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Submittal of the Final Feasibility Study (Slip Pages), Volume IV of the TNT Area B Remedial Investigation, Former Plum Brook Ordnance Works, Sandusky, Ohio; Contract Number DACA62-94-D-0030; IT Project Number 775616

Dear Mrs. Ingram:

In accordance with the requirements of Delivery Order Number 0034 of Contract Number DACA62-94-D-0030 and as discussed, IT Corporation is pleased to submit the final Feasibility Study (Volume IV) of the Remedial Investigation of TNT Area B at the former Plum Brook Ordnance Works (PBOW) in Sandusky, Ohio. Because of the minor changes required to the draft FS submittal (December 2000), replacement pages have been prepared to address the technical review comments. Please replace the document covers and slip pages in the previous submittal with those enclosed as indicated.

Enclosed are fifteen copies of the final FS replacement pages including a new cover, the Executive Summary, and Section 2.0. Should you have any questions or require additional information regarding this submittal, please do not hesitate to call the undersigned at (860) 688-1151 or Michael Gunderson at (865) 690-3211.

Sincerely,

Mikael L. Spangberg
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Enclosures

IT CORPORATION

DISCIPLINE SIGN-OFF REVIEW

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Volume IV – Feasibility Study

TNT Area B Remedial Investigation
Former Plum Brook Ordnance Works
Sandusky, Ohio