitude below the RLs of 20 and 100 µg/L, respectively. Therefore, it appears likely that chlorobenzene is not truly present in groundwater or is not at all prevalent.

- ***Methylene chloride.*** Reported in 12 of 26 samples (5.95 J to 98 J µg/L) used in the BHHRA. Each of the reported detections was at a concentration equal to or less than one-half the RL. This common laboratory compound was also reported in four other samples not used in the BHHRA because they were "B" qualified as blank contaminated.

- ***Toluene.*** Detected in 25 of 28 samples (1.2 to 180 µg/L), with at least 1 xylene detection in each of the downgradient bedrock wells. Consistent with the analytical results of the other BTEX compounds, naphthalene, and 2-methylnaphthalene, the highest concentrations were detected in wells BED-MW17 and BED-MW27. As mentioned, petroleum hydrocarbons were found at depth in these wells located in the Limestone. Therefore, it is likely that the toluene in these wells is associated with naturally occurring petroleum.

- ***Xylenes.*** Detected in 27 of 30 samples (6.4 to 560 µg/L), with at least 1 xylene detection in each of the downgradient bedrock wells. Consistent with the analytical results of the other BTEX compounds, naphthalene, and 2-methylnaphthalene, the highest concentrations were detected in wells BED-MW17 and BED-MW27. As mentioned, petroleum hydrocarbons were found at depth in

these wells located in the Limestone. Therefore, it is likely that the xylenes in these wells is associated with naturally occurring petroleum.

- ***Cyanide.*** Detected in 2 of 28 samples, at 16 and 320 µg/L. Both of these are substantially less than the RL of 1,000 µg/L, and only the MDC exceeded the RBSC (73 µg/L). Cyanide was not detected at concentrations exceeding the RBSC in any of the on-site samples; thus, cyanide does not seem to be site related or prevalent.

Table H-1

Synopsis of Evaluation for Site Relatedness[a]

TNT Area A		
COPC	**Identified as Site Related?**	**Rationale for Inclusion/Exclusion[b]**
Aluminum	No	Sampling method[c]
Arsenic	No	Sampling method
Chromium	No	Sampling method
Iron	No	Sampling method
Lead	No	Sampling method
Manganese	No	Sampling method
Nickel	No	Sampling method
Vanadium	No	Sampling method
2,4-Dintirotoluene	Yes	Site history[d]
2,6-Dinitrotoluene	Yes	Site history
4_amino-2,6-dinitrotoluene	Yes	Site history
2-Nitrotoluene	Yes	Site history
1,3-Dinitrobenzene	Yes	Site history
Nitrobenzene	Yes	Site history
Benzene	No	Natural petroleum[e]
Chloromethane	No	Infrequent, low detection; not found in other media
Ethylbenzene	No	Natural petroleum
Methylene chloride	No	Laboratory artifact[f]
Toluene	No	Natural petroleum
Xylenes	No	Natural petroleum
Naphthalene	No	Natural petroleum
2-Methylnaphthalene	No	Natural petroleum
Bis(2-ethylhexyl)phthalate	No	Laboratory artifact
Chrysene	No	Natural petroleum
Dibenzofuran	No	Natural petroleum
Fluorene	No	Natural petroleum
Phenanthrene	No	Natural petroleum
TNT Area B		
COPC	**Identified as Site Related?**	**Rationale for Inclusion/Exclusion**
Aluminum	No	Sampling method
Arsenic	No	Sampling method
Chromium	No	Sampling method
Iron	No	Natural reducing conditions are responsible for dissolved iron
Lead	No	Sampling method
Manganese	No	Natural reducing conditions are responsible for dissolved manganese
Vanadium	No	Sampling method; not found above background in soil
2-Methylnaphthalene	No	Natural petroleum
Naphthalene	No	Natural petroleum
Benzene	No	Natural petroleum

TNT Area C		
COPC	**Identified as Site Related?**	**Rationale for Inclusion/Exclusion**
2-Methylnaphthalene	No	Natural petroleum
Bis(2-ethylhexyl)phthalate	No	Laboratory artifact
Naphthalene	No	Natural petroleum
Benzene	No	Natural petroleum
Bromomethane	No	Not present in duplicate or in other site media
Methylene chloride	No	Laboratory artifact
Toluene	No	Natural petroleum
Xylenes	No	Natural petroleum
Pentolite Road Red Water Pond Area		
COPC	**Identified as Site Related?**	**Rationale for Inclusion/Exclusion**
Chromium	No	Sampling method
Iron	No	Natural reducing conditions are responsible for dissolved iron
Manganese	No	Only 1 well exceeds background and not greatly; wells generally at background; WRS results[9] indicate no difference; natural reducing conditions present
Thallium	No	Infrequent detection; not present in other media
2,4-Dintirotoluene	Yes	Site history
2,6-Dinitrotoluene	Yes	Site history
4-Amino-2,6-dinitrotoluene	Yes	Site history
Nitrobenzene	Yes	Site history
2-Methylnaphthalene	No	Natural petroleum
4-Methylphenol	No	Laboratory artifact
Bis(2-ethylhexyl)phthalate	No	Natural petroleum
Naphthalene	No	Natural petroleum
1,1,2-Trichloroethane	No	Infrequent, low detection; not present in other media
Acetone	No	Laboratory artifact (looks correlated with presence of natural petroleum-related compounds; not present in other media
Benzene	No	Natural petroleum
Ethylbenzene	No	Natural petroleum
Methylene chloride	No	Laboratory artifact
Toluene	No	Natural petroleum
Xylenes	No	Natural petroleum
West Area Red Water Ponds Area		
COPC	**Identified as Site Related?**	**Rationale for Inclusion/Exclusion**
Arsenic	No	Concentrations essentially same as background
Cobalt	Yes	Filtered samples exceed background
Nickel	Yes	Filtered samples exceed background
Vanadium	No	Laboratory artifact
2,4-Dinitrophenol	Yes	Site history
4,6-Dinitro-2-methylphenol	Yes	Site history
2,4-Dinitrotoluene	Yes	Site history
3-Nitroaniline	Yes	Site history
Nitrobenzene	Yes	Site history
Benzene	No	Natural petroleum
Nitrate	Yes	Exceed background; site history
Nitrate-nitrite	Yes	Site history

Downgradient Bedrock Wells		
COPC	**Identified as Site Related?**	**Rationale for Inclusion/Exclusion**
Chromium	No	Sampling method
Iron	No	Sampling method
Manganese	No	Sampling method
2,4-Dinitrotoluene	Yes	Site history
2,6-Dinitrotoluene	Yes	Site history
2-Nitrotoluene	Yes	Site history
Nitrobenzene	Yes	Site history
2-Methylnaphthalene	No	Laboratory artifact
Bis(2-ethylhexyl)phthalate	No	Laboratory artifact
Naphthalene	No	Natural petroleum
Benzene	No	Natural petroleum
Chlorobenzene	No	Infrequent detection at low concentration; not present in on-site soil or groundwater
Methylene chloride	No	Laboratory artifact
Toluene	No	Natural petroleum
Xylenes	No	Natural petroleum
Cyanide	No	Infrequent detection at low concentration; not identified as a COPC in on-site groundwater.

COPC - Chemical of potential concern.

