Eighth Quarterly (December 2003) Background Groundwater Report
Former Plum Brook Ordnance Works
Sandusky, Ohio

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Revision 0

March 2004

Table of Contents

Page

List of Appendices ii
List of Tables iii
List of Figures iii
List of Acronyms iv
1.0 Introduction 1-1
1.1 Objectives 1-2
1.2 Facility Location and Description 1-3
1.3 Site History and Potential for Contamination 1-4
2.0 Field Activities 2-1
2.1 Investigative Methods 2-1
2.2 Groundwater Sampling 2-1
2.3 Decontamination Procedures 2-2
2.4 IDW Management 2-3
3.0 Analytical Program 3-1
3.1 Analytical Program and Methodologies 3-1
3.2 Data Quality Evaluation 3-2
3.3 Blank Evaluation 3-2
3.4 Comparison to Screening Criteria 3-3
3.4.1 Risk-Based Screening 3-3
3.4.2 Background Screening 3-4
3.4.3 Screening and Risk Evaluation Protocol 3-5
4.0 Analytical Results 4-1
4.1 Groundwater Sampling Events 4-1
4.2 Analytical Results 4-1
4.2.1 Background Monitoring Wells 4-2
4.2.2 Overburden/Shale 4-2
4.2.3 Summary of Overburden/Shale Sampling Events 4-3
4.2.4 Bedrock 4-4
4.2.5 Summary of Bedrock Sampling Events 4-7
5.0 Planned Activities 5-1
6.0 References 6-1

List of Appendices

Appendix A – Teleconference Notes on Natural Petroleum in Bedrock
Appendix B – Sample Collection Logs
Appendix C – Data Validation Summary
Appendix D – Chemical Analytical Data Summary
Appendix E – Detected Hits Summary Excluding "B" Qualifiers
Appendix F – Data Quality Evaluation
Appendix G – Chains-of-Custody
Appendix H – Response to Comments

List of Tables

Table	Title	Follows Text
1-1	Summary of Background Investigations	
2-1	Summary of Groundwater Samples Collected	
2-2	Final Field Measurements of Groundwater Samples	
3-1	Summary of Analytical Parameters and Methods	
4-1	Detected Constituents in Background Monitoring Wells	

List of Figures

Figures	Title	Follows Text
1-1	Vicinity Map	
1-2	Locations of Areas of Concern	
1-3	Active/Inactive Natural Oil and Gas Wells of Erie County, Ohio	
2-1	Detected Constituents in Overburden/Bedrock Background Monitoring Wells (November 1997, May 1998, September-October 2001, January, April, July, October 2002, April, September, and December 2003)	
3-1	Protocol for Screening and Risk Evaluation	

List of Acronyms

BHHRA	baseline human health risk assessment
BSC	background screening concentration
°C	degrees Celsius
DNT	dinitrotoluene
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
HQ	hazard quotient
IDW	investigation-derived waste
ILCR	incremental lifetime cancer risk
IT	IT Corporation
MDC	maximum detected concentration
mV	millivolt
µg/L	micrograms per liter
µmhos/cm	microhmos per centimeter
NASA	National Aeronautics and Space Administration
NTU	nephelometric turbidity unit
OEPA	Ohio Environmental Protection Agency
PBOW	Plum Brook Ordnance Works
PVC	polyvinyl chloride
QAPP	quality assurance project plan
RBSC	risk-based screening concentration
RDX	cyclotrimethylenetrinitramine
RI	remedial investigation
SAP	sampling and analysis plan
Shaw	Shaw Environmental, Inc.
SSAP	site-specific sampling and analysis plan
SSHP	site-specific health and safety plan
STL	Severn Trent Laboratories, Inc.
SVOC	semivolatile organic compound
TBD	to be determined
TNT	trinitrotoluene
VOC	volatile organic compound

List of Acronyms *(Continued)*

USACE	U.S. Army Corps of Engineers
YSI	Yellow Springs Instrument Company

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. The former Plum Brook Ordnance Works (PBOW), located in Sandusky, 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 of the John Glenn Research Center with headquarters based out of Lewis Field 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 continue a groundwater remedial investigation (RI) at two red water pond areas and three former trinitrotoluene (TNT) manufacturing areas at PBOW. The two red water pond areas are the West Area Red Water Ponds and the Pentolite Road Red Water Ponds. The three former TNT manufacturing areas are TNT Area A, TNT Area B, and TNT Area C (Figure 1-2).

Eighth-quarter sampling activities were conducted pursuant to the following documents: the final site-specific sampling and analysis plan (SSAP) (IT, 2001a), final site-specific safety and health plan (SSHP) (IT, 2001b), the March 2002 letter amendment to the SSAP (IT, 2002a), the site-wide sampling and analysis plan (SAP) (IT, 1996a), the quality assurance project plan (QAPP) (IT, 1996b), and the site-wide safety and health plan (IT, 1996c).

The purpose of the quarterly background sampling is to provide seasonal collection events to evaluate groundwater quality and determine if a trending pattern of organics and inorganics is present in the groundwater of the background monitoring wells. Background (upgradient) groundwater data will be used as part of a groundwater data set for metals in the various groundwater risk assessments. Following completion of the final background sampling event (anticipated June 2004), groundwater screening concentrations will be calculated. The background data values generated will be compared to values from PBOW site wells for

determination of any site-related contamination and may also be used for risk evaluation purposes.

Since minor concentrations of nitroaromatics (less than 0.5 part per million) were detected in three background wells during the month of April 2002 (3rd quarter), a joint decision was made by the USACE, Ohio Environmental Protection Agency (OEPA), NASA, Shaw, and Pacific Environmental Services to continue background groundwater sampling for two additional events. One event was scheduled during the dry season (October 2002) and the other event was scheduled during the wet season (April 2003).

To determine if locations of present background monitoring wells on PBOW property are truly in "background" locations and to further characterize the background groundwater, two additional background monitoring wells (PB-BED-MW28 and PB-BED-MW29) were installed August 4 through 13, 2003 (Figure 1-2). Well PB-BED-MW28 is located on NASA property outside the security fencing, near the intersection of Taft and Mason Road. It is approximately 2,100 feet upgradient of background well PB-BED-MW20. Monitoring well PB-BED-MW29 is located on private property outside NASA security fencing, approximately 1,100 feet upgradient of background well PB-BED-MW25. With the addition of two new background monitoring wells, a decision was made to continue background groundwater sampling for an additional four quarters (September and December 2003, and March and June 2004). Table 1-1 presents a summary of background groundwater sampling investigations and sampling events conducted to date.

1.1 Objectives

The objectives, as scoped for the quarterly background sampling, were as follows (USACE, 2001, 2003):

1. Determine the quality of bedrock groundwater entering the PBOW site in the upgradient direction (west, south, and southwest).

2. Determine the quality of residuum groundwater upgradient of selected sites at PBOW.

3. Perform trend analysis to determine if any changes in the concentrations of inorganics are seasonally dependent.

4. Establish the range and determine the background concentrations of inorganics in residuum and bedrock groundwater.

Additional background sampling objectives:

5. Evaluate the detection of nitroaromatics reported in April 2002 in background monitoring wells to determine a possible source for this contamination.

6. Determine if groundwater quality of background monitoring wells is adequate for establishing background concentrations.

7. Provide additional groundwater quality data for risk assessment.

Due to drought conditions, establishing background concentrations of inorganics in overburden groundwater was eliminated from the objectives.

This report presents:

- Groundwater sampling procedures
- Results of the background quarterly sampling events (first through eighth quarterly events)
- Laboratory analytical data of the eighth quarter (December 2003) groundwater sampling. Results from previous events are also presented. These sampling events occurred as follows:

  - First quarter results, September 2001 (IT, 2002b)
  - Second quarter results, January 2002 (IT, 2002c)
  - Third quarter results, April 2002 (IT, 2002d)
  - Fourth quarter results, July 2002 (Shaw, 2003a)
  - Fifth quarter results, October 2002 (IT, 2003)
  - Sixth quarter results, April 2003 (Shaw, 2003b)
  - Seventh quarter results, September 2003 (Shaw, 2003c)

- Handling and disposal of investigation-derived waste (IDW).

1.2 Facility Location and Description

As mentioned above, the former PBOW site is currently owned by NASA. Most of the aerospace testing facilities at PBOW were constructed in the 1960s and are presently in a standby or inactive status. The site is located approximately 4 miles south of Sandusky, Ohio,

and 59 miles west of Cleveland, Ohio. Although primarily in Perkins and Oxford Townships, the eastern edge of the site extends into Huron and Milan Townships. PBOW is bound on the north by Bogart Road, on the south by Mason Road, on the west by County Road 43, and on the east by U.S. Highway 250. The area immediately surrounding PBOW is mostly agricultural, but residential sections are present along the northern and northeast perimeter. Public access at PBOW is restricted except during the annual deer hunting season.

1.3 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. 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.

After the plant was shut down, decontamination of TNT, acid, pentolite, and DNT processing lines began. Decontamination was completed during the last quarter of 1945. The property was initially transferred to the Ordnance Department and 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.

NASA acquired PBOW on March 15, 1963, and is presently utilizing the site. 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 its John Glenn Research Center. The details of these land transactions are listed in the site management plan and can be found at the NASA Plum Brook Station.

Based on review of historical use of the site and findings of previous investigations, potential chemicals in the groundwater at PBOW may include nitroaromatic compounds, volatile organic compounds (VOC), semivolatile organic compounds (SVOC), cyanide, and inorganics.

Review of documents (Herdendorf, 1966 and Stout, 1941) and discussions with OEPA and Ohio Department of Natural Resources (Appendix A) personnel indicated that the Columbus and Delaware bedrock units (the same bedrock units in which one of the PBOW background wells is

screened) contain active and abandoned natural gas and petroleum hydrocarbon wells (Figure 1-3). Therefore, it is important to note that some VOCs (primarily benzene, toluene, ethylbenzene, and total xylenes) and SVOCs may be naturally occurring in site groundwater.

2.0 Field Activities

2.1 Investigative Methods

Eighth quarter groundwater sampling of background monitoring wells was conducted following the same procedures used during the previous seven background groundwater sampling events. Specific sampling procedures are detailed in the approved SSAP/SSHP (IT, 2001a,b).

2.2 Groundwater Sampling

Eighth quarter groundwater sampling was conducted from December 9 to 12, 2003. Background wells sampled included six bedrock wells (PB-BED-MW20, PB-BED-MW24, BG8-BEDGW-001, PB-BED-MW25, PB-BED-MW28, and PB-BED-MW29). Bedrock well PB-BED-MW26 was scheduled for sampling; however, the well was dry, so no groundwater sample could be collected. Background overburden well IT-MW01 was not scheduled to be sampled. Table 2-1 shows a list of the groundwater samples collected. The background monitoring wells sampled are located on the extreme west and southwest portion of PBOW (Figure 2-1). On-site background monitoring wells were selected by the USACE based on the groundwater investigation conducted in 1997 (USACE, 2001). Newly installed background wells (PB-BED-MW28 and PB-BED-MW29) were selected to determine if locations of present background monitoring wells are truly in "background" locations and to further characterize the background groundwater.

Groundwater samples 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). Final field measurements of groundwater samples are presented in Table 2-2. Well locations are shown on Figure 2-1. Sample collection logs are provided in Appendix B.

Six of the seven background bedrock wells were sampled using the low-flow (minimal drawdown) sampling methodology. The following wells were sampled using low-flow methodology: PB-BED-MW24, PB-BED-MW25, PB-BED-MW20, BG8-BEDGW-001, PB-BED-MW28, and PB-BED-MW29. Monitoring well PB-BED-MW26 exhibited a water column of only 1.57 feet. Based upon groundwater level measurements from previous events, the limited water column, and the known minimal water recharge in the well, a groundwater sample from monitoring well PB-BED-MW26 was not collected. Low-flow minimal drawdown is

performed when adequate groundwater recharge is present. Water quality measurements were recorded by use of an inline flow-through cell connected to a Yellow Springs Instrument Company (YSI) meter.

A bladder pump was used for the low-flow minimal drawdown sampling. The pump was inserted into the screened portion of the monitoring well, and the well was pumped at a rate that minimized drawdown. Typically, purging rates were on the order of 200 to 500 milliliters per minute. The purge rate was set so that drawdown in the well was never greater than 6 inches. The following water chemistry parameters were monitored for stability: pH, oxidation-reduction potential, conductivity, temperature, dissolved oxygen, turbidity.

Overburden/shale monitoring well IT-MW01 was not scheduled to be sampled during the eighth quarter groundwater sampling event. An indentation in the PVC riser of this well prevents insertion of a bailer or pump. During previous sampling events (July 2002, October 2002, and April 2003), groundwater sampling was performed at this well using a peristaltic pump. With the peristaltic pump, Teflon-lined tubing was inserted into the screened portion of the well. Cyclic compressions on the tubing were made by the peristaltic pump and a vacuum was created removing groundwater from the well. Groundwater recharge rates did not permit low-flow sampling in this well.

Samples collected for dissolved metals analysis were filtered in the field through a 0.45-micrometer high-capacity filter attached to the discharge line of the bladder pump. Sample filtration, preservation, packing, and shipment were performed in accordance with Section 5.4 of the site-wide QAPP (IT, 1996b).

2.3 Decontamination Procedures

Decontamination of all sampling equipment was performed in accordance with Section 4.3 of the SSAP (IT, 2001a). Specifically, the water level indicator and low-flow pump were the only instruments that required complete decontamination procedures. Decontamination was performed in sequence by rinsing with soapy water, deionized water, and isopropyl alcohol, with a final rinse of deionized water. The bladder pump was decontaminated by running the decontamination fluids through the pump head. Equipment was then air dried before use. The bladder pump was wrapped in aluminum foil, with the shiny side out, after decontamination. Bailers, if needed, and tubing were not decontaminated because new items were used for each

well. To prevent damage to sensitive membranes, the water quality instrument YSI 650, was thoroughly rinsed only with deionized water.

2.4 IDW Management

IDW generated during the December 2003 groundwater sampling event included groundwater, decontamination water, and personal protective equipment. All IDW was managed and handled in accordance with procedures described in the SAP (IT, 1996a).

An estimated total of 30 gallons of decontamination and purge water were generated from the background monitoring wells. All liquid was contained in a labeled 55-gallon drum. Since off-site background well PB-BED-MW29 is located on property not owned by NASA, purge water generated from this well was not permitted to be staged at the NASA facility. Purge and decontamination water from all background wells was transferred and stored at the Shaw facility in Findlay, Ohio. Soiled personal protective gear and disposable field equipment generated during the project were double-bagged and placed in an on-site industrial dumpster.

The September and December 2003 nonhazardous purge and decontamination water stored at the Shaw office in Findlay, Ohio is scheduled for transport and disposal at the Evergreen landfill located in Toledo, Ohio. Transport and disposal will take place during the week ending March 5, 2004. Therefore, the required bill of lading for nonhazardous water was not able to be included in this report.

3.0 Analytical Program

Severn Trent Laboratories, Inc. (STL) of Knoxville, Tennessee, analyzed primary and field duplicate project samples. STL's Canton, Ohio laboratory provided analyses for water quality parameters. Accutest Laboratory of Orlando, Florida analyzed the field split. Shaw performed data validation for primary and field duplicate project samples. Datachek validated the field split as part of the preparation of the chemical quality assurance report. The validation summary for the primary and duplicate samples analyzed by Severn Trent is provided in Appendix C. The analytical results are summarized in Appendix D. Tables of detected hits that exclude "B"-qualified data (data that were not detected significantly above method blank or field blank levels) are included in Appendix E. A data quality evaluation is located in Appendix F. Chain-of-custody documentation is provided in Appendix G. Appendix H contains responses to comments.

3.1 Analytical Program and Methodologies

Chemical analyses for the investigation were performed in accordance with guidelines detailed in the Environmental Protection Agency's (EPA) *Test Methods for Evaluating Solid Waste (SW-846), Physical/Chemical Methods,* Third Edition (EPA, 1986) and subsequent revisions and EPA 600/4-79-020, *Method for Chemical Analysis of Water and Wastes* (EPA, 1983). The groundwater samples and associated quality assurance/quality control samples were analyzed for VOCs, SVOCs, metals, nitroaromatics, and several water quality parameters. Methods used for analysis of groundwater during the eighth quarterly sampling event are summarized in Table 3-1.

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 EPA *Contract Laboratory Program National Functional Guidelines for Organic Data Review*, October 1999 (EPA, 1999) and *Contract Laboratory Program National Functional Guidelines for Inorganic Data Review*, February 2002 (EPA, 2002a). 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). The criteria for blank evaluation were based on those detailed in *Region III Modifications to National Functional Guidelines for Organic Data Review,* September 1994 (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 3.3.

3.2 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, 1996a) and QAPP (IT, 1996b) and their 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 evaluation found in Appendix F.

3.3 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 or 10 times the blank result, the sample result is qualified "B." The 10 times limit is applicable only for common laboratory contaminants such as acetone, methylene chloride, 2-butanone, and certain phthalates.
- For organics, if the sample result is less than the practical quantitation limit and less than 5 times or 10 times 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 or 10 times 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. Sample results are not corrected.

3.4 Comparison to Screening Criteria

This section describes a protocol that will be used in the baseline human health risk assessment (BHHRA) to screen analytical data from site (i.e., non-background) monitoring wells. Site analytical data will be screened in the BHHRA using risk-based screening concentrations (RBSC), and inorganics detected in site samples will be screened against PBOW background screening concentrations (BSC). RBSCs are described in Section 3.4.1 and BSCs are described in Section 3.4.2. The BHHRA protocol for screening is depicted on Figure 3-1. Because only background wells were sampled during the eighth quarterly event, screening values do not apply to this most recent round of sampling.

The Section 4.0 table includes a column for maximum detected concentrations (MDC) and BSCs. The MDC represents the maximum concentration of a particular analyte detected within an area of concern. Although "B"-qualified data are identified on the tables, these results are not included in the MDC because all "B"-qualified data will be removed during the BHHRA. Final MDC results for the area of concern will be based on the overall maximum detected concentration for that area, including all quarterly sampling events. BSC values will not be established until quarterly background sampling is complete and a final determination is made as to which wells truly represent background groundwater conditions. Therefore, BSC values for inorganics are denoted by "to be determined" (TBD) in the Section 4.0 table. Two additional background groundwater sampling events will be conducted (March and June 2004) prior to the completion of the RI; the BSCs for inorganics will be based on the resulting data set. These BSC values will be included in the RI and the BHHRA.

3.4.1 Risk-Based Screening

Site groundwater analytical results will be compared to RBSCs in the BHHRA. Groundwater RBSCs are derived from EPA Region 9 preliminary remediation goals tap water criteria, based either on chronic noncancer or cancer effects (EPA, 2002b). For noncancer effects, RBSCs are adjusted to a hazard quotient (HQ) of 0.1. Adjusting the HQ downward accounts for possible additive effects of multiple chemicals during risk-based screening. For cancer-based effects,

both RBSCs and preliminary remediation goals are based on an incremental lifetime cancer risk (ILCR) of 1E-6. Some chemicals exhibit both chronic noncancer and cancer effects. For these chemicals, the RBSC represents either an HQ of 0.1 or an ILCR of 1E-6, whichever results in a lower concentration. The RBSCs are based on a generalized residential drinking water scenario, assumed to be the most restrictive use of groundwater. It is emphasized that RBSCs do not imply a regulatory limit or mandated cleanup level.

In the BHHRA, each chemical with an MDC less than the RBSC will not be considered further. Those chemicals whose MDCs exceed RBSCs will be subject to further evaluation. Risk-based screening is the initial step of the risk screening and evaluation protocol, depicted on Figure 3-1, that will be used in the BHHRA. Based on the findings of the BHHRA, a chemical exceeding its RBSC may or may not be subject to cleanup. No attempt was made to develop RBSCs for ubiquitous, nutritionally essential elements unlikely to be toxic at concentrations ordinarily found in environmental media and for which toxicity values are unavailable (e.g., calcium, magnesium, potassium, and sodium).

3.4.2 Background Screening

Background screening in the BHHRA will apply only to inorganic constituents that exceed RBSCs. Although certain organic compounds in site groundwater (benzene, toluene, ethylbenzene, xylenes, and polynuclear aromatic hydrocarbons) may be attributable to background conditions, these will not be summarily screened out, but rather will be carried through the risk assessment process (i.e., exposure assessment, toxicity assessment, risk characterization), unless screened out on the basis of comparison to RBSCs as described in Section 3.4.1. Final PBOW BSCs will be based on either the 95th upper tolerance limit or the MDC of the background data set (when generated), whichever is less.

BSC values can be finalized only after additional background groundwater samples are collected and a subsequent evaluation of flow direction is performed to determine which wells are truly representative of background conditions. This final groundwater flow direction will be confirmed after all new monitoring wells are installed. Confirmation of the flow direction will be included in a final background summary report anticipated to be submitted in October 2004. Therefore, values for the BSC column on the table in Section 4.0 are left as "TBD." The finalized BSCs will be included in analogous tables in the RI as points of reference, but screening on the basis of background is performed in the BHHRA.

3.4.3 Screening and Risk Evaluation Protocol

Figure 3-1 depicts how risk-based and background screening support the risk assessment decision process that will be applied in the BHHRA. As described in Section 3.4.1 and 3.4.2, the on-site groundwater MDC for a given inorganic analyte that exceeds its RBSC will be screened against its BSC. The "further evaluation" box shown on Figure 3-1, just before the "risk management decision" may include a spatial analysis of site analytical data to determine if elevated concentrations of chemicals that exceed risk criteria are found in small isolated plumes or are evenly distributed throughout the site. This analysis would also examine the potential effect of the distribution on remediation decisions. A geochemical evaluation may be performed for inorganics to further determine whether apparent exceedances in groundwater may be associated with background groundwater conditions.

4.0 Analytical Results

4.1 Groundwater Sampling Events

In December 2003, background groundwater samples representative of low groundwater levels, or dry season conditions, were collected. The background samples were collected from the same monitoring wells sampled in November 1997 and May 1998 (BG8-BEDGW-001 and PB-BED-MW20) as well as from the other background wells (PB-BED-MW24, PB-BED-MW25, PB-BED-MW28, and PB-BED-MW29). A groundwater sample was not collected from background well PB-BED-MW26 due to insufficient water. A quarterly sampling schedule was chosen for these wells to obtain background bedrock groundwater data to determine if similar patterns or trends of chemical constituents are present and thus establish background groundwater constituent concentrations for the bedrock groundwater.

Field measurements of groundwater collected during purge activities of background monitoring wells are shown on page 2 of the sample collection logs in Appendix B. Final measurements representative of the groundwater samples collected are shown on Table 2-2. These results are summarized as follows:

- Temperatures of December 2003 groundwater samples ranged from 8.9 degrees Celsius (°C) (BG8-BEDGW-001) to 11.1°C (PB-BED-MW20).
- Final turbidity readings in 4 of the 6 wells was 0 nephelometric turbidity units (NTU), with the highest level recorded at 1.9 NTUs in well PB-BED-MW29.
- Conductivity measurements were typically below 1.5 micromhos per centimeter (µmhos/cm). Higher recordings were observed in wells PB-BED-MW29 (8.49 µmhos/cm) and PB-BED-MW20 (51.46 µmhos/cm).
- Eh measurements of groundwater samples ranged from 7.5 millivolts (mV) (PB-BED-MW28) to –331.7 mV (PB-BED-MW24). The positive and negative Eh values are indicative of oxidizing and reducing environments, respectively.
- Dissolved oxygen values were low with the maximum concentration detected in well PB-BED-MW20 at 0.46 parts per million.

4.2 Analytical Results

The following sections present the blank-evaluated results of the first through the eighth quarterly sampling events. As a comparison tool, the November 1997, May 1998, and previous

results are shown on Figure 2-1 with the December 2003 data. Analytical detections for the first through eighth quarters are presented in Table 4-1. All eighth quarter analytical data are presented in Appendices C and D.

4.2.1 Background Monitoring Wells

Due to an indentation in the PVC riser of overburden background well IT-MW01, groundwater was not collected during the September-October 2001 (first quarter), January 2002 (second quarter), or April 2002 (third quarter) sampling events. Groundwater from the well was purged and sampled during the July 2002 (fourth quarter), October 2002 (fifth quarter) and April 2003 (sixth quarter) sampling events using a peristaltic pump. Groundwater for VOC analysis was collected and inserted into the appropriate sample bottle by a pipetting action using the Teflon®-lined tubing for each event. No additional sampling of the well was scheduled following April 2003. Figure 2-1 shows the location of the overburden-shale background well.

Seven bedrock wells were selected to be sampled on a quarterly basis to determine background bedrock groundwater values. These background bedrock monitoring wells are PB-BED-MW20, PB-BED-MW24, PB-BED-MW25, BG8-BEDGW-001, PB-BED-MW26, PB-BED-MW28, and PB-BED-MW29 (Figure 2-1). Groundwater from the background bedrock wells was sample by using either low-flow sampling procedures or by a bailer. Groundwater was analyzed for VOCs, SVOCs, nitroaromatics, metals (total and dissolved), cyanide, and water quality parameters.

Previous and current groundwater sampling results of background overburden/shale and bedrock monitoring wells are described in the following subsections.

4.2.2 Overburden/Shale

September/October 2001, Dry Season Sampling Event (First Quarterly). Due to an indentation of the polyvinyl chloride (PVC) riser, monitoring well IT-MW01 could not be sampled.

January 2002, Wet Season Sampling Event (Second Quarterly). On January 16, 2002, an attempt was made to repair IT-MW01. As with the September-October 2001 sampling, an indentation of the PVC riser (2 feet below the top of the casing) prevented sampling equipment (pump and bailer) from reaching groundwater in the well. Review of the IT-MW01 well construction diagram showed that the bottom of the only riser joint (3.2 feet stickup to 4 feet

below ground surface) is located within the filter pack. Therefore, this precluded removal of the riser for replacement. Attempts by the sampling personnel were not successful to remove or push back the indentation in the riser.

April 2002, Wet Season Sampling Event (Third Quarterly). Due to an indentation of the PVC riser, monitoring well IT-MW01 could not be sampled.

July 2002, Dry Season Sampling Event (Fourth Quarterly). No nitroaromatics or SVOCs were detected in the overburden background well. Two VOCs, acetone and methylene chloride, were detected and both values were "B" qualified. Several unfiltered and filtered metals were detected. Aluminum, barium, cobalt, copper, iron, manganese, nickel, and zinc were detected in both phases (Table 4-1).

October 2002, Dry Season Sampling Event (Fifth Quarterly). No nitroaromatics or SVOCs were detected in the overburden background well. One VOC, 2-butanone, was detected and it was "B" qualified. Twenty-one unfiltered and 12 filtered metals were detected (Table 4-1).

April 2003, Wet Season Sampling Event (Sixth Quarterly). No nitroaromatics were detected in the overburden background well. Two VOCs, acetone and carbon disulfide, and one SVOC, diethyl phthalate, were detected. Acetone and diethyl phthalate were both "B" qualified. Sixteen unfiltered and 16 filtered metals were detected (Table 4-1).

September 2003, Dry Season Sampling Event (Seventh Quarterly). Overburden/shale monitoring well IT-MW01 was not scheduled to be sampled.

December 2003, Dry Season Sampling Event (Eighth Quarterly). Overburden/shale monitoring well IT-MW01 was not scheduled to be sampled.

4.2.3 Summary of Overburden/Shale Sampling Events

No nitroaromatics have been detected in the overburden groundwater from well IT-MW01 during the sampling events from November 1997 to April 2003. Six VOCs have been detected, and all but one detection of toluene (May 1998 - 22 micrograms per liter [µg/L]) and carbon disulfide (April 2003 - 0.1 µg/L) were "B" qualified. One SVOC (diethyl phthalate – April

2003) was detected, but it was "B" qualified. A total of 22 unfiltered and 16 filtered metals have been detected.

4.2.4 Bedrock

September-October 2001, Dry Season Sampling Event (First Quarterly). No nitroaromatic compounds were detected in groundwater samples from the background monitoring wells. Six VOCs (acetone, benzene, ethylbenzene, methylene chloride, toluene, and total xylenes) were detected in well PB-BED-MW24, and 9 VOCs (acetone, benzene, carbon disulfide, chloroform, ethylbenzene, 4-methyl-2-pentanone, methylene chloride, toluene, and total xylenes) were detected in well PB-BED-MW25. SVOC bis(2-ethylhexyl)phthalate was detected in wells PB-BED-MW20 and PB-BED-MW25. Four SVOCs (2,4-dimethylphenol, 2-methylnaphthalene, naphthalene, and phenol) were also detected in well PB-BED-MW24. In the sample from well BG8-BEDGW-001, 9 unfiltered and 8 filtered metals were detected, 13 unfiltered and filtered metals were detected in PB-BED-MW20, 8 unfiltered and 7 filtered metals were detected in PB-BED-MW24, and 9 unfiltered and 9 filtered metals were detected in PB-BED-MW25 (Table 4-1).

January 2002, Wet Season Sampling Event (Second Quarterly). No nitroaromatic compounds were detected in any of the background bedrock monitoring wells. The VOC toluene was detected in the groundwater sample from well PB-BED-MW20; benzene, toluene, ethylbenzene, total xylenes, 2-butanone, carbon disulfide, and chloromethane were detected in well PB-BED-MW24; and carbon disulfide was detected in well PB-BED-MW25. Naphthalene and 2-methylnaphthalene were the only SVOCs detected, and they were found in well PB-BED-MW24. In the groundwater samples from the following wells, the numbers of filtered and unfiltered metals that were detected are listed in parentheses: BG8-BEDGW-001 (11 unfiltered and 11 filtered), PB-BED-MW20 (10 unfiltered and 10 filtered), PB-BED-MW24 (10 unfiltered and 10 filtered), and PB-BED-MW25 (10 unfiltered and 7 filtered). All of the bedrock wells exhibited unfiltered thallium detections that were noted with a "B" validation qualifier. The "B" validation qualifier means that thallium was not detected at a level significantly greater than that found in the associated method blanks or field blanks. Due to a low water column, only unfiltered metals were sampled in well PB-BED-MW26. Analyte detections in well PB-BED-MW26 included aluminum, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, vanadium, and zinc. Unfiltered metals detections from monitoring well PB-BED-MW26 were compared with analytical results from the other sampled

wells, and the results from PB-BED-MW26 were anomalously high. Therefore, these results were considered to be outliers (Table 4-1).

April 2002, Wet Season Sampling Event (Third Quarterly). Three nitroaromatic compounds were detected in background bedrock wells. Nitrobenzene was detected in wells PB-BED-MW20, PB-BED-MW24, and PB-BED-MW25. Nitroaromatics 2,6-DNT and cyclo-trimethylenetrinitramine (RDX) were detected in PB-BED-MW24. VOCs acetone and total xylenes were detected in well BG8-BEDGW-001, while VOCs acetone, benzene, toluene, ethylbenzene, total xylenes, 2-butanone, and carbon disulfide were detected in well PB-BED-MW24 and carbon disulfide, methylene chloride, and toluene were detected in well PB-BED-MW25. The only SVOCs that were detected were naphthalene and 2-methylnaphthalene in well PB-BED-MW24. The groundwater sample from well BG8-BEDGW-001 contained 11 unfiltered and 9 filtered metals, well PB-BED-MW20 contained 13 unfiltered and 12 filtered, well PB-BED-MW24 contained 7 unfiltered and 8 filtered, and well PB-BED-MW25 contained 9 unfiltered and 8 filtered metals (Table 4-1).

July 2002, Dry Season Sampling Event (Fourth Quarterly). No nitroaromatic compounds were detected in the groundwater samples of the background monitoring wells. VOCs acetone and 2-butanone were detected in the groundwater sample from well BG8-BEDGW-001; acetone, benzene, bromomethane, 2-butanone, and toluene were detected in well PB-BED-MW20; and acetone, benzene, 2-butanone, ethylbenzene, toluene, and total xylenes were detected in well PB-BED-MW24. Acetone and carbon disulfide were detected in well PB-BED-MW25. SVOC bis(2-ethylhexyl)phthalate was detected in wells BG8-BEDGW-001, PB-BED-MW24, and PB-BED-MW25. The groundwater sample from monitoring well PB-BED-MW24 also exhibited SVOCs 2,4-dimethyphenol, 2-methylnaphthalene, and naphthalene. The groundwater sample from well BG8-BEDGW-001 showed detections of 12 unfiltered and 11 filtered metals; well PB-BED-MW20 contained 10 unfiltered and 10 filtered metals; well PB-BED-MW24 detected 16 unfiltered and 7 filtered metals; and groundwater samples in well PB-BED-MW25 exhibited 8 unfiltered and 9 filtered metals (Table 4-1).

October 2002, Dry Season Sampling Event (Fifth Quarterly). One nitroaromatic compound, nitrobenzene, was detected and it was found in background well PB-BED-MW25. VOCs acetone and carbon disulfide were detected in the groundwater sample from well BG8-BEDGW-001; benzene, carbon disulfide, and toluene were detected in the sample from well PB-BED-MW20; benzene, ethylbenzene, toluene, total xylenes, and carbon disulfide were shown in

well PB-BED-MW24; and acetone, benzene, total xylenes, and carbon disulfide were found in the groundwater sample from well PB-BED-MW25. The only SVOC that was detected was 2-methylnaphthalene, and it was from monitoring well PB-BED-MW24. The groundwater sample from well BG8-BEDGW-001 exhibited 9 unfiltered and 9 filtered metals; well PB-BED-MW20 showed 12 unfiltered and 11 filtered metals; well PB-BED-MW24 exhibited 9 unfiltered and 9 filtered metals; and well PB-BED-MW25 showed 9 unfiltered and 9 filtered metals detections (Table 4-1).