[a] As explained in the text of this appendix, an attempt was made to err on the side of inclusion as site related, rather than exclusion.
[b] These rationale are presented in abbreviated format. Refer to the text of this appendix for a more complete evaluation of each COPC.
[c] "Sampling method" indicates that COPC is likely present at relatively high concentration due to the sampling method; this generally refers to the use of bailer-collected samples couple with likely high turbidity.
[d] "Site history" means that the chemical is included based on the facility's former use as an ordnance manufacturing facility.
[e] "Natural petroleum" indicates that the COPC is likely associated with naturally occurring petroleum, prevalent in the local region.
[f] "Laboratory artifact" generally means that other data points within the data set were qualified "B" blank at comparable or greater concentrations.
[g] "WRS results" refers to the results of the Wilcoxon Rank-Sum comparison of site to background data. WRS results are only mentioned where they were appropriate for consideration. Unless stated otherwise. "WRS results" was used as a basis for inclusion as site-related; i.e., the WRS tests indicated that the site data set had greater concentrations than the background data set. WRS statistical output is provided in Appendix C to the BHHRA.

RESPONSE TO COMMENTS

Draft Baseline Human Health Risk Assessment of Groundwater
Plum Brook Ordnance Works
March 10, 2006

Comments by Mark Bohne, Co-Chairman, Plum Brook Ordnance Works Restoration Advisory Board, received by the U.S. Army Corps of Engineers (USACE)–Huntington District May 5, 2006:

Comment 1: **My comments relate to our discussion at the December RAB meeting concerning two issues. First, the affect of the de-watering of the site by the NASA "pump and filter" system to alleviate contamination issues from underground storage tanks, and the sump used at the reactor site to keep the site dry. Also, Mike Gunderson indicated that Wagner Quarries may also be contributing to the de-watering (an indication that a pathway for site groundwater to migrate off-site.) I feel these issues need to be researched to determine what affects there are to the past, present, and future groundwater research at Plum Brook.**

Response 1: The on-site reactor sumps and the overburden remediation system remove a limited amount of water from the aquifer system relative to total groundwater flow through the site. However, as noted in the RAB meeting, the amount of groundwater being removed by the Wagner Quarry is much more significant. Regardless, the most important factor in the groundwater studies being conducted at PBOW is the determination of the mass of contamination that could potentially enter the bedrock groundwater. This determination is based on analytical results from soil and groundwater samples and from contaminant transport modeling of the unsaturated and saturated zones. Currently, only limited contamination has been detected in the bedrock groundwater. If modeling suggests that unacceptable concentrations of contaminants will leach from the overburden to the bedrock in the future, remedial alternatives will be evaluated in the on-going groundwater feasibility study to address these sources. By addressing source area contamination before it has time to leach to the groundwater, further evaluation of the alteration of groundwater flow paths by groundwater extraction may not be necessary as part of the contaminant studies. In addition, long-term lowering of bedrock water levels (i.e., dewatering) are interpreted to be insignificant at the PBOW site due to distance from the Wagner Quarry and also the low rates of groundwater extraction from the reactor area sump and remediation wells.

Comment 2: **The second consideration is the oil-like contamination in the monitoring wells. Testing should be done to identify the true source. While some speculation has been made about the contaminants being "naturally-occurring," only testing will assure the contamination is not from another source relating to site usage over the past sixty plus years. This is called "fingerprinting."**

Bennett & Williams made some recommendations for the RAB to present to the Army Corps relative to the groundwater studies. The first

recommendation would be to recommend that the "fingerprinting" testing be performed in the near future on the oil-like contamination. Bob Lallier (NASA) indicated in December, that NASA will be performing the testing, but it would be wise if that testing was performed with input from the Army Corps and their contractors.

The second recommendation was that Shaw use a second model (the USDA Root Zone Water Quality Model or "RZWQM") to cross-check their present model (the US EPA Vadose Zone Leaching and Saturated Zone Mixing Model or "VLEACHSM"), to bolster their research. As mentioned in Bennett & William's teaching document, RZWQM has a fracture module that is calibrated for Ohio's Type II rainfall events, and has been calibrated in Ohio for Ohio soils.

Response 2: It is agreed that fingerprinting of the petroleum-related materials present as free product in some of the wells, and as an oily sheen in others, is a useful exercise. It is the Corps' understanding that NASA has collected a sample for fingerprinting from elsewhere on PBOW. However, as of September 5, 2006, the analytical results of this sample were not yet available. For the sites evaluated in the groundwater BHHRA, it was apparent that the petroleum-related compounds encountered are naturally occurring based on the following observations: 1) A lack of petroleum-related compounds in the overburden soil or groundwater; 2) A lack of petroleum during drilling until reaching a substantial depth (minimum depths of 33 to 68 feet below ground surface, depending on the well); 3) The presence of naturally occurring petroleum within the region. With respect to use of the USDA Root Zone Water Quality Model, please see the response to Julie Weatherington-Rice's Comment No. 2.

Comment 3: **The third recommendation is to request the possibility of installing additional monitoring wells to be placed in the overburden/shale and limestone on the northern and eastern boundary of the Plum Brook facility. Shaw has recommended that the groundwater models be rerun as more information is developed for the site outside the surrounding boundaries. More monitoring wells would provide more data and calibration points for their research. With all modeling techniques, there are a certain number of assumptions made based on available data. More data translates into more informed assumptions affording better research.**

Response 3: Comment noted for future reference. The BHHRA must be based on data collected to date so that the project schedule may be adequately maintained. The necessity for additional monitoring wells along the northern and eastern perimeter will be contingent on conclusions drawn from the groundwater feasibility study.

Comments by Julie Weatherington-Rice, Bennett & Williams Environmental Consultants, Inc., Plum Brook Ordnance Works Restoration Advisory Board, received by the U.S. Army Corps of Engineers (USACE), Huntington District, April 28, 2006:

General Comment

Comment 1: **Since we are not providing an editorial proof review of this document, we will not include information regarding grammar, punctuation, and spelling. We are assuming that level of review will be developed by others. There is, however, one item that we wish to note. For the most part, in Ohio, when geologic and hydrogeologic documents are written, the authoring agencies and organizations usually adhere to the National Ground Water Association (headquartered here in Central Ohio) standard of writing "ground water" as two words, like "drinking water" and "surface water." When used as a modifying term, it is hyphenated as "ground-water". While there are other schools of thought in this matter, regarding spelling of the term it is disconcerting to an Ohio reader to read through a text of this length with the word consistently spelled as "groundwater".**

Response 1: The USACE and Shaw are aware that there are two common ways to spell the term "groundwater" or "ground water". According to some historical accounts, the single word version gained use in the early 20th century based on the use by German engineers in the 1800s of the correct German word "Grundwasser"; apparently, use of this single word then started to appear as "groundwater" in English. The U.S. Geological Survey objected and took the position in the late 1920s-early 1930s that two words should be used. There tended to be a dichotomy among engineers and geologists that to some extent exists to this day.

Both the USACE and Shaw have many excellent and highly qualified geologists and engineers who may spell the term as one word. For a variety of reasons, Shaw has made the decision to use the term as one word unless instructed otherwise by a client. A web search will turn up the terms "groundwater" and "ground water" as a common example of a term with two conventions regarded as correct. Currently, college-level textbooks and course names may use either spelling of the term. Even though many individuals maintain that two words should be used, the single word term may be gaining usage. An evidence of this is that the on-line version of both the Encyclopedia Britannica and Merriam-Webster's Dictionary list exclusively the one-word version. The term is listed only as a single word in Microsoft Network Encarta Dictionary, though "ground water" is offered as an alternative spelling. However, the on-line American Heritage Dictionary lists the term as two words, and offers "groundwater" as an alternative spelling.

In summary, there is no universal consensus on which convention to use. Neither convention can authoritatively be called "incorrect," though either may be properly asserted as correct. Certain publications require a particular

convention for consistency and/or other reasons which must be followed by authors publishing therein. However, such requirements do not constitute, to date, a general consensus. PBOW documents have been submitted using the single word to this point. For the sake of consistency, use of the single word "groundwater" will continue in the final BHHRA.

Baseline Risk Assessment Report

Comment 1: **We note that the report uses the standard "risk assessment" protocol and references the standard references.**

Response 1: Agreed.

Comment 2: **We appreciate that the final risk assessment for each site is determined by residential land use, private well installation, and risk for a child. This is the most conservative level of review and requires the greatest level of clean-up, but it also grants the greatest flexibility in future land use decisions.**

Response 2: Comment noted.

Comment 3: **We have some technical concerns about the leaching and ground water flow modeling which will be addressed in that section of the report.**

Response 3: Responses to comments on the PBOW groundwater model are provided below.

Comment 4: **We note, that where possible, the collected data has gone through statistical "smoothing".**

Response 4: Comment noted. The statistical approach taken to determine exposure point concentrations is provided in Section 3.2 of the BHHRA and is consistent with that described in the BHHRA work plan.

Comment 5: **We note the concerns about using ground water chemical analyses from wells that have not been sampled by both low-flow sampling techniques and by bailer sample collection. We recognize the difficulty of intermingling the two sets of data but agree that, given the situation, all data should be used wherever possible.**

Response 5: Comment noted.

Comment 6: **We recognize that while every chemical of potential concern does not trigger a remediation effort at each site, the determination for remediation will be determined by the most limiting agent as it is encountered, in this case, in the ground water.**

Response 6: Agreed.

Comment 7: **We note that where chemicals of potential concern can be attributed to laboratory contamination, they are.**

Response 7: Comment noted.

Comment 8: **We note that where chemicals of potential concern can be attributed to natural background materials, they are where possible, especially as noted with arsenic, iron, and manganese.**

Response 8: Comment noted. Iron and manganese in the PRRWP Area, and iron in TNTB, have been re-categorized in the Final BHHRA as non-site related based on strongly reducing conditions.

Comment 9: **We note that Section 10.2 "Conclusions" states that current site bedrock concentrations and downgradient boundary exceeds the respective risk management criteria for residential use.**

Response 9: Comment noted. We emphasize that exceedance of risk criteria must be evaluated under the assumption that groundwater will be used as a drinking water source.

Comment 10: **We found the tables extremely helpful in the clarification of the information presented in the text. We especially appreciated the Table 2 series and the Table 6 series. We also found the Table 9 series to provide helpful summaries of the risk assessment research.**

Response 10: The kind words are appreciated. We strive to communicate accurately and effectively.

<u>Appendix D, PBOW Site Groundwater Model</u>

Comment 1: **We noted that the soil and overburden leaching model used on this project is the US EPA "Vadose Zone Leaching and Saturated Zone Mixing Model" (VZLEACHSM). This model was developed by the US EPA for national application. It works on the premise of primary porosity (matrix flow). We noted on page 4-2, that the input Hydraulic Conductivity (ft/day) for the Unsaturated Zone of this model was a recharge rate of 0.025 ft/yr. How was this number developed?**

When developing site hydraulic conductivity numbers to input into a surficial and overburden model, excellent references include the following:

Haefner, RJ. 2000. Characterization methods for fractured glacial tills. *Ohio J Sci* 100(3/4):73-87, 2006.

Kim EK, Christy AD. 2006. Use of soil texture analysis to predict subsurface fracturing in glacial tills and other unconsolidated materials. *Ohio J Sci* 106(2):22-26, 2006.

Response 1: There was no site-specific data for the vertical hydraulic conductivity in the unsaturated zone. The input value of 0.025 ft/yr was determined by the preliminary transport calibration in the unsaturated zone at soil boring TNTA-SO080. This was the only location where transport calibration could be completed due to availability of both soil and groundwater data for nitroaromatics. As more data are collected in the future, such calibration can be modified and better results can be obtained if deemed necessary. However, based on hydraulic conductivity values for the saturated overburden at PBOW and review of the references cited in the comment, the value selected (0.025 ft/year) is interpreted to be representative of PBOW soils.

Comment 2: **We noted that there is a recommendation by Shaw to remodel the site as more information is gathered. When this happens, USACE might want to request that VLEACHSM data be cross checked with information gathered by running the USDA Root Zone Water Quality Model (RZWQM) as well. While traditionally used for pesticide modeling, the RZWQM can be adjusted for other contaminants of concern by altering the partitioning coefficient in the input code. Unlike VLEACHSM, RZWQM has a macropore module, is calibrated for Ohio's Type II rainfall events, and has been calibrated here in Ohio with Ohio soils. There is a significant body of literature published on this model. USACE and Shaw can access this literature by starting with three Ohio papers recently published and working back through the cited references. Those three papers are:**

Malone, R.W., S. Logsdon, M. J. Shipitalo, J. Weatherington-Rice, L. Ajuja, L. Ma. 2003. Tillage effect on macroporosity and herbicide transport in percolate. *Geoderma* 116:191*215.

Malone RW, Shipitalo MJ, Meek DW. 2004. Relationship between herbicide concentration in percolate, percolate breakthrough time, and number of active macropores. *Trans ASAE* 47(5):1453-1456.

Malone, R. W., J. Weatherington-Rice, M. Shipitalo, N. Fausey, L. Ma, L. Ahuja, R. D. Wauchpe, Q. Ma. 2004. Herbicide leaching as affected by macropore flow and within-storm rainfall intensity variation: a RZWQM simulation. *Pesticide Management Science* 60:277-285.

The conditions at the PBOW would most closely parallel "no-till" tillage conditions when reading literature discussing the RZWQM.

Response 2: The recommendation to update the groundwater model is contingent on obtaining new soil and aquifer data that would alter the current interpretations at the site. However, if new data become available and there are objectives that could be met through update of the groundwater model, the USACE will evaluate the necessity of using another vadose zone model such as the USDA Root Zone Water quality Model at that time.

Comment 3: **On page 4-6, we noted in the first paragraph, a series of ranges for hydraulic conductivity for the overburden from a low of 0.0024 ft/day to a high of 212 ft/day. This range of approximate five orders of magnitude is typical of materials that exhibit double-block and/or multiple porosities. The advantage of using a leaching model that allows for multiple hydraulic conductivities is that all the information collected can be honored. In this case, the average hydraulic conductivity was calculated that was neither as fast as the most rapid macropore flow would allow or as slow as the matrix flow would control.**

Response 3: Comment noted. The interpretation of soil data is complex due to widely spaced samples and the heterogeneity of soil, particularly in glacial sediments. Use of the average was deemed acceptable based on our modeling experience at this site and at other similar sites.