April 2003, Wet Season Sampling Event (Sixth Quarterly). One nitroaromatic compound, RDX, was detected in well PB-BED-MW20, and one nitroaromatic compound, 2,4,6-TNT, was detected in well PB-BED-MW24. Although RDX was detected, it was not manufactured at PBOW. VOCs acetone (B qualified) and 2-butanone were detected in the groundwater sample from well BG8-BEDGW-001; benzene, carbon disulfide, and methylene chloride (B qualified) were detected in the sample from well PB-BED-MW20; acetone, benzene, ethylbenzene, methylene chloride, toluene, and total xylenes were detected in well PB-BED-MW24; and carbon disulfide was detected in well PB-BED-MW25. The only SVOCs detected were 2-methylnaphthalene and naphthalene in the groundwater sample from well PB-BED-MW24. The groundwater sample from well BG8-BEDGW-001 showed detections of 10 unfiltered and 11 filtered metals; well PB-BED-MW20 showed detections of 12 unfiltered and 10 filtered metals; well PB-BED-MW24 exhibited 10 unfiltered and 8 filtered metals; and well PB-BED-MW25 showed detections of 9 unfiltered and 11 filtered metals (Table 4-1).

September 2003, Dry Season Sampling Event (Seventh Quarterly). One nitroaromatic compound (4-amino-2,6-dinitrotoluene) was detected and it was found in the groundwater sample from background monitoring well PB-BED-MW20. The compound was "J" qualified, meaning it was detected but it was below the laboratory's reporting limit. VOCs acetone and total xylenes were detected in the groundwater sample from well PB-BED-MW29 and benzene, toluene, and total xylenes were detected in well PB-BED-MW24. No SVOCs were detected in groundwater samples from any well above laboratory reporting limits. The groundwater sample from well BG8-BEDGW-001 showed detections of 9 unfiltered and 9 filtered metals; well PB-BED-MW20 exhibited 13 unfiltered and 13 filtered metals; well PB-BED-MW24 contained 8 unfiltered and 9 filtered metals; and well PB-BED-MW25 showed detections of 10 unfiltered and 9 filtered metals. The groundwater sample in the newly installed background well PB-BED-MW28 exhibited 11 unfiltered and 11 filtered metals detections, while

newly installed well PB-BED-MW29 showed 11 unfiltered and 12 filtered metals detections (Table 4-1).

December 2003, Dry Season Sampling Event (Eighth Quarterly). No nitroaromatic compounds were detected in the groundwater samples of the background monitoring wells. The VOCs carbon disulfide and chloromethane were detected in the groundwater sample from well BG-BEDGW-001; benzene, carbon disulfide, and toluene (B qualified) were detected in well PB-BED-MW20; carbon disulfide, benzene, ethyl benzene, toluene, and total xylenes detected in well PB-BED-MW24; carbon disulfide in well PB-BED-MW25; chloromethane, benzene, ethyl benzene, toluene, and total xylenes in well PB-BED-MW28; and carbon disulfide, chloromethane, benzene, ethyl benzene, and total xylenes in well PB-BED-MW29. The SVOCs 2-methylnaphthalene and naphthalene were detected in the groundwater sample from well PB-BED-MW24. The groundwater sample from well BG8-BEDGW-001 showed detections of 10 unfiltered and 11 filtered metals; well PB-BED-MW20 exhibited 10 unfiltered and 10 filtered metals; well PB-BED-MW24 contained 10 unfiltered and 7 filtered metals; well PB-BED-MW25 showed detections of 10 unfiltered and 8 filtered metals; well PB-BED-MW28 exhibited 10 unfiltered and 10 filtered metals detections; and well PB-BED-MW29 showed 12 unfiltered and 12 filtered metals detections (Table 4-1).

4.2.5 Summary of Bedrock Sampling Events

Four nitroaromatics (2,6-DNT, nitrobenzene, RDX, and 2,4,6-TNT) were detected in the three bedrock wells sampled during the background groundwater sampling events November 1997 to December 2003. Nitrobenzene was found in the groundwater samples from wells PB-BED-MW20, PB-BED-MW24, and PB-BED-MW25. Nitroaromatics 2,6-DNT, RDX, and 2,4,6-TNT were detected in groundwater samples from PB-BED-MW24. No nitroaromatics have been detected in groundwater samples from background wells BG8-BEDGW-001, PB-BED-MW28, and PB-BED-MW29. Background well BG8-BEDGW-001 has detected VOCs 2-butanone, carbon disulfide, and chloromethane. Benzene, ethylbenzene, toluene, total xylenes, and carbon disulfide have been detected in the groundwater samples from wells PB-BED-MW20, PB-BED-MW24, PB-BED-MW28, and PB-BED-MW29. Acetone, benzene, total xylenes, and carbon disulfide have been detected in the groundwater samples in well PB-BED-MW25. SVOCs naphthalene and 2-methylnaphthalene have only been detected in well PB-BED-MW24. Twenty-two different unfiltered and 19 filtered metals were detected in groundwater samples from background wells. Excluding the nutritionally essential compounds (calcium, magnesium,

potassium, and sodium), barium, iron, and manganese were the metals most commonly detected in the unfiltered and filtered samples.

5.0 Planned Activities

The following activities are scheduled:

- Continued monitoring and collection of groundwater samples from the seven existing background bedrock monitoring wells (the remaining sampling events are scheduled for March and June 2004)
- Reporting of analytical data and field activities on a quarterly basis following receipt of validated analytical data
- Preparation of a groundwater data summary and evaluation report presenting all background groundwater analytical results, conclusions, and calculated background screening concentrations.

6.0 References

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TABLES

Table 1-1

Summary of Background Investigations
Eighth Quarterly Background Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Investigation Conducted By	Date of Activity	Groundwater Level Conditions	Designation	Activity
IT	August 2001	Dry	Groundwater RI	Included installation of 3 background bedrock wells.
IT	September-October 2001	Dry	1st Quarterly Background	Low-flow groundwater sample collection from background wells and selected non-background wells.
IT	January 2002	Wet	2nd Quarterly Background	Low-flow groundwater sample collection from background wells.
IT	April 2002	Wet	3rd Quarterly Background	Low-flow groundwater sample collection from background wells and selected non-background wells.
[a]Shaw	July 2002	Dry	4th Quarterly Background	Low-flow groundwater sample collection from background wells.
Shaw	October 2002	Dry	5th Quarterly Background	Low-flow groundwater sample collection from background wells.
Shaw	April 2003	Wet	6th Quarterly Background	Low-flow groundwater sample collection from background wells.
Shaw	September 2003	Dry	7th Quarterly Background	Low-flow groundwater sample collection from background wells, including new backgroud wells PB-BED-MW28 and PB-BED-MW29.
Shaw	December 2003	Dry	8th Quarterly Background	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 2-1

Summary of Groundwater Samples Collected
Eighth Quarterly Background Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Well Identification	Sample Identification	Sample Date	Number
IT-BG8-BEDGW-001	PBOW-03-IT-BG8-BEDGW-001-DD3001	12-DEC-03	DD3001
PB-BED-MW20	PBOW-03-GW-PB-BED-MW20-DD3002	12-DEC-03	DD3002
PB-BED-MW24	PBOW-03-PB-BED-MW24-DD3003	12-DEC-03	DD3003
PB-BED-MW25	PBOW-03-PB-BED-MW25-DD3004	11-DEC-03	DD3004
PB-BED-MW25	PBOW-03-PB-BED-MW25-DD3005	12-DEC-03	DD3005[a]
PB-BED-MW25	PBOW-03-PB-BED-MW25-DD3006	12-DEC-03	DD3006[b]
PB-BED-MW28	PBOW-03-GW-PB-BED-MW28-DD3007	12-DEC-03	DD3007
PB-BED-MW29	PBOW-03-GW-PB-BED-MW29-DD3008	12-DEC-03	DD3008

[a] Field duplicate.
[b] Field split.

Table 2-2

Final Field Measurements of Groundwater Samples
Eighth Quarterly Background Report
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 Overburden Well (1997 through September 2003)												
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	NA	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.						
Background Bedrock Wells (1997 through September 2003)												
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
	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
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	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
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	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	0.0	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

Table 2-2

Final Field Measurements of Groundwater Samples
Eighth Quarterly Background Report
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 September 2003), 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	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
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.						
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
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

Water quality measurements recorded at time of sample collection. PID and H_2S readings taken as monitoring well lid removed.

°C - Degrees Celsius.
Eh - Oxidation-reduction potential.
H_2S - Hydrogen sulfide.
gal - Gallons.
µmhos/cm - Micromhos 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.

[a]Final water quality reading collected from last purged groundwater due to a very limited water volume. Well was purged on 1/15/02 and sample was collected on 1/17/02 at 0820.

Table 3-1

Summary of Analytical Parameters and Methods
Eighth Quarterly Groundwater Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

Sample Matrix	Analytical Parameters[a]	Analytical Method[b]
Groundwater (Monitoring Well)	Nitroaromatic Compounds	SW-846 8330M
	TCL Volatile Organic Compounds	SW-846 5030/8260B
	TCL Semivolatile Organic Compounds	SW-846 3510C/8270C
	TAL Metals (T/D)	SW-846 3005A/6010B/7470A
	Turbidity	EPA 180.1
	Alkalinity	EPA 310.1
	Hardness	EPA 200.7
	Total Organic Carbon	EPA 415.1
	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

[a]Target analyte list (TAL) and target compound list (TCL) are used to designate parameter lists with no requirements for Contract Laboratory Program method quality control or data reporting packages

[b] Analyses found in the U.S. Environmental Protection Agency's (EPA), *Test Methods for Evaluating Solid Waste (SW-846), Physical/Chemical Methods,* Third Edition, September 1996, *Methods for Chemical Analysis of Water and Wastes,* March 1983, and their subsequent revisions.

T/D - Total and dissolved (i.e., filtered).

Table 4-1

Detected Constituents in Background Monitoring Wells
Eighth Quarterly Background Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

			Location	IT-BG8-BEDGW-001																			
			Sample No.	5410		5415		BD3007		CA3006		CB3007		CC3001		CD3001		DA3001		DC3000		DD3001	
			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	
			Low-Flow Sample	No		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	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				
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
Chloroform	ug/L	1.1	NE																				
Chloromethane	ug/L	1.3	NE																			0.26	J
Ethylbenzene	ug/L	38	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	210	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	93200	TBD	9020		307		51.6	B	78.7	B	31.5	J	65.2	B	83.6	B	141	B	101	B		
Antimony	ug/L	8	TBD																				
Arsenic	ug/L	56.8	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
Beryllium	ug/L	5.2	TBD							1.2	B												
Cadmium	ug/L	3.3	TBD																				
Calcium	ug/L	2290000	TBD	161000		57700		124000	J	91300		81500		134000		122000		66600		131000		86200	
Chromium	ug/L	454	TBD	18.2				1.4	B														
Cobalt	ug/L	82.8	TBD											12.1	J			1	J				
Copper	ug/L	293	TBD	59.5								3.3	J										
Iron	ug/L	232000	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	
Manganese	ug/L	7470	TBD	2240		130		71.6		107		29		688		51.1		35		63.8		166	
Mercury	ug/L	0.45	TBD																				
Nickel	ug/L	457	TBD									6.8	J	8.6	J			8.6	J			4.8	J
Potassium	ug/L	334000	TBD	32900				41100		13300		2530	J	30500		41200	J	5290	J	42700	J	7630	
Selenium	ug/L	5	TBD																				
Sodium	ug/L	9130000	TBD	399000				459000		93200		23600		395000		462000		48900		471000		86300	
Thallium	ug/L	7.1	TBD							3.3	B									3.8	B	2.5	B
Vanadium	ug/L	142	TBD																				
Zinc	ug/L	789	TBD	126		49.7	B			12.6	J	15.6	J	10		0.83	J	2.5	B			30.1	

Table 4-1

Detected Constituents in Background Monitoring Wells
Eighth Quarterly Background Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

			Location	IT-BG8-BEDGW-001																			
			Sample No.	5410		5415		BD3007		CA3006		CB3007		CC3001		CD3001		DA3001		DC3000		DD3001	
			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	
			Low-Flow Sample	No		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	Result	VQ
METALS-FILTERED																							
Aluminum	ug/L	1470	TBD					56.6	B	83.6	B	52	B	113	B	86.7	B	113	B	75	B		
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
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
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	
Manganese	ug/L	1300	TBD	1300		658		73.5		117		23.6		728		52.2		73.8		64		164	
Mercury	ug/L	0.24	TBD																				
Nickel	ug/L	82.9	TBD									7	J	8.5	J			9.8	J			4.8	J
Potassium	ug/L	170000	TBD	32000		14400		40700		16700		2470	J	31000		43200	J	5930	J	42100	J	9690	J
Selenium	ug/L		TBD																				
Sodium	ug/L	9110000	TBD	398000		139000		459000		121000	J	24400		392000		472000		62800		472000		112000	J
Thallium	ug/L	7.3	TBD							4.6	B							6.9	B	4.7	B	2.7	B
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	
WATER QUALITY PARAMETERS																							
Alkalinity	ppm	979	NE	350		180		357	J	200		157		367		332		168		355		255	
Chloride	ppm	34600	NE	780		34		932		78		63.2	J	896		999		77.7		1000		132	
Cyanide, total	ppm	0.004	NE																				
Hardness	ppm	20000	NE	1000		340		719		380		314		647		687		320		710		313	
Nitrate	ppm	22	NE			7.3				22		10.4						8.6				0.58	
Nitrate-Nitrite	ppm	0.2	NE	0.2																			
Sulfate	ppm	416	NE	70		45		28.3		68		63.3		9.2		11.2		57.5		23.3		54.4	
Total dissolved solids	ppm	43800	NE	1800		300		1990		500		458		2040		1870		174		1880		584	
Total organic carbon	ppm	9.9	NE			1								1.9		1.3				1.2		1.2	
Total suspended solids	ppm	280	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 4-1

Detected Constituents in Background Monitoring Wells
Eighth Quarterly Background Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

			Location	IT-MW01									
			Sample No.	5530		5535/5535R		CC3009		CD3002		DA3002	
			Sample Date	19-Nov-97		16-May-98		10-Jul-02		16-Oct-02		9-Apr-03	
			Low-Flow Sample	No		No		No		No		No	
Parameter	Units	MDC	BSC	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	B			1.5	B
Benzene	ug/L	110	NE										
Bromomethane	ug/L	0.27	NE										
Butanone, 2-	ug/L	17	NE							0.7	B		
Carbon disulfide	ug/L	29	NE									0.1	J
Chloroform	ug/L	1.1	NE										
Chloromethane	ug/L	1.3	NE										
Ethylbenzene	ug/L	38	NE										
Methyl-2-pentanone, 4-	ug/L	0.3	NE										
Methylene chloride	ug/L	21	NE	0.33	B	0.58	B	0.19	B				
Toluene	ug/L	100	NE			22							
Trichloroethene	ug/L	0.59	NE										
Xylenes, total	ug/L	210	NE	0.31	B								
SEMIVOLATILES													
Bis(2-ethylhexyl)phthalate	ug/L	5.4	NE										
Diethyl phthalate	ug/L	1.5	NE									1.5	B
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	93200	TBD					117	J	10200	J	1400	
Antimony	ug/L	8	TBD							8	J		
Arsenic	ug/L	56.8	TBD							52.6			
Barium	ug/L	26900	TBD					75.9	J	139	J	60.7	J
Beryllium	ug/L	5.2	TBD							4.6	J	0.84	B
Cadmium	ug/L	3.3	TBD							1.5	J	0.38	J
Calcium	ug/L	2290000	TBD	46400		47900		39400		56300		44400	
Chromium	ug/L	454	TBD							14.1			
Cobalt	ug/L	82.8	TBD					7.5	J	14	J	35.8	J
Copper	ug/L	293	TBD					9.1	J	72.2		48.8	
Iron	ug/L	232000	TBD	1320		2200	J	563		52100		3530	
Lead	ug/L	101	TBD							101		8.8	
Magnesium	ug/L	1040000	TBD	17500		16300		15900		19500		19800	
Manganese	ug/L	7470	TBD	323		348		292		490		396	
Mercury	ug/L	0.45	TBD	0.45									
Nickel	ug/L	457	TBD					15	J	35	J	74.9	
Potassium	ug/L	334000	TBD	6160		5560		6780	J	6480		7450	J
Selenium	ug/L	5	TBD							5			
Sodium	ug/L	9130000	TBD	22800		22000		19400		17800		19200	
Thallium	ug/L	7.1	TBD							5.7	J	4	B
Vanadium	ug/L	142	TBD							35.9	J		
Zinc	ug/L	789	TBD	51.6		149		34.3		124	J	74.8	

Table 4-1

Detected Constituents in Background Monitoring Wells
Eighth Quarterly Background Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

			Location	IT-MW01									
			Sample No.	5530		5535/5535R		CC3009		CD3002		DA3002	
			Sample Date	19-Nov-97		16-May-98		10-Jul-02		16-Oct-02		9-Apr-03	
			Low-Flow Sample	No		No		No		No		No	
Parameter	Units	MDC	BSC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
METALS-FILTERED													
Aluminum	ug/L	1470	TBD			276		62.2	B	71.6	B	1470	
Antimony	ug/L	0	TBD										
Arsenic	ug/L	6.9	TBD										
Barium	ug/L	26200	TBD					82.5	J	89.1	J	52.6	J
Beryllium	ug/L	1.5	TBD									1.2	B
Cadmium	ug/L	1.2	TBD									0.48	J
Calcium	ug/L	2570000	TBD	44900		53100		39300		57700		47400	
Chromium	ug/L	0	TBD										
Cobalt	ug/L	34.8	TBD					10.3	J	4.9	J	34.8	J
Copper	ug/L	49.2	TBD					2.8	J	3.7	J	49.2	
Iron	ug/L	6180	TBD	1090		1970		745		1840		2480	
Lead	ug/L	8.7	TBD									8.7	
Magnesium	ug/L	1090000	TBD	17000		19500		14600		20300		20900	
Manganese	ug/L	1300	TBD	331		395		326		424		360	
Mercury	ug/L	0.24	TBD										
Nickel	ug/L	82.9	TBD					26.2	J	10.5	J	82.9	
Potassium	ug/L	170000	TBD	6180		6390		6390	J	6400	J	7270	J
Selenium	ug/L		TBD										
Sodium	ug/L	9110000	TBD	22200		25100		19200		19400		18400	
Thallium	ug/L	7.3	TBD									4.9	B
Vanadium	ug/L	0	TBD										
Zinc	ug/L	673	TBD	46.9		47.5	B	124		13.1	J	73.8	
WATER QUALITY PARAMETERS													
Alkalinity	ppm	979	NE	360		110		90		209		9.9	
Chloride	ppm	34600	NE	4		3		3.4		9.9		3	
Cyanide, total	ppm	0.004	NE										
Hardness	ppm	20000	NE	420		200		144		263		196	
Nitrate	ppm	22	NE					0.19					
Nitrate-Nitrite	ppm	0.2	NE										
Sulfate	ppm	416	NE	79		140		118		67.3		211	
Total dissolved solids	ppm	43800	NE	310		400		279		342		137	
Total organic carbon	ppm	9.9	NE	8.6		7		7.1		9.9		3.8	
Total suspended solids	ppm	280	NE	84		5		4		5		21	
Turbidity	NTU	742	NE					1.7		10.6		14	

Table 4-1

Detected Constituents in Background Monitoring Wells
Eighth Quarterly Background Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

			Location	PB-BED-MW20																			
			Sample No.	5960		5965		BD3026		CA3005		CB3001		CC3003		CD3003		DA3003		DC3001		DD3002	
			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	
			Low-Flow Sample	No		Yes		Yes		Yes		Yes		No		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																	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								
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	
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
Chloroform	ug/L	1.1	NE																				
Chloromethane	ug/L	1.3	NE																	0.47	B		
Ethylbenzene	ug/L	38	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				
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
Trichloroethene	ug/L	0.59	NE																				
Xylenes, total	ug/L	210	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	93200	TBD	3290		678	J	207	J			48.6	J	83.4	B	155	J	143	B	115	B	57.9	B
Antimony	ug/L	8	TBD																				
Arsenic	ug/L	56.8	TBD																	3.3	J		
Barium	ug/L	26900	TBD	19000		16400		23900		22500		23700		24000		25700		26900		25200		26100	
Beryllium	ug/L	5.2	TBD													0.51	B						
Cadmium	ug/L	3.3	TBD																				
Calcium	ug/L	2290000	TBD	2140000		1960000	J	2060000	J	1860000		1890000		2000000		2050000		2180000		2180000		2290000	
Chromium	ug/L	454	TBD					7.6	B			1.7	J					1.3	B				
Cobalt	ug/L	82.8	TBD					7.1	J			6.1	J	8	J	8.1	J	8.5	J	8.6	J	6.8	J
Copper	ug/L	293	TBD	32.8				15.8	B	32.8		30.5											
Iron	ug/L	232000	TBD	13200		6770		5920	J	6480		853		4970		5310		257		4120		2030	
Lead	ug/L	101	TBD																				
Magnesium	ug/L	1040000	TBD	920000		861000		943000	J	860000		884000		960000		941000		981000		1040000		1040000	
Manganese	ug/L	7470	TBD	180		153		189	J	128		156		190		185		162		192		202	
Mercury	ug/L	0.45	TBD																				
Nickel	ug/L	457	TBD					3.5	J			3.4	J					7.2	J	4	J		
Potassium	ug/L	334000	TBD	92300		78600		85800	J	165000		86700	J	101000	J	91700	J	81700	J	104000	J	72600	J
Selenium	ug/L	5	TBD																				
Sodium	ug/L	9130000	TBD	7660000		7300000		7980000	J	6830000		7770000		8380000		8190000		8430000		8540000		9130000	
Thallium	ug/L	7.1	TBD							7.1	B					4.1	B			4.6	B		
Vanadium	ug/L	142	TBD																				
Zinc	ug/L	789	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	

Table 4-1

Detected Constituents in Background Monitoring Wells
Eighth Quarterly Background Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

			Location	PB-BED-MW20																			
			Sample No.	5960		5965		BD3026		CA3005		CB3001		CC3003		CD3003		DA3003		DC3001		DD3002	
			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	
			Low-Flow Sample	No		Yes		Yes		Yes		Yes		No		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
METALS-FILTERED																							
Aluminum	ug/L	1470	TBD					40.9	B			55.9	B	63.1	B	69.8	B	109	B	91.4	B		
Antimony	ug/L	0	TBD																				
Arsenic	ug/L	6.9	TBD					2.8	J											4.8	J	4.1	J
Barium	ug/L	26200	TBD	21000		4950		24400		21300		23800		23900		24500		26200		25700		25700	
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
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
Copper	ug/L	49.2	TBD					2	B	5.7	J	26.5											
Iron	ug/L	6180	TBD	2310		1320		5350		6180		1130		5100		4940				3800		1830	
Lead	ug/L	8.7	TBD																				
Magnesium	ug/L	1090000	TBD	1090000		223000	J	965000		829000		888000		969000		911000		953000		1070000		1020000	
Manganese	ug/L	1300	TBD	162		47		188		129		156		193		182		160		220		200	
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		
Potassium	ug/L	170000	TBD	103000		21600		87400	J	170000		86900	J	102000	J	88400	J	79000	J	105000	J	70500	J
Selenium	ug/L		TBD																				
Sodium	ug/L	9110000	TBD	9110000		1870000		8100000		6870000		7830000		8120000		7750000		8210000		8710000		9000000	J
Thallium	ug/L	7.3	TBD							7.3	B									4.1	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	
WATER QUALITY PARAMETERS																							
Alkalinity	ppm	979	NE	240		260		255	J	280		229		293		259		246		248		238	
Chloride	ppm	34600	NE	19000		21000		22400		18000		17300	J	19000		21100		34600		19100		21300	
Cyanide, total	ppm	0.004	NE																				
Hardness	ppm	20000	NE	20000		10000		9360		8200		8850		8140		9390		9200		9690		9940	
Nitrate	ppm	22	NE																				
Nitrate-Nitrite	ppm	0.2	NE																				
Sulfate	ppm	416	NE							3.2													
Total dissolved solids	ppm	43800	NE	32000		24000		27400	J	26000		27800		35500		43800		32600		42700		33600	
Total organic carbon	ppm	9.9	NE					0.5	J	1.1	J	0.74	J										
Total suspended solids	ppm	280	NE	74		90		125		13		13		33		19		100		112		39	
Turbidity	NTU	742	NE					48.4	J	8.8		10.5		7.4		19.2		3.9		6.2		18.4	J

Table 4-1

Detected Constituents in Background Monitoring Wells
Eighth Quarterly Background Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

			Location	PB-BED-MW24															
			Sample No.	BD3029		CA3001		CB3008		CC3004		CD3004		DA3004		DC3002		DD3003	
			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	
			Low-Flow Sample	Yes		Yes		Yes		Yes		No		Yes		Yes		Yes	
Parameter	Units	MDC	BSC	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	
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
Chloroform	ug/L	1.1	NE																
Chloromethane	ug/L	1.3	NE			1.3	J												
Ethylbenzene	ug/L	38	NE	19	J	32		38		8	J	4.8	J	15	J	13	J	10	
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	
Trichloroethene	ug/L	0.59	NE																
Xylenes, total	ug/L	210	NE	110		180		210		55		23		82		67		50	J
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
Naphthalene	ug/L	8.7	NE	2.9	J	7		4	J	8.7	J			4.6	J	3.5	J	2.3	J
Phenol	ug/L	1.4	NE	1.4	J														
METALS-UNFILTERED																			
Aluminum	ug/L	93200	TBD	37.8	J	77.7	B	35.7	J	1150		115	J	141	B	78	B	194	J
Antimony	ug/L	8	TBD																
Arsenic	ug/L	56.8	TBD							4.3									
Barium	ug/L	26900	TBD	932		938		1160		680		1080		1140		690		642	
Beryllium	ug/L	5.2	TBD			1.2	B												
Cadmium	ug/L	3.3	TBD																
Calcium	ug/L	2290000	TBD	158000		157000		161000		346000		159000		167000		168000		151000	
Chromium	ug/L	454	TBD							9.4									
Cobalt	ug/L	82.8	TBD							2.9				1.2	J			7.7	J
Copper	ug/L	293	TBD							8.6									
Iron	ug/L	232000	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	
Manganese	ug/L	7470	TBD	24.8		19.2		14.8	J	420		23.6		14.1	J	27.4		25.8	
Mercury	ug/L	0.45	TBD											0.035	J				
Nickel	ug/L	457	TBD							7.9									
Potassium	ug/L	334000	TBD	32100		46600		47600	J	41600		22900	J	26400	J	24100	J	24300	
Selenium	ug/L	5	TBD																
Sodium	ug/L	9130000	TBD	90800		90600		106000		101000		91800		104000		80400		67000	
Thallium	ug/L	7.1	TBD			4.2	B									3.8	B	2.5	B
Vanadium	ug/L	142	TBD							6.1									
Zinc	ug/L	789	TBD							28.4		3.9	J	1.2	B			9.3	J

Table 4-1

Detected Constituents in Background Monitoring Wells
Eighth Quarterly Background Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

			Location	PB-BED-MW24															
			Sample No.	BD3029		CA3001		CB3008		CC3004		CD3004		DA3004		DC3002		DD3003	
			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	
			Low-Flow Sample	Yes		Yes		Yes		Yes		No		Yes		Yes		Yes	
Parameter	Units	MDC	BSC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
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
Antimony	ug/L	0	TBD																
Arsenic	ug/L	6.9	TBD																
Barium	ug/L	26200	TBD	942		962		1170		670		1140		1160		689		669	
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
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	
Manganese	ug/L	1300	TBD	22.1		18.7		16.6		44.2		15.5		13.7	J	35		25.5	
Mercury	ug/L	0.24	TBD																
Nickel	ug/L	82.9	TBD																
Potassium	ug/L	170000	TBD	30700	J	43300		44400	J	38300		24000	J	25800	J	23200	J	24500	J
Selenium	ug/L		TBD																
Sodium	ug/L	9110000	TBD	90500		87800	J	105000		98500		92500		105000		79600		67900	J
Thallium	ug/L	7.3	TBD			4.1	B												
Vanadium	ug/L	0	TBD																
Zinc	ug/L	673	TBD					3.4	J			5.7	B	0.97	J	2.9	B		
WATER QUALITY PARAMETERS																			
Alkalinity	ppm	979	NE	697	J	810		157		979		757		803		846		726	
Chloride	ppm	34600	NE	149		140		175	J	155		126		105		98		48.7	
Cyanide, total	ppm	0.004	NE											0.004	B				
Hardness	ppm	20000	NE	566		710		715		1370		808		820		761		130	
Nitrate	ppm	22	NE																
Nitrate-Nitrite	ppm	0.2	NE																
Sulfate	ppm	416	NE	21.4		150		23.6		32.3				20.3		24.6		32.6	
Total dissolved solids	ppm	43800	NE	948		1000		2200		1020		990		949		988		779	
Total organic carbon	ppm	9.9	NE	3		1.8		2.4		3.7		3.7		2.4		1.9		1.6	
Total suspended solids	ppm	280	NE					14		124		62		5				4	
Turbidity	NTU	742	NE	266		61		116		742		49.6		68.8		138		74	

Table 4-1

Detected Constituents in Background Monitoring Wells
Eighth Quarterly Background Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

			Location	PB-BED-MW25															
			Sample No.	BD3030		CA3002		CB3004		CC3005		CD3005		DA3005		DC3003		DD3004	
			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	
			Low-Flow Sample	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
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						
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
Chloroform	ug/L	1.1	NE	1.1															
Chloromethane	ug/L	1.3	NE																
Ethylbenzene	ug/L	38	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										
Trichloroethene	ug/L	0.59	NE																
Xylenes, total	ug/L	210	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	93200	TBD	78.2	B	79.8	B	41.3	J	44.6	J	79.7	J	137	B	86.5	B	61.2	B
Antimony	ug/L	8	TBD																
Arsenic	ug/L	56.8	TBD																
Barium	ug/L	26900	TBD	226		247		434		164	J	277		558		177	J	187	J
Beryllium	ug/L	5.2	TBD			1.2	B												
Cadmium	ug/L	3.3	TBD																
Calcium	ug/L	2290000	TBD	134000		158000		173000		183000		200000		194000		159000		141000	
Chromium	ug/L	454	TBD																
Cobalt	ug/L	82.8	TBD																
Copper	ug/L	293	TBD																
Iron	ug/L	232000	TBD	795		357		91.1	J	103		207		102		156		140	
Lead	ug/L	101	TBD																
Magnesium	ug/L	1040000	TBD	79500		80000		68000		69100		80200		81200		62000		54000	
Manganese	ug/L	7470	TBD	89		56.2		68.8		95.6		86.5		79.8		72.9		58.5	
Mercury	ug/L	0.45	TBD																
Nickel	ug/L	457	TBD																
Potassium	ug/L	334000	TBD	17600		21600		14500	J	11400	J	16200	J	19200	J	12100	J	11900	
Selenium	ug/L	5	TBD																
Sodium	ug/L	9130000	TBD	112000		115000		196000		92300		187000		223000		120000		122000	
Thallium	ug/L	7.1	TBD			4.7	B									3.1	B	3	B
Vanadium	ug/L	142	TBD																
Zinc	ug/L	789	TBD	7.7	J			79.5				1.7	J	1.4	B	4.8	J	74.4	

Table 4-1

Detected Constituents in Background Monitoring Wells
Eighth Quarterly Background Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

			Location	PB-BED-MW25															
			Sample No.	BD3030		CA3002		CB3004		CC3005		CD3005		DA3005		DC3003		DD3004	
			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	
			Low-Flow Sample	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
METALS-FILTERED																			
Aluminum	ug/L	1470	TBD	68.7	B			52.7	B	97.8	B	69.8	B	135	B	61.8	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
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
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	
Manganese	ug/L	1300	TBD	87		52.2		65.6		94		84.2		75.7		71.5		55.2	
Mercury	ug/L	0.24	TBD											0.056	J				
Nickel	ug/L	82.9	TBD																
Potassium	ug/L	170000	TBD	17000		20200		14900	J	12100	J	15900	J	18400	J	11900	J	11100	J
Selenium	ug/L		TBD																
Sodium	ug/L	9110000	TBD	109000		114000		196000		97600		180000		217000		118000		115000	J
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 QUALITY PARAMETERS																			
Alkalinity	ppm	979	NE	278	J	320		337		329		314		344		313		316	
Chloride	ppm	34600	NE	404		460		558	J	219		631		615		257		221	
Cyanide, total	ppm	0.004	NE											0.004	B				
Hardness	ppm	20000	NE	627		720		611		772		848		820		700		540	
Nitrate	ppm	22	NE																
Nitrate-Nitrite	ppm	0.2	NE																
Sulfate	ppm	416	NE	121		79		36.2		416		79.5		38.6		264		136	
Total dissolved solids	ppm	43800	NE	1000		1100		1330		1180		1440		767		1100		834	
Total organic carbon	ppm	9.9	NE	4	B	2		3		2.7		2.7		2		2.8		2.4	
Total suspended solids	ppm	280	NE	4				9		5				4		5		8	
Turbidity	NTU	742	NE	21.7	J	21		112		23.6		35.8		98		22.9		64.4	