Comment 4: **The same situation is noted for the hydraulic conductivities in the Delaware Limestone although the range is not as large.**

Response 4: Comment noted.

Comment 5: **While it was noted in the report in several places that the Delaware Limestone is fractured and jointed and that water moves through the formation along the fractures, bedding planes and karstic portions of the formation, not enough information was available to use one of the more complex fractured bedrock flow models. Therefore, the bedrock ground water flow model of choice for this exercise was USGS's MODFLOW.**

MODFLOW was developed by the USGS to use in buried valley sand and gravel settings and for large-scale regional ground water modeling. The model assumes an equivalent porous media behavior in the cells being modeled. We first began using the model in 1984 on the mainframe of Ohio State University (Weatherington-Rice, 1985) and have used it "in house" at B&W since 1986. It has been our experience that while it is not a successful model for contaminant transport over a short distance, which requires faster time of travel (which is usually through fractures and joints), on a larger scale over significant time, the results are acceptable if the input parameters are carefully controlled and calibrated. The scale of this model is probably appropriate for a MODFLOW application.

There are, however, some recent papers that address the problems of using double-block porosite models with somewhat limited data. Several of these papers are as follows:

Helmke MF, Simpkins WW, Horton R. 2005. Simulating conservative tracers in fractured till under realistic timescales. Ground Water 43(6):877-889.

Jorgensen PR, Helpstrup T, Urup J, Seifert D. 2004. Modeling of non-reactive solute transport in fractured clayey till during variable flow rate and time. J Contam Hydrol 68:193-216.

Jorgensen PR, McKay LD, Kistrup JP. 2004. Aquifer vulnerability to pesticide migration through till aquitards. Ground Water 42(6):841-855.

Klint KES, Gravesen P, Rosenbom A, Larouche C, Trenty L, Lethiez P, Sanchez F, Molinelli L, Tsakiroglou CD. 2004. Mulit-scale characterization of fractured rocks used as a means for the realistic simulation of pollutant migration pathways in contaminated sites: A case study. Water, Air, and Soil Pollution: Focus 4:201-214.

Response 5: Comment noted. The references cited will be further reviewed for future reference.

Comment 6: **We concur with Shaw's recommendation that the model should be rerun as more information is developed for the site and outside the surrounding boundaries. We concur with Mark Bohne's suggestion that the pumping cones on site and the large quarry off site should be factored into the program inputs and outputs. The information for the offsite quarry can be obtained from ODNR Division of Water, Water Withdrawal Section which should have records of annual pumping rates. In addition, input of the dewatering elevation at the quarry may be useful in calibration. Additionally, more monitoring wells installed in the overburden and the bedrock at the northern and eastern boundaries of the site will enhance the static water level control built into the model and will allow for even better calibration.**

Response 6: Comment noted. Please see response to Mark Bohne's Comment No 3.

Comments received from U.S. Army Corps of Engineers, Nashville District, May 5, 2006:

Reviewer: Jim Beaujon, Geologist

Comment 1: **Page 1-1, 2nd sentence after bullets: The sentence beginning with "Therefore, as described" is not a complete sentence. Please correct.**

Response 1: The sentence will be restructured and grammatically corrected.

Comment 2: **Page 1-4, Section 1.3, 2nd paragraph: The statement is made-**

there are eight known permitted private wells within 1 mile downgradient of PBOW; it is unknown if any of these wells are currently used for drinking water or any other purpose."

In 2003 the USACE conducted a downgradient, private well mail survey and sampled some of the private wells for qualitative information concerning nitroaromatics in the downgradient groundwater. USACE will provide SHAW with the results of this investigation if they haven't already. Please incorporate the findings as appropriate in Section 1.3, Section 3.1, and elsewhere.

Response 2: This information will be incorporated into the text. The summary letter sent to participants in the survey and the analytical summary table will be appended.

Comment 3: **Page 2-7, two lines up from bottom of text: There is an unintended paragraph break splitting a sentence.**

Response 3: This break will be removed.

Comment 4: **Page 3-7, last paragraph on page, sentence beginning with "For cancer evaluation": There appears to be a redundancy in the sentence as it gives the day equivalency of 70 years (25,550 days) and then states the 70 years should be "multiplied by 365 days/year". Please edit the sentence.**

Response 4: The phrase, "…multiplied by 365 days/year…" will be moved to before the parenthetical statement (25,550 days, the assumed human lifetime)".

Comment 5: **Page 3-12, Section 3.2.2, 1st line: I believe you intend the sentence to read "released from groundwater used as tap water", rather than "released from groundwater and used as tap water".**

Response 5: Text will be corrected consistent with this comment.

Reviewer: Lannae Long, Risk Assessor

Comment 1: **Section 2.3 and General: Where are the low level nitroaromatics found in the downgradient wells? Would it be possible to attach sample results for each AOC in an appendix? I would like to be able to confirm calculations.**

Response 1: The four nitroaromatic COPCs were detected at least once among 5 of the 6 downgradient wells. These are characterized as follows:

- 2,4-dinitrotoluene was detected only in MW-27
- 2,6-dinitrotoluene was detected at its highest concentration in MW-27
- 2-nitrotoluene was detected at its highest concentration in MW-17
- Nitrobenzene was detected at its highest concentration in MW-17 (though each detection was essentially equal).

The reviewer has been sent the raw data electronically and has communicated that this would be sufficient.

Comment 2: **<u>Section 6.1.6, 1st sentence</u>: Re-write the phase "which more is conservative…" to "which IS MORE conservative…"**

Response 2: The typographical error will be corrected as suggested.

Comment 3: **<u>Section 6.2 Site-Relatedness</u>: An explanation of this section needs to be included.**

I suggest changing the section title to "Groundwater Risk Results Related to Nitroaromatics and Certain Inorganics", or just show nitroaromatic HI and Risk results as being known site-related results.

Why are iron and manganese site-related in TNT B, but not in TNT A? If the same processes took place, I would expect the same site-related chemicals?

Why is cobalt considered a site-related chemical in the WARWP, but not at PRRWP, or any other AOC? Is cobalt a common TNT manufacturing chemical?

Response 3: A brief explanation of site-relatedness will be added to Section 6.2. Also, Table 7-2 of the draft BHHRA will be renumbered and referenced in Section 6.2. Please refer to the response to OEPA Comment No. 9.

<u>Response 3a</u>: Section 7.2.3 describes the lines of evidence considered in determining site-relatedness. Appendix G of the Draft BHHRA evaluates these lines of evidence for each COPC. The intent was to thoroughly and objectively assess all of the analytical results with respect to all available information such as statistical comparison to background, boring logs, quality control information, comparisons to concentrations in soil and overburden groundwater, as well as historical site information. As stated in Section 7.2.3 and Appendix G, an effort was made to err on the inclusion as site-related rather than exclusion. Care was also taken not to remove a chemical as site related without logical cause.

Therefore, certain inorganics are included as site-related for a given AOC even though they have no specific history of use in that AOC. A statement will be added to the end of Section 7.2.3 to the effect: "Thus, the list of site-related chemicals (Table 6-39) is intended as a suggestion for site management decisions. Further consideration during the feasibility study may result in an amended list of site-related chemicals."