Table 4-1

Detected Constituents in Background Monitoring Wells
Eighth Quarterly Background Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

			Location	PB-BED-MW26		PB-BED-MW28				PB-BED-MW29			
			Sample No.	CA3004		DC3004		DD3007		DC3005		DD3008	
			Sample Date	17-Jan-02		17-Sep-03		9-Dec-03		16-Sep-03		9-Dec-03	
			Low-Flow Sample	No		Yes		Yes		Yes		Yes	
Parameter	Units	MDC	BSC	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							17			
Benzene	ug/L	110	NE			2.4	J	2.2				0.96	J
Bromomethane	ug/L	0.27	NE										
Butanone, 2-	ug/L	17	NE										
Carbon disulfide	ug/L	29	NE							0.44	J	13	
Chloroform	ug/L	1.1	NE							0.25	J		
Chloromethane	ug/L	1.3	NE					0.97	J			0.3	J
Ethylbenzene	ug/L	38	NE					0.13	J	0.86	J	0.87	J
Methyl-2-pentanone, 4-	ug/L	0.3	NE										
Methylene chloride	ug/L	21	NE										
Toluene	ug/L	100	NE			1.7	J	0.62	J	0.12	J		
Trichloroethene	ug/L	0.59	NE			0.59	J						
Xylenes, total	ug/L	210	NE					0.41	J	5.5		5.1	J
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	93200	TBD	93200		147	J	42.6	B	309		49.9	B
Antimony	ug/L	8	TBD										
Arsenic	ug/L	56.8	TBD	56.8		7.4	J	5.4	J			3.3	J
Barium	ug/L	26900	TBD	1970		374		395		11300		11800	
Beryllium	ug/L	5.2	TBD	5.2									
Cadmium	ug/L	3.3	TBD	3.3	J								
Calcium	ug/L	2290000	TBD	2180000		20800		20000		316000		295000	
Chromium	ug/L	454	TBD	454									
Cobalt	ug/L	82.8	TBD	82.8						3.9	J	3.6	J
Copper	ug/L	293	TBD	293									
Iron	ug/L	232000	TBD	232000		235		398		932		1550	
Lead	ug/L	101	TBD	79.2									
Magnesium	ug/L	1040000	TBD	958000		8320		7780		217000		198000	
Manganese	ug/L	7470	TBD	7470		20.3		16.6		62.7		50.7	
Mercury	ug/L	0.45	TBD	0.14	J								
Nickel	ug/L	457	TBD	457									
Potassium	ug/L	334000	TBD	334000		7240	J	6050		75800	J	67800	
Selenium	ug/L	5	TBD										
Sodium	ug/L	9130000	TBD	3790000		290000		285000		1390000		1350000	
Thallium	ug/L	7.1	TBD			4.2	B			5.1	B	2.4	B
Vanadium	ug/L	142	TBD	142									
Zinc	ug/L	789	TBD	789		2.5	B	247		6.9	J	507	

Table 4-1

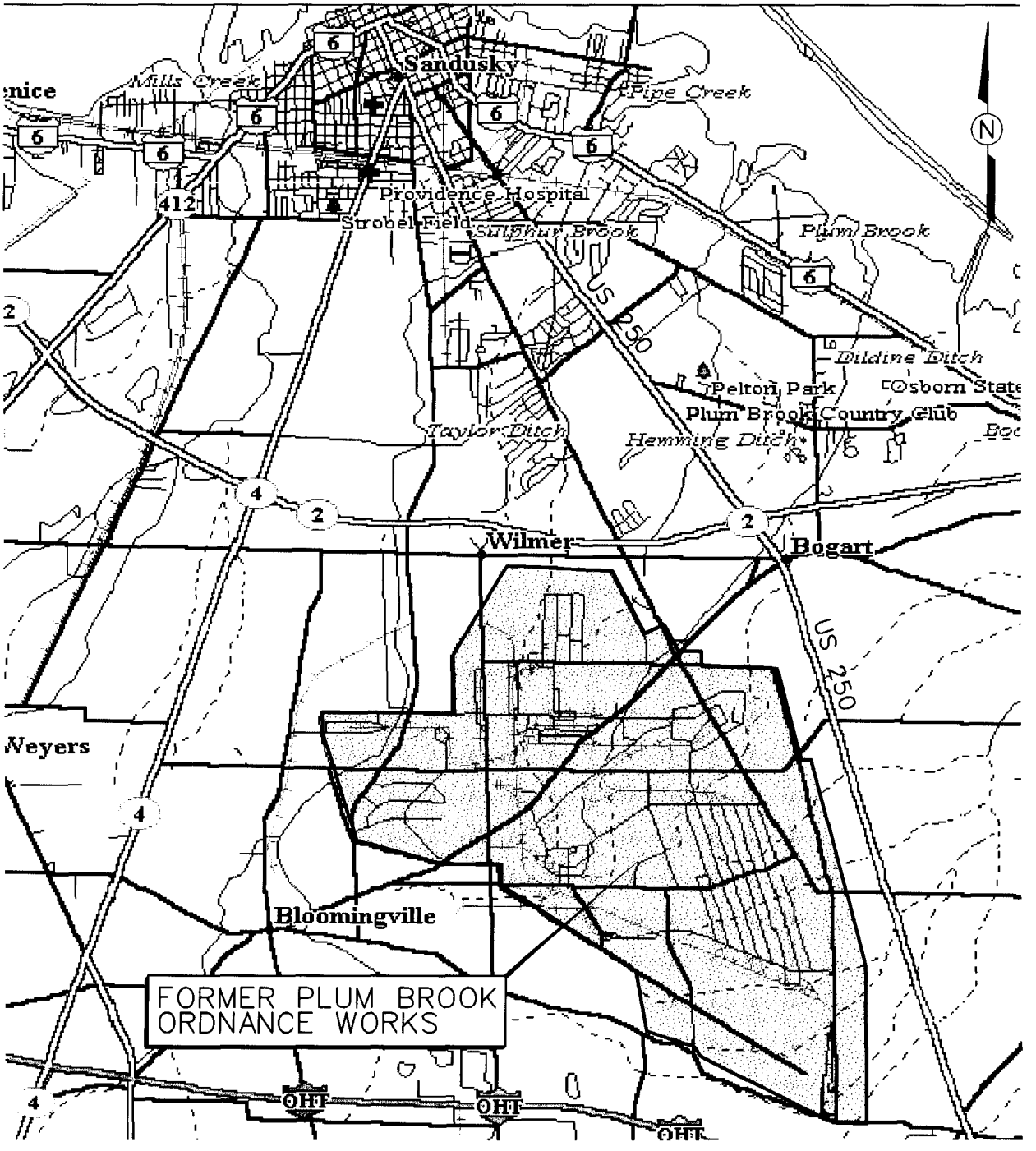
Detected Constituents in Background Monitoring Wells
Eighth Quarterly Background Report
Former Plum Brook Ordnance Works, Sandusky, Ohio

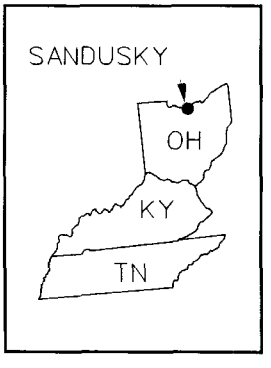
			Location	PB-BED-MW26		PB-BED-MW28				PB-BED-MW29			
			Sample No.	CA3004		DC3004		DD3007		DC3005		DD3008	
			Sample Date	17-Jan-02		17-Sep-03		9-Dec-03		16-Sep-03		9-Dec-03	
			Low-Flow Sample	No		Yes		Yes		Yes		Yes	
Parameter	Units	MDC	BSC	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
METALS-FILTERED													
Aluminum	ug/L	1470	TBD			152	J			83.1	B	66.9	B
Antimony	ug/L	0	TBD										
Arsenic	ug/L	6.9	TBD			6.9	J	5.6	J	2.6	J	3.1	J
Barium	ug/L	26200	TBD			371		374		10500		10800	
Beryllium	ug/L	1.5	TBD										
Cadmium	ug/L	1.2	TBD										
Calcium	ug/L	2570000	TBD			20300		19700	J	316000		283000	J
Chromium	ug/L	0	TBD										
Cobalt	ug/L	34.8	TBD							6.1	J	3.4	J
Copper	ug/L	49.2	TBD										
Iron	ug/L	6180	TBD			242		354		350		1490	
Lead	ug/L	8.7	TBD										
Magnesium	ug/L	1090000	TBD			8120		7670		219000		189000	
Manganese	ug/L	1300	TBD			15.8		16.4		55.1		49.3	
Mercury	ug/L	0.24	TBD										
Nickel	ug/L	82.9	TBD										
Potassium	ug/L	170000	TBD			7140	J	5920	J	76500	J	60700	J
Selenium	ug/L		TBD										
Sodium	ug/L	9110000	TBD			289000		280000	J	1390000		1250000	J
Thallium	ug/L	7.3	TBD			4.1	B	3.8	B	6.2	B	3.8	B
Vanadium	ug/L	0	TBD										
Zinc	ug/L	673	TBD			3.8	B	247		8.5	J	528	
WATER QUALITY PARAMETERS													
Alkalinity	ppm	979	NE			474		444		443		432	
Chloride	ppm	34600	NE			171		148		3540		2930	
Cyanide, total	ppm	0.004	NE										
Hardness	ppm	20000	NE			99.5		81.6		1750		1500	
Nitrate	ppm	22	NE							0.39			
Nitrate-Nitrite	ppm	0.2	NE										
Sulfate	ppm	416	NE			35.2		13.1		5.7			
Total dissolved solids	ppm	43800	NE			833		697		6580		3880	
Total organic carbon	ppm	9.9	NE			5.9		5.3		2.6		3.9	
Total suspended solids	ppm	280	NE					4		46		7	
Turbidity	NTU	742	NE			3.3		1.6	J	14.7		7	J

BSC - Background screening concentration.
MDC - Maximum detected concentration.
ug/L - Micrograms per liter.
NE - Not evaluated.
RDX - Cyclotrimethylenetrinitramine.
NTU - Nephelometric turbidity unit.
ppm - Parts per million.
TBD - To be determined.

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.

FIGURES



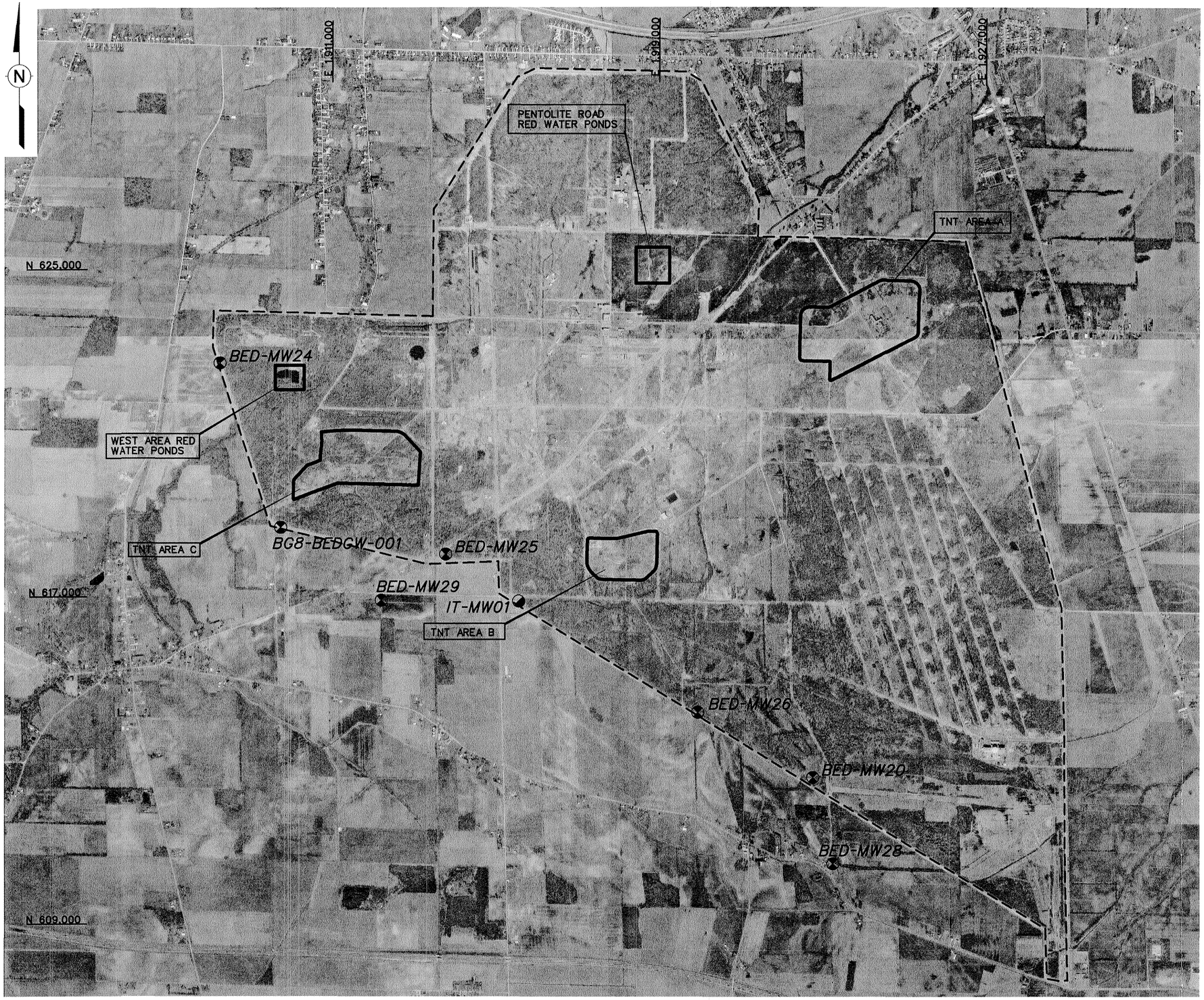


NOT TO SCALE

FIGURE 1-1
VICINITY MAP

FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw® Shaw Environmental, Inc.



LEGEND

▭	AREAS OF CONCERN
IT-MW01	OVERBURDEN/SHALE MONITORING WELL LOCATION
BED-MW20	BEDROCK MONITORING WELL LOCATION
– – – – –	PBOW PROPERTY BOUNDARY

SCALE

0 2500 5000 FEET

FIGURE 1-2
LOCATIONS OF AREAS OF CONCERN

FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw™ Shaw Environmental, Inc.

STARTING DATE: 12MAY03
DRAWN BY: C.TUMLIN
INITIATOR: D.KESSLER
CADD REVIEW: C.BENTLEY
TECH. REVIEW: D.KESSLER
PROJ. MGR.: S.DOWLEY
DWG. NO.: 843656-pbow-ssap-0002.dgn
PROJ. NO.: 843656

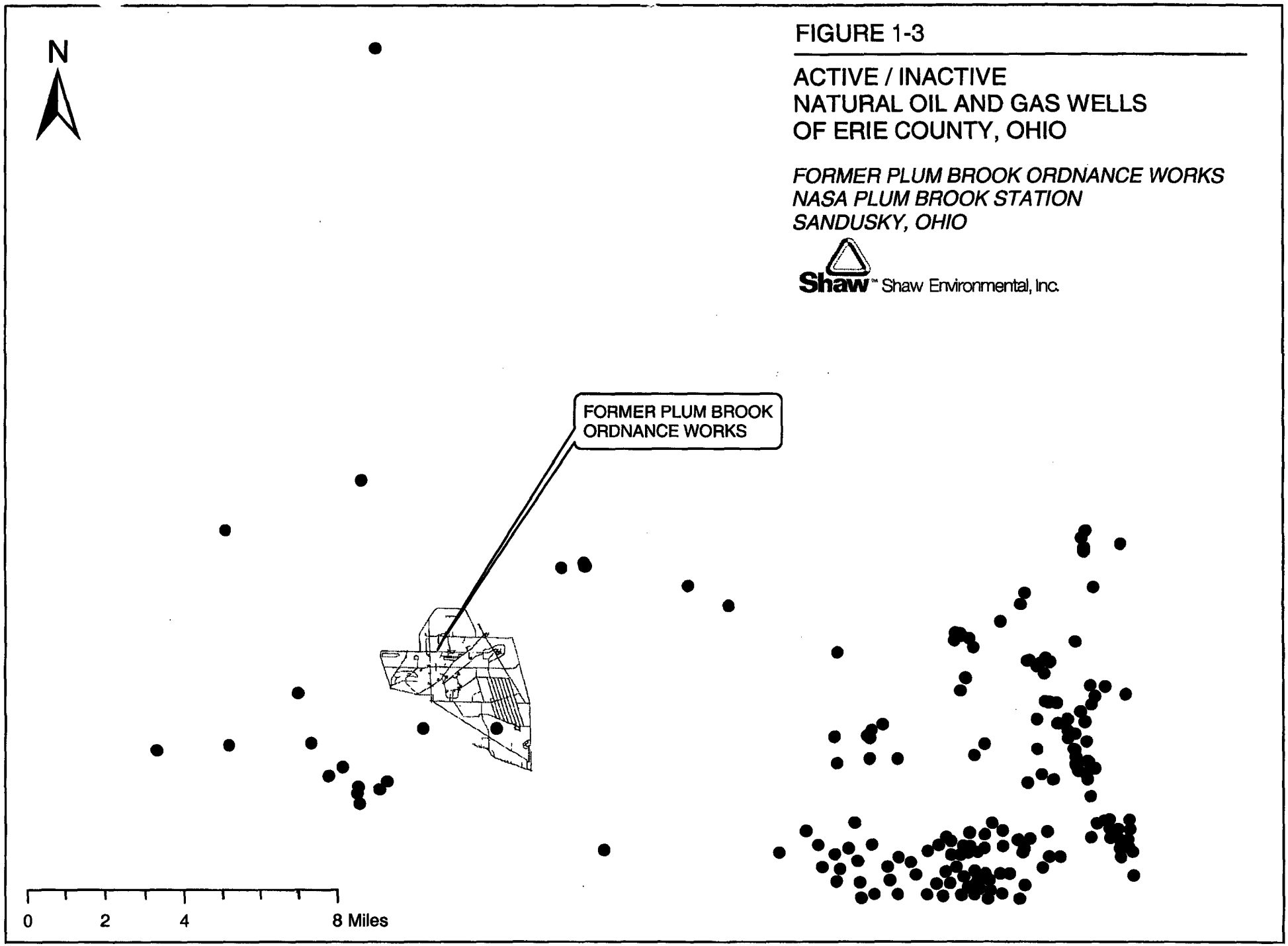


FIGURE 1-3

ACTIVE / INACTIVE
NATURAL OIL AND GAS WELLS
OF ERIE COUNTY, OHIO

FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw™ Shaw Environmental, Inc.

X:\pbow\gisworkspace\lleonard\output\figure_1_3.pdf (pbow_active_and_inactive_natural_oil_and_gas_wells.mxd)

Location		PB-BED-MW24															
Sample No.		BD3029		CA3001		CB3008		CC3004		CD3004		DA3004		DC3002		DD3003	
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	
Low-Flow Sample		Yes		Yes		Yes		Yes		No		Yes		Yes		Yes	
Parameter	Units	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
EXPLOSIVES																	
Dinitrotoluene, 2,6-	ug/L					0.43											
Nitrobenzene	ug/L					0.33											
RDX	ug/L					0.22	J										
Trinitrotoluene, 2,4,6-	ug/L											0.081	J				
VOLATILES																	
Acetone	ug/L	120	J			170	J	60				88	B				
Benzene	ug/L	60		91		110		14	J	9.3	J	36	J	32		36	
Butanone, 2-	ug/L			8.1		17	J	12	B								
Carbon disulfide	ug/L			1.2		0.59	J			29						3.4	J
Chloromethane	ug/L			1.3	J												
Ethylbenzene	ug/L	19	J	32		38		8	J	4.8	J	15	J	13	J	10	
Methylene chloride	ug/L	21	J									14	J				
Toluene	ug/L	58		90		100		17	J	14		43	J	37		31	
Xylenes, total	ug/L	110		180		210		55		23		82		67		50	J
SEMIVOLATILES																	
Bis(2-ethylhexyl)phthalate	ug/L							4.6	B								
Dimethylphenol, 2,4-	ug/L	1.1	J					0.76	J								
Methylnaphthalene, 2-	ug/L	3.6	J	5.6		4.6	J	10	J	1.4	J	5.5	J	4	J	2.9	J
Naphthalene	ug/L	2.9	J	7		4	J	8.7	J			4.6	J	3.5	J	2.3	J
Phenol	ug/L	1.4	J														
METALS-UNFILTERED																	
Aluminum	ug/L	37.8	J	77.7	B	35.7	J	1150		115	J	141	B	78	B	194	J
Arsenic	ug/L							4.3									
Barium	ug/L	932		938		1160		680		1080		1140		690		642	
Beryllium	ug/L			1.2	B												
Calcium	ug/L	158000		157000		161000		346000		159000		167000		168000		151000	
Chromium	ug/L							9.4									
Cobalt	ug/L							2.9				1.2	J			7.7	J
Copper	ug/L							8.6									
Iron	ug/L	48.3	J	72.7	B			13400		403							
Lead	ug/L							5.2	B								
Magnesium	ug/L	78500		78900		82900		88800		75400		84500		80600		70800	
Manganese	ug/L	24.8		19.2		14.8	J	420		23.6		14.1	J	27.4		25.8	
Mercury	ug/L											0.035	J				
Nickel	ug/L							7.9									
Potassium	ug/L	32100		46600		47600	J	41600		22900	J	26400	J	24100	J	24300	
Sodium	ug/L	90800		90600		106000		101000		91800		104000		80400		67000	
Thallium	ug/L			4.2	B									3.8	B	2.5	B
Vanadium	ug/L							6.1									
Zinc	ug/L							28.4		3.9	J	1.2	B			9.3	J
METALS-FILTERED																	
Aluminum	ug/L	55.1	B	89.6	B	74	B	110	B	87	B	128	B	69.9	B	50.8	B
Barium	ug/L	942		962		1170		670		1140		1160		689		669	
Beryllium	ug/L			1.5	B												
Calcium	ug/L	159000		158000		161000		147000		160000		168000		169000		152000	J
Cobalt	ug/L									1.4	J	1.5	J	3.7	J		
Iron	ug/L			40.7	B												
Magnesium	ug/L	78500		78800		82800		79400		77600		83600		79900		71100	
Manganese	ug/L	22.1		18.7		16.6		44.2		15.5		13.7	J	35		25.5	
Potassium	ug/L	30700	J	43300		44400	J	38300		24000	J	25800	J	23200	J	24500	J
Sodium	ug/L	90500		87800	J	105000		98500		92500		105000		79600		67900	J
Thallium	ug/L			4.1	B												
Zinc	ug/L					3.4	J			5.7	B	0.97	J	2.9	B		
WATER QUALITY PARAMETERS																	
Alkalinity	ppm	697	J	810		157		979		757		803		846		726	
Chloride	ppm	149		140		175	J	155		126		105		98		48.7	
Cyanide, total	ppm											0.004	B				
Hardness	ppm	566		710		715		1370		808		820		761		130	
Sulfate	ppm	21.4		150		23.6		32.3				20.3		24.6		32.6	
Total dissolved solids	ppm	948		1000		2200		1020		990		949		988		779	
Total organic carbon	ppm	3		1.8		2.4		3.7		3.7		2.4		1.9		1.6	
Total suspended solids	ppm					14		124		62		5				4	
Turbidity	NTU	266		61		116		742		49.6		68.8		138		74	

Location		PB-BED-MW25															
Sample No.		BD3030		CA3002		CB3004		CC3005		CD3005		DA3005		DC3003		DD3004	
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	
Low-Flow Sample		Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes	
Parameter	Units	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
EXPLOSIVES																	
Nitrobenzene	ug/L					0.076	J			0.12	J						
VOLATILES																	
Acetone	ug/L	1.7	B					1.4	B	1.6	J						
Benzene	ug/L	0.37	J							0.15	J						
Carbon disulfide	ug/L	0.48	J	1.5		0.36	J	0.17	J	1.3	J	1.5	J			0.77	J
Chloroform	ug/L	1.1															
Ethylbenzene	ug/L	0.22	J														
Methyl-2-pentanone, 4-	ug/L	0.3	J														
Methylene chloride	ug/L	0.3	B			0.21	B										
Toluene	ug/L	0.8	J			0.25	J										
Xylenes, total	ug/L	1.5								0.37	J						
SEMIVOLATILES																	
Bis(2-ethylhexyl)phthalate	ug/L	0.86	J					3	B								
METALS-UNFILTERED																	
Aluminum	ug/L	78.2	B	79.8	B	41.3	J	44.6	J	79.7	J	137	B	86.5	B	61.2	B
Barium	ug/L	226		247		434		164	J	277		558		177	J	187	J
Beryllium	ug/L			1.2	B												
Calcium	ug/L	134000		158000		173000		183000		200000		194000		159000		141000	
Iron	ug/L	795		357		91.1	J	103		207		102		156		140	
Magnesium	ug/L	79500		80000		68000		69100		80200		81200		62000		54000	
Manganese	ug/L	89		56.2		68.8		95.6		86.5		79.8		72.9		58.5	
Potassium	ug/L	17600		21600		14500	J	11400	J	16200	J	19200	J	12100	J	11900	
Sodium	ug/L	112000		115000		196000		92300		187000		223000		120000		122000	
Thallium	ug/L			4.7	B									3.1	B	3	B
Zinc	ug/L	7.7	J			79.5				1.7	J	1.4	B	4.8	J	74.4	
METALS-FILTERED																	
Aluminum	ug/L	68.7	B			52.7	B	97.8	B	69.8	B	135	B	61.8	B		
Barium	ug/L	224		234		452		160	J	270		545		177	J	175	J
Calcium	ug/L	128000		146000		176000		187000		198000		188000		158000		135000	J
Cobalt	ug/L											2	J				
Iron	ug/L	713		337				59.8	J	157		18.8	J	92.7	J	74.5	J
Magnesium	ug/L	76800		74400		69700		74100		78600		77900		61400		51400	
Manganese	ug/L	87		52.2		65.6		94		84.2		75.7		71.5		55.2	
Mercury	ug/L											0.056	J				
Potassium	ug/L	17000		20200		14900	J	12100	J	15900	J	18400	J	11900	J	11100	J
Sodium	ug/L	109000		114000		196000		97600		180000		217000		118000		115000	J
Thallium	ug/L							6.4	J								
Zinc	ug/L	3	J			19.9	J			1.5	B	1	J	2.6	B	21.7	
WATER QUALITY PARAMETERS																	
Alkalinity	ppm	278	J	320		337		329		314		344		313		316	
Chloride	ppm	404		460		558	J	219		631		615		257		221	
Cyanide, total	ppm											0.004	B				
Hardness	ppm	627		720		611		772		848		820		700		540	
Sulfate	ppm	121		79		36.2		416		79.5		38.6		264		136	
Total dissolved solids	ppm	1000		1100		1330		1180		1440		767		1100		834	
Total organic carbon	ppm	4	B	2		3		2.7		2.7		2		2.8		2.4	
Total suspended solids	ppm	4				9		5				4		5		8	
Turbidity	NTU	21.7	J	21		112		23.6		35.8		98		22.9		64.4	

Location		IT-MW01									
Sample No.		5530		5535/5535R		CC3009		CD3002		DA3002	
Sample Date		19-Nov-97		16-May-98		10-Jul-02		16-Oct-02		9-Apr-03	
Low-Flow Sample		No		No		No		No		No	
Parameter	Units	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
VOLATILES											
Acetone	ug/L					3.5	B			1.5	B
Butanone, 2-	ug/L							0.7	B		
Carbon disulfide	ug/L									0.1	J
Methylene chloride	ug/L	0.33	B	0.58	B	0.19	B				
Toluene	ug/L			22							
Xylenes, total	ug/L	0.31	B								
SEMIVOLATILES											
Diethyl phthalate	ug/L									1.5	B
METALS-UNFILTERED											
Aluminum	ug/L					117	J	10200	J	1400	
Antimony	ug/L							8	J		
Arsenic	ug/L							52.6			
Barium	ug/L					75.9	J	139	J	60.7	J
Beryllium	ug/L							4.6	J	0.84	B
Cadmium	ug/L							1.5	J	0.38	J
Calcium	ug/L	46400		47900		39400		56300		44400	
Chromium	ug/L							14.1			
Cobalt	ug/L					7.5	J	14	J	35.8	J
Copper	ug/L					9.1	J	72.2		48.8	
Iron	ug/L	1320		2200	J	563		52100		3530	
Lead	ug/L							101		8.8	
Magnesium	ug/L	17500		16300		15900		19500		19800	
Manganese	ug/L	323		348		292		490		396	
Mercury	ug/L	0.45									
Nickel	ug/L					15	J	35	J	74.9	
Potassium	ug/L	6160		5560		6780	J	6480		7450	J
Selenium	ug/L							5			
Sodium	ug/L	22800		22000		19400		17800		19200	
Thallium	ug/L							5.7	J	4	B
Vanadium	ug/L							35.9	J		
Zinc	ug/L	51.6		149		34.3		124	J	74.8	
METALS-FILTERED											
Aluminum	ug/L			276		62.2	B	71.6	B	1470	
Barium	ug/L					82.5	J	89.1	J	52.6	J
Beryllium	ug/L									1.2	B
Cadmium	ug/L									0.48	J
Calcium	ug/L	44900		53100		39300		57700		47400	
Cobalt	ug/L					10.3	J	4.9	J	34.8	J
Copper	ug/L					2.8	J	3.7	J	49.2	
Iron	ug/L	1090		1970		745		1840		2480	
Lead	ug/L									8.7	
Magnesium	ug/L	17000		19500		14600		20300		20900	
Manganese	ug/L	331		395		326		424		360	
Nickel	ug/L					26.2	J	10.5	J	82.9	
Potassium	ug/L	6180		6390		6390	J	6400	J	7270	J
Sodium	ug/L	22200		25100		19200		19400		18400	
Thallium	ug/L									4.9	B
Zinc	ug/L	46.9		47.5	B	124		13.1	J	73.8	
WATER QUALITY PARAMETERS											
Alkalinity	ppm	360		110		90		209		9.9	
Chloride	ppm	4		3		3.4		9.9		3	
Hardness	ppm	420		200		144		263		196	
Nitrate	ppm					0.19					
Sulfate	ppm	79		140		118		67.3		211	
Total dissolved solids	ppm	310		400		279		342		137	
Total organic carbon	ppm	8.6		7		7.1		9.9		3.8	
Total suspended solids	ppm	84		5		4		5		21	
Turbidity	NTU					1.7		10.6		14	