<u>Response 3b</u>: A further review of the groundwater chemistry shows strongly reducing conditions in the bedrock groundwater at TNTB. Field Eh measurements of groundwater indicate strongly reducing conditions, ranging from -364 to -43 millivolts. Hydrogen sulfide was also present in 2 of 3 groundwater samples in which it was analyzed and a "strong PAH odor" was noted on a sampling log which suggests the presence of petroleum. The

presence of hydrogen sulfide and petroleum both likewise indicate reducing conditions. Under such reducing conditions, elevated dissolved iron (indicative of ferrous iron) and manganese (indicative of 2+ manganese) are expected. Elevated iron and manganese concentrations were not observed in soil, which suggests a lack of source associated with site operations. Therefore, the presence of elevated dissolved iron and manganese are attributed to reducing conditions and will be identified as non-site related in the final BHHRA. Similarly, the elevated iron concentrations associated with the PRRWP Area were also identified as related to reducing conditions after further evaluation. These conditions are indicated by field Eh measurements ranging from -325 to -20, the presence of hydrogen sulfide, and evidence of naturally occurring petroleum. The final BHHRA will identify iron in PRRWP Area groundwater as non-site related.

Iron and manganese were initially included as site-related in TNTB because of their relatively high concentrations in filtered samples and the Wilcoxon Rank-Sum (WRS) tests showed their concentrations to be statistically greater than background concentrations. For TNTA, the site concentrations were not statistically different from background. It is agreed that based on historical operations, there would not be an expected difference in iron and manganese concentrations between TNTA and TNTB.

Response 3c: Cobalt is not known to be associated with TNT manufacturing. However, it was included as site-related based on its considerable exceedance of the background screening concentration, in both filtered and unfiltered fractions. It is not expected that cobalt will be identified as a COC in the feasibility study.

Comment 4: **Section 6.3 Modeled GW Risk: The simulation seemed to have gone out 150 years, rather than 130 years. Edit the text to change all accounts of this reference.**

Response 4: The simulation was run to 150 years. A statement to this effect will be added to the first paragraph of Section 6.3 for clarification. As stated in the last two sentences of Section 6.3 (p. 6-13), the modeled risks for each AOC are based on the year predicted to have the maximum bedrock groundwater concentrations for the three modeled nitroaromatics. These differ for each AOC. The reference to 130 years in Sections 6.3.1 (TNTA) and 6.3.2 (TNTB) are references to the year at which the maximum nitroaromatics concentrations are expected.

Comment 5: **Section 6.5 Sulfate section, last sentence: What are sulfate and sodium concentrations in background wells? I would like to see a numerical comparison. What are other sites sample results with known sellite dumping? Are they comparable? Is it fair to say that the "likely" source of sodium is from sellite?**

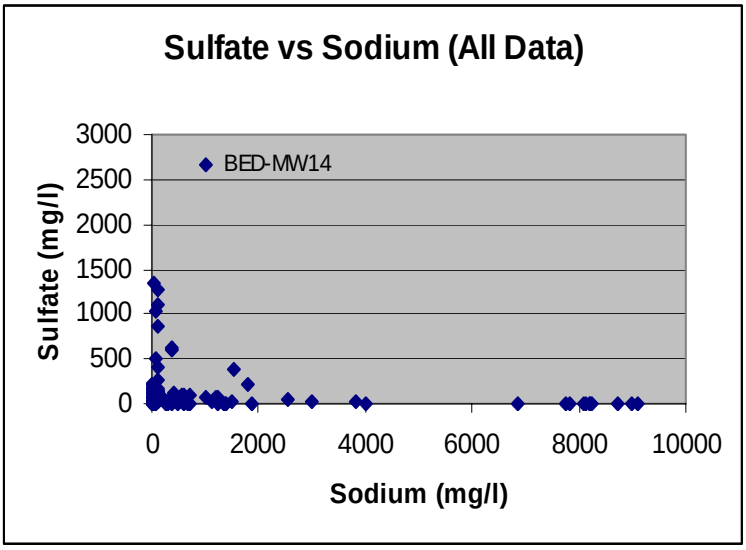
Response 5: The maximum concentrations of sodium and sulfate in all bedrock site wells, downgradient boundary wells, and background and background wells are shown on the table below.

Site	Maximum Detected Sodium Concentration (mg/L)	Maximum Detected Sulfate Concentration (mg/L)
Background	9,130	514
TNTA	4,050	388
TNTB	849	165
TNTC	1,330	1,340
WARWP	1,020	2,660
PRRP	1,810	218
Downgradient Perimeter	685	150

As can be observed, the concentration of sodium typically exceeds that of sulfate by a factor of at least four. The two exceptions to this are wells in the TNTC and WARWP areas. The concentration of sulfate relative to sodium appears to be high at TNTC, but this cannot definitively be attributed to contamination since nitroaromatics were not detected in this well (TNTC-BEDGW-001). The source of contamination at this site would likely be from a drown tank used to quench reaction products. Sellite was not used at this site. TNTC-BEDGW-001 was completed in the Delaware Limestone, and it is unclear why the concentrations are elevated as there is not a record of hydrogen sulfide being produced from this well. The well was sampled twice and the concentrations of sulfate were similarly high during both events. It is possible that hydrogen sulfide is present and is contributing to the sulfate concentrations in groundwater and simply was not observed during the two rounds of groundwater sampling.

As noted in the risk assessment, the WARWP area well (BED-MW14) is suspected to be impacted by site activities due to the presence of nitroaromatics. This is an entirely plausible explanation for the elevated sulfate since the WARWP received wastewater from the TNT manufacturing process which included the residual sellite wash water discharged from the Wash Houses. The elevated sulfate concentration of 2,660 mg/l was reported in only one of three samples collected from BED-MW14 (the concentrations in the other two samples from this well were 630 mg/L and 610 mg/L). This sample also had elevated sodium (1,020 mg/l) when compared to the other two samples (360 mg/l and 365 mg/l, respectively) collected from this well. As can be seen however, the sodium concentration of 1,020 mg/l is not anomalously high relative to other areas at PBOW. A plot of sodium versus sulfate for all site wells is shown below in Figure 1.

Figure 1



Based on this data, it is apparent that the data from BED-MW14 is anomalously high for sulfate. Given the nature of sulfate (dissolved), the sampling methodology probably had little effect on this concentration.

Reviewing the text referenced by this comment, it is now apparent that the text implies that the sodium concentration was elevated relative to site-wide data, which is not the case. The text will be revised to clarify that sodium in this sample was elevated with respect to the other samples collected from this well.

Only limited data are available from other TNT Manufacturing facilities so drawing a conclusion based on findings from other sites is problematic. The final sentence in this section states that the sulfate is "likely" from the disposal of waste products. This is suggested by the co-occurrence with high sodium and high nitroaromatics concentrations (approximately 150 µg/L) relative to other samples collected from this well.