Location		PB-BED-MW20																			
Sample No.		5960		5965		BD3026		CA3005		CB3001		CC3003		CD3003		DA3003		DC3001		DD3002	
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	
Low-Flow Sample		No		Yes		Yes		Yes		Yes		No		Yes		Yes		Yes		Yes	
Parameter	Units	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	J		
Nitrobenzene	ug/L									0.088	J										
RDX	ug/L															0.17	J				
VOLATILES																					
Acetone	ug/L					1.2	J			5.3	J	10	B								
Benzene	ug/L	0.93	J	1.6		0.25	J					3.2		1.3	J	0.23	J	1.4	J	1.2	
Bromomethane	ug/L											0.27	J								
Butanone, 2-	ug/L											9.8									
Carbon disulfide	ug/L			0.17	J									1.1	J	0.21	J			0.16	J
Chloromethane	ug/L																	0.47	B		
Ethylbenzene	ug/L	0.15	J																		
Methylene chloride	ug/L	0.3	B	0.49	B											0.31	B				
Toluene	ug/L	0.73	B	0.95	B			2.4	B			0.76	B	0.35	J			0.45	B	0.26	B
Xylenes, total	ug/L	2.6		0.91	J					0.67	J										
SEMIVOLATILES																					
Bis(2-ethylhexyl)phthalate	ug/L			5.4	B	2.9	J														
Methylnaphthalene, 2-	ug/L	1.1	J																		
METALS-UNFILTERED																					
Aluminum	ug/L	3290		678	J	207	J			48.6	J	83.4	B	155	J	143	B	115	B	57.9	B
Arsenic	ug/L																	3.3	J		
Barium	ug/L	19000		16400		23900		22500		23700		24000		25700		26900		25200		26100	
Beryllium	ug/L													0.51	B						
Calcium	ug/L	2140000		1960000	J	2060000	J	1860000		1890000		2000000		2050000		2180000		2180000		2290000	
Chromium	ug/L					7.6	B			1.7	J					1.3	B				
Cobalt	ug/L					7.1	J			6.1	J	8	J	8.1	J	8.5	J	8.6	J	6.8	J
Copper	ug/L	32.8				15.8	B	32.8		30.5											
Iron	ug/L	13200		6770		5920	J	6480		853		4970		5310		257		4120		2030	
Magnesium	ug/L	920000		861000		943000	J	860000		884000		960000		941000		981000		1040000		1040000	
Manganese	ug/L	180		153		189	J	128		156		190		185		162		192		202	
Nickel	ug/L					3.5	J			3.4	J					7.2	J	4	J		
Potassium	ug/L	92300		78600		85800	J	165000		86700	J	101000	J	91700	J	81700	J	104000	J	72600	J
Sodium	ug/L	7660000		7300000		7980000	J	6830000		7770000		8380000		8190000		8430000		8540000		9130000	
Thallium	ug/L							7.1	B					4.1	B			4.6	B		
Zinc	ug/L	41.6		42.1	B	5.3		23.4		64.9		9.7	J	15.6	J	5.3	B	5.7	J	612	
METALS-FILTERED																					
Aluminum	ug/L					40.9	B			55.9	B	63.1	B	69.8	B	109	B	91.4	B		
Arsenic	ug/L					2.8	J											4.8	J	4.1	J
Barium	ug/L	21000		4950		24400		21300		23800		23900		24500		26200		25700		25700	
Beryllium	ug/L													0.24	B						
Calcium	ug/L	2570000	J	491000	J	2110000		1720000		1910000		2020000		1990000		2120000		2270000		2240000	J
Cobalt	ug/L					6.4	J			5.9	J	8	J	7.5	J	9.3	J	23.8	J	6.2	J
Copper	ug/L					2	B	5.7	J	26.5											
Iron	ug/L	2310		1320		5350		6180		1130		5100		4940				3800		1830	
Magnesium	ug/L	1090000		223000	J	965000		829000		888000		969000		911000		953000		1070000		1020000	
Manganese	ug/L	162		47		188		129		156		193		182		160		220		200	
Mercury	ug/L			0.24												0.032	J				
Nickel	ug/L					2.9	J			3.2	J					6.5	J	6	J		
Potassium	ug/L	103000		21600		87400	J	170000		86900	J	102000	J	88400	J	79000	J	105000	J	70500	J
Sodium	ug/L	9110000		1870000		8100000		6870000		7830000		8120000		7750000		8210000		8710000		9000000	J
Thallium	ug/L							7.3	B									4.1	B		
Zinc	ug/L					3.3	J	21.6		59.2	J	3.2	J	78.3		4.8	J	6.4	J	673	
WATER QUALITY PARAMETERS																					
Alkalinity	ppm	240		260		255	J	280		229		293		259		246		248		238	
Chloride	ppm	19000		21000		22400		18000		17300	J	19000		21100		34600		19100		21300	
Hardness	ppm	20000		10000		9360		8200		8850		8140		9390		9200		9690		9940	
Sulfate	ppm							3.2													
Total dissolved solids	ppm	32000		24000		27400	J	26000		27800		35500		43800		32600		42700		33600	
Total organic carbon	ppm					0.5	J	1.1	J	0.74	J										
Total suspended solids	ppm	74		90		125		13		13		33		19		100		112		39	
Turbidity	NTU					48.4	J	8.8		10.5		7.4		19.2		3.9		6.2		18.4	J

Location		PB-BED-MW29			
Sample No.		DC3005		DD3008	
Sample Date		16-Sep-03		9-Dec-03	
Low-Flow Sample		Yes		Yes	
Parameter	Units	Result	VQ	Result	VQ
VOLATILES					
Acetone	ug/L	17			
Benzene	ug/L			0.96	J
Carbon disulfide	ug/L	0.44	J	13	
Chloroform	ug/L	0.25	J		
Chloromethane	ug/L			0.3	J
Ethylbenzene	ug/L	0.86	J	0.87	J
Toluene	ug/L	0.12	J		
Xylenes, total	ug/L	5.5		5.1	J
METALS-UNFILTERED					
Aluminum	ug/L	309		49.9	B
Arsenic	ug/L			3.3	J
Barium	ug/L	11300		11800	
Calcium	ug/L	316000		295000	
Cobalt	ug/L	3.9	J	3.6	J
Iron	ug/L	932		1550	
Magnesium	ug/L	217000		198000	
Manganese	ug/L	62.7		50.7	
Potassium	ug/L	75800	J	67800	
Sodium	ug/L	1390000		1350000	
Thallium	ug/L	5.1	B	2.4	B
Zinc	ug/L	6.9	J	507	
METALS-FILTERED					
Aluminum	ug/L	83.1	B	66.9	B
Arsenic	ug/L	2.6	J	3.1	J
Barium	ug/L	10500		10800	
Calcium	ug/L	316000		283000	J
Cobalt	ug/L	6.1	J	3.4	J
Iron	ug/L	350		1490	
Magnesium	ug/L	219000		189000	
Manganese	ug/L	55.1		49.3	
Potassium	ug/L	76500	J	60700	J
Sodium	ug/L	1390000		1250000	J
Thallium	ug/L	6.2	B	3.8	B
Zinc	ug/L	8.5	J	528	
WATER QUALITY PARAMETERS					
Alkalinity	ppm	443		432	
Chloride	ppm	3540		2930	
Hardness	ppm	1750		1500	
Nitrate	ppm	0.39			
Sulfate	ppm	5.7			
Total dissolved solids	ppm	6580		3880	
Total organic carbon	ppm	2.6		3.9	
Total suspended solids	ppm	46		7	
Turbidity	NTU	14.7		7	J

Location		PB-BED-MW28			
Sample No.		DC3004		DD3007	
Sample Date		17-Sep-03		9-Dec-03	
Low-Flow Sample		Yes		Yes	
Parameter	Units	Result	VQ	Result	VQ
VOLATILES					
Benzene	ug/L	2.4	J	2.2	
Chloromethane	ug/L			0.97	J
Ethylbenzene	ug/L			0.13	J
Toluene	ug/L	1.7	J	0.62	J
Trichloroethene	ug/L	0.59	J		
Xylenes, total	ug/L			0.41	J
METALS-UNFILTERED					
Aluminum	ug/L	147	J	42.6	B
Arsenic	ug/L	7.4	J	5.4	J
Barium	ug/L	374		395	
Calcium	ug/L	20800		20000	
Iron	ug/L	235		398	
Magnesium	ug/L	8320		7780	
Manganese	ug/L	20.3		16.6	
Potassium	ug/L	7240	J	6050	
Sodium	ug/L	290000		285000	
Thallium	ug/L	4.2	B		
Zinc	ug/L	2.5	B	247	
METALS-FILTERED					
Aluminum	ug/L	152	J		
Arsenic	ug/L	6.9	J	5.6	J
Barium	ug/L	371		374	
Calcium	ug/L	20300		19700	J
Iron	ug/L	242		354	
Magnesium	ug/L	8120		7670	
Manganese	ug/L	15.8		16.4	
Potassium	ug/L	7140	J	5920	J
Sodium	ug/L	289000		280000	J
Thallium	ug/L	4.1	B	3.8	B
Zinc	ug/L	3.8	B	247	
WATER QUALITY PARAMETERS					
Alkalinity	ppm	474		444	
Chloride	ppm	171		148	
Hardness	ppm	99.5		81.6	
Sulfate	ppm	35.2		13.1	
Total dissolved solids	ppm	833		697	
Total organic carbon	ppm	5.9		5.3	
Turbidity	NTU	3.3		1.6	J

Location		[illegible]
Parameter	Units	Result / VQ
[illegible]	[illegible]	[illegible]

Location		PB-BED-MW26
Parameter	Units	Result / VQ
[illegible]	[illegible]	[illegible]

LEGEND:

Symbol	Description
IT-MW01	OVERBURDEN MONITORING WELL LOCATION
PB-BED-MW20	BEDROCK MONITORING WELL LOCATION
	BUILDINGS
	RAILROAD
	SURFACE WATER
	DITCH
	FENCE
O.B. FLOW	OVERBURDEN/SHALE GROUNDWATER FLOW DIRECTION
BED FLOW	BEDROCK GROUNDWATER FLOW DIRECTION

NOTES:

1. GROUNDWATER FLOW DIRECTION ON MAY 4, 2002.
2. UNABLE TO SAMPLE IT-MW01 IN SEPTEMBER 2001, JANUARY OR APRIL 2002. PVC CASING WAS DAMAGED AND PREVENTED ACCESS.
3. MONITORING WELL PB-BED-MW26 HAS NOT BEEN SAMPLED SINCE JANUARY 2002 DUE TO INSUFFICIENT WATER.

NE - NOT ESTABLISHED

NO	DATE	REVISION	BY	CHKD	DSGN ENGR	ENGR	PROJ MGR	APPR

STARTING DATE 07/21/02 | INITIATOR D. KESSLER | CHKD | DRAWN VANDERGRIFT | CHKD C. TUMLIN | PROJECT MNGR S. DOWNEY

Shaw Environmental, Inc.
KNOXVILLE, TENNESSEE

EIGHTH QUARTERLY BACKGROUND GROUNDWATER REPORT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

FIGURE 2-1
DETECTED CONSTITUENTS IN OVERBURDEN/BEDROCK BACKGROUND MONITORING WELLS (NOVEMBER 1997, MAY 1998, SEPTEMBER-OCTOBER 2001, JANUARY, APRIL, JULY, OCTOBER 2002, APRIL, SEPTEMBER, AND DECEMBER 2003)

AREA	JOB NO.	DRAWING NO.	REV
	843656	843656_001.DGN	

843656_001.dgn 3:54:43 PM 3/15/2004

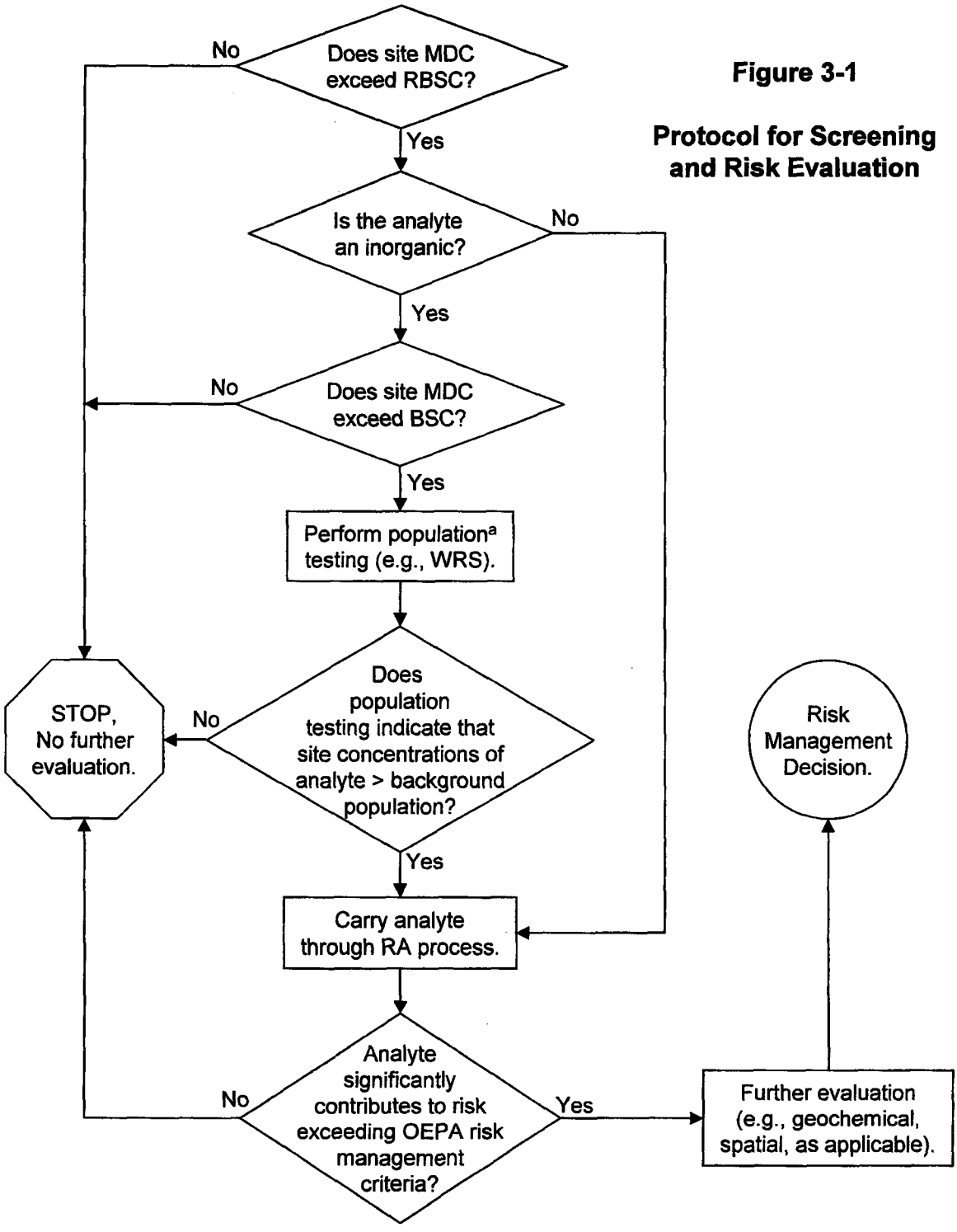


Figure 3-1

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).

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KN4\PBOW\8th Qtr\Fig3-1.ppt\3/15/2004 12:03 PM

APPENDIX A

TELECONFERENCE NOTES ON NATURAL PETROLEUM IN BEDROCK

INTERNATIONAL TECHNOLOGY CORPORATION

RECORD OF ☒ TELECON ☐ MEETING

Project Name	Number	Phase	Task	Subtask
PBOW				

Date 11/18/98 Time 1315

CALL FROM ☒ CALL TO ☐ NAME: David Kessler

Other Participants — Name/Location/Representing:

CALL FROM ☐ CALL TO ☒ NAME: Martin Jones (V.P.)

Telephone Number: 419-625-8141

Company Name: Wagner Quarry

Address:

Topic BTEX in Bedrock

City Sandusky

State OH Zip Code

Summary (Decisions & Specific Actions Required by Named Persons):

Inquired about H_2S and BTEX in bedrock.

Martin Jones (VP - mechanical 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 organics 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 ___

5484-9-87

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

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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 B

SAMPLE COLLECTION LOGS

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Sample Collection Log

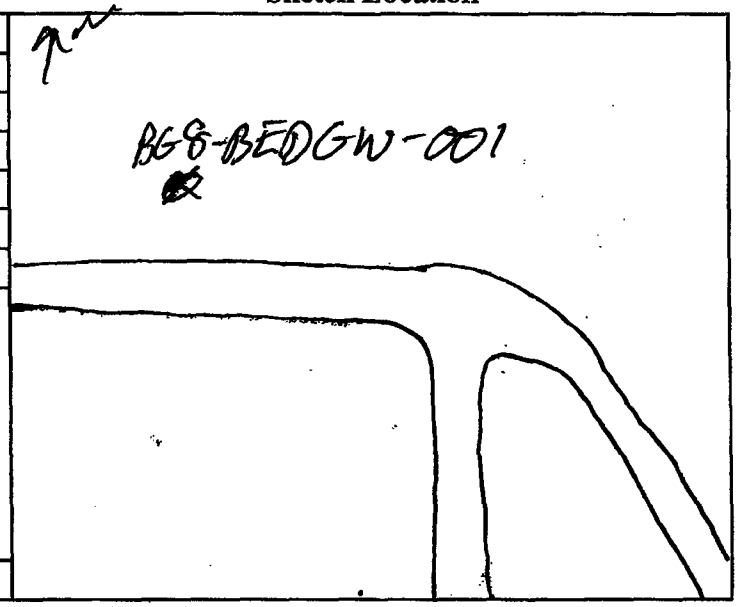
Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	**IT-BG8-BEDGW-001**	Collection Date:	12/10/03
Sample Number:	**DD3001**	Collection Time:	1620
Sample Name:	**PBOW-03-IT-BG8-BEDGW-001-DD3001**	Start Depth:	14
Sampling Method:	**Low Flow**	End Depth:	—
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: All samples immediately placed on ice.
Removed 3 gal

Logged by/Date: [signature] 12.10.03

Reviewed by/Date: David Kessler 12/10/03

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GROUNDWATER PURGE FORM

Location Code: **IT-BG8-BEDGW-001**

Sample Number: **DD3001**

Water Quality Parameter Measurements									
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)
1540	4.51	275	0.0	—	—	—	—	—	—
1545	4.75	"	1.375	10.45	1.220	7.41	-18.1	4.46	0.0
1550	4.76	"	2.75	10.86	1.046	7.33	-40.3	0.77	0.0
1555	4.79	"	4.125	11.01	1.003	7.28	-50.3	0.35	0.0
1600	"	"	5.50	11.03	0.999	7.28	-50.2	0.34	0.0
1605	"	"	6.875	11.05	0.976	7.25	-50.3	0.36	0.0
1610	"	220	7.975	11.08	0.976	7.24	-50.5	0.34	0.0
1615	"	"	9.075	11.12	0.984	7.23	-50.3	0.30	0.0
1620	"	"	10.175	11.11	0.988	7.23	-50.5	0.31	0.0
Purging completed. Sample # DD3001 collected at 1620.									

Abbreviations: BTOC - Below top of casing; DTW - Depth to water; mL - milliliter; L - Liter

GROUNDWATER SAMPLING FORM

Shaw®

Project Number:	843656	Collection Date:	12.10.03	Form Completed By:	Z. Barham
Project Name:	PBOW	Collection Time:	1620	Sampler(s):	Z. Barham / D. Kessler
Investigation Site:	Background	Sample Filtered (Yes/No):	Metals		
RFA/COC Number:	1210035TL-E	Weather/Temp:	Cold Rain	Reviewed By:	David Kessler

Sample ID: P B O W 0 3 P B B G S B E D G W 0 0 1 0 0 1 1 4 D D 3 8

MONITORING WELL INFORMATION [use top of casing (TOC) for all measurements]

Well Number: BGS-BEDGW-001	Outside Casing Dia. (in): 2"	Odor:
Well Secure (Yes / No):	Depth to Product (ft): NA	Vapor Monitor Type: PID / LEL
Well Labeled (Yes / No):	Total Well Depth (ft): 20	Vapor Monitor S/N: 82386 1H842697
Well Condition: Good	Depth to Water (ft): 4.51	Reading (ppm): 0.0 LEL = 0 % O_2 = 20.2%
Top of Screen: 5'	Water Column: 15.49	C = 0 ppm H_2S= 0 ppm
Screen Height: 15'	Top of Filter Pack: 5'	Depth Pump Set: 14'
Casing Type: PVC	Pump Type: bladder	Pump Settings: CPM4 10/5 9 psi
		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 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 = 16 ft.

Tubing Volume (Liters) = ([Tubing Liters/ft. x Tubing length] + Pump volume) x 3 = ([0.01 L/ft x 16 ft] + 0.3 L) x 3 = 1.38 L

Total Volume Purged: 1.38 L Liters to gallons = L x 0.26gal/L = .3588 gal

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Sample Collection Log

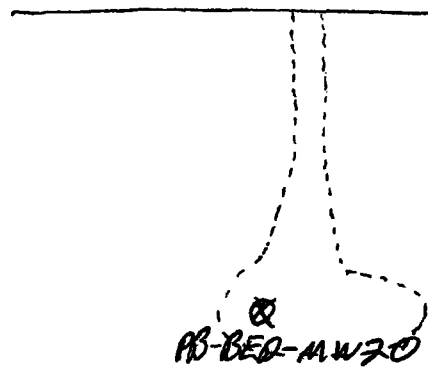
Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	**PB-BED-MW20**	Collection Date:	12.10.03
Sample Number:	**DD3002**	Collection Time:	1200
Sample Name:	**PBOW-03-GW-PB-BED-MW20-DD3002**	Start Depth:	32'
Sampling Method:	**Low Flow**	End Depth:	—
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	1 - 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: All samples immediately placed on ice.
Removed 1.5 gal

Logged by/Date: [signature]

Reviewed by/Date: David Kessler 12/10/03

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GROUNDWATER PURGE FORM

Location Code: **PB-BED-MW20**

Sample Number: **DD3002**

Water Quality Parameter Measurements									
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)
1050	13.80	100	0.0	—	—	—	—	—	—
1055	13.84	"	.5	10.58	25.62	6.93	45.3	5.96	3.9
1100	13.89	"	1.0	10.34	49.33	6.93	35.0	2.66	1.0
1105	13.99	"	1.5	10.17	51.61	6.66	40.2	0.77	0.0
1110	14.09	"	2.0	10.08	51.66	6.64	34.2	0.53	0.0
1115	14.20	"	2.5	10.05	51.62	6.65	34.0	0.48	0.1
1120	14.23	"	3.0	9.96	51.62	6.62	34.5	0.49	0.1
1125	14.28	90	3.25	9.77	51.59	6.69	9.9	0.43	0.1
1130	14.38	"	3.50	9.38	51.62	6.67	-30.6	0.41	0.4
1135	14.34	"	3.75	9.18	51.58	6.66	-30.0	0.43	0.0
1140	14.31	"	4.00	9.10	51.51	6.68	-30.1	0.43	0.1
1145	14.30	"	4.25	9.07	51.46	6.67	-30.8	0.44	0.2
1150	14.29	"	4.50	8.83	51.50	6.68	-30.0	0.44	0.3
1155	14.26	"	4.75	8.86	51.46	6.68	-30.2	0.46	0.1
Purging completed. Began sampling DD3002 @ 1155.									

Abbreviations: BTOC - Below top of casing; DTW - Depth to water; mL - milliliter; L - Liter

GROUNDWATER SAMPLING FORM

Shaw®

Project Number:	843656	Collection Date:	12.10.03	Form Completed By:	Z. Parham
Project Name:	PBOW	Collection Time:	1200	Sampler(s):	Z. Parham / D. Kessler
Investigation Site:	Background	Sample Filtered (Yes/No):	Metals		
RFA/COC Number:	PB09183 STL-KFC	Weather/Temp:	Rainy / Cold	Reviewed By:	David Kessler 12/10/03

PB 12/10/03 STL

Sample Number: P B O W 0 3 P B - B E D - M W 2 0 - D D 3 0 0 2 - 3 2

MONITORING WELL INFORMATION [use top of casing (TOC) for all measurements]

Well Number: MW20	Outside Casing Dia. (in): 2"	Odor: —
Well Secure (Yes/No):	Depth to Product (ft): NA	Vapor Monitor Type: PID / LEL
Well Labeled (Yes/No):	Total Well Depth (ft): 48.6	Vapor Monitor S/N: 1
Well Condition: Good	Depth to Water (ft): 13.80	Reading (ppm): 0.0 LEL = 0 % O_2 = 20.3 %
Top of Screen: 28'	Water Column: 34.8	C = 0 ppm H_2S = 0 ppm
Screen Height: 20'	Top of Filter Pack: 26'	Depth Pump Set: 32'
Casing Type: PVC	Pump Type: bladder	Pump Settings: 20 psi refill: 10 disch: 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 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 = 33 ft.

Tubing Volume (Liters) = ([Tubing Liters/ft. x Tubing length] + Pump volume) x 3 = ([0.01 L/ft x 33 ft] + 0.3 L) x 3 = 1.89 L

Total Volume Purged: 1.89 L Liters to gallons = L x 0.26gal/L = .4914 gal

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Sample Collection Log

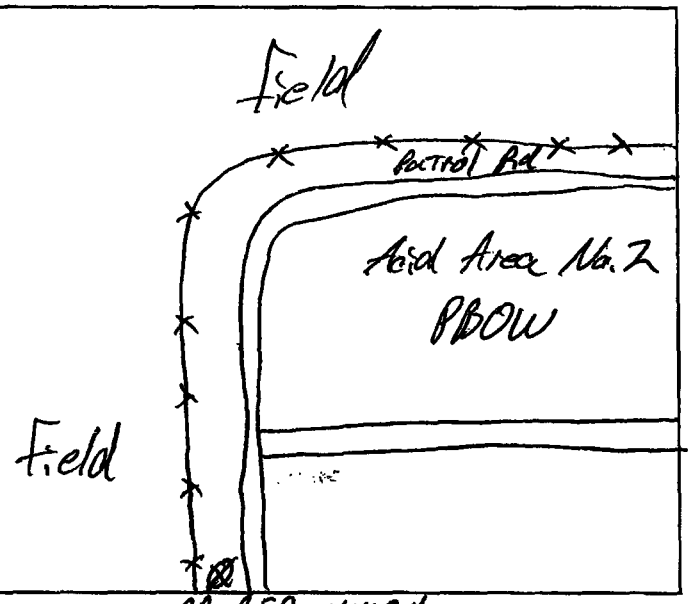
Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	PB-BED-MW24	Collection Date:	12.11.03
Sample Number:	DD3003	Collection Time:	1035
Sample Name:	PBOW-03-PB-BED-MW24-DD3003	Start Depth:	36.5
Sampling Method:	Low Flow	End Depth:	—
Sample Type:	GW	Sample Matrix:	WATER
Sample Purpose:	REG	Sample Team:	Kessler/Parham

Analytical Suite	Containers
FILTERED METALS	1 - 250 mL HDPE
TAL 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: All Samples Immediately placed on ice
Tot PV = 3.2 gal

Logged by/Date: [signature]

Reviewed by/Date: David Kessler 12/11/03

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GROUNDWATER PURGE FORM

Location Code: **PB-BED-MW24**

Sample Number: **DD3003**

Water Quality Parameter Measurements									
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)
0945	26.35	200	0.0	—	—	—	—	—	—
0950	26.39	240	1.0	8.83	1.319	6.55	-308.4	8.65	18.2
0955	26.46	"	2.2	8.88	1.303	6.53	-306.5	3.23	16.3
1000	26.51	"	3.5	9.73	1.293	6.56	-328.1	-0.36	14.3
1005	26.53	"	4.7	9.97	1.308	6.58	-326.1	-1.03	9.8
1010	"	"	5.9	10.06	1.320	6.59	-329.1	-1.24	7.4
1015	"	"	7.1	10.06	1.344	6.60	-329.7	-1.52	3.3
1020	"	"	8.3	10.07	1.357	6.60	-330.1	-1.67	2.9
1025	"	"	9.5	10.08	1.375	6.61	-331.1	-1.92	0.8
1030	"	"	10.7	10.06	1.391	6.61	-331.0	-1.98	0.0
1035	"	"	11.9	10.06	1.408	6.61	-331.7	-1.99	0.0
- Purging completed. Began Sampling DD3003 at 1035 —									

12-1-03

Abbreviations: BTOC - Below top of casing; DTW - Depth to water; mL - milliliter; L - Liter

GROUNDWATER SAMPLING FORM

Shaw®

Project Number:	843656	Collection Date:	12.11.03	Form Completed By:	Z. Parhan
Project Name:	PBOW	Collection Time:	1035	Sampler(s):	Z. Parhan / D Kessler
Investigation Site:	Background	Sample Filtered (Yes/No):	Metals		
RFA/COC Number:	PB1211035TLK	Weather/Temp:	Cold/Cloudy	Reviewed By:	David Kessl 12/11/03

Sample Number: P B O W - 0 3 - P B - B E D - M W 2 4 - G W - D D 3 0 0 3 - 3 6

MONITORING WELL INFORMATION [use top of casing (TOC) for all measurements]

Well Number: PB-BED-MW24	Outside Casing Dia. (in): 2"	Odor: 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): 41.00	Vapor Monitor S/N: /
Well Condition: Good	Depth to Water (ft): 26.35	Reading (ppm): PID 58.3 LEL = 17 % O_2 = 20.8%
Top of Screen: 25.5	Water Column: 14.65	C = 0 ppm H_2S = >50 ppm ppm
Screen Height: 15'	Top of Filter Pack: 19	Depth Pump Set: 36.5
Casing Type: PVC	Pump Type: Bladder	Pump Settings: 20 psi 10/5
		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 = 37.5 ft.

Tubing Volume (Liters) = ([Tubing Liters/ft. x Tubing length] + Pump volume) x 3 = ([0.01 L/ft x 37.5 ft] + 0.3 L) x 3 = 2.02 L

Total Volume Purged: 2.02 L Liters to gallons = L x 0.26gal/L = .5252 gal

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Sample Collection Log

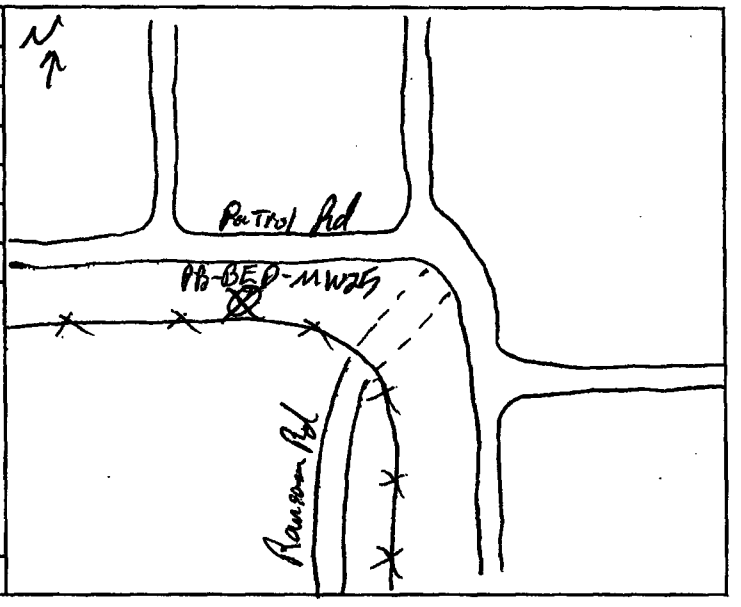
Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	**PB-BED-MW25**	Collection Date:	12.11.03
Sample Number:	**DD3004**	Collection Time:	1755
Sample Name:	**PBOW-03-PB-BED-MW25-DD3004**	Start Depth:	35'
Sampling Method:	**Low Flow**	End Depth:	—
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: All Samples placed on ice immediately.
Removed ~3.6 gal

Logged by/Date: [signature] 12.11.03 Reviewed by/Date: David Kessler 12/11/03

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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:	12.11.03
Sample Number:	**DD3004-MS**	Collection Time:	1355
Sample Name:	**PBOW-03-PB-BED-MW25-DC3004-MS**	Start Depth:	35
Sampling Method:	**Low Flow**	End Depth:	—
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# DD3004 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# DD3004 for purge and location information.

Logged by/Date: [signature] 12.11.03

Reviewed by/Date: David Kessler 12/11/03

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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:	12.11.03
Sample Number:	DD3004-MS0	Collection Time:	1355
Sample Name:	PBOW-03-PB-BED-MW25-DC3004-MSD	Start Depth:	35'
Sampling Method:	Low Flow	End Depth:	—
Sample Type:	GW	Sample Matrix:	WATER
Sample Purpose:	MS0	Sample Team:	Kessler/Parham

Analytical Suite	Containers	Sketch Location
FILTERED METALS	1 - 250 mL HDPE	See sample# DD3004 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# DD3004 for purge and location information.

Logged by/Date: Zach Pash 12/11/03

Reviewed by/Date: David Kessler 12/11/03

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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:	12.11.03
Sample Number:	**DD3005**	Collection Time:	1355
Sample Name:	**PBOW-03-PB-BED-MW25-DD3005**	Start Depth:	35'
Sampling Method:	**Low Flow**	End Depth:	—
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# DD3004 for location information.
TAL 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# DD3004 for purge and location information.

Logged by/Date: [signature] 12.11.03

Reviewed by/Date: David Kessler 12/11/03

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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:	12.11.03
Sample Number:	**DD3006**	Collection Time:	1355
Sample Name:	**PBOW-03-PB-BED-MW25-DD3006**	Start Depth:	35'
Sampling Method:	**Low Flow**	End Depth:	—
Sample Type:	**GW**	Sample Matrix:	**WATER**
Sample Purpose:	**FS**	Sample Team:	**Kessler/Parham**

Analytical Suite	Containers	Sketch Location
FILTERED METALS	1 - 250 mL HDPE	See sample# DD3004 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# DD3004 for purge and location information.