Comment 6: **<u>Section 7.2.3, paragraph 3</u>: Which wells and in which AOC were the wells that had petroleum and then were sampled? Did those wells coordinate with the BETX detections? Is it that all the wells a PBOW have this problem, or just one well associated with an AOC? Add more description of the petroleum status.**

Response 6: Review of boring logs and sample collection logs was completed for all bedrock wells used in the risk assessment. This review indicates that all but one of the monitoring wells completed in the Delaware Limestone had evidence of petroleum detected during well installation and sampling. This included petroleum stains on rock cores, visible petroleum on drilling bits, free product detected during groundwater sampling, and detectable levels hydrogen sulfide in boreholes and monitoring wells. The exception to this was BED-MW18 at TNT Area A. This well was completed across the contact of the Olentangy Shale and Delaware Limestone. Groundwater from all of the wells completed

in the Delaware Limestone (including BED-MW18) had reportable concentrations of petroleum related compounds. The concentrations for benzene and total xylenes exceeded 1,000 ug/l in some site wells. With the exception of TNT Area B, each site addressed in the risk assessment had at least one well completed in the Delaware Limestone.

Three bedrock wells completed at TNT Area B had hydrogen sulfide detected in isolated intervals during drilling. These three wells (TNTB-BEDGW-001, TNTB-BEDGW-003, and TNTB-BEDGW-004) were all completed in the Olentangy Shale. No staining or product was observed in rock cores or drilling equipment during completion of these wells. The detection of hydrogen sulfide suggests the possibility that petroleum may be present, but the lack of observable staining indicates that if present, the concentrations are much lower than those found in the Delaware Limestone Petroleum related compounds (benzene, ethylbenzene, toluene and xylene) were also detected in the background wells at concentrations similar to those observed in TNT Area B. The background wells were all completed in the Olentangy Shale.

Additional text will be excerpted from this response and added to Section 7.2.3

Comment 7: **<u>Section 7.2.6 GW-to-Air Model</u>: What differences would there be if a house has a basement vs no basement, crawl space vs slab? How does the model account for house construction? The houses on the access road to PBOW do not have basements.**

Response 7: The groundwater-to-air model (EPA, 1991) prescribed by OEPA comments on the work plan is based on groundwater use. The type of basement does not affect the model.

Comment 8: **Map 1-2: Include the hydropunch locations on the map. Would it be possible to have six maps, one for each AOC to show exactly which wells and hydropunch locations were used for risk assessment of each area?**

Response 8: Individual maps will be included for each AOC. Hydropunch locations will be included on these maps.

Comment 9: **Tables 9-2 through 9-6:**

a. Include a column for the background statistic for the metals.
b. In a footnote, define shaded rows.

Response 9: <u>Response 9a</u>: A column for the background screening concentration (BSC) will be included on the relevant tables. The BSC will also be included in Table 9-1.

<u>Response 9b</u>: Rows in shaded italics are identified in footnote "a".

Comment 10: **<u>Appendix D, Figures</u>: Is it possible to see a combined chemical plume for all nitroaromatics shown? For example put time 0 for TNT and DNTs all**

on one map, and the same for 50, 100, and 150 years for each AOC? I would be interested to see what the total nitroaromatic projection would be.

Response 10: This could be done, but would require extensive effort and modeling time. Therefore, Shaw recommends not including this approach.

Comments received from Mr. Larry Tannenbaum, Environmental Health Risk Assessment Program, U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM), April 27, 2006.

Comment 1: **The US Army Center for Health Promotion and Preventive Medicine (USACHPPM) reviewed the subject document on behalf of the Office of The Surgeon General pursuant to AR 200-1 (Environmental Protection and Enhancement). We appreciate the opportunity to review this risk assessment. Our minor comments on this very thorough and readable document appear in the paragraphs below.**

Response 1: Thank you for the positive feedback on the document.

Comment 2: **The subject document prominently notes on page ES-2 and elsewhere that the unacceptable cancer risk threshold is 1E-05, following the policy of Ohio EPA. The subject document should clearly indicate that this is not in keeping with the Army's policy, where the cancer risk level that is said to "trigger" remedial action concerns is a full order of magnitude higher, at 1E-04. Please ensure that the distinction is apparent to the reader in the revised risk assessment.**

Response 2: The Army's policy of using a cancer risk trigger level of 1E-4 will be noted in the Executive Summary, Section 5.1, and elsewhere in the document as appropriate. The document already includes references to the NCP 1E-6 to 1E-4 risk management range. These references will be retained, but statements will be added to note that the U.S. Army policy is to use the upper end of this range as the cancer risk level to trigger remedial action concerns.

Comment 3: **The last paragraph of page ES-4 is confusing to the reader. It appears to begin by saying that site-related cancer risk exceeds the criterion, but it then concludes that potential future ground-water users "are unlikely to suffer adverse human health effects or an unacceptable additional risk of cancer." It may be that there is a distinction between the "facility boundary" and the "property boundary" that accounts for the discrepancy. Please address this matter in the revised risk assessment.**

Response 3: This paragraph will be revised to distinguish between residential risks associated with using water at the PBOW facility boundary at current concentrations versus using water at the boundary based on modeled future concentrations. Incidentally, since submittal of the draft report, the modeled

downgradient locations were revisited and it was found that concentrations at the facility boundary downgradient of TNTB would result in a drinking water risk of 2E-5, not 1E-6, as previously reported. Thus, the paragraph will be revised to reflect this correction.

Comment 4: **Please note that the second sentence beneath the bullet points on page 1-1 is incomplete.**

Response 4: The sentence will be restructured and grammatically corrected.

Comment 5: **There are two tables (#s 2-9 and 2-17) that screen for COPCs where the more essential reason for the non-selection of a chemical as a COPC is not given. There are numerous instances of a chemical having a frequency of detection of less than 5%, and where this is the case, there is no need for a risk-based screen, or to indicate that the lack of an exceedance of such a screen is the reason for the non-selection of a chemical as a COPC. Please make the necessary modifications to the identified tables.**

Response 5: The reviewer is certainly correct that chemicals detected in less than 5 percent of samples are not generally held to meeting the RBSC and included as COPCs. However, the protocol for this risk assessment is specifically depicted on Figure 2-1 which shows that comparison to the RBSC is the first step. This protocol was agreed to as part of the Work Plan approval. Therefore, text will be added to Section 2.1 to more clearly describe that detected analytes are identified as COPCs if their MDCs exceed the RBSC and they are not identified as infrequently detected, associated with background, or are essential human macronutrients. The end result is the same: If a chemical is detected in less than 5 percent of samples, it is not identified as a COPC unless there is historical or other specific evidence to suggest that the analyte is site related.

Comments by Ohio Environmental Protection Agency (OEPA), Division of Emergency and Remedial Response (DERR), received by the U.S. Army Corps of Engineers (USACE), Huntington District, May, 2, 2006.

Comment 1: **General Comment: Since this report is an evaluation of groundwater data at the Former Plum Brook Ordnance Works facility, I recommend that Ohio EPA groundwater technical support (John Weaver) review and comment on this report.**

Response 1: OEPA subsequently communicated via a June 7, 2006 email from Paul Jayco to Richard Meadows (USACE) that John Weaver would have no comments.

Comment 2: **<u>General Comment</u>: Please consider including line numbers in these draft reports to help facilitate the review, comment and comment response cycle.**

Response 2: Comment noted for future reference.