Logged by/Date: Jack Parsh 12.11.03 Reviewed by/Date: David Kessler 12/11/03

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GROUNDWATER PURGE FORM

Location Code: **PB-BED-MW25**

Sample Number: **DD3004**

Water Quality Parameter Measurements									
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)
1310	13.85	310	0.0	—	—	—	—	—	—
1315	13.94	"	1.5	10.47	1.487	7.35	-188.2	4.05	2.8
1320	"	"	3.0	10.77	1.533	7.23	-258.4	0.63	0.0
1325	"	"	4.5	10.87	1.477	7.15	-315.9	0.26	0.0
1330	"	"	6.0	10.80	1.484	7.14	-325.3	0.14	0.0
1335	"	"	7.5	10.78	1.501	7.13	-325.1	0.13	0.0
1340	"	"	9.0	10.82	1.506	7.12	-325.8	0.12	0.0
1345	"	"	10.5	10.90	1.507	7.12	-325.0	0.11	0.0
1350	"	"	12.0	10.81	1.511	7.11	-325.9	0.11	0.0
1355	"	"	13.5	10.82	1.509	7.11	-325.6	0.10	0.0
Purging completed at 1355. Began sampling								DD3004/MS/MSD	
								DD3005/DD3006	

Abbreviations: BTOC - Below top of casing; DTW - Depth to water; mL - milliliter; L - Liter

GROUNDWATER SAMPLING FORM

Shaw®

Project Number:	843656	Collection Date:	12.11.03	Form Completed By:	Z. Pawlan
Project Name:	PBOW	Collection Time:	1355	Sampler(s):	Z. Pawlan / D. Kessler
Investigation Site:	Background	Sample Filtered (Yes/No):	Metals		
RFA/COC Number:	PB121103STL-4C	Weather/Temp:	Cold	Reviewed By:	David Kessler

Sample Number: P B O W - 0 3 - P B - BED GW - MW25 - DC300 - 35

MONITORING WELL INFORMATION [use top of casing (TOC) for all measurements]

Well Number: PB-BED-MW25	Outside Casing Dia. (in): 2"	Odor:
Well Secure (Yes/No): Yes	Depth to Product (ft): NA	Vapor Monitor Type: PID / LEL (PID)
Well Labeled (Yes / No): Yes	Total Well Depth (ft): 40.68	Vapor Monitor S/N: /
Well Condition: Good	Depth to Water (ft): 13.83	Reading (ppm): 0.0 LEL = 0 % O_2 = 20.7 %
Top of Screen: 30'	Water Column: 26.85	C = 0 ppm H_2S = 0 ppm
Screen Height: 10'	Top of Filter Pack: 25	Depth Pump Set: 35'
Casing Type: PVC	Pump Type: Bladder	Pump Settings: 20 psi 10/5
		Remarks:

MONITORING WELL PURGE CALCULATIONS

(Section struck through by hand: "Low Flow Sampled")

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 = ([0.01 L/ft x 38 ft] + 0.3 L) x 3 = 2.04 L

Total Volume Purged: 2.04 L Liters to gallons = L x 0.26gal/L = .5304 gal

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Sample Collection Log

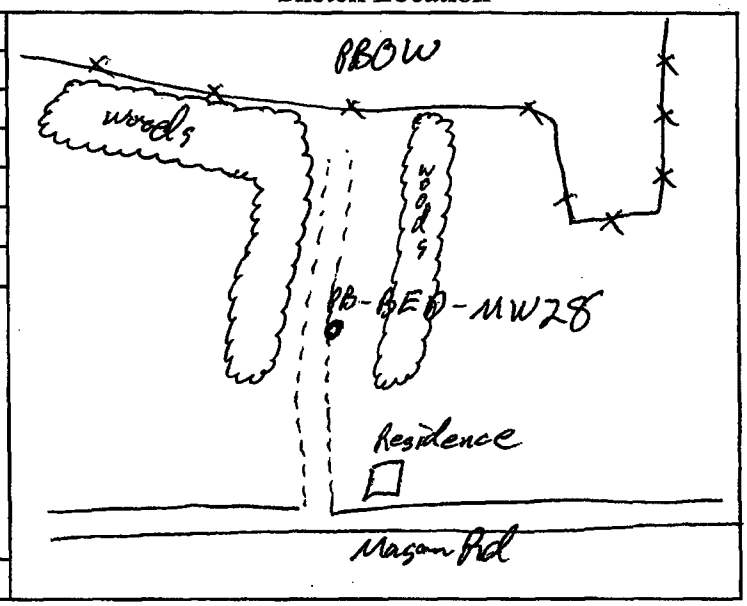
Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	PB-BED-MW28	Collection Date:	12.9.03
Sample Number:	DD3007	Collection Time:	1320
Sample Name:	PBOW-03-GW-PB-BED-MW28-DD3007	Start Depth:	34.15
Sampling Method:	Low Flow	End Depth:	—
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: PID = 0.0 % O_2 = 20.7 H_2S = 0.0 ppm CO = 0.0 ppm
DTW = 6.13
All Samples immediately placed on ice.

Logged by/Date: [signature] 12.9.03 Reviewed by/Date: David Kessler 12/9/03

10 - refill
5 - discharge
18 - psi

Tubing length: 37.14
Tot purge vol = 1.5 gal

Removed 1.5 gal

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GROUNDWATER PURGE FORM

Location Code: **PB-BED-MW28**

Sample Number: **DD3007**

Water Quality Parameter Measurements									
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)
1240	6.13	180	0.0	—	—	—	—	—	—
1245	6.33	"	.9	9.90	0.694	7.48	150.2	3.15	-0.7
1250	6.38	"	1.8	10.04	1.427	7.57	69.8	0.98	0.0
1255	6.41	120	2.7	10.13	1.433	7.57	27.3	0.70	0.0
1300	6.41	120	3.3	10.19	1.426	7.56	1.0	0.53	0.0
1305	6.41	120	3.9	10.20	1.416	7.56	7.6	0.51	0.0
1310	6.41	"	4.5	10.21	1.406	7.55	7.9	0.48	0.0
1315	6.41	"	5.1	10.21	1.390	7.55	7.8	0.47	0.0
1320	6.41	"	5.7	10.28	1.391	7.54	7.5	0.45	0.0
Purging completed at 1320. Began sampling DD3007.									

Abbreviations: BTOC - Below top of casing; DTW - Depth to water; mL - milliliter; L - Liter

GROUNDWATER SAMPLING FORM

Shaw®

Project Number:	843656	Collection Date:	12/9/03	Form Completed By:	D. Kessler
Project Name:	PBOW	Collection Time:	1320	Sampler(s):	D. Kessler / Z. Parham
Investigation Site:	Background	Sample Filtered (Yes/No):	yes		
RFA/COC Number:	PB1209035TL-K	Weather/Temp:	cloudy, cold, wet (40°)	Reviewed By:	David Kessler

P B O W 0 3 P B G W B E - D M W 2 8 - D D 3 0 0 7 - 3 4 - 3 4

MONITORING WELL INFORMATION [use top of casing (TOC) for all measurements]

Well Number:	PB-BED-MW28	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):	E	Total Well Depth (ft):	41.90'	Vapor Monitor S/N:	82386 / 4842697
Well Condition:	Excellent	Depth to Water (ft):	6.13'	Reading (ppm):	LEL = 0 % O_2 = 20.7 %
Top of Screen:	26.05'	Water Column:	35.77'	PID = 0.0 ppm	C = 0 ppm H_2S = 0 ppm
Screen Height:	15'	Top of Filter Pack:	17.5'	Depth Pump Set:	34'
Casing Type:	2" PVC	Pump Type:	Bladder	Pump Settings:	18 psi, 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 = 37 ft.

Tubing Volume (Liters) = ([Tubing Liters/ft. x Tubing length] + Pump volume) x 3 = ([0.01 L/ft x 37 ft] + 0.3 L) x 3 = ____ L

Total Volume Purged: ____ L Liters to gallons = L x 0.26gal/L

Total Volume purged = 1.5 gal

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Sample Collection Log

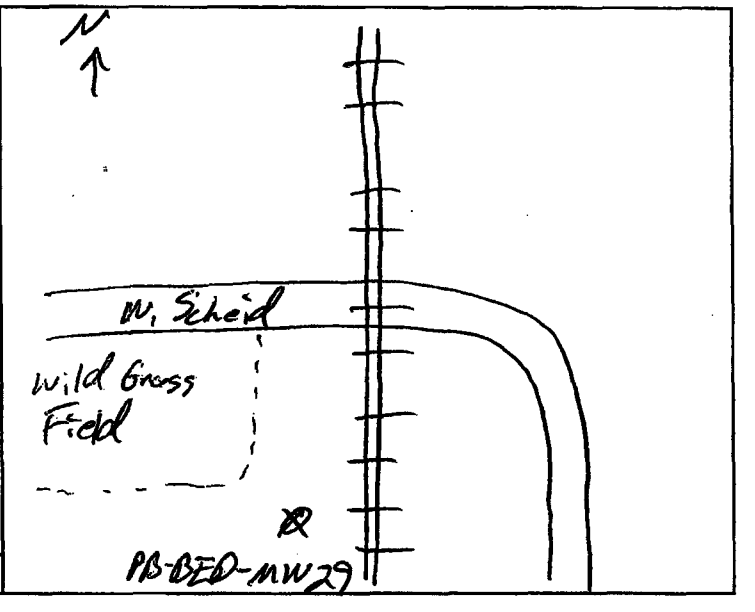
Plum Brook Ordnance Works

Project No: 843656 Project Manager: S. Downey

Location Code:	**PB-BED-MW29**	Collection Date:	12.9.03
Sample Number:	**DD3008**	Collection Time:	1535
Sample Name:	**PBOW-03-GW-PB-BED-MW29-DD3008**	Start Depth:	32'
Sampling Method:	**Low Flow**	End Depth:	—
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: PID = 0.0 % O_2 = 20.8 H_2S = 0.0 CO = 0.0
DTW = 2.41
All samples immediately placed on ice

Logged by/Date: [signature] 12.9.03 Reviewed by/Date: David Kessler 12/9/03

refill = 10
Discharge = 5
PSI = 20

Tubing Length = 36'
tot purge vol = 1.50 gal

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GROUNDWATER PURGE FORM

Location Code: **PB-BED-MW29**

Sample Number: **DD3008**

Water Quality Parameter Measurements									
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)
1500	2.39	150	0.0	—	—	—	—	—	—
1505	2.46	"	.75	9.32	6.998	6.93	37.9	4.22	6.1
1510	2.48	"	1.50	9.36	7.031	6.91	36.2	3.73	7.9
1515	2.55	"	2.25	9.77	7.522	6.87	24.1	1.23	9.8
1520	2.66	150	3.00	10.21	8.087	6.84	3.9	0.49	6.1
1525	2.66	"	3.75	10.09	8.209	6.83	2.9	0.41	6.7
1530	"	"	4.50	10.02	8.487	6.82	3.4	0.39	4.3
1535	"	"	5.25	10.00	8.490	6.82	3.0	0.39	1.9
1540	"	120 mL	6.00	9.94	8.460	6.82	3.1	0.38	0.8

Purging completed at 1540. Began sampling DD3008.

Abbreviations: BTOC - Below top of casing; DTW - Depth to water; mL - milliliter; L - Liter

GROUNDWATER SAMPLING FORM

Shaw®

Project Number:	843656	Collection Date:	12/9/03	Form Completed By:	D. Kessler
Project Name:	PBOW	Collection Time:	1535	Sampler(s):	Zach Parham / D. Kessler
Investigation Site:	Background	Sample Filtered (Yes/No):	yes		
RFA/COC Number:	PB120903STL-KC	Weather/Temp:	Cloudy, sleet (40°)	Reviewed By:	David Kessler

P B O W 0 3 P B G W B E - D M W 2 9 - D D 3 0 0 8 - 3 2 - 3 2

MONITORING WELL INFORMATION [use top of casing (TOC) for all measurements]

Well Number:	PB-BED-MW29	Outside Casing Dia. (in):	2	Odor:	None Benzene/BTEX during sampling
Well Secure (Yes / No):		Depth to Product (ft):	NA	Vapor Monitor Type:	PID / LEL
Well Labeled (Yes / No):		Total Well Depth (ft):	37.90'	Vapor Monitor S/N:	82386 / 18842697
Well Condition:	Excellent	Depth to Water (ft):	2.39'	Reading (ppm):	LEL = 0 % O_2 = 20.7 %
Top of Screen:	27.65	Water Column:	35.51'	During sampling - PID = 0.0 ppm PID = 8.0 ppm	C = 0 ppm H_2S = 0 ppm
Screen Height:	10'	Top of Filter Pack:	25'	Depth Pump Set:	32
Casing Type:	PVC	Pump Type:	Bladder	Pump Settings:	15.5-20 psi, Refill = 10, Discharge = 5
				Remarks:	

MONITORING WELL PURGE CALCULATIONS

Low-Flow

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 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 = 36 ft.

Tubing Volume (Liters) = ([Tubing Liters/ft. x Tubing length] + Pump volume) x 3 = ([0.01 L/ft x 36 ft] + 0.3 L) x 3 = 1.98 L

Total Volume Purged: 1.98 L Liters to gallons = L x 0.26gal/L 1.98 x 0.26 = 0.52 gal

Total volume purged = 1.50 gal

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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:	12/10/03
Sample Number:	**DD3009**	Collection Time:	
Sample Name:	**PBOW-03-PB-BED-MW26-DD3009**	Start Depth:	
Sampling Method:	**Low Flow**	End Depth:	
Sample Type:	**GW**	Sample Matrix:	**WATER**
Sample Purpose:	**REG**	Sample Team:	**Kessler/Parham**

Not Sampled

Analytical Suite	Containers	Sketch Location
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	

Comments: Depth to water = 58.78', TD = 60.35', Water column = 1.57'

Logged by/Date: David Kessler 12/10/03 Reviewed by/Date: David Kessler 12/10/03

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GROUNDWATER PURGE FORM

Location Code: **PB-BED-MW26**

Sample Number: **DD3009**

Water Quality Parameter Measurements									
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

Not Sampled

GROUNDWATER SAMPLING FORM

Shaw®

Project Number:	843656	Collection Date:	—	Form Completed By:	D. Kessler
Project Name:	PBOW	Collection Time:	—	Sampler(s):	—
Investigation Site:	Background	Sample Filtered (Yes/No):	—		
RFA/COC Number:	—	Weather/Temp:	—	Reviewed By:	David Kessler

P B O W 0 3 P B

MONITORING WELL INFORMATION [use top of casing (TOC) for all measurements]

Well Number:	PB-BED-MW26	Outside Casing Dia. (in):	2	Odor:	
Well Secure (Yes / No):	Yes	Depth to Product (ft):	None	Vapor Monitor Type:	PID / LEL
Well Labeled (Yes / No):	Yes	Total Well Depth (ft):	60.35	Vapor Monitor S/N:	823861 / H842697
Well Condition:	Excellent	Depth to Water (ft):	58.78'	Reading (ppm):	LEL = % O_2 = %
Top of Screen:		Water Column:	1.57'		C = ppm H_2S= ppm
Screen Height:	15 Ft	Top of Filter Pack:		Depth Pump Set:	—
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

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.)

Not Sampled

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

APPENDIX C

DATA VALIDATION SUMMARY

Data Validation Summary Report
Quarterly Groundwater Sampling – December 2003
Plum Brook Ordnance Works
Sandusky, Ohio

1.0 Introduction

Level III data validation was performed on 100 percent of the environmental samples collected for December 2003 sampling event. The analytical data consisted of one sample delivery group (SDG) PB045, which was analyzed by Severn Trent Laboratories (STL). In addition, validation of the field-split data, 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
PB045	DD3001, DD3002, DD3003, DD3004, DD3005, DD3007, DD3008
F21096	DD3006

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, TSD, TSS, Hardness, Cyanide)

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. All completed validation checklists are included in attachment A. 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.

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:

<u>Holding Times</u>

Technical holding time criteria were met for all samples.

<u>Initial and Continuing Calibration</u>

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
PB045	All	4-Methyl-2-pentanone	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
PB045	All	1,1,2,2-Tetrachloroethane, Bromoform, Styrene, Xylene (total)	J/UJ
	DD3001, DD3002, DD3007, DD3008	trans-1,3-Dichloropropene	UJ
	DD3003, DD3004, DD3005	Acetone, Methylene Chloride	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	Samples Affected	Compound(s)	Blank Contaminant	Validation Qualifier
PB045	DD3002	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. The RPD (30%) QC criteria were met with the following exception(s):

SDG Number	Samples Affected	Compound(s)	Validation Qualifier
PB045	DD3004 (original) DD3005 (FD)	Carbon Disulfide	J

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 relative standard deviation (%RSD) >30 and/or CCAL percent difference (%D) >20:

SDG Number	Samples Affected	Compound(s)	Validation Qualifier
PB045	All	2,4-Dinitrophenol	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
PB045 (total)	DD3001, DD3004, DD3005, DD3008	Thallium	Calibration	B
	DD3002, DD3004, DD3005, DD3007, DD3008	Aluminum	Calibration	B
PB045 (dissolved)	DD3001, DD3003, DD3005, DD3007, DD3008	Thallium	Calibration	B
	DD3003, DD3005, DD3008	Aluminum	Calibration	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	Samples Affected	Element(s)	Validation Qualifier
PB045 (total)	All	Calcium, Potassium, Sodium	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
PB045 (total)	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 "J", 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
PB045	All	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:

Holding Times
Technical holding time criteria were met for all samples with the following exception(s).

SDG Number	Samples Affected	Compound(s)	Validation Qualifier
PB045	DD3001, DD3002, DD3007, DD3008	Turbidity	J

- The samples were reanalyzed outside of hold times since they were not homogenized when the original analysis was performed.

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
PB045	DD3001, DD3002, DD3003, DD3004, DD3007, DD3008	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. Results rejected in favor of a preferred result (e.g., due to dilution or reanalysis) were qualified as rejected "R".

5.0 Quality Assurance Field Split Sample Data Evaluation

Data from the quality assurance split sample: SDG F21096 sample DD3006, were validated. The FS sample was analyzed for Volatiles by SW846 8260B, Semivolatiles by SW846 8270C, Explosives by WS846 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. 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.

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.

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.

Internal Standards
All internal standards met QC criteria.

Field Split/Original Sample Comparison

SDG F21096
DD3004 (original) and DD3006 (FS) results were evaluated. It should be noted that both samples had positive results below the reporting limits for Carbon disulfide. It should also be noted that carbon disulfide results for the original and field duplicate (FD) samples were qualified due to a high RPD.

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.

5.2 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
The initial calibration and continuing calibrations associated with the project samples met QC criteria with the following exception(s):

SDG Number	Samples Affected	Compound(s)	Validation Qualifier
F21096	DD3006	2,4-Dinitrophenol	UJ

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

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 F21096

DD3004 (original) and DD3006 (FS) results were evaluated. It should be noted that both samples were non-detect for all compounds. Both samples had 2,4-Dinitrophenol qualified for calibration problems.

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. 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

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 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 F21096

DD3004 (original) and DD3006 (FS) results were evaluated. All RPD QC criteria for total and dissolved results were met with the exception of high RPDs for iron (total and dissolved) and a high RPD for zinc (dissolved). High RPDs were likely attributed to the lack of sample homogeneity.

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 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

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
F21096	DD3006	Tetryl	UJ

Laboratory Control Sample

LCS analysis was performed for the project samples, and all QC criteria were met.

Field Split/Original Sample Comparison

SDG F21096

DD3004 (original) and DD3006 (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. Results rejected in favor of a preferred result (e.g., due to dilution or reanalysis) were qualified as rejected "R".

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 judgment 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

APPENDIX D

CHEMICAL ANALYTICAL DATA SUMMARY

Plum Brook O dnance Works
Quarterly Grou ıter Monitoring
Data Summary

LOCATION_CODE			IT-BG8-BEDGW-001			PB-BED-MW20			PB-BED-MW24			PB-BED-MW25			PB-BED-MW25		
SAMPLE_NO			DD3001			DD3002			DD3003			DD3004			DD3005		
SAMPLE_DATE			10-Dec-03			9-Dec-03			11-Dec-03			11-Dec-03			11-Dec-03		
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
Cyanide																	
Cyanide, total	ug/L	N	10	U	UJ	10	U	UJ	10	U	UJ	10	U	UJ			
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	255			238			726			316					
Chloride	ppm	N	132			21300			48.7			221					
Hardness	ppm	N	313			9940			130			540					
Nitrate	ppm	N	0.58			0.1	U	U	0.1	U	U	0.1	U	U			
Sulfate	ppm	N	54.4			5	U	U	32.6			136					
Total dissolved solids	ppm	N	584			33600			779			834					
Total organic carbon	ppm	N	1.2			1	U	U	1.6			2.4					
Total suspended solids	ppm	N	4			39			4			8					
Turbidity	NTU	N	5.2		J	18.4		J	74			64.4					

Plum Brook Ordnance Works
Quarterly Groundwater Monitoring
Data Summary

LOCATION_CODE			IT-BG8-BEDGW-001			PB-BED-MW20			PB-BED-MW24			PB-BED-MW25			PB-BED-MW25		
SAMPLE_NO			DD3001			DD3002			DD3003			DD3004			DD3005		
SAMPLE_DATE			10-Dec-03			9-Dec-03			11-Dec-03			11-Dec-03			11-Dec-03		
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
Metals																	
Aluminum	ug/L	N	200	U	U	57.9	B	B	194	B	J	61.2	B	B	47.9	B	B
Aluminum	ug/L	Y	200	U	U	200	U	U	50.8	B	B	200	U	U	44.1	B	B
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	10	U	U	10	U	U	10	U	U	10	U	U
Arsenic	ug/L	Y	10	U	U	4.1	B	J	10	U	U	10	U	U	10	U	U
Barium	ug/L	N	73.2	B	J	26100			642			187	B	J	179	B	J
Barium	ug/L	Y	81.8	B	J	25700			669			175	B	J	180	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	1.2	B	J	5	U	U	5	U	U	5	U	U	5	U	U
Calcium	ug/L	N	86200			2290000			151000			141000			138000		
Calcium	ug/L	Y	89900		J	2240000		J	152000		J	135000		J	139000		J
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	6.8	B	J	7.7	B	J	50	U	U	50	U	U
Cobalt	ug/L	Y	50	U	U	6.2	B	J	50	U	U	50	U	U	50	U	U
Copper	ug/L	N	25	U	U	25	U	U	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	908			2030			100	U	U	140			133		
Iron	ug/L	Y	856			1830			100	U	U	74.5	B	J	54.3	B	J
Lead	ug/L	N	5	G U	U	118	G U	U	11	G U	U	10	G U	U	10	G U	U
Lead	ug/L	Y	6	G U	U	118	G U	U	10	G U	U	10	G U	U	9	G U	U
Magnesium	ug/L	N	37100			1040000			70800			54000			52700		
Magnesium	ug/L	Y	40000			1020000			71100			51400			53400		
Manganese	ug/L	N	166			202			25.8			58.5			56.2		
Manganese	ug/L	Y	164			200			25.5			55.2			56.8		
Mercury	ug/L	N	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U
Mercury	ug/L	Y	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U	0.2	U	U
Nickel	ug/L	N	4.8	B	J	40	U	U	40	U	U	40	U	U	40	U	U
Nickel	ug/L	Y	4.8	B	J	40	U	U	40	U	U	40	U	U	40	U	U
Potassium	ug/L	N	7630			72600	B	J	24300			11900			10800		
Potassium	ug/L	Y	9690		J	70500	B	J	24500		J	11100		J	11000		J
Selenium	ug/L	N	5	U	U	5	U	U	5	U	U	5	U	U	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	86300			9130000			67000			122000			118000		
Sodium	ug/L	Y	112000		J	9000000		J	67900		J	115000		J	120000		J
Thallium	ug/L	N	2.5	B	B	10	U	U	2.5	B	B	3	B	B	3.2	B	B
Thallium	ug/L	Y	2.7	B	B	10	U	U	10	U	U	10	U	U	6.2	B	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	30.1			612			9.3	B	J	74.4			69.4		
Zinc	ug/L	Y	35.9			673			20	U	U	21.7			20.8		

LOCATION_CODE			IT-BG8-BEDGW-001			PB-BED-MW20			PB-BED-MW24			PB-BED-MW25			PB-BED-MW25		
SAMPLE_NO			DD3001			DD3002			DD3003			DD3004			DD3005		
SAMPLE_DATE			10-Dec-03			9-Dec-03			11-Dec-03			11-Dec-03			11-Dec-03		
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
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
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
Benzoic acid	ug/L	N															
Benzyl alcohol	ug/L	N															
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	U	50	U	U	50	U	U	50	U	U	50	U	U
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
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

Plum Brook Ordnance Works
Quarterly Groundw Monitoring
Data Summary

LOCATION_CODE			IT-BG8-BEDGW-001			PB-BED-MW20			PB-BED-MW24			PB-BED-MW25			PB-BED-MW25		
SAMPLE_NO			DD3001			DD3002			DD3003			DD3004			DD3005		
SAMPLE_DATE			10-Dec-03			9-Dec-03			11-Dec-03			11-Dec-03			11-Dec-03		
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
Methylnaphthalene, 2-	ug/L	N	10	U	U	10	U	U	2.9	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	2.3	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

Plum Brook Ordnance Works
Quarterly Groundwater Monitoring
Data Summary

LOCATION_CODE			IT-BG8-BEDGW-001			PB-BED-MW20			PB-BED-MW24			PB-BED-MW25			PB-BED-MW25		
SAMPLE_NO			DD3001			DD3002			DD3003			DD3004			DD3005		
SAMPLE_DATE			10-Dec-03			9-Dec-03			11-Dec-03			11-Dec-03			11-Dec-03		
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
Volatiles																	
Acetone	ug/L	N	10	U	U	10	U	U	100	U	UJ	10	U	UJ	10	U	UJ
Benzene	ug/L	N	1	U	U	1.2			36			1	U	U	1	U	U
Bromodichloromethane	ug/L	N	1	U	U	1	U	U	10	U	U	1	U	U	1	U	U
Bromoform	ug/L	N	1	U	UJ	1	U	UJ	10	U	UJ	1	U	UJ	1	U	UJ
Bromomethane	ug/L	N	2	U	U	2	U	U	20	U	U	2	U	U	2	U	U
Butanone, 2-	ug/L	N	5	U	U	5	U	U	50	U	U	5	U	U	5	U	U
Carbon disulfide	ug/L	N	0.3	J	J	0.16	J	J	3.4	J	J	0.77	J	J	1.4		J
Carbon tetrachloride	ug/L	N	1	U	U	1	U	U	10	U	U	1	U	U	1	U	U
Chlorobenzene	ug/L	N	1	U	U	1	U	U	10	U	U	1	U	U	1	U	U
Chloroethane	ug/L	N	2	U	U	2	U	U	20	U	U	2	U	U	2	U	U
Chloroform	ug/L	N	1	U	U	1	U	U	10	U	U	1	U	U	1	U	U
Chloromethane	ug/L	N	0.26	J	J	2	U	U	20	U	U	2	U	U	2	U	U
Dibromochloromethane	ug/L	N	1	U	U	1	U	U	10	U	U	1	U	U	1	U	U
Dichloroethane, 1,1-	ug/L	N	1	U	U	1	U	U	10	U	U	1	U	U	1	U	U
Dichloroethane, 1,2-	ug/L	N	1	U	U	1	U	U	10	U	U	1	U	U	1	U	U
Dichloroethene, 1,1-	ug/L	N	1	U	U	1	U	U	10	U	U	1	U	U	1	U	U
Dichloroethene, 1,2-	ug/L	N	1	U	U	1	U	U	10	U	U	1	U	U	1	U	U
Dichloroethene, cis-1,2-	ug/L	N															
Dichloroethene, trans-1,2-	ug/L	N															
Dichloropropane, 1,2-	ug/L	N	1	U	U	1	U	U	10	U	U	1	U	U	1	U	U
Dichloropropene, cis-1,3-	ug/L	N	1	U	U	1	U	U	10	U	U	1	U	U	1	U	U
Dichloropropene, trans-1,3-	ug/L	N	1	U	UJ	1	U	UJ	10	U	U	1	U	U	1	U	U
Ethylbenzene	ug/L	N	1	U	U	1	U	U	10			1	U	U	1	U	U
Hexanone, 2-	ug/L	N	5	U	U	5	U	U	50	U	U	5	U	U	5	U	U
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	U	20	U	UJ	2	U	UJ	2	U	UJ
Styrene	ug/L	N	1	U	UJ	1	U	UJ	10	U	UJ	1	U	UJ	1	U	UJ
Tetrachloroethane, 1,1,2,2-	ug/L	N	1	U	UJ	1	U	UJ	10	U	UJ	1	U	UJ	1	U	UJ
Tetrachloroethene	ug/L	N	1	U	U	1	U	U	10	U	U	1	U	U	1	U	U
Toluene	ug/L	N	1	U	U	0.26	J	B	31			1	U	U	1	U	U
Trichloroethane, 1,1,1-	ug/L	N	1	U	U	1	U	U	10	U	U	1	U	U	1	U	U
Trichloroethane, 1,1,2-	ug/L	N	1	U	U	1	U	U	10	U	U	1	U	U	1	U	U
Trichloroethene	ug/L	N	1	U	U	1	U	U	10	U	U	1	U	U	1	U	U
Vinyl chloride	ug/L	N	1	U	U	1	U	U	10	U	U	1	U	U	1	U	U
Xylenes, total	ug/L	N	1	U	UJ	1	U	UJ	50		J	1	U	UJ	1	U	UJ

Plum Brook Ordnance Works
Quarterly Groundwater Monitoring
Data Summary

LOCATION_CODE			PB-BED-MW28			PB-BED-MW29		
SAMPLE_NO			DD3007			DD3008		
SAMPLE_DATE			9-Dec-03			9-Dec-03		
SAMPLE_PURPOSE			REG			REG		
Parameter	Units	Filtered	Result	Qual	ValQual	Result	Qual	ValQual
Cyanide								
Cyanide, total	ug/L	N	10	U	UJ	10	U	UJ
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	UJ	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	444			432		
Chloride	ppm	N	148			2930		
Hardness	ppm	N	81.6			1500		
Nitrate	ppm	N	0.1	U	U	0.1	U	U
Sulfate	ppm	N	13.1			5	U	U
Total dissolved solids	ppm	N	697			3880		
Total organic carbon	ppm	N	5.3			3.9		
Total suspended solids	ppm	N	4			7		
Turbidity	NTU	N	1.6		J	7		J

LOCATION_CODE			PB-BED-MW28			PB-BED-MW29		
SAMPLE_NO			DD3007			DD3008		
SAMPLE_DATE			9-Dec-03			9-Dec-03		
SAMPLE_PURPOSE			REG			REG		
Parameter	Units	Filtered	Result	Qual	ValQual	Result	Qual	ValQual
Metals								
Aluminum	ug/L	N	42.6	B	B	49.9	B	B
Aluminum	ug/L	Y	200	U	U	66.9	B	B
Antimony	ug/L	N	60	U	U	60	U	U
Antimony	ug/L	Y	60	U	U	60	U	U
Arsenic	ug/L	N	5.4	B	J	3.3	B	J
Arsenic	ug/L	Y	5.6	B	J	3.1	B	J
Barium	ug/L	N	395			11800		
Barium	ug/L	Y	374			10800		
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
Calcium	ug/L	N	20000			295000		
Calcium	ug/L	Y	19700		J	283000		J
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	3.6	B	J
Cobalt	ug/L	Y	50	U	U	3.4	B	J
Copper	ug/L	N	25	U	U	25	U	U
Copper	ug/L	Y	25	U	U	25	U	U
Iron	ug/L	N	398			1550		
Iron	ug/L	Y	354			1490		
Lead	ug/L	N	3	U	U	20	G U	U
Lead	ug/L	Y	3	U	U	19	G U	U
Magnesium	ug/L	N	7780			198000		
Magnesium	ug/L	Y	7670			189000		
Manganese	ug/L	N	16.6			50.7		
Manganese	ug/L	Y	16.4			49.3		
Mercury	ug/L	N	0.2	U	U	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	6050			67800		
Potassium	ug/L	Y	5920		J	60700		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	285000			1350000		
Sodium	ug/L	Y	280000		J	1250000		J
Thallium	ug/L	N	10	U	U	2.4	B	B
Thallium	ug/L	Y	3.8	B	B	3.8	B	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	247			507		
Zinc	ug/L	Y	247			528		

LOCATION_CODE			PB-BED-MW28			PB-BED-MW29		
SAMPLE_NO			DD3007			DD3008		
SAMPLE_DATE			9-Dec-03			9-Dec-03		
SAMPLE_PURPOSE			REG			REG		
Parameter	Units	Filtered	Result	Qual	ValQual	Result	Qual	ValQual
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
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
Benzoic acid	ug/L	N						
Benzyl alcohol	ug/L	N						
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	U
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	U	50	U	U
Dinitrophenol, 2,4-	ug/L	N	50	U	UJ	50	U	UJ
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
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

LOCATION_CODE			PB-BED-MW28			PB-BED-MW29		
SAMPLE_NO			DD3007			DD3008		
SAMPLE_DATE			9-Dec-03			9-Dec-03		
SAMPLE_PURPOSE			REG			REG		
Parameter	Units	Filtered	Result	Qual	ValQual	Result	Qual	ValQual
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

LOCATION_CODE			PB-BED-MW28			PB-BED-MW29		
SAMPLE_NO			DD3007			DD3008		
SAMPLE_DATE			9-Dec-03			9-Dec-03		
SAMPLE_PURPOSE			REG			REG		
Parameter	Units	Filtered	Result	Qual	ValQual	Result	Qual	ValQual
Volatiles								
Acetone	ug/L	N	10	U	U	10	U	U
Benzene	ug/L	N	2.2			0.96	J	J
Bromodichloromethane	ug/L	N	1	U	U	1	U	U
Bromoform	ug/L	N	1	U	UJ	1	U	UJ
Bromomethane	ug/L	N	2	U	U	2	U	U
Butanone, 2-	ug/L	N	5	U	U	5	U	U
Carbon disulfide	ug/L	N	1	U	U	13		
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	0.97	J	J	0.3	J	J
Dibromochloromethane	ug/L	N	1	U	U	1	U	U
Dichloroethane, 1,1-	ug/L	N	1	U	U	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
Dichloroethene, cis-1,2-	ug/L	N						
Dichloroethene, trans-1,2-	ug/L	N						
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	0.13	J	J	0.87	J	J
Hexanone, 2-	ug/L	N	5	U	U	5	U	U
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	UJ	1	U	UJ
Tetrachloroethane, 1,1,2,2-	ug/L	N	1	U	UJ	1	U	UJ
Tetrachloroethene	ug/L	N	1	U	U	1	U	U
Toluene	ug/L	N	0.62	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	U	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	0.41	J	J	5.1		J

Laboratory Qualifier Definitions (Qual)

B (inorganic) - Analyte detected below the reporting limit. Estimated value

G - Reporting limit is elevated because of matrix interferences

J - Analyte detected below the reporting limit. Estimated value

U - Not detected

Validation Qualifier Definitions (Val Qual)

B - The analyte was not detected above the value found in an associated blank.