Comment 3: **<u>Executive Summary, page ES-4</u>: Clarification needed. The last paragraph states in the first few sentences that site-related ILCR = 3E-5 for the resident at the facility boundary. This is confusing because the sentences that follow indicate that three downgradient areas along the facility boundary were modeled and respective ICLR's ranged from 9E-9 to 1E-6.**

Response 3: The ILCR of 3E-5 is based on concentrations from samples that have been collected from the downgradient boundary wells, whereas the three downgradient areas along the facility boundary were identified and modeled for future concentrations. The second sentence of this paragraph will be revised to state: "Based on current groundwater conditions, the site-related noncancer HI (0.4) meets the target criterion of 1, but the site-related ILCR (3E-5) exceeds the OEPA criterion of 1E-5."

Comment 4: **<u>Section 2.2.1, page 2-5, third paragraph</u>: Per U.S. EPA Office of Water, The MCLG for lead is 0. Sulfate in drinking water currently has a secondary maximum contaminant level (SMCL) of 250 milligrams per liter (mg/L). This regulation is not a Federally enforceable standard, but is provided as a guideline for States and public water systems.**

Response 4: The respective values for lead and sulfate used in the BHHRA were selected instead of the MCLG and SMCL values as risk-based screening for different reasons. The value of 15 µg/L for lead is the promulgated Safe Drinking Water Act (SDWA) action level for utilities providing drinking water. This value is regarded as protective by the EPA Office of Water. This action level triggers treatment or other requirements if exceeded by more than 10 percent of homes tested for a given utility. Lead concentrations of 15 µg/L require no treatment. Note that risks associated with lead are evaluated using the lead integrated exposure uptake biokinetic approach (as performed in Appendix C of the draft BHHRA) and are not regarded as additive with the effects of other chemicals. Therefore, a value of 15 µg/L was regarded as appropriate for screening purposes, as it would meet EPA drinking water requirements and issues of additive risk are not of concern based on the toxicological and exposure information used in the lead model.

A statement will be added to this paragraph noting the existence of the sulfate SMCL, a brief description of the basis for the SMCL (i.e., odor and taste), and the fact that it is used as guideline for public water systems. No adverse health effects have been associated with the SMCL, but the EPA Office of Water advises that the onset of minor adverse health affects may occur at the Health Advisory (HA) level (500 µg/L) and higher concentrations. It is our perspective that the focus of risk assessment should address actual or potential health risks. Therefore, the HA was selected as the risk-based screening value.

Comment 5: **<u>Section 3.1.3.2, page 3-8</u>: Prior to RAGS Part E being finalized, Region 3 recommended using median values for showering and bathing times (adult shower, 12 minutes with 20 minutes total in shower room; child bath, 20**

minutes). RAGS E now is final guidance and recommends 95th percentile values (adult shower, 35 minutes; child bath, 60 minutes). Please revise.

Response 5: The November 2004 draft, January 2005 draft final, and October 2005 final version of the groundwater BHHRA work plan each described an adult showering duration of 12 minutes and a young child bathing duration of 20 minutes (EPA, 2003). The 12-minute bathing and 20-minute showering durations would yield slightly higher risk estimates than would the 15-minute durations identified in the previous PBOW work plans (IT Corporation, 1999; 1998) for the child and child/adult resident used to evaluate long-term residential cancer risks.

It is the position of the USACE and Shaw that the showering and bathing durations should not be revised, but that these RAGS E values should be included in the uncertainties analysis. This revision would represent a substantial level of recalculation and revision/rechecking of values in the text and tables. However, because risks are generally driven by the ingestion pathway, recalculation would not change the basic conclusions of the BHHRA. It is also the opinion of the USACE and Shaw that the application of a 60-minute bathing duration for a young child is likely a considerable overestimate of even an upper bound. We base this opinion on the following:

- The survey on which the Exposure Factors Handbook (EPA, 1997) is based does not include children. Instead, this value is based only on adults (age 18 and older).

- A young child would need constant attention because of safety concerns; for a young child to remain in the bathtub for an hour would mean that the parent does essentially nothing but bathe and stay with the child for an hour every day. It is highly doubtful that in 2006 one could find 1 parent in 20 (equating to the 95th percentile) with this kind of time on their hands, even if the parent wished to spend it in this fashion.

- Multiple children in the family would multiply this time.

- Long bathing durations, especially for young children, can lead to skin problems such as eczema.

Moreover, even if an average duration of 60 minutes per bathing event were assumed for a child, it is noted that EPA has identified that children in the age group of 1 through 6 years bathe only, on average, approximately every other day (EPA, 2001). Thus, if an average bathing duration for an exposed individual were assumed to be 60 minutes per bathing event, the average daily duration would be only about 30 minutes.

Although the current Exposure Factors Handbook references survey data that describes 12 minutes for showering and 20 minutes for bathing as median values, a previous version of the Exposure Factors Handbook (EPA, 1989)

referenced a paper (James and Knimann, 1987) that identifies a 7-minute showering/bathing duration as the median and 12 minutes as an upper-end estimate. The 1997 EFH revisited the James and Knuimann study and found that only 50 of 2550 respondents reported taking showers of greater than 20 minutes duration. This re-evaluation identified a mean shower duration of 8 minutes and a 95th percentile of 16 minutes, as well as a median of 7 minutes. These values are far closer to the 12 minutes used in the BHHRA than is the 35 minutes identified by the RAGS E document.

Also, after looking at the Exposure Factors Handbook and survey studies therein, it is apparent that some individuals—either intentionally or unintentionally—exaggerate. An example of this might be found in the Tsang and Klepeis (1996) study referenced in the EFH which forms the basis for the recommendation of the 60-minute bath. The average number of showers per day for the study was up to 10 for some of the respondents; the average number of baths was 15 per day for some individuals. These high values would appear to be unlikely. The researchers apparently understood some of their values to be exaggerated, as they assumed any survey value greater than 60 minutes to be 61 minutes. It is noted that the number of baths per day also included "baths given" in the survey. Thus, the estimated daily time durations that baths were given to young children (or invalids) were also counted by adults as "bathing time". For these reasons, the USACE and Shaw suggest that the 60-minute average daily bathing duration for the 95th percentile individual may be an exaggeration, even for an adult (and assumed by RAGS E to also represent a child) , because the time spent bathing a child does not represent a true "bathing exposure" scenario for the adult. We also note that the USACE and Shaw have spoken with some USEPA risk assessors who agree that the RAGS E values appear to be obviously out of line and welcome the justified use of alternative values.

In summary, USACE and Shaw used the bathing/showering duration values included in the draft and final work plans, and appropriately referenced therein. These values are consistent with the values accepted in previous PBOW work plans, even providing more conservativeness than the values in those work plans. USACE and Shaw, as well as some EPA risk assessors, consider the RAGS E bathing duration values for children, especially, to be unnecessarily high. A review of the data from which they were derived strongly suggests some exaggeration. Further, childhood exposure was not considered in the bathing survey. Thus, from a technical perspective, the USACE and Shaw consider the bathing duration values used in the PBOW draft BHHRA to be more defensible than the corresponding RAGS E values. Also, incorporation of the RAGS E bathing duration values would involve a substantial level of effort and would result in changing most of the risk output in the BHHRA. These calculation changes would not have any substantive effect on the results of the BHHRA. Therefore, the USACE and Shaw strongly recommend that the RAGS E bathing duration values not be incorporated into the calculations, but mentioned in the uncertainties analysis.

Comment 6: **<u>Section 3.2.4 page 3-13</u>: In the second paragraph, please remove the word "interim" from the first sentence. The reason for this is because during the last team meeting, terminology regarding remedial actions for soils were discussed. Ohio EPA is not sure if this issue has been resolved within the Army Corps. Therefore, keep the text general regarding the type of remedial action.**

Response 6: The word "interim" will be removed as requested.

Comment 7: **<u>Section 6.1.1 page 6-1</u>: In the second sentence of "Site Worker" summary, please replace the word "Risks associated with two target..." with "adverse effects" (or another similar word such as Hazards) since this sentence is discussing HI results which are based on threshold levels.**

Response 7: As requested, the word "risks" will be removed and replaced to reflect hazards.

Comment 8: **<u>Executive Summary and Section 6.1.1</u>: Please check the accuracy of the reported ILCR and HI estimates in these sections as there are differences in the text of these sections. For example, at TNT A, the executive summary reports that the risks/hazards associated with use of groundwater by the onsite worker is ILCR = 1E-5 and HI = 0.2 (page ES-3) whereas these estimates are reported on pages 6-1 to 6-2 as ILCR = 3E-4 and HI total = 10 which is further segregated based on target organs to an HI = 5 based on CNS as the target and HI = 2 based on blood cells as the target. Please check all values for all receptors throughout the report and correct as necessary.**

Response 8: Section 6.1.1 reports the overall risks, whereas the Executive Summary summarizes the site-related risks. The referenced values for the TNTA site worker are reported accurately in the Executive Summary, these are the same as shown in Section 6.2.1 on page 6.

Comment 9: **<u>Section 6.2 Site Related Groundwater Risk Results, page 6-8</u>: More detail is needed to explain exactly how these "site related" risks were determined. Please add a detailed discussion to explain the rationale for this determination.**

Response 9: Text will be added to state the general bases on which determinations of site-relatedness were made for the COPCs. A statement will be made that determinations to either include or exclude COPCs as site related were based on site history, prevalence and detected concentrations, presence or lack thereof in other media, potential for association with naturally occurring petroleum, statistical testing results, and status as possible laboratory artifacts. It will also state that Appendix H (Appendix G in the draft BHHRA) presents a line-of-evidence approach that considers all of these criteria, as applicable, for each COPC. Table 7-2 will be renumbered and referenced in Section 6.2.

OEPA commented on the January 31, 2005 submittal of the BHHRA Work Plan that statistical comparisons to background should be done only in the uncertainty analysis. The USACE and Shaw agreed to follow this approach, which formed the basis of reporting both overall and site-related risks. In preparing the BHHRA report, it became apparent for most of the non-modeled evaluations that the majority of the risks were associated with chemicals that did not appear to be site related. Therefore, Shaw and the USACE judged it best to present all of the risk characterization data in one chapter, both overall (Section 6.1) and site-related (Section 6.2), rather than presenting extensive overall risk characterization results in the risk characterization (Chapter 6) and site-related risk characterization results only in the uncertainties analysis (Chapter 7). It is still our goal to meet OEPA's expressed desire that the uncertainties associated with risk-relatedness be clearly presented. Therefore, Section 6.2 will still clearly reference the presentation of site relatedness as an uncertainty that made in Section 7.2.3. The output of the statistical analysis, provided in Appendix B of the draft BHHRA, is referenced in Section 7.2.3 as is the detailed qualitative analysis of site relatedness which is provided in Appendix G. Table 7-2, referenced in Section 7.2.3 (and which will be moved to Section 6), provides a synopsis of the results of the site relatedness evaluation provided in what will now be Appendix H (Appendix).

Comment 10: **<u>Section 7.2.3 page 7-4, first paragraph</u>: The second sentence indicates that visual signs of petroleum were noted in some wells and at these wells, the petroleum had to be bailed out prior to sampling. It is unclear if the wells were background wells or onsite wells. Please clarify.**

Response 10: Clarification will be provided to indicate that the text refers to on-site and downgradient wells.

Comment 11: **<u>General Comment</u>: There is not a "recommendations" section included in this report. Please add a recommendations section to address how the unacceptable risks and hazards noted from the risk assessment evaluation will be handled.**

Response 11: A brief recommendation section will be added. Essentially, the recommendation will be that a feasibility study be performed.

Comment 12: **<u>Appendix G</u>: The information in this appendix appears to be a big part of the rationale for determining which COPCs are site-related. It may be helpful to summarize this information in table format so that a summary can be included in the main text.**

Response 12: It is agreed that Appendix G of the draft BHHRA provides the rationale for site-relatedness. Table 7-2 is a synopsis of the results of Appendix G. As mentioned in the response to Comment No. 9, this table will be moved to Chapter 6 in the final BHHRA. Also, this table will be re-labeled "Table H-1" and inserted into Appendix H as well; note that Appendix G of the draft will be relabeled as "Appendix H" in the final BHHRA.

References for Responses to OEPA Comments:

IT Corporation (IT), 1999a, ***Baseline Human Health Risk Assessment and Ecological Risk Assessment Work Plans, TNT Area B, Final, Former Plum Brook Ordnance Works, Sandusky, Ohio***, May.

IT Corporation (IT), 1998, ***Baseline Human Health Risk Assessment and Ecological Risk Assessment Work Plans, Red Water Ponds Areas, Final, Former Plum Brook Ordnance Works, Sandusky, Ohio***, September.

James, I.R., and M.W. Nuimann, 1987, "An Application of Bayes Methodology to the Analysis of Diary Records from a Water Use Study," ***Journal of the American Statistics Association***, Volume 82, No. 399, pp. 705-711.

Tsang, A.M., and N.E. Klepeis, 1996, ***Results tables from a detailed analysis of the National Human Activity Pattern Survey (NHAPS) response***, draft report prepared for the U.S. Environmental Protection Agency by Lockheed Martin, Contract No. 68-W6-001, DO No. 13.

U.S. Environmental Protection Agency (EPA), 2003a, ***Updated Dermal Exposure Assessment Guidance***, EPA Region 3, Philadelphia, Pennsylvania, June.

U.S. Environmental Protection Agency (EPA), 2001, ***Age-Group Recommendation for Assessing Childhood Exposure and the Adequacy of the Existing Exposure Factors Data for Children, Risk Assessment Forum***, Technical Issues Paper, Washington, D.C., October, EPA/630/R-03/005.

U.S. Environmental Protection Agency (EPA), 1997, ***Exposure Factors Handbook***, Office of Research and Development, National Center for Environmental Assessment, Washington, D.C., EPA/600/P-95/002F, August.

U.S. Environmental Protection Agency (EPA), 1989, ***Exposure Factors Handbook***, Office of Emergency and Remedial Response, Washington, D.C., EPA/600/3-89/013F, August.

The Draft Baseline Human Health Risk Assessment for Groundwater was also reviewed by USACE, Huntington District whose only comment, communicated verbally was that the private well survey should be incorporated into the text; this comment was addressed by the response to Jim Beaujon, USACE Nashville, Comment No. 2. This report was also reviewed by USACE Hazardous, Toxic and Radioactive Waste Center of Excellence (HTRW-CX), Omaha, Nebraska. The HTRW-CX had no comments.