J - The analyte was positively identified; the concentration is estimated.

U - Not detected. The analyte was not detected above the reporting limit.

UJ - Not detected. The associated reporting limit may be inaccurate or imprecise.

R - Data rejected.

APPENDIX E

DETECTED HITS SUMMARY EXCLUDING "B" QUALIFIERS

Plum Brook Ordnance Works
Quarterly Groundwater Monitoring
Detected Hits Summary

			IT-BG8-BEDGW-001			PB-BED-MW20			PB-BED-MW24			PB-BED-MW25			PB-BED-MW25		
			DD3001			DD3002			DD3003			DD3004			DD3005		
			10-Dec-03			9-Dec-03			11-Dec-03			11-Dec-03			11-Dec-03		
			REG			REG			REG			REG			FD		
Parameter	Units	Filtered	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual
General Chemistry																	
Alkalinity	ppm	N	255			238			726			316					
Chloride	ppm	N	132			21300			48.7			221					
Hardness	ppm	N	313			9940			130			540					
Nitrate	ppm	N	0.58			.	.	.	.	.	.	.	.	.			
Sulfate	ppm	N	54.4			.	.	.	32.6			136					
Total dissolved solids	ppm	N	584			33600			779			834					
Total organic carbon	ppm	N	1.2			.	.	.	1.6			2.4					
Total suspended solids	ppm	N	4			39			4			8					
Turbidity	NTU	N	5.2		J	18.4		J	74			64.4					
Metals																	
Aluminum	ug/L	N	.	.	.	.	.	.	194	B	J	.	.	.	.	.	.
Arsenic	ug/L	N	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Arsenic	ug/L	Y	.	.	.	4.1	B	J	.	.	.	.	.	.	.	.	.
Barium	ug/L	N	73.2	B	J	26100			642			187	B	J	179	B	J
Barium	ug/L	Y	81.8	B	J	25700			669			175	B	J	180	B	J
Cadmium	ug/L	Y	1.2	B	J	.	.	.	.	.	.	.	.	.	.	.	.
Calcium	ug/L	N	86200			2290000			151000			141000			138000		
Calcium	ug/L	Y	89900		J	2240000		J	152000		J	135000		J	139000		J
Cobalt	ug/L	N	.	.	.	6.8	B	J	7.7	B	J	.	.	.	.	.	.
Cobalt	ug/L	Y	.	.	.	6.2	B	J	.	.	.	.	.	.	.	.	.
Iron	ug/L	N	908			2030			.	.	.	140			133		
Iron	ug/L	Y	856			1830			.	.	.	74.5	B	J	54.3	B	J
Magnesium	ug/L	N	37100			1040000			70800			54000			52700		
Magnesium	ug/L	Y	40000			1020000			71100			51400			53400		
Manganese	ug/L	N	166			202			25.8			58.5			56.2		
Manganese	ug/L	Y	164			200			25.5			55.2			56.8		
Nickel	ug/L	N	4.8	B	J	.	.	.	.	.	.	.	.	.	.	.	.
Nickel	ug/L	Y	4.8	B	J	.	.	.	.	.	.	.	.	.	.	.	.
Potassium	ug/L	N	7630			72600	B	J	24300			11900			10800		
Potassium	ug/L	Y	9690		J	70500	B	J	24500		J	11100		J	11000		J
Sodium	ug/L	N	86300			9130000			67000			122000			118000		
Sodium	ug/L	Y	112000		J	9000000		J	67900		J	115000		J	120000		J
Zinc	ug/L	N	30.1			612			9.3	B	J	74.4			69.4		
Zinc	ug/L	Y	35.9			673			.	.	.	21.7			20.8		

Plum Brook Ordnance Works
Quarterly Groundwater Monitoring
Detected Hits Summary

			IT-BG8-BEDGW-001			PB-BED-MW20			PB-BED-MW24			PB-BED-MW25			PB-BED-MW25		
			DD3001			DD3002			DD3003			DD3004			DD3005		
			10-Dec-03			9-Dec-03			11-Dec-03			11-Dec-03			11-Dec-03		
			REG			REG			REG			REG			FD		
Parameter	Units	Filtered	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual	Result	Qual	ValQual
Semivolatiles																	
Methylnaphthalene, 2-	ug/L	N	-	-	-	-	-	-	2.9	J	J	-	-	-	-	-	-
Naphthalene	ug/L	N	-	-	-	-	-	-	2.3	J	J	-	-	-	-	-	-
Volatiles																	
Benzene	ug/L	N	-	-	-	1.2			36			-	-	-	-	-	-
Carbon disulfide	ug/L	N	0.3	J	J	0.16	J	J	3.4	J	J	0.77	J	J	1.4		J
Chloromethane	ug/L	N	0.26	J	J	-	-	-	-	-	-	-	-	-	-	-	-
Ethylbenzene	ug/L	N	-	-	-	-	-	-	10		-	-	-	-	-	-	-
Toluene	ug/L	N	-	-	-	-	-	-	31		-	-	-	-	-	-	-
Xylenes, total	ug/L	N	-	-	-	-	-	-	50	J	-	-	-	-	-	-	-

Plum Brook Ordnance Works
Quarterly Groundwater Monitoring
Detected Hits Summary

			PB-BED-MW28			PB-BED-MW29		
			DD3007			DD3008		
			9-Dec-03			9-Dec-03		
			REG			REG		
Parameter	Units	Filtered	Result	Qual	ValQual	Result	Qual	ValQual
General Chemistry								
Alkalinity	ppm	N	444			432		
Chloride	ppm	N	148			2930		
Hardness	ppm	N	81.6			1500		
Nitrate	ppm	N	-	-	-	-	-	-
Sulfate	ppm	N	13.1			-	-	-
Total dissolved solids	ppm	N	697			3880		
Total organic carbon	ppm	N	5.3			3.9		
Total suspended solids	ppm	N	4			7		
Turbidity	NTU	N	1.6		J	7		J
Metals								
Aluminum	ug/L	N	-	-	-	-	-	-
Arsenic	ug/L	N	5.4	B	J	3.3	B	J
Arsenic	ug/L	Y	5.6	B	J	3.1	B	J
Barium	ug/L	N	395			11800		
Barium	ug/L	Y	374			10800		
Cadmium	ug/L	Y	-	-	-	-	-	-
Calcium	ug/L	N	20000			295000		
Calcium	ug/L	Y	19700		J	283000		J
Cobalt	ug/L	N	-	-	-	3.6	B	J
Cobalt	ug/L	Y	-	-	-	3.4	B	J
Iron	ug/L	N	398			1550		
Iron	ug/L	Y	354			1490		
Magnesium	ug/L	N	7780			198000		
Magnesium	ug/L	Y	7670			189000		
Manganese	ug/L	N	16.6			50.7		
Manganese	ug/L	Y	16.4			49.3		
Nickel	ug/L	N	-	-	-	-	-	-
Nickel	ug/L	Y	-	-	-	-	-	-
Potassium	ug/L	N	6050			67800		
Potassium	ug/L	Y	5920		J	60700		J
Sodium	ug/L	N	285000			1350000		
Sodium	ug/L	Y	280000		J	1250000		J
Zinc	ug/L	N	247			507		
Zinc	ug/L	Y	247			528		

Plum Brook Ordnance Works
Quarterly Groundwater Monitoring
Detected Hits Summary

			PB-BED-MW28			PB-BED-MW29		
			DD3007			DD3008		
			9-Dec-03			9-Dec-03		
			REG			REG		
Parameter	Units	Filtered	Result	Qual	ValQual	Result	Qual	ValQual
Semivolatiles								
Methylnaphthalene, 2-	ug/L	N	-	-	-	-	-	-
Naphthalene	ug/L	N	-	-	-	-	-	-
Volatiles								
Benzene	ug/L	N	2.2			0.96	J	J
Carbon disulfide	ug/L	N	-	-	-	13		
Chloromethane	ug/L	N	0.97	J	J	0.3	J	J
Ethylbenzene	ug/L	N	0.13	J	J	0.87	J	J
Toluene	ug/L	N	0.62	J	J	-	-	-
Xylenes, total	ug/L	N	0.41	J	J	5.1		J

Laboratory Qualifier Definitions (Qual)

B (inorganic) - Analyte detected below the reporting limit. Estimated value

J - Analyte detected below the reporting limit. Estimated value

Validation Qualifier Definitions (Val Qual)

J - Estimated value

APPENDIX F

DATA QUALITY EVALUATION

Table of Contents

Page

List of Tables ..... F-ii
List of Acronyms ..... F-iii
F.1.0 Introduction F-1
F.2.0 Field Sampling and QC Activities F-2
F.2.1 Trip Blanks F-2
F.2.2 Field Duplicates F-3
F.2.3 Field Split Samples F-4
F.3.0 Analytical Program and QC Activities F-5
F.3.1 Laboratory QA/QC Procedures F-5
F.3.1.1 Method/Calibration Blanks F-6
F.3.1.2 Matrix Spikes and Laboratory Control Spikes F-6
F.3.1.3 Calibration F-8
F.3.1.4 Column Agreement F-8
F.3.2 Reporting Limits F-8
F.3.3 Holding Times/Preservation F-9
F.4.0 Data Evaluation and Usability F-10
F.5.0 References F-13

List of Tables

Table	Title
F-1	Sample Cross-reference
F-2	Summary of Analytes Detected in Blanks
F-3	Summary of Original, Field Duplicate, and Field Split Results and RPD Calculations
F-4	Summary of Data Validation Reason Codes
F-5	Summary of Data Validation Qualifiers Assigned and Reason Codes for Qualification
F-6	Laboratory and Validation Qualifier Definitions

List of Acronyms

AR/COC	analysis request/chain of custody
CCAL	continuing calibration
CLP	Contract Laboratory Program
DI	deionized
DQE	data quality evaluation
DQO	data quality objectives
HPLC	high performance liquid chromatograph
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
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

F.1.0 Introduction

This appendix of the Eighth 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 December 2003. Severn Trent Laboratories (STL) in Knoxville, Tennessee, and 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. Where applicable, method and laboratory quality assurance and quality control requirements supercede these guidelines. 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.

F.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 F-1 summarizes the field sample number, location, sample type, date of collection, and sample delivery group for each sample collected. Table F-2 summarizes the detected compounds in the method blank and trip blanks associated with the PBOW samples.

F.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. Three trip blanks contained target analytes and one sample was 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
PB045	DD3002	Toluene	B

F.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 F-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.

F.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 F-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.

F.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 3520/8270C
Nitroaromatic Compounds	SW-846 8330
Metals	SW-846 3005A/6010B/7470A
Gasoline Range Organics	SW-846 5030/8015B
Diesel Range Organics	SW-846 8015B
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 D 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.

F.3.1 Laboratory QA/QC Procedures

The following sections discuss specific QA/QC protocols required and performed by the laboratory during this investigation.

F.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 only for common laboratory contaminants such as acetone, methylene chloride, 2-butanone, and certain phthalates. No samples were qualified because of method blank contamination.

For some analyses, an initial and continuing calibration blank 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 detects in the calibration blanks are summarized below:

Lot Number	Sample Number Affected	Blank Contaminant	Blank	Validation Qualifier
PB045	DD3003, DD3005, DD3008	Aluminum (dissolved)	Calibration	B
PB045	DD3001, DD3003, DD3005, DD3007, DD3008	Thallium (dissolved)	Calibration	B
PB045	DD3002, DD3004, DD3005, DD3007, DD3008	Aluminum (total)	Calibration	B
PB045	DD3001, DD3004, DD3005, DD3008	Thallium (total)	Calibration	B

B - blank contamination

F.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 DD3004. 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. Calcium, potassium, and sodium recoveries were high in the dissolved metals MS of DD3004. Antimony recovery was high in the MSD of the total metals analysis. Calcium was detected at 133 percent. Potassium was detected at 129 percent. Sodium was detected at 139 percent. Antimony was detected at 127 percent. The upper lab limit for all analytes is 125 percent. Antimony was not detected in the samples, so no data were qualified. The other metals results should be considered biased high. Two MS/MSD pairs were analyzed for cyanide. Both pairs resulted in low recoveries of 49 and 50 percent and 68 and 64 percent. The lower lab limit is 77 percent. Cyanide results should be considered biased low. Tetryl was not detected in either the MS or MSD. The MS and MSD recoveries for tetryl were zero. The lab's lower limit is 42 percent. All tetryl results should be considered biased low. The following samples were qualified:

Lot Number	Sample Number Affected	Analyte(s)	Validation Qualifier
Explosives			
F21096	DD3006	Tetryl	UJ
Metals			
PB045	DD3001, DD3002, DD3003, DD3004, DD3005, DD3007, DD3008	Calcium, Potassium, Sodium	J
Wet Chemistry			
PB045	DD3001, DD3002, DD3003, DD3004, DD3007, DD3008	Cyanide	UJ

J - estimated

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.

F.3.1.3 Calibration

A few compounds exhibited unacceptable performances in the calibration standards. The relative response factor (RRF) of 4-Methyl-2-pentanone was less than 0.1. It was 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.

Lot Number	Analysis	Samples	Compounds	Validation Qualifier
PB045	Volatiles	DD3001, DD3002, DD3003, DD3004, DD3005, DD3007, DD3008	1,1,2,2-Tetrachloroethane, Bromoform, Styrene, Xylenes (total)	J/UJ
PB045	Volatiles	DD3001, DD3002, DD3007, DD3008	trans-1,3-Dichloropropene	UJ
PB045	Volatiles	DD3003, DD3004, DD3005	Acetone, Methylene chloride	UJ
PB045 / F21096	Semivolatiles	DD3001, DD3002, DD3003, DD3004, DD3005, DD3006, DD3007, DD3008	2,4 Dinitrophenol	UJ

J - estimated
UJ - undetected, estimated

F.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.

F.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 can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. It is set at the lowest standard used for the calibration curve.
- ***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 MRL) 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. Six samples had elevated MQLs due to dilutions. Six samples had elevated MQLs due to matrix interference.

F.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. Four turbidity samples were not homogenized before analysis. The samples were reanalyzed outside of the holding time. The reanalysis results were used instead of the original results in samples

DD3001, DD3002, DD3007, DD3008. All other holding time criteria were acceptable for the samples collected.

F.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 F-5 summarizes all compounds requiring qualifier application due to anomalies discovered during data validation. Table F-4 defines the reason codes for qualification, and Table F-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

RPD is calculated as follows:

$$RPD = \left[\frac{|D1 - D2|}{\frac{D1 + D2}{2}} \right] * 100$$

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, 6 monitoring wells were sampled resulting in approximately 1111 targeted analytical records, including duplicate and split records. Six data points were rejected due to anomalies discovered during the validation process. Using the above calculation, greater than 99% 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.

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 F-1 through F-6 summarize the analytical program and the results for the data validation effort for all samples collected by Shaw at PBOW.

F.5.0 References

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), 1999, ***USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review***, October.

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 F-1

Sample Cross-reference
Groundwater Wells
Former Plum Brook Ordnance Works
Sandusky, Ohio

Sample Type	Sample Location	Sample Number	Sample Date	Sample Purpose	Lot Number
GW	IT-BG8-BEDGW-001	DD3001	10-Dec-03	REG	PB045
GW	PB-BED-MW20	DD3002	9-Dec-03	REG	PB045
GW	PB-BED-MW24	DD3003	11-Dec-03	REG	PB045
GW	PB-BED-MW25	DD3004	11-Dec-03	REG	PB045
GW	PB-BED-MW25	DD3004-MS	11-Dec-03	MS	PB045
GW	PB-BED-MW25	DD3004-MSD	11-Dec-03	MSD	PB045
GW	PB-BED-MW25	DD3005	11-Dec-03	FD	PB045
GW	PB-BED-MW25	DD3006	11-Dec-03	FS	F21096
GW	PB-BED-MW28	DD3007	9-Dec-03	REG	PB045
GW	PB-BED-MW29	DD3008	9-Dec-03	REG	PB045

FD - Field duplicate
FS - Field split
GW - Groundwater
MS - Matrix spike
MSD - Matrix spike duplicate
REG - Regular

Table F-2

Summary of Analytes Detected in Blanks
Former Plum Brook Ordnance Works
Sandusky, Ohio

Lot Number	Sample Number	Analysis Date	Sample Purpose	Parameter	Result	Units	Lab Qualifier
PB045	DD5001	9-Dec-03	TB	Carbon disulfide	0.13	ug/L	J
PB045	DD5002	10-Dec-03	TB	Chloroform	0.29	ug/L	J
PB045	DD5002	10-Dec-03	TB	Toluene	0.13	ug/L	J
PB045	DD5003	11-Dec-03	TB	Chloroform	0.25	ug/L	J
PB045	DD5003	11-Dec-03	TB	Toluene	0.12	ug/L	J

J - Concentration is below the reporting limit
TB - Trip blank
ug/L - Micrograms per liter

Table F-3

Summary of Original, Field Duplicate, and Field Split Results and RPD Calculations
Former Plum Brook Ordnance Works
Sandusky, Ohio

		LOCATION_CODE	PB-BED-MW25		PB-BED-MW25		PB-BED-MW25		Relative	Relative
		SAMPLE_NO	DD3004		DD3005		DD3006		Percent	Percent
		SAMPLE_DATE	11-Dec-03		11-Dec-03		11-Dec-03		Difference	Difference
		SAMPLE_PURPOSE	REG		FD		FS		between	between
Parameter	Units	Filtered	Result	VQ	Result	VQ	Result	VQ	REG and FD	REG and FS
Aluminum	ug/L	N	61.2	B	47.9	B	200	U	24.38	106.28
Aluminum	ug/L	Y	200	U	44.1	B	200	U	127.73	0.00
Barium	ug/L	N	187	J	179	J	169	J	4.37	10.11
Barium	ug/L	Y	175	J	180	J	165	J	2.82	5.88
Calcium	ug/L	N	141000		138000		125000		2.15	12.03
Calcium	ug/L	Y	135000	J	139000	J	119000		2.92	12.60
Iron	ug/L	N	140		133		264	J	5.13	61.39
Iron	ug/L	Y	74.5	J	54.3	J	203	J	31.37	92.61
Magnesium	ug/L	N	54000		52700		48600		2.44	10.53
Magnesium	ug/L	Y	51400		53400		46400		3.82	10.22
Manganese	ug/L	N	58.5		56.2		48.8		4.01	18.08
Manganese	ug/L	Y	55.2		56.8		47.6		2.86	14.79
Potassium	ug/L	N	11900		10800		12200		9.69	2.49
Potassium	ug/L	Y	11100	J	11000	J	11300		0.90	1.79
Sodium	ug/L	N	122000		118000		110000		3.33	10.34
Sodium	ug/L	Y	115000	J	120000	J	106000		4.26	8.14
Thallium	ug/L	N	3	B	3.2	B	10	U	6.45	107.89
Thallium	ug/L	Y	10	U	6.2	B	10	U	46.91	0.00
Zinc	ug/L	N	74.4		69.4		58		6.95	24.77
Zinc	ug/L	Y	21.7		20.8		13.2	J	4.24	48.74
Carbon disulfide	ug/L	N	0.77	J	1.4	J	1.1	J	58.06	35.29

RPD > 30%
ug/L - Micrograms per liter
FD - Field duplicate
FS - Field split
REG - Regular field sample
N - No
Y - Yes
RPD - Relative percent difference
VQ - Validation qualifier

Table F-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 F-5

Summary of Data Validation Qualifiers Assigned and Reason Codes for Qualification
Former Plum Brook Ordnance Works
Sandusky, Ohio

Lot Number	Sample Number	Analysis	Parameter	VQ	Reason Codes (1,2) R1	R2	R3	R4
PB045	DD3001	Cyanide	Cyanide, total	UJ	08A			
PB045	DD3001	Explosives	Tetryl	UJ	08A			
PB045	DD3001	Metals (Dissolved)	Barium	J	15			
PB045	DD3001	Metals (Dissolved)	Cadmium	J	15			
PB045	DD3001	Metals (Dissolved)	Calcium	J	08A			
PB045	DD3001	Metals (Dissolved)	Nickel	J	15			
PB045	DD3001	Metals (Dissolved)	Potassium	J	08A	13		
PB045	DD3001	Metals (Dissolved)	Sodium	J	08A			
PB045	DD3001	Metals (Dissolved)	Thallium	B	06B	15		
PB045	DD3001	Metals (Total)	Barium	J	15			
PB045	DD3001	Metals (Total)	Nickel	J	15			
PB045	DD3001	Metals (Total)	Thallium	B	06B	15		
PB045	DD3001	Semivolatiles	Dinitrophenol, 2,4-	UJ	05B			
PB045	DD3001	Turbidity	Turbidity	J	02B			
PB045	DD3001	Volatiles	Bromoform	UJ	05B			
PB045	DD3001	Volatiles	Carbon disulfide	J	15			
PB045	DD3001	Volatiles	Chloromethane	J	15			
PB045	DD3001	Volatiles	Dichloropropene, trans-1,3-	UJ	05B			
PB045	DD3001	Volatiles	Methyl-2-pentanone, 4-	R	04A	05A		
PB045	DD3001	Volatiles	Styrene	UJ	05B			
PB045	DD3001	Volatiles	Tetrachloroethane, 1,1,2,2-	UJ	05B			
PB045	DD3001	Volatiles	Xylenes, total	UJ	05B			
PB045	DD3002	Cyanide	Cyanide, total	UJ	08A			
PB045	DD3002	Explosives	Tetryl	UJ	08A			
PB045	DD3002	Metals (Dissolved)	Arsenic	J	15			
PB045	DD3002	Metals (Dissolved)	Calcium	J	08A			
PB045	DD3002	Metals (Dissolved)	Cobalt	J	15			
PB045	DD3002	Metals (Dissolved)	Potassium	J	08A	13		
PB045	DD3002	Metals (Dissolved)	Sodium	J	08A			
PB045	DD3002	Metals (Total)	Aluminum	B	06B	15		
PB045	DD3002	Metals (Total)	Cobalt	J	15			
PB045	DD3002	Metals (Total)	Potassium	J	15			
PB045	DD3002	Semivolatiles	Dinitrophenol, 2,4-	UJ	05B			
PB045	DD3002	Turbidity	Turbidity	J	02B			
PB045	DD3002	Volatiles	Bromoform	UJ	05B			
PB045	DD3002	Volatiles	Carbon disulfide	J	15			
PB045	DD3002	Volatiles	Dichloropropene, trans-1,3-	UJ	05B			
PB045	DD3002	Volatiles	Methyl-2-pentanone, 4-	R	04A	05A		
PB045	DD3002	Volatiles	Styrene	UJ	05B			
PB045	DD3002	Volatiles	Tetrachloroethane, 1,1,2,2-	UJ	05B			
PB045	DD3002	Volatiles	Toluene	B	06D	15		
PB045	DD3002	Volatiles	Xylenes, total	UJ	05B			
PB045	DD3003	Cyanide	Cyanide, total	UJ	08A			
PB045	DD3003	Explosives	Tetryl	UJ	08A			
PB045	DD3003	Metals (Dissolved)	Aluminum	B	06B	15		
PB045	DD3003	Metals (Dissolved)	Calcium	J	08A			
PB045	DD3003	Metals (Dissolved)	Potassium	J	08A	13		
PB045	DD3003	Metals (Dissolved)	Sodium	J	08A			
PB045	DD3003	Metals (Total)	Aluminum	J	15			

Table F-5

Summary of Data Validation Qualifiers Assigned and Reason Codes for Qualification
Former Plum Brook Ordnance Works
Sandusky, Ohio

Lot Number	Sample Number	Analysis	Parameter	VQ	Reason Codes [1,2] R1	R2	R3	R4
PB045	DD3003	Metals (Total)	Cobalt	J	15			
PB045	DD3003	Metals (Total)	Thallium	B	06B	15		
PB045	DD3003	Metals (Total)	Zinc	J	15			
PB045	DD3003	Semivolatiles	Dinitrophenol, 2,4-	UJ	05B			
PB045	DD3003	Semivolatiles	Methylnaphthalene, 2-	J	15			
PB045	DD3003	Semivolatiles	Naphthalene	J	15			
PB045	DD3003	Volatiles	Acetone	UJ	05B			
PB045	DD3003	Volatiles	Bromoform	UJ	05B			
PB045	DD3003	Volatiles	Carbon disulfide	J	15			
PB045	DD3003	Volatiles	Methyl-2-pentanone, 4-	R	04A	05A		
PB045	DD3003	Volatiles	Methylene chloride	UJ	05B			
PB045	DD3003	Volatiles	Styrene	UJ	05B			
PB045	DD3003	Volatiles	Tetrachloroethane, 1,1,2,2-	UJ	05B			
PB045	DD3003	Volatiles	Xylenes, total	J	05B			
PB045	DD3004	Cyanide	Cyanide, total	UJ	08A			
PB045	DD3004	Explosives	Tetryl	UJ	08A			
PB045	DD3004	Metals (Dissolved)	Barium	J	15			
PB045	DD3004	Metals (Dissolved)	Calcium	J	08A			
PB045	DD3004	Metals (Dissolved)	Iron	J	15			
PB045	DD3004	Metals (Dissolved)	Potassium	J	08A	13		
PB045	DD3004	Metals (Dissolved)	Sodium	J	08A			
PB045	DD3004	Metals (Total)	Aluminum	B	06B	15		
PB045	DD3004	Metals (Total)	Barium	J	15			
PB045	DD3004	Metals (Total)	Thallium	B	06B	15		
PB045	DD3004	Semivolatiles	Dinitrophenol, 2,4-	UJ	05B			
PB045	DD3004	Volatiles	Acetone	UJ	05B			
PB045	DD3004	Volatiles	Bromoform	UJ	05B			
PB045	DD3004	Volatiles	Carbon disulfide	J	15	17		
PB045	DD3004	Volatiles	Methyl-2-pentanone, 4-	R	04A	05A		
PB045	DD3004	Volatiles	Methylene chloride	UJ	05B			
PB045	DD3004	Volatiles	Styrene	UJ	05B			
PB045	DD3004	Volatiles	Tetrachloroethane, 1,1,2,2-	UJ	05B			
PB045	DD3004	Volatiles	Xylenes, total	UJ	05B			
PB045	DD3005	Explosives	Tetryl	UJ	08A			
PB045	DD3005	Metals (Dissolved)	Aluminum	B	06B	15		
PB045	DD3005	Metals (Dissolved)	Barium	J	15			
PB045	DD3005	Metals (Dissolved)	Calcium	J	08A			
PB045	DD3005	Metals (Dissolved)	Iron	J	15			
PB045	DD3005	Metals (Dissolved)	Potassium	J	08A	13		
PB045	DD3005	Metals (Dissolved)	Sodium	J	08A			
PB045	DD3005	Metals (Dissolved)	Thallium	B	06B	15		
PB045	DD3005	Metals (Total)	Aluminum	B	06B	15		
PB045	DD3005	Metals (Total)	Barium	J	15			
PB045	DD3005	Metals (Total)	Thallium	B	06B	15		
PB045	DD3005	Semivolatiles	Dinitrophenol, 2,4-	UJ	05B			
PB045	DD3005	Volatiles	Acetone	UJ	05B			
PB045	DD3005	Volatiles	Bromoform	UJ	05B			
PB045	DD3005	Volatiles	Carbon disulfide	J	17			
PB045	DD3005	Volatiles	Methyl-2-pentanone, 4-	R	04A	05A		

Table F-5

Summary of Data Validation Qualifiers Assigned and Reason Codes for Qualification
Former Plum Brook Ordnance Works
Sandusky, Ohio

Lot Number	Sample Number	Analysis	Parameter	VQ	Reason Codes [1,2] R1	R2	R3	R4
PB045	DD3005	Volatiles	Methylene chloride	UJ	05B			
PB045	DD3005	Volatiles	Styrene	UJ	05B			
PB045	DD3005	Volatiles	Tetrachloroethane, 1,1,2,2-	UJ	05B			
PB045	DD3005	Volatiles	Xylenes, total	UJ	05B			
F21096	DD3006	Explosives	Tetryl	UJ	08A			
F21096	DD3006	Metals (Dissolved)	Barium	J	15			
F21096	DD3006	Metals (Dissolved)	Iron	J	15			
F21096	DD3006	Metals (Dissolved)	Zinc	J	15			
F21096	DD3006	Metals (Total)	Barium	J	15			
F21096	DD3006	Metals (Total)	Iron	J	15			
F21096	DD3006	Semivolatiles	Dinitrophenol, 2,4-	UJ	04B			
F21096	DD3006	Volatiles	Carbon disulfide	J	15			
PB045	DD3007	Cyanide	Cyanide, total	UJ	08A			
PB045	DD3007	Explosives	Tetryl	UJ	08A			
PB045	DD3007	Metals (Dissolved)	Arsenic	J	15			
PB045	DD3007	Metals (Dissolved)	Calcium	J	08A			
PB045	DD3007	Metals (Dissolved)	Potassium	J	08A	13		
PB045	DD3007	Metals (Dissolved)	Sodium	J	08A			
PB045	DD3007	Metals (Dissolved)	Thallium	B	06B	15		
PB045	DD3007	Metals (Total)	Aluminum	B	06B	15		
PB045	DD3007	Metals (Total)	Arsenic	J	15			
PB045	DD3007	Semivolatiles	Dinitrophenol, 2,4-	UJ	05B			
PB045	DD3007	Turbidity	Turbidity	J	02B			
PB045	DD3007	Volatiles	Bromoform	UJ	05B			
PB045	DD3007	Volatiles	Chloromethane	J	15			
PB045	DD3007	Volatiles	Dichloropropene, trans-1,3-	UJ	05B			
PB045	DD3007	Volatiles	Ethylbenzene	J	15			
PB045	DD3007	Volatiles	Methyl-2-pentanone, 4-	R	04A	05A		
PB045	DD3007	Volatiles	Styrene	UJ	05B			
PB045	DD3007	Volatiles	Tetrachloroethane, 1,1,2,2-	UJ	05B			
PB045	DD3007	Volatiles	Toluene	J	15			
PB045	DD3007	Volatiles	Xylenes, total	J	05B	15		
PB045	DD3008	Cyanide	Cyanide, total	UJ	08A			
PB045	DD3008	Explosives	Tetryl	UJ	08A			
PB045	DD3008	Metals (Dissolved)	Aluminum	B	06B	15		
PB045	DD3008	Metals (Dissolved)	Arsenic	J	15			
PB045	DD3008	Metals (Dissolved)	Calcium	J	08A			
PB045	DD3008	Metals (Dissolved)	Cobalt	J	15			
PB045	DD3008	Metals (Dissolved)	Potassium	J	08A	13		
PB045	DD3008	Metals (Dissolved)	Sodium	J	08A			
PB045	DD3008	Metals (Dissolved)	Thallium	B	06B	15		
PB045	DD3008	Metals (Total)	Aluminum	B	06B	15		
PB045	DD3008	Metals (Total)	Arsenic	J	15			
PB045	DD3008	Metals (Total)	Cobalt	J	15			
PB045	DD3008	Metals (Total)	Thallium	B	06B	15		
PB045	DD3008	Semivolatiles	Dinitrophenol, 2,4-	UJ	05B			
PB045	DD3008	Turbidity	Turbidity	J	02B			
PB045	DD3008	Volatiles	Benzene	J	15			
PB045	DD3008	Volatiles	Bromoform	UJ	05B			

Table F-5

Summary of Data Validation Qualifiers Assigned and Reason Codes for Qualification
Former Plum Brook Ordnance Works
Sandusky, Ohio

Lot Number	Sample Number	Analysis	Parameter	VQ	Reason Codes (1,2)			
					R1	R2	R3	R4
PB045	DD3008	Volatiles	Chloromethane	J	15			
PB045	DD3008	Volatiles	Dichloropropene, trans-1,3-	UJ	05B			
PB045	DD3008	Volatiles	Ethylbenzene	J	15			
PB045	DD3008	Volatiles	Methyl-2-pentanone, 4-	R	04A	05A		
PB045	DD3008	Volatiles	Styrene	UJ	05B			
PB045	DD3008	Volatiles	Tetrachloroethane, 1,1,2,2-	UJ	05B			
PB045	DD3008	Volatiles	Xylenes, total	J	05B			

Footnotes:
(1) Table F-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 F-6

Laboratory and Validation Qualifier Definitions
Former Plum Brook Ordnance Works
Sandusky, Ohio

Qualifier	Definition
Laboratory - Organic	
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	The analyte is rejected due to deficiencies or anomalies in the data or process.
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 G

CHAINS-OF-CUSTODY

H3L100268

Shaw™
Shaw E & I, Inc.

ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB12 09 03STL-K

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: FBOW
Sample Team Member: David Kessler
Profit Center: Knoxville
Project Manager: Steve Downey
Project No.: 843656
Required Report Date: 21 DAYS

Sample Shipment Date: 12/9/03
Laboratory Destination: STL- Knoxville
Laboratory Contact: Jamie McKinney
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: 836531447439

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DD3007	WATER	12/9/03 1320	2 - Amber	1 L	Cool	Explosives by 8830	Custody Seals Intact	
			1 - HDPE	250 mL	HNO3	Total TAL Metals by 6010B/7470A ph<2	Received Temp. 2°C	
			1 - HDPE	250 mL	HNO3	Dissolved TAL Metals by 6010B/7470A ph<2	1 COOLER / FEDEX	
			2 - Amber	1 L	Cool	TCL SVOCs by 8270C	T# 836531447439	
			3 - Glass	40 mL	HCL	TCL VOCs by 8260B	MDF 12-10-03	
			1 - HDPE	1 L	NaOH	Cyanide by 9010/9012 ph>12		
DD3008	WATER	12/9/03 1535	2 - Amber	1 L	Cool	Explosives by 8830		
			1 - HDPE	250 mL	HNO3	Total TAL Metals by 6010B/7470A ph<2		
			1 - HDPE	250 mL	HNO3	Dissolved TAL Metals by 6010B/7470A ph<2		
			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		
	WATER		2 - Amber	1 L	Cool	Explosives by 8830		
			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		
			3 - Glass	40 mL	HCL	TCL VOCs by 8260B		
			1 - HDPE	1 L	NaOH	Cyanide by 9010/9012		
DD5001	TRIP BLANK		2-Glass	40 ml	HCL	TRIP Blank		

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 12	Date: 12/9/03 Time: 1800	1. Received by: Andrew D. Flower STL	Date: 12-10-03 Time: 09:00
2. Relinquished by:	Date: Time:	2 Received by:	Date: Time:
3. Relinquished by:	Date: Time:	2. Received by:	Date: Time:

Comments:

178

Shaw
Shaw E & I, Inc.

ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB12 09 03STL

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: 12/09/03
Laboratory Destination: STL-North Canton
Laboratory Contact: Ken Kuzior
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: 836531447444

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
DD3007	WATER	12/9/03 1320	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		
DD3008	WATER	12/9/03 1535	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		
						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	Date: 12/9/03 Time: 1810	1. Received by: John Dorsett	Date: 12-10-03 Time: 9:40
2. Relinquished by:	Date: Time:	2. Received by:	Date: Time:
3. Relinquished by:	Date: Time:	2. Received by:	Date: Time:

Comments:

H3L110180

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Shaw E & I, Inc.

ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB12 10 03STL-K

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: 12/10/03
Laboratory Destination: STL- Knoxville
Laboratory Contact: Jamie McKinney
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: 839702140125

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DD3002	WATER	12/10/03 1200	2 - 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		
			~~2 - Amber~~	1 L	Cool	TCL SVOCs by 8270C	Rec'd temp 2°C	
			3 - Glass	40 mL	HCL	TCL VOCs by 8260B	Custody seals intact	
			1 - HDPE	1 L	NaOH	Cyanide by 9010/9012 ph12	1 Cooler Fedex #	
DD3001	WATER	12/10/03 1620	2 - Amber	1 L	Cool	Explosives by 8330	839702140125	
			1 - HDPE	250 mL	HNO3	Total TAL Metals by 6010B/7470A ph2	MRH 12-11-03	
			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	
	DKK WATER	12/10/03	~~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		
			~~3 - Glass~~	~~40 mL~~	HCL	TCL VOCs by 8260B		
			~~1 - HDPE~~	~~1 L~~	NaOH	Cyanide by 9010/9012		
DD5002	water	12/10/03	2 - Glass	40ml	HCL	TKIP Blank		

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: 12/10/03 Time: 1800	1. Received by: [signature]	Date: 12-11-03 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.: PB12 10 03STL

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: 12/10/03
Laboratory Destination: STL-North Canton
Laboratory Contact: Ken Kuzior
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: 839702140158

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
DP3002	WATER	12/10/03 1200	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		
DD3001	WATER	12/10/03 1620	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	12/10/03						

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: 12/10/03 Time: 1800	1. Received by: [illegible]	Date: 12-11-03 Time: 10:10
2. Relinquished by:	Date: Time:	2. Received by:	Date: Time:
3. Relinquished by:	Date: Time:	2. Received by:	Date: Time:

Comments:

page 1 of 3

H3L120208

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ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB12 11 03STL-K

PAGE 1 OF 3

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: 12/11/03
Laboratory Destination: STL- Knoxville
Laboratory Contact: Jamie McKinney
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: 839702140147

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
DD3003	WATER	12/11/03 1035	X - Amber	1 L	Cool	Explosives by 8330	Rec'd temp. 3°c Custody seals intact 2 coolers Fedex 839702140147 MF 12-12-03	
			1 - HDPE	250 mL	HNO3	Total TAL Metals by 6010B/7470A Ph2		
			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		
			1 - HDPE	1 L	NaOH	Cyanide by 9010/9012 Ph12		
DD3004	WATER	12/11/03 1355	X - 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 ↓		
			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		
	DKK 12/11/03							

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: 12/11/03 Time: 1800	1. Received by: Matthew J. Howard	Date: 12-12-03 Time: 09:00
2. Relinquished by:	Date: Time:	2. Received by:	Date: Time:
3. Relinquished by:	Date: Time:	2. Received by:	Date: Time:

Comments:

page 2 of 3

H3L120208

Shaw™
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ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB12 11 03STL-K

PAGE 2 OF 3

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: 12/11/03
Laboratory Destination: STL- Knoxville
Laboratory Contact: Jamie McKinney
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: 839702140147

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DD3004-MS	WATER	12/11/03 1355	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 +		
			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		
DD3004-MSD	WATER	12/11/03 1355	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 +		
			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		
DKK 12/11/03								

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: 12/11/03 Time: 1800	1. Received by: Matthew F. Howard	Date: 12-12-03 Time: 09:00
2. Relinquished by:	Date: Time:	2. Received by:	Date: Time:
3. Relinquished by:	Date: Time:	2. Received by:	Date: Time:

Comments:

page 3 of 3

H32120208

Shaw™
Shaw E & I, Inc.

ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB12 11 03STL-K

PAGE 3 OF 3

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: 12/11/03
Laboratory Destination: STL- Knoxville
Laboratory Contact: Jamie McKinney
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: 839702140147

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DD3005	WATER	12/11/03 1355	1 X - Amber	1 L	Cool	Explosives by 8330		
			1 - HDPE	250 mL	HNO3	Total TAL Metals by 6010B/7470A PM3		
			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		
			~~1 - HDPE~~	~~1 L~~	~~NaOH~~	~~Cyanide by 9010/9012~~ ← DKK 12/11/03		
DD5003	Water	12/11/03	2-Glass	40ml	HCL	TRIP BLANK		

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: 12/11/03 Time: 1800	1. Received by: Matthew F. Hoard	Date: 12-12-03 Time: 09:00
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.: PB12 11 03STL

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: 12/11/03
Laboratory Destination: STL-North Canton
Laboratory Contact: Ken Kuzior
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: 839702 140136

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
DD 3003	WATER	12/11/03 1035	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		
DD 3004	WATER	12/11/03 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		
DD 3004-MS	WATER	12/11/03 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		

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: 9/11/03 Time: 1800	1. Received by: [signature]	Date: 12/12/03 Time: 9:45
2. Relinquished by:	Date: Time:	2. Received by:	Date: Time:
3. Relinquished by:	Date: Time:	2. Received by:	Date: Time:

Comments:

207

page 2 of 2

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Shaw E & I, Inc.

ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

REFERENCE COC NO.: PB12 11 03STL

PAGE 2 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/843656
Sample Team Member: David Kessler
Profit Center: Knoxville
Project Manager: Steve Downey
Project No.: 843656
Required Report Date: 21 days

Sample Shipment Date: 12/11/03
Laboratory Destination: STL-North Canton
Laboratory Contact: Ken Kuzior
Project Contact/Phone: Maureen McMyler/865-690-3211
Carrier Waybill No.: —

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DD3004-MSD	WATER	12/11/03 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		
DD3005	WATER	12/11/03 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		
	DKK 12/11/03							

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: 12/11/03 Time: 1800	1. Received by:	Date: 12/12/03 Time: 9:45
2. Relinquished by:	Date: Time:	2. Received by:	Date: Time:
3. Relinquished by:	Date: Time:	2. Received by:	Date: Time:

Comments:

208

Shaw
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ANALYSIS REQUEST AND CHAIN-OF-CUSTODY RECORD

F21096

FILE/INVOICE NO.: PB12 11 03ACC

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: 12/11/03
Laboratory Destination: Accutest
Laboratory Contact: Sue Bell
Project Contact/Phone: Maureen McMyler/865-560-5271
Carrier Waybill No.: 843490779408

Sample Number	Sample Type/ Description	Date/Time Collected	Container Type	Sample Volume	Pre-servative	Requested Testing Program	Condition on Receipt	Disposal Record
DD3006	WATER	12/11/03 1355	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		
DD5004	WATER	12/11/03	3 - 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	Date: 12/11/03 Time: 1800	1. Received by: FedEx	Date: Time:
2. Relinquished by: FedEx	Date: Time:	2. Received by: Muna Mohammed	Date: 12/12/03 Time: 0915
3. Relinquished by:	Date: Time:	2. Received by:	Date: Time:

Comments:

3.1 3

F21096: Chain of Custody
Page 1 of 2

ACCUTEST Laboratories

APPENDIX H

RESPONSE TO COMMENTS

RESPONSE TO COMMENTS
RESTORATION ADVISORY BOARD
SEVENTH QUARTERLY BACKGROUND GROUNDWATER REPORT
FORMER PLUM BROOK ORDNANCE WORKS, SANDUSKY, OHIO
(Dated December 2003)

Reference: Comments from Mark Bohne, Co-Chairman of the PBOW Restoration Advisory Board (RAB) for the Seventh Quarterly Background Groundwater Report. Comments will be incorporated into the Eighth Quarterly Background Groundwater Report.

Comment 1: **Paragraph 1.3 on Page 1-5, the document states, "Review of documents and discussion with OEPA personnel indicated that the Columbus and Delaware bedrock units (the same bedrock units in which one of the PBOW background wells is screened) contain actively producing petroleum hydrocarbon wells (Shaw, 2003a). Therefore, it is important to note that some VOCs (primarily benzene, toluene, ethylbenzene, and total xylenes) and SVOCs may be naturally occurring in the site groundwater."**

Again, in paragraph 3.4.2 on Page 3-4, the document reiterates,

"Although certain organic compounds in site groundwater (benzene, toluene, ethylbenzene, total xylenes, and polynuclear aromatic hydrocarbons) may be attributable to background conditions...."

First, there are no "actively producing petroleum hydrocarbon wells" documented by the Ohio EPA in the area immediately surrounding the Plum Brook Site. Any oil-producing sites are many miles to the east or to the west. This statement would lead the reader to believe that there is enough crude oil available in the immediate area to support production. That is simply not the case.

Response 1: Agree. The statement "actively producing petroleum hydrocarbon wells" needs to be re-worded so the reader does not get the impression that there is enough crude oil to support production. The intent of the statement was not meant to imply economical quantities can be produced on or in the immediate vicinity of PBOW. As noted, the nearest wells producing economic quantities of petroleum are located approximately 8 miles southeast of PBOW. The intent of the statement was to provide the reviewer with an indication of the potential for naturally occurring petroleum hydrocarbons to be present in the bedrock. Attached is a figure prepared from information obtained from the Ohio Department of Natural Resources, Division of Geological Survey web site of known active and abandoned oil and gas wells in Erie County. These wells are screened in the upper Devonian (Columbus or Delaware Limestones) bedrock. The web page can be found at: http://www.ohiodnr.com/geosurvey/ogcim/petrol/ftpmaps.htm.

Once at the site, the URL is:
ftp://ftp.dnr.state.oh.us/Geological_Survey/well_db/erie.dbf.

This GIS figure was constructed from well locations surveyed with Ohio State Plane coordinates plotted with coordinates of the Plum Brook facility.

While the Delaware Limestone (deepest bedrock unit screened at PBOW) may not yield economical quantities of oil or gas for commercial production at PBOW, even minor amounts of BTEX and PAH compounds in the bedrock groundwater are detected by the sensitive analytical methods used in the environmental investigations. It is important to note that of the 18 monitoring wells that are screened in the Delaware bedrock, 16 of the wells have traces of petroleum hydrocarbon, petroleum odors and/or hydrogen sulfide present. In addition, hydrocarbon was also encountered in the rock cores that were collected during the drilling of monitoring wells PB-BED-MW24, PB-BED-MW27, and TNTA-BEDGW-001 (photographs in the Shaw June 2003, 2002 Groundwater Data Summary and Evaluation Report). These wells are screened in the Delaware bedrock and are positioned at different locations across the PBOW site (indicative of widespread occurrence).

As shown on Figure 1-3 in the report, one of the gas and oil wells is on PBOW property and its existence has been confirmed. The well is presently abandoned. The location of the former well is near background well PB-BED-MW20. Information from PBS personnel indicates that it was a natural gas well that belonged to the former property owner in pre-ordnance plant days.

With the evidence obtained (hydrocarbon on rock cores, instrument measurements, and analytical detections) and references cited (11/18/98 telecon, 8/29/02 email, and 2/3/04 telecon), petroleum hydrocarbon in the Delaware bedrock unit is present. Because BTEX and PAHs are part of the natural makeup of petroleum hydrocarbon, the statement in the text that petroleum hydrocarbons may be naturally present in the bedrock groundwater is used only as supporting evidence when BTEX and PAH concentrations were found in the bedrock groundwater where they were not expected.

Even so, the detection of BTEX and PAHs in overburden and bedrock groundwater samples collected during the background and site investigations will not be ignored or eliminated as possibly being a result of past DOD activities. As stated in the 2002 Groundwater Data Summary and Evaluation Report (Shaw, 2003), "*all detections of VOCs and SVOCs will not be summarily screened out, but rather will be carried through the risk assessment process (i.e., exposure assessment, toxicity assessment, and risk characterization")*. The sitewide groundwater risk assessment will be performed upon completion of the background quarterly sampling.

Comment 2: **The text mentions [OEPA] "documents" supporting the hypothesis that the background levels of VOCs and SVOCs may be "naturally occurring" and impacting the background wells. I am only aware of one document of tests run on shale near a site in the vicinity of the Huron River. The document I reviewed was not refereed by others and appeared incomplete (containing many hand-written entries). If any documents are to be used to substantiate the hypotheses, then they are worthy of entry to Section 6.0 References, for review and critique by other scientists.**

Response 2: The text states that documents were reviewed (not OEPA documents), to determine whether the Delaware and Columbus bedrock units contained petroleum hydrocarbon producing wells. Shaw used one document and text from a geology quadrangle map for additional evidence of hydrocarbon in the Delaware Limestone bedrock. From this, it was inferred that if petroleum hydrocarbon was present, then BTEX and PAHs may be present (naturally) in the bedrock groundwater. The reference for the documents (C.E. Herdendorf, 1966, ***Geology of the Vermilion West and Berlin Heights Quadrangles, Ohio***, Ohio Division of Geological Survey, Report of Investigations 60 and Wilbur Stout, 1941, ***Dolomites and Limestones of Western, Ohio***, Geological Survey of Ohio, Bulletin No. 42, p. 362-365 and 357-358) will be added to future quarterly background reports and the sitewide groundwater report. As noted in comment 1 above, the statement that BTEX and PAHs may be naturally present in the bedrock groundwater is used only for supporting evidence of concentrations found where they were not expected. Detections of BTEX and PAH in groundwater samples collected during the background and site investigations will not be ignored or eliminated. As stated in the Shaw 2002 Groundwater Data Summary and Evaluation Report, all concentrations will be further reviewed during the risk assessment, which will be prepared and submitted following the quarterly sampling activities.

Comment 3: **The text mentions "discussions" with the Ohio EPA supporting the hypotheses that the background levels of VOCs and SVOCs may be "naturally occurring" and impacting the background wells. These also bear further documentation if they are to be given substantial merit in the research.**

Much of the research into the hypothesis concerning "naturally occurring" hydrocarbons was produced to reinforce a flawed groundwater study performed at the Erie County Landfill site by Metcalf and Eddy entitled the "Groundwater Quality Assessment Report – Erie County Landfill", which was revised in April 1995. Another reputable environmental firm, Bennett and Williams, disputes this hypothesis in a report entitled the, "Preliminary Evaluation of the Erie County Landfills

as they Relate to the Suitability for Vertical Expansion" submitted in January 1997.

Response 3: Please see response no. 2.

Comment 4: **No mention (or known research) has been performed on the possible environmental impact on groundwater since the National Space Administration and NASA started work at the site. There is already one permit issued by the Ohio EPA to NASA for a "pump and clean" system arising from groundwater contamination by a UST that contained diesel fuel used for power generators at the nuclear reactor site. Other facilities were also used to test propellants or for the performance of routine maintenance functions at the site. Any one could have added to the presence of SVOCs or VOCs in the groundwater.**

Response 4: A pump and treat system is currently installed at the Reactor Area for remediation of a former NASA leaking trichloroethylene (TCE) UST, while a second system is currently in place at the Maintenance Shop Area for a former NASA leaking oil/solvent UST. True, either one of these leaking USTs could have added to the presence of VOCs or SVOCs in the groundwater, but both these units are treating groundwater of the shallow overburden water-bearing zone, not in the bedrock (Delaware) water-bearing zone.

The USACE will continue to work with NASA personnel in cleanup activities at the PBOW site, although the first concern is remediation of contaminants caused by historic PBOW activities. Groundwater reports concerning NASA leaking USTs are under the auspices of CERCLA requirements and can be reviewed with NASA personnel. As previously noted, the presence of petroleum hydrocarbons and other former DOD contamination in the groundwater will be evaluated in the sitewide groundwater risk assessment.

Comment 5: **It is important to note that the overburden soils are deeper in the southern areas of the property than in the northern reaches. Migration of organic compounds could have moved south instead of north, even though it seems that groundwater flows in the opposite direction. Another point of interest is the fact that similar studies (by the same research firm supplying data for the Erie County Landfill) of the hydrogeology in the area have indicated that groundwater moves at a rate of six inches per year. This could prove important when considering the density of the bedrock and the possible migration of contaminants through the overburden.**

Response 5: A review of the current overburden thickness contour map (Figure 2-9) presented in the Shaw 2002 Groundwater Data Summary and Evaluation Report, shows that the soil is much thicker (deeper) in the northern part of PBOW. Soil thickness is greatest near the Reactor Area (> 25 feet) compared

to shallower depths (approximately 6.5 feet) in the southern area. A bedrock high runs east-west through PBOW, north of the TNT B Area, with weathered shale exposed at the surface near wells MK-16 and TNTB-BEDGW-002. A top of bedrock elevation contour map (Figure 2-8 in the same report) shows that the bedrock is at an elevation of 668-ft (PB-BED-MW26) in the southern region of PBOW compared to a lower elevation of 608 ft (PB-BED-MW22) in the northern region. Both of these maps indicate that PBOW overburden groundwater flows in a northerly direction toward Lake Erie.

Hydraulic conductivity tests of PBOW overburden monitoring wells have shown results that range from a maximum of 212 ft/day (ABG-GW002) to a minimum of 0.74 ft/day. Conductivity tests performed in bedrock wells range from a maximum of 22 ft/day (ABG-BEDGW-001) to as little as 0.003 ft/day (TNTB-BEDGW-003). The rate of groundwater movement of 6 inches per year applies only to the location of the study area (presumably the Erie County Landfill). Given the variation in glacial deposits, the hydraulic conductivity and resultant flow velocity cannot be used to represent the groundwater flow rates on PBOW. A sitewide groundwater flow model is being completed for PBOW that will provide groundwater flow rates and direction across the site. Submittal date of the flow model is expected in early 2005.

Comment 6: **As the documents produced by the OEPA are suspect in this matter, it would be wise to produce separate and more carefully prepared documents to support the hypothesis before coming to another, possibly flawed, conclusion about background levels of SVOCs and VOCs.**

Response 6: Comment noted. Additional references will be included in future quarterly reports and the sitewide groundwater report to document sources of information as well as discussions with ODNR personnel regarding this issue. References to text pertaining to petroleum hydrocarbon in the Delaware Limestone will be included (see Response to Comment No. 2).

Comment 7: **The importance of determining the exact levels (and probable sources) of all background chemical contamination in and around the Plum Brook site is foundational to the research arising from the Trojan Powder Works. Therefore, appropriate emphasis concerning the validity of any and all documents presented in the research is crucial to the accuracy of the study.**

As the Restoration Advisory Board is the "voice of community" in these matters, it is important that we feel confident in the outcome of the research and subsequent work to be performed to remediate the environmental impacts that are discovered. Nothing should be left to chance. No hypotheses should go without study. No questions should go unanswered. The credibility of all stakeholders is important, but

ultimately, after the work is complete, it is the community members who will remain to be judged on the quality of the finished product. Therefore, the points raised in this commentary should be addressed before any groundwater study is judged as "complete and accurate."

Response 7: Agree. The purpose of these quarterly reports is to present the data being collected in a timely fashion and to solicit comments and concerns from the RAB. The USACE appreciates input from the RAB, and continued interaction with the PBOW RAB prior to completion of the final sitewide groundwater report is essential to assure that concerns by all stakeholders are addressed.

RESPONSE TO COMMENTS
U.S. ARMY CORPS OF ENGINEERS (CELRN-EC-R-D)
SEVENTH QUARTERLY BACKGROUND GROUNDWATER REPORT
FORMER PLUM BROOK ORDNANCE WORKS, SANDUSKY, OHIO
(Report Dated December 2003)

Reference: Comments forwarded by Linda Ingram (dated January 29, 2004) for the Seventh Quarterly Background Groundwater Report. Comments will be incorporated into the Eighth Quarterly Background Groundwater Report.

Comments by Doug Mullendore (Chemical Engineer)

Comment 1: **Page 2-2, 1st Complete Paragraph, Last Sentence. Suggest changing hydrogen ion concentration to pH.**

Response 1: Agreed. Hydrogen ion concentration will be changed to pH in future quarterly reports for easier recognition.

Comment 2: **Page 3-4, Section 3.4.2, 1st Paragraph, 1st Sentence. Suggest adding a sentence that identifies when the evaluation of flow direction will be performed.**

Response 2: The following sentences will be included after the first sentence in the noted section: "This final groundwater flow direction will be confirmed after all background monitoring wells are installed. Confirmation of this flow direction will be included in a final background summary report anticipated to be submitted in October 2004".

Comment 3: **Page 3-3, Section 3.4. I recommend inserting an introductory paragraph to this section to identify the purpose of this section. A good start for this introductory paragraph is found on page 3-4, 1st complete paragraph.**

Response 3: Agreed. Section 3.4 will be revised for the eighth quarterly report. Parts of the paragraph suggested on page 3-4 will be incorporated into the revised introduction. Most of the text in the first paragraph of Section 3.4 will be moved to Section 3.4.1.

Comment 4: **Page 3-3, Section 3.4. The first sentence of the first paragraph states *"Background groundwater data are not subjected to risk assessment screening in this document"* but sections 3.4.1 and 3.4.2 expand further on the screening process. Neither of these sections state that the background concentrations will be screened against Risk Based Screening Concentrations (RBSC). Instead the 2nd paragraph of Section 3.4 (Page 3-4) states that "Background screening in the BHHRA will apply only to inorganic constituents that exceed RBSCs". Background concentrations aren't being screened against RBSC; chemical concentrations that exceed RBSCs are being screened against background. Based on my**

understanding of the mentioned text, I suggest revising the first sentence of this paragraph.

Response 4: As described in the response to the reviewer's Comment 3, the first paragraph will be revised for the eighth quarterly report. Note that screening is performed only on site (non-background) data which was not collected during the seventh quarterly sampling event (nor during the eighth which was completed in December 2003). Because the seventh quarter includes only background wells, the protocol described in Section 3.4 does not apply to the seventh quarterly sampling. The intent of this italicized statement is to communicate to the reader that none of the analytical data (from the background wells) described in this report is subject to the screening presented in Section 3.4.1.

Comment 5: **Page 3-5, Section 3.4.3. This section is somewhat confusing. In explaining Figure 3-1, the text states "...may include a spatial analysis of the data to determine...are found in a small isolated plume or more evenly distributed throughout the site", I suggest adding we clarify exactly what data, I assume we mean data from contaminated areas, will have spatial analysis performed on it. The same can be said regarding the geochemical analysis.**

Response 5: In the eighth quarterly report, the third sentence of this paragraph will be revised to state: "The 'further evaluation' box shown on Figure 3-1, just before the 'risk management decision,' may include a spatial analysis of site analytical data to determine if elevated concentrations of chemicals that exceed risk criteria are found in small isolated plumes or are evenly distributed throughout the site." The geochemical analysis would likely be performed on the complete data set for the area being evaluated. If applicable, the geochemical analysis may even include a separate evaluation of the background data as an additional line of evidence.

Comment 6: **Section 4.0. I suggest adding some discussion regarding the physical characteristics, based on field measurements, of the groundwater. Table 2-2 shows that many of the wells have low dissolved oxygen and negative Ehs. This information might be helpful during evaluations of source area sampling data. Additionally, I noticed some anamolies in some of the data presented in Table 2-2 that bring into question the validity of specific data points, as an example PB-BED-MW20 had a dissolved oxygen concentration below 5 ppm, 7 of the 9 times it was sampled. The other two times it had a dissolved oxygen content of over 9 ppm. I did a charge balance on the filtered results from these two sampling events and both times the milliequivalent charge did not balance (>80% difference between the "+" and "-" charges). I also did a charge balance on several of the lower dissolved oxygen containing samples and the charges balance was within 10% of each other. I recommend evaluating some of the more**

spurrious results and considering deleting them from any background calculations.

Response 6: Agreed. This data will be presented but not evaluated in future quarterly reports. A complete evaluation of analytical data and field parameters will be presented in the sitewide groundwater report.

<u>Comments from Becky Terry (Chemist)</u>

Comment 1: **Page 1-5. First paragraph. First sentence. Edit. The Delaware and Bedrock units do not contain actively producing petroleum hydrocarbon *wells*.**

Response 1: During discussion with Ohio Department of Natural Resources (DNR) and a recently obtained oil and gas map, many active/inactive petroleum wells are present in the Delaware and Columbus Limestone bedrock units. One document and text from a geology quadrangle map provide additional evidence of hydrocarbon in the Delaware Limestone bedrock. The reference for the documents (C.E. Herdendorf, 1966, ***Geology of the Vermilion West and Berlin Heights Quadrangles, Ohio***, Ohio Division of Geological Survey, Report of Investigations 60 and Wilbur Stout, 1941, ***Dolomites and Limestones of Western, Ohio***, Geological Survey of Ohio, Bulletin No. 42, p. 362-365 and 357-358) will be added to future quarterly background reports and the sitewide groundwater report.

Comment 2: **Section 2.2. Paragraph three through six. It would be more accurate to state that low-flow methods were utilized for all samples collected for this sampling event.**

Response 2: Agreed. Information in the four paragraphs pertaining to sample collection with a bailer during this event will be removed. Remaining information will be reviewed and sentence structure adjusted accordingly.

Comment 3: **Section 3.0. First paragraph. Sixth sentence. Appendix B is the validation summary for the primary and duplicate samples analyzed by Severn Trent. Correct.**

Response 3: The 6th sentence will be corrected to state "The validation summary for primary and duplicate samples analyzed by Severn Trent is provided in Appendix C".

Comment 4: **Section 3.4. Third paragraph. First sentence states that all tables in "Chapter 4" include a column for MDC and a column for BSC. Please correct reference to " Chapter 4".**

Response 4: The beginning of the sentence will be revised to state "All tables in reference to Section 4.0 include a....".

Comment 5: **Section 3.4.2. Second sentence. Correct reference to "Chapter 4".**

Response 5: Chapter 4 will be replaced with "Section 4".

Comment 6: **Appendix E. Section E.2.2. Second paragraph. Take out extra spaces.**

Response 6: Data quality evaluation data in Appendix E is not planned to be resubmitted. Additional care of sentence structure and formatting will be taken during submission of the Eighth Quarterly Background Groundwater report to omit extra spacing in the paragraphs.

Comment 7: **Appendix E. Table E-2. Sample DC3001 was omitted from the Table. Page E-3 indicates that it be included based on the fact that Blank contamination was detected for the following: Chloromethane and toluene.**

Response 7: Disagree. Table E-2 includes only blank samples and not project samples. Therefore, it should not be included.

RESPONSE TO COMMENTS
OHIO ENVIRONMENTAL PROTECTION AGENCY
SEVENTH QUARTERLY BACKGROUND GROUNDWATER REPORT
FORMER PLUM BROOK ORDNANCE WORKS, SANDUSKY, OHIO
(Report Dated December 17, 2003)

Reference: Comments forwarded by Linda Ingram (dated February 10, 2004) for the Seventh Quarterly Background Groundwater Report. Comments will be incorporated into the Eighth Quarterly Background Groundwater Report.

Comments by John Weaver, through Geoff Leking, Geologist 4, (DDAGW-NWDO)

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 NASA Plum Brook Station, hereafter referred to as the NPBS, was built in early 1941 and consists of 6400 acres located 4 miles south of Sandusky, Ohio in Erie county. From December 1941 to 1945, the facility manufactured trinitrotoluene (TNT), dinitrotoluene (DNT), acid, and pentolite for use as explosives during WWII. NASA acquired the site on March 15, 1963 and is currently utilizing the site to conduct aerospace research.

The U.S. Army is conducting environmental investigations at previously owned U.S. Department of Defense (DOD) properties, of which the NPBS is one such facility. The 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 & Infrastructure, Inc. (Shaw), formerly International Technology Corporation, to provide engineering and consulting services for the NPBS investigation. NPBS and Shaw are currently performing a sitewide ground water investigation (GWI) at the facility. In support of the sitewide GWI, Shaw has completed several ground water sampling events at the background overburden and bedrock monitoring wells. The December 17, 2003 Seventh Quarterly Background Groundwater Report is the subject of this review.

Conclusions:

1. **NPBS/Shaw should review Comments 1, 3.g., 7, 8, and 10 below to assist them in completing the sitewide GWI at NPBS.**

Comment 1: **In support of the site-wide ground water investigation (GWI) at the NASA Plum Brook Station (NPBS), US Army Corps of Engineers (USACE) Nashville District, and Shaw Environmental, Inc. (Shaw), are currently performing background ground water sampling from a series**

of overburden and bedrock monitoring wells. The purpose of the GWI is in part, to generate a database to calculate background concentrations in both saturated zones. Background monitoring well network details and completed sampling events to date are provided in the table below.

Saturated Zone	Well	Sampling Dates
Overburden	IT-MW01	07/10/02 10/16/02 04/09/03
Bedrock	PB-BED-MW20 PB-BED-MW24 PB-BED-MW25 [1]PB-BED-MW26 BG8-BEDGW-001 [2]PB-BED-MW28 [2]PB-BED-MW29	09/27/01 - 10/09/01 01/16/02 04/03/02 07/11/02 10/18/02 04/10/03 09/18/03

Notes:

1 -Well will be eliminated from background network as it is very low-yielding and turbid.

2 -Installed on August 4-13, 2003 in support of sitewide GWI.

All ground water samples collected on the dates were obtained using low-flow methodologies.

To date, Ohio EPA has not received soil boring logs, well construction diagrams, well development logs, survey data, or any other pertinent information representing background bedrock wells PB-BED-MW28 and PB-BED-MW29. Ohio EPA requests that NPBS include the above information in a future sitewide GWI report submittal.

Response 1: Groundwater samples were collected from wells IT-MW01 (all dates listed), PB-BED-MW20 (10/17/02 and 9/26/01), and PB-BED-MW24 (10/19/03) (but not by using low-flow sampling techniques). See Table 2-2 of report for low-flow sampling ability (low-flow sampling column listed).

All soil boring logs, well construction diagrams, well development logs, survey data, or any other pertinent information collected under this groundwater investigation will be presented in the sitewide GWI report submittal, anticipated in 2005.

Comment 2: **For historical perspective, the following strategy for collecting and generating a background database for the bedrock saturated zone will be implemented in support of the GWI. The items were agreed upon by NPBS, USACE, and Ohio EPA during a September 11, 2002 meeting at NPBS. A statistical approach will be submitted to Ohio EPA in a future GWI report for review and concurrence.**

- **Background monitoring well PB-BED-MW26 recharges very slowly and is very turbid. It was installed on September 9, 2001 and was never fully developed as its yield was very low. Therefore, this well will be removed from the background network. It will be utilized as a ground water surface elevation point only.**

- **Analytical results from future sampling events at wells BED-MW20, PB-BED-MW24, and PB-BED-MW25 will be evaluated closely to determine they are truly representative of background conditions in the bedrock zone. Nitroaromatic compounds have been previously detected in the wells.**

- **NPBS will calculate both filtered and unfiltered background bedrock ground water concentrations. However, only unfiltered background bedrock values will be used for the purposes of a risk evaluation in support of the sitewide GWI.**

- **NPBS will only use low-flow sampling (i.e., bladder pump) analytical results in background bedrock calculations to generate a single database. Analytical results from background samples collected using a bailer will be utilized in a qualitative manner to characterize ground water quality at the NPBS on a sitewide and area of concern basis where appropriate and applicable.**

- **NPBS will periodically recalculate all of the background bedrock ground water concentrations for the purposes of the sitewide GWI. And,**

- **NPBS intends to calculate background bedrock concentrations for 23 target analyte list metals, 17 polynuclear aromatic hydrocarbons (PAHs), and BTEX. As stated earlier, a background database for organic constituents will be developed to address the occurrence of natural hydrocarbons in the bedrock zone. Constituents for which background bedrock concentrations will be calculated are provided in Table 1 below.**

Response 2: Comments noted. No response required.

Comment 3: **The following is a brief synopsis of background sampling activities at the NPBS.**

a. **September-October 2001: Due to an indentation in the PVC riser, overburden well IT-MW01 could not be sampled. All bedrock background monitoring wells were sampled for TCL volatile organic compounds (VOCs), nitroaromatics, TCL semivolatile organic compounds (SVOCs), TAL metals (total and dissolved), turbidity,**

alkalinity, hardness, TOC, TDS, TSS, chloride, total cyanide, nitrate, and sulfate.

b. **January 2002: Attempts to repair well IT-MW01 were unsuccessful; well could not be sampled. All bedrock background monitoring wells were sampled for the parameters noted in item a. above.**

c. **April 2002: Due to an indentation in the PVC riser, overburden/shale well IT-MW01 could not be sampled. All bedrock background monitoring wells were sampled for the parameters noted in item a. above.**

d. **July 2002: Well IT-MW01 was finally sampled for the parameters noted in item a. above. The well was not repaired but sampled using a peristaltic pump and tubing which was able to bypass the indentation. All bedrock background monitoring wells were sampled for the parameters noted in item a. above.**

e. **October 2002: Overburden background well IT-MW01 and all bedrock background monitoring wells were sampled for the parameters noted in item a. above with the exception of well PB-BED-MW26 which was observed to be dry.**

f. **April 2003: Overburden background well IT-MW01 and all bedrock background monitoring wells (PB-BED-MW20, PB-BED-MW24, BG8-BEDGW-001, and PB-BED-MW25) were sampled for the parameters noted in item a. above. And,**

f. **September 2003: Bedrock background monitoring wells PB-BED-MW20, PB-BED-MW24, BG8-BEDGW-001, PB-BED-MW25, PB-BED-MW28, and PB-BED-MW29 were sampled for the parameters noted in item a. above. Monitoring well PB-BED-MW26 was not sampled due to insufficient recharge. Overburden well IT-MW01 was not sampled because the sampling bailer could not pass an indentation observed in the riser pipe. A bailer was used to sample the well as there was insufficient recharge to support low-flow purging methodologies (i.e., bladder pump and tubing). If well IT-MW01 is to remain as an overburden background location, then it should be appropriately repaired or properly abandoned and replaced.**

Response 3: We agree with the synopsis presented (comments 3a through 3f).

Response 3g: No attempt was made to sample overburden well IT-MW01. The well is not scheduled to be sampled during the remaining quarterly background sampling events. The USACE will evaluate the need to repair or abandon/replace well IT-MW01 based on future monitoring needs at the site. Information on any

planned activities associated with this well will be forwarded to Ohio EPA for review.

Comment 4: **Shaw completed the seventh quarter background sampling event at the overburden and bedrock monitoring well networks on September 16-19, 2003. This event represents a 'dry' season sampling event at NPBS. Ground water samples were submitted to Severn Trent Laboratories, Inc. (STL) of Knoxville, TN for analysis. Shaw has included ground water sampling forms (Appendix A), chain of custody documentation (Appendix F), and analytical data (Appendix C) in the December 17, 2003 Seventh Quarterly (September 2003) Background Groundwater Report (data report). NPBS/Shaw have adequately documented well purging and sampling activities.**

Response 4: Noted.

Comment 5: **Samples collected for dissolved metals analyses were filtered in the field using a 0.45 micron filter.**

Response 5: Noted.

Comment 6: **Provided in the table below are selected analytical results from the bedrock background monitoring well network representing the seventh quarter (September 2003).**

Well/ Parameter	MCL	PB-BED-MW20	PB-BED-MW24	PB-BED-MW25	BG8-BEDGW-001	PB-BED-MW28	PB-BED-MW29
4-amino-2,6-dinitrotoluene	-	0.19J	ND	ND	ND	ND	ND
benzene	5	1.4J	32	ND	ND	2.4J	ND
ethylbenzene	700	ND	13J	ND	ND	ND	0.86J
toluene	1000	ND	37	ND	ND	1.7J	0.12J
total xylenes	10,000	ND	67	ND	ND	ND	5.5
2-methylnaphthalene	-	ND	4J	ND	ND	ND	ND
naphthalene	-	ND	3.5J	ND	ND	ND	ND
trichloroethene	5	ND	ND	ND	ND	0.59J	ND
acetone	-	ND	ND	ND	ND	ND	17

Notes:
All values in micrograms/liter (ug/l).
MCL -Maximum contaminant level.
ND -Non detect.

There were no constituents detected above associated MCLs during the seventh quarterly background event. Dissolved (filtered) manganese was detected above its action level of 50 ug/l in wells BG8-BEDGW-001, PB-BED-MW20, PB-BED-MW25, and PB-BED-MW29 during the seventh quarterly event.

Benzene, toluene, ethylbenzene, and xylenes (BTEX) were detected in wells PB-BED-MW20, PB-BED-MW24, PB-BED-MW28, and PB-BED-MW29. Based upon historical analytical data collected from the bedrock background monitoring well network, it is apparent that hydrocarbons are naturally occurring in certain bedrock deposits beneath the facility and especially in the Delaware Limestone.

Response 6: Noted.

Comment 7: **Per previous discussions with NPBS, Shaw, and USACE, if detections of organics/PAHs in the bedrock background monitoring well network are determined to be related to natural hydrocarbons, then the establishment of background concentrations will be considered. Shaw adds that organic/PAH background concentrations will be utilized on a sitewide or regional basis for comparison to downgradient analytical data. Ohio EPA is amenable to this approach as long as a statistical plan or similar document is provided to the agency for review and concurrence which notes at a minimum, (1) what constituents will be considered for background calculations and the corresponding rationale, (2) how background concentrations will be calculated, and (3) how the background values will be utilized.**

Response 7: An initial qualitative and, if appropriate, statistical evaluation of petroleum-related organics/PAHs in the bedrock monitoring well network will be completed to determine if they are indeed naturally occurring. This evaluation will present the rationale for determining if the organics are naturally occurring and how the information will be applied to site wells. Calculation of actual background concentrations is not currently planned but may be warranted after the initial evaluation is completed. The evaluation of organics in bedrock groundwater will be done in conjunction with OEPA through interim memos, conference calls and team meetings.

Comment 8: **Appendix C of the data report indicates that the 'reporting limit' or method detection limit (MDL) for bis(2-ethylhexyl)phthalate is 10 ug/l. The federal drinking water MCL for the constituent is 6 ug/l. Ohio EPA**

requests that NPBS/Shaw provide the contracted laboratory's (STL) MDL for bis(2-ethylhexyl)phthalate. NPBS/Shaw is reminded that the laboratory must be able to achieve MDLs which are below corresponding MCLs.

Response 8: The reporting limit is not the method detection limit (MDL). The MDL is the minimum concentration of an analyte that can be measured and reported with 99 percent confidence that the concentration is greater than zero. The reporting limit is the lowest level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. It is set at the lowest standard used for the calibration curve. STL's current MDL for bis(2-ethylhexyl)phthalate is 2.2 ug/L.

Comment 9: **NPBS/Shaw have provided an adequate discussion of the ground water analytical results, data validation, and data quality objectives in Appendices B, C, D, and E of the data report.**

Response 9: Noted.

Comment 10: **As noted in Section 5.0 of the data report, NPBS intends to perform the following activities in support of the sitewide GWI.**

a. **Continued background data collection from the bedrock monitoring well network (PB-BED-MW20, PB-BED-MW24, PB-BED-MW25, PB-BED-MW26, BG8-BEDGW-001, PB-BED-MW28, and PB-BED-MW29). Sampling events are currently slated for December 2003 and March and June 2004.**

Response 10a: Agreed.

b. **Reporting of quarterly ground water monitoring data. And,**

Response 10b: Agreed.

c. **Preparation of an all-encompassing background ground water monitoring report.**

Ohio EPA is amenable to the above proposed activities with the addition of submitting a background statistical plan or similar document as detailed in Comment 7 above.

Ohio EPA is unclear as to why NPBS is continuing to sample well PB-BED-MW26 as it has already been agreed upon that this well will be eliminated from the background bedrock network. This well is to be used to collect ground water level elevations only. Ohio EPA requests clarification on this issue.

Response 10c: The methodology for evaluating background inorganics in groundwater has been agreed upon during team meetings. The methodology is summarized in the 2002 Groundwater Data Summary and Evaluation Report. Submission of a background statistical plan is not currently scoped as part of this investigation.

Please note that groundwater samples have not been collected from PB-BED-MW26 except unfiltered metals in January 2002. No additional sampling is planned for this well.

RESPONSE TO COMMENTS
OHIO ENVIRONMENTAL PROTECTION AGENCY
SIXTH QUARTERLY BACKGROUND GROUNDWATER REPORT
FORMER PLUM BROOK ORDNANCE WORKS, SANDUSKY, OHIO
(Report Dated July 31, 2003)

Reference: Comments forwarded by Linda Ingram (dated February 10, 2004) for the Sixth Quarterly Background Groundwater Report. Comments, if applicable, will be incorporated into the Eighth Quarterly Background Groundwater Report.

Comments by John Weaver, through Geoff Leking, Geologist 4, (DDAGW-NWDO)

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 NASA Plum Brook Station, hereafter referred to as the NPBS, was built in early 1941 and consists of 6400 acres located 4 miles south of Sandusky, Ohio in Erie County. From December 1941 to 1945, the facility manufactured trinitrotoluene (TNT), dinitrotoluene (DNT), acid, and pentolite for use as explosives during WWII. NASA acquired the site on March 15, 1963 and is currently utilizing the site to conduct aerospace research.

The U.S. Army is conducting environmental investigations at previously owned U.S. Department of Defense (DOD) properties, of which the NPBS is one such facility. The 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 & Infrastructure, Inc. (Shaw), formerly International Technology Corporation, to provide engineering and consulting services for the NPBS investigation. NPBS and Shaw are currently performing a sitewide ground water investigation (GWI) at the facility. In support of the sitewide GWI, Shaw has completed several ground water sampling events at the background overburden and bedrock monitoring wells. The Sixth Quarterly Background Groundwater Report is the subject of this review.

Conclusions:

1. **NPBS/Shaw should review Comment 1 through 9 below to assist them in completing the site-wide ground water investigation at NPBS.**

Comment 1: **In support of the site-wide ground water investigation (GWI) at the NASA Plum Brook Station (NPBS), US Army Corps of Engineers (USACE) Nashville District, and Shaw Environmental, Inc. (Shaw), formerly International Technology Corporation, performed several quarterly background ground water sampling events during a period of**

time from 2001 to 2003. Quarterly background ground water analytical results are contained in the following reports.

a. **First quarter (September-October 2001) sampling results are contained in the document entitled, '2001 Groundwater Remedial Investigation, Former Plum Brook Ordnance Works, Sandusky, Ohio', International Technology Corporation, March 15, 2002.**

b. **Second quarter (January 2002) sampling results are contained in the document entitled, 'Second Quarterly Background Report, Former Plum Brook Ordnance Works, Sandusky, Ohio', International Technology Corporation, May 2002.**

c. **Third quarter (April 2002) sampling results are contained in the document entitled, 'Third Quarterly Background Report, Former Plum Brook Ordnance Works, Sandusky, Ohio', International Technology Corporation, July 2002.**

d. **Fourth quarter (July 2002) sampling results are contained in the document entitled, 'Draft First Annual Data Summary and Evaluation Report, International Technology Corporation', August 29, 2002 and '2002 Groundwater Data Summary and Evaluation Report, Former Plum Brook Ordnance Works, Sandusky, Ohio', Shaw, June 2003.**

e. **Fifth quarter (October 2002) sampling results are contained in the document entitled, 'Fifth Quarterly Background Groundwater Report, Former Plum Brook Ordnance Works, Sandusky, Ohio, document dated February 18, 2003; International Technology Corporation. Received by the Ohio EPA on February 19, 2003. And,**

f. **Sixth quarter (April 2003) sampling results are contained in this document under review.**

Response 1: Agreed. A summary of the each of the five background groundwater sampling events is included in each identified report.

Comment 2: **The purpose of the site-wide GWI quarterly background sampling is to generate a database to calculate background concentrations in both the bedrock and overburden (shallow) saturated zones. For clarification, the current bedrock background monitoring well network consists of wells PB-BED-MW20, PB-BED-MW24, BG8-BEDGW-001, and PB-BED-MW25. Bedrock background well PB-BED-MW26 has been removed from the network. NPBS/Shaw propose to install and sample 2-3 additional background monitoring wells in the summer/fall 2003. The overburden background monitoring well network consists of well IT-MW01.**

The following is a brief synopsis of background sampling activities at the NPBS.

a. **September-October 2001: Due to an indentation in the PVC riser, overburden well IT-MW01 could not be sampled. All bedrock background monitoring wells were sampled for TCL VOCs, TCL SVOCs, TAL metals (total and dissolved), turbidity, alkalinity, hardness, TOC, TDS, TSS, chloride, total cyanide, nitrate, and sulfate.**

b. **January 2002: Attempts to repair well IT-MW01 were unsuccessful; well could not be sampled. All bedrock background monitoring wells were sampled for the parameters noted in item a. above.**

c. **April 2002: Due to an indentation in the PVC riser, overburden/shale well IT-MW01 could not be sampled. All bedrock background monitoring wells were sampled for the parameters noted in item a. above.**

d. **July 2002: Well IT-MW01 was finally sampled for the parameters noted in item a. above. The well was not repaired but sampled using a peristaltic pump and tubing which was able to bypass the indentation. All bedrock background monitoring wells were sampled for the parameters noted in item a. above.**

e. **October 2002: Overburden background well IT-MW01 and all bedrock background monitoring wells were sampled for the parameters noted in item a. above with the exception of well PB-BED-MW26 which was observed to be dry.**

g. **April 2003: Overburden background well IT-MW01 and all bedrock background monitoring wells (PB-BED-MW20, PB-BED-MW24, BG8-BEDGW-001, and PB-BED-MW25) were sampled for the parameters noted in item a. above**

Response 2: The presented synopsis of the background groundwater sampling is correct.

To include analytical results in the background groundwater summary calculations from the two new background monitoring wells, an additional four quarters of background groundwater samples will be collected. The last background groundwater sampling event is planned to be performed in June 2004 and the report is anticipated to be submitted in September 2004.

Comment 3: **Shaw has included ground water sampling logs in Appendix A and chain of custody documentation in Appendix F of the July 31, 2003 Sixth Quarterly Background Groundwater Report (data report) to represent the fifth (October 2002) and sixth (April 2003) quarterly background**

sampling events. NPBS/Shaw have adequately documented well purging and sampling activities.

Response 3: Noted. Sample collection logs and chain-of-custody forms will continue to be submitted in the quarterly reports.

Comment 4: **Provided in the table below are dates of background sampling completed at both the overburden and background monitoring well networks at NPBS which will be utilized in part for background concentration calculations (refer to Table 2-2 of the submittal).**

Saturated Zone	Well	Sampling Dates
Overburden	IT-MW01	07/10/02 10/16/02 04/09/03
Bedrock	PB-BED-MW20 PB-BED-MW24 PB-BED-MW25 BG8-BEDGW-001 Two additional wells installed in summer 2003	09/26-27/01 - 10/09/01 01/15-17/02 04/03-04/02 07/10-12/02 10/17-19/02 04/09-11/03 4 additional events beginning after well installation in 2003

Response 4: Correct. The additional four quarters of background groundwater sampling include two event which have already occurred (September 2003 and December 2003), and two which are anticipated to be conducted in March 2004 and June 2004.

Comment 5: **Three nitroaromatic compounds and benzene, ethylbenzene, methylene, chloride, xylenes, and bis(2-ethylhexyl) phthalate have been detected in the bedrock background monitoring network during the period of background data acquisition (2001-April 2003). Therefore, NPBS/Shaw shall perform quarterly ground water sampling at the background bedrock monitoring well network for one year to '...confirm, deny, and enhance the values of the background data set.' Ohio EPA concurs with this approach as additional background data are necessary to adequately evaluate ground water conditions upgradient of the NPBS.**

Response 5: Noted.

Comment 6: **Appendix C of the submittal indicates that the 'reporting limit' or method detection limit (MDL)' for bis(2-ethylhexyl)phthalate is 10 ug/l. The federal drinking water maximum contaminant level (MCL) for the constituent of concern (COC) is 6 ug/l. Ohio EPA requests that NPBS/Shaw provide the contracted laboratory's (Severn Trent Laboratories, Inc. of Knoxville, TN) MDL for bis(2-ethylhexyl)phthalate.**

NPBS/Shaw is reminded that the laboratory must be able to achieve MDLs which are below corresponding MCLs.

Response 6: The reporting limit is not the method detection limit (MDL). The MDL is the minimum concentration of an analyte that can be measured and reported with 99 percent confidence that the concentration is greater than zero. The reporting limit is the lowest level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. It is set at the lowest standard used for the calibration curve. STL's current MDL for bis(2-ethylhexyl)phthalate is 2.2 ug/L.

Comment 7: **Figure 2-1 of the data report displays detected constituents in the overburden and bedrock background monitoring wells for all six quarterly sampling events completed to date. Based upon recent discussions with NPBS, Shaw, and USACE, the total inorganic (metals) data noted on Figure 2-1 appears to constitute the background database for use in the calculation of background concentrations for each inorganic COC. Ohio EPA requests clarification from NPBS/Shaw if this is an accurate statement.**

Response 7: The unfiltered metals data presented on Figure 2-1 represents all data collected for the evaluation of the background concentrations of inorganics in groundwater. However, some of the data presented ultimately may be removed from the data set. For example, analytical results for well PB-BED-MW24 may be eliminated as a background well due to reinterpretation of groundwater flow conditions in this area of PBOW. Note that the water level data obtained from this well suggests groundwater is flowing off of PBOW in this area of the site. Another example is PB-BED-MW26, which does not yield sufficient water to allow collection of representative groundwater samples. In summary, the data presented on Figure 2-1 represents all data *potentially* useable for determining background.

Comment 8: **NPBS/Shaw have provided an adequate discussion of the ground water analytical results, data validation, and data quality objectives in Appendices B, C, D, and E of the data report.**

Response 8: Noted.

Comment 9: **Based upon an evaluation of background ground water analytical data collected to date, NPBS/Shaw have scheduled the following activities in support of the sitewide GWI.**

a. **Expand the remedial investigation to further characterize background and downgradient ground water quality and the extent of COCs associated with the NPBS.**

b. **Install 5 downgradient bedrock monitoring wells to determine the full rate, extent, and concentrations of COCs in the bedrock saturated zone.**

c. **Collect additional ground water samples from the background bedrock monitoring well network (2 recently installed [August 2003] and 4 existing) on a quarterly basis for a period of at least one year.**

d. **Collect ground water samples from 8 downgradient bedrock monitoring wells (3 existing and 5 to be installed) on a semiannual basis for 1 year. Note: In Section 5.0, page 5-1, fifth bullet, of the data report, NPBS/Shaw state on a 'biannual' basis for one year which is incorrect grammar; wording should note semiannual. And,**

e. **Submittal of analytical results and investigative findings on a quarterly basis.**

Ohio EPA is amenable with the above proposed activities.

Response 9: The listed synopsis of scheduled activities in support of the background and sitewide groundwater investigation is correct.

RESPONSE TO COMMENTS
OHIO ENVIRONMENTAL PROTECTION AGENCY
FIFTH QUARTERLY BACKGROUND GROUNDWATER REPORT
FORMER PLUM BROOK ORDNANCE WORKS, SANDUSKY, OHIO
(Report Dated February 18, 2003)

Reference: Comments forwarded by Linda Ingram (dated February 10, 2004) for the Fifth Quarterly Background Groundwater Report. Comments, if applicable, will be incorporated into the Eighth Quarterly Background Groundwater Report.

Comments by John Weaver, through Geoff Leking, Geologist 4, (DDAGW-NWDO)

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 NASA Plum Brook Station, hereafter referred to as the NPBS, was built in early 1941 and consists of 6400 acres located 4 miles south of Sandusky, Ohio in Erie county. From December 1941 to 1945, the facility manufactured trinitrotoluene (TNT), dinitrotoluene (DNT), acid, and pentolite for use as explosives during WWII. NASA acquired the site on March 15, 1963 and is currently utilizing the site to conduct aerospace research.

The U.S. Army is conducting environmental investigations at previously owned U.S. Department of Defense (DOD) properties, of which the NPBS is one such facility. The 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 & Infrastructure, Inc. (Shaw), formerly International Technology Corporation, to provide engineering and consulting services for the NPBS investigation. During 2002, Shaw performed ground water sampling at NPBS in support of a site-wide ground water investigation. The Shaw Fifth Quarterly Background Groundwater Report is the subject of this review.

Conclusions:

Shaw should review Comments 2 through 7 below to assist them in completing the site-wide ground water investigation at NPBS.

Comment 1: **In support of the site-wide ground water investigation (GWI) at the NASA Plum Brook Station (NPBS), US Army Corps of Engineers (Nashville District) and Shaw Environmental & Infrastructure, Inc. (Shaw), formerly International Technology Corporation, performed several quarterly background ground water sampling events in 2001 and 2002. The Shaw February 2003 submittal focuses on the fifth quarterly**

background event. Results of the first through fourth quarterly background sampling events are contained in the following reports:

a. **First quarter (September-October 2001) sampling results are contained in the document entitled, '2001 Groundwater Remedial Investigation, Former Plum Brook Ordnance Works, Sandusky, Ohio, International Technology Corporation, March 15, 2002.**

b. **Second and third quarter sampling results are contained in Second and Third Quarterly Background Reports, respectively. And,**

c. **Fourth quarter sampling results are contained in the document entitled, 'Draft First Annual Data Summary and Evaluation Report, International Technology Corporation, August 29, 2002.**

Response 1: We agree with the above statements.

Comment 2: **The purpose of the site-wide GWI quarterly background sampling is to generate a database to calculate background concentrations in both the bedrock and overburden (shallow) saturated zones. For clarification, the bedrock background monitoring well network consists of wells PB-BED-MW20, PB-BED-MW24, BG8-BEDGW-001, PB-BED-MW25, and PB-BED-MW26 while the overburden background monitoring well network consists of well IT-MW01 (Figure 1).**

The following is a brief synopsis of background sampling activities at the NPBS.

a. **September-October 2001: Due to an indentation in the PVC riser, overburden well IT-MW01 could not be sampled. All bedrock background monitoring wells were sampled for TCL VOCs, TCL SVOCs, TAL metals (total and dissolved), turbidity, alkalinity, hardness, TOC, TDS, TSS, chloride, total cyanide, nitrate, and sulfate.**

Response 2a: In addition, bedrock monitoring well PB-BED-MW26 was not sampled during September-October 2001 due to insufficient water.

b. **January 2002: Attempts to repair well IT-MW01 were unsuccessful; well could not be sampled. All bedrock background monitoring wells were sampled for the parameters noted in item a. above.**

Response 2b: Only unfiltered TAL metals were sampled from background bedrock well PB-BED-MW26 during the January 2002 sampling event.

c. **April 2002: Due to an indentation in the PVC riser, overburden well IT-MW01 could not be sampled. All bedrock background monitoring wells were sampled for the parameters noted in item a. above.**

Response 2c: All bedrock background monitoring wells were sampled in April 2002 except well PB-BED-MW26 (insufficient water).

d. **July 2002: Well IT-MW01 was finally sampled for the parameters noted in item a. above. All bedrock background monitoring wells were sampled for the parameters noted in item a. above.**

Response 2d: All bedrock background monitoring wells were sampled in July 2002 except well PB-BED-MW26 (insufficient water).

e. **October 2002: Overburden background well IT-MW01 and all bedrock background monitoring wells were sampled for the parameters noted in item a. above with the exception of well PB-BED-MW26 which was observed to be dry.**

Response 2e: Agreed.

For those wells with adequate recharge, purging and sampling was performed using low-flow equipment and methodologies. Remaining wells were purged and sampled using disposable HDPE bailers.

Shaw should have provided an explanation in the submittal as to how the background overburden well IT-MW01 was repaired for the purpose of performing ground water sampling.

Response 2: Repair of the indentation in the PVC riser was not possible to allow a 2-inch outside diameter pump or bailer to enter the well. Groundwater from the well was purged and sampled using a peristaltic pump. With a peristaltic pump, only 3/8-inch Teflon-lined tubing is inserted into the well for groundwater removal. Information of the sampling method will be included in Sections 2.2 and 4.2.1 of the Eighth Quarterly Background Groundwater report.

Comment 3: **Shaw should have included chain of custody documentation in the submittal to represent the fifth quarterly background sampling event.**

Response 3: Chain-of-custody forms for the fifth quarterly sampling were included in the Sixth Quarterly Background Groundwater report.

Comment 4: **Per discussions at a September 11, 2002 meeting at NPBS , the following determinations have been made in support of the site-wide GWI.**

a. **Overburden and bedrock background concentrations will be calculated using total (unfiltered) ground water analytical results. Total results will also be utilized for screening and risk assessment purposes.**

Response 4a: Agreed.

b. **Analytical results from bedrock well PB-BED-MW26 will be excluded from the background database as the ground water was observed to be extremely turbid (muddy).**

Response 4b: Agreed.

c. **Only those analytical results obtained from background wells sampled using low-flow equipment and methodologies will be used to generate background ground water concentrations.**

Response 4c: Agreed.

d. **Shaw will utilize either 95% upper tolerance limit statistical methodologies or the maximum detected concentration of a constituent of concern (COC), whichever is less, to calculate background ground water concentrations.**

Response 4d: Agreed.

e. **One-half (½) of the laboratory reporting limit will be used in background and statistical calculations for COCs which are non-detect. Background data acquisition will be continued for at least one additional sampling event (April 2003) due to the detection of several nitroaromatics in several of the background bedrock wells.**

Response 4e: As noted, one-half of the laboratory reporting limit will be used for COC's which are non-detect. Two additional background monitoring wells (PB-BED-MW28 and PB-BED-MW29) were installed on off-site property to assist in further defining the nitroaromatic, VOC, SVOCs, and metals detections in the groundwater. With the addition of two new wells to the background monitoring well set, background groundwater sampling was decided to be continued for an additional four quarters, after the April 2003 sampling. Mention of this was included in the Seventh Quarterly (September 2003) Background Groundwater Report, Section 1.0, last paragraph.

f. **Installation of two offsite background bedrock monitoring wells and one offsite downgradient well (Figure 1). And,**

Response 4f: To completely define the downgradient area in which nitroaromatics may be leaving the PBOW property boundary and further define the groundwater flow interpretation directions, five off-site, downgradient monitoring wells will be installed. One well will be on the west side of PBOW (west of well PB-BED-MW24), one well north of onsite monitoring well PB-BED-MW19, and three in a general northwest direction of former monitoring well PB-BED-MW27.

g. Abandonment of downgradient bedrock well PB-BED-MW27 due to hydrogen sulfide gas.

Response 4g: Correct. To eliminate the hydrogen sulfide odor emanating from monitoring well PB-BED-MW27 in response to public concerns, the monitoring well was abandoned in January 2003.

Comment 5: **Provided in the table below are dates of background sampling completed at both the overburden and background monitoring well networks at NPBS which will be utilized in part for background concentration calculations (refer to Table 2-2 of the submittal). Shaw should review this table for accuracy per discussions during the September 11, 2002 meeting at NPBS.**

Saturated Zone	Well	Sampling Dates
Overburden	IT-MW01	09/27/01 01/16/02 04/02/02 07/10/02 10/16/02 additional event scheduled for April 2003
Bedrock	PB-BED-MW20 PB-BED-MW24 PB-BED-MW25 BG8-BEDGW-001 Potentially two more; anticipated installation in 2003	09/26-27/01 - 10/09/01 01/15-17/02 04/03-04/02 07/10-12/02 10/17-19/02 additional event scheduled for April 2003

Response 5: Since two additional background monitoring wells (PB-BED-MW-28 and PB-BED-MW29) have been installed at PBOW, it was decided that background groundwater sampling would continue for at least four additional quarters. At the completion of background groundwater sampling, a quarterly background report will be submitted. The anticipated submittal date is October 2004.

The following is an updated table that presents a list of the background monitoring wells that have been sampled at the end of the seventh quarterly sampling event:

Saturated Zone	Well	Sampling Dates								
		11/1997	5/1998	9-10/2001	1/2002	4/2002	7/2002	10/2002	4/2003	9/2003
Overburden	IT-MW01	B	B	NS	NS	NS	B	B	B	NS
Bedrock	PB-BED-MW20	B	B	B	LF	LF	LK	B	LF	LF
	PB-BED-MW24	NS	NS	LF	LF	LF	LF	B	LF	LF
	PB-BED-MW25	NS	NS	LF	LF	LF	LF	LF	LF	LF
	PB-BED-MW26	NS	NS	NS	um	NS	NS	NS	NS	NS
	BG8-BEDGW-001	B	B	LF	LF	LF	LF	LF	LF	LF
	PB-BED-MW28	NS	NS	NS	NS	NS	NS	NS	NS	LF
	PB-BED-MW29	NS	NS	NS	NS	NS	NS	NS	NS	LF

LF - Sampled by Low-Flow
B - Sampled by Bailer
NS - Not sampled
um – Unfiltered TAL metals only

Comment 6: **Three nitroaromatic compounds and benzene, ethylbenzene, methylene, chloride, xylenes, and bis(2-ethylhexyl) phthalate have been detected in the bedrock background monitoring network during the period of background data acquisition. Therefore, an additional quarterly sampling event(s) will be performed in part to determine the adequacy of the current network to provide upgradient ground water quality data in the bedrock and overburden saturated zones.**

A decision on the future collection, use, and representativeness of the background data will have to be discussed between NPBS, US Army Corps of Engineers, Shaw, and Ohio EPA as (1) benzene, toluene, ethylbenzene, and xylene occur naturally as a free-phase liquid (hydrocarbon) in carbonate bedrock (Delaware Limestone) beneath NPBS and (2) at least one of the nitroaromatic compounds detected in the background bedrock well network was never manufactured at NPBS. Additional items for discussion concerning background ground water quality include;

a. Should locations of proposed additional background wells be re-evaluated.

Response 6a: Two additional wells have been installed at offsite locations, in an upgradient direction of the PBOW groundwater flow. Groundwater in these locations is believed to be representative of the background groundwater quality. These locations were selected in conjunction with the USACE and OEPA.

b. How many data points (i.e., sampling rounds) are appropriate to be collected from the background monitoring well networks.

Response 6b: At least four additional rounds of background groundwater sampling will be necessary due to the installation of the two new background wells. Quarterly sampling of the new wells will provide information on the seasonal variability of groundwater quality. This sampling schedule will provide data consistent with other background data previously collected for the site.

c. How data collected from any additional background bedrock monitoring wells should be incorporated into the database.

Response 6c: All data collected from the new background monitoring wells by low-flow sampling methodologies will be entered into the database for calculation of background inorganic concentrations.

d. Specific methodologies for calculating background concentrations.

Response 6d: Specific methodologies will be calculated by the means presented at the September 2002 meeting between the OEPA, USACE, NASA, and Shaw.

e. For which COCs should background concentrations be calculated. And,

Response 6e: Background screening concentrations (BSC) will be derived for inorganics detected in the background groundwater wells. Background concentrations of petroleum-related hydrocarbons (polynuclear aromatic hydrocarbons [PAH] and benzene, toluene, ethylbenzene, and xylene [BTEX]) may be qualitatively and statistically compared to those found in downgradient (i.e., "site") groundwater samples, but no organic compounds will be screened on the basis of background concentrations.

f. How background and downgradient analytical data will be statistically evaluated.

Response 6f: Appendix L of the 2002 Groundwater Data Summary and Evaluation Report describes that the BSC values will be derived from the background groundwater analytical data using the Chebychev inequality, and that where

statistical population testing is necessary, the Wilcoxon Rank-Sum test will be performed.

Comment 7: **As previously observed by Ohio EPA, several VOCs compounds were detected in the bedrock background monitoring well network. : As VOCs are normally non-naturally occurring, the bedrock wells with observed detections of VOCs may not be appropriate to characterize background bedrock ground water quality at the NPBS. As such, additional background wells may be warranted to be installed at different locales. NPBS, Ohio EPA, US Army Corps of Engineers, and Shaw need to discuss this situation as to how it will affect the following items:**

a. Calculation of bedrock background concentrations.

b. How the detection of organics in background bedrock wells will affect the risk-based approach for the site-wide GWI. And,

c. How the source and rate and extent of contamination in the bedrock zone is defined due to the existence of naturally occurring hydrocarbons in the local bedrock saturated zone.

If the detection of organics in the bedrock background monitoring well network is determined to be related to natural hydrocarbons, then the development of an organic background database may be warranted similar to the inorganic COCs. Alternatively, the locations of current and future background (bedrock) monitoring wells may have to be re-evaluated where locations are secured further upgradient of NPBS.

Response 7: Two new bedrock monitoring wells (PB-BED-MW28 and PB-BED-MW29) have been installed upgradient (south) of the PBOW site in response to detections of organics in other site background wells. The locations of these two off-site, background bedrock wells are believed to be representative of the groundwater quality found in the background locations of PBOW. The organic data will be carefully evaluated to determine whether detections of petroleum-related compounds (specifically BTEX and PAHs) are from naturally occurring sources. The concentration of organics in groundwater, if determined to be naturally occurring, will not be used to derive background screening concentrations. However, the concentration of naturally occurring organics may be used to qualitatively compare background to site concentrations of organics. In addition, the data may be used for population testing of site versus background. The evaluation of organics in bedrock groundwater will be done in conjunction with OEPA through interim memos, conference calls and team meetings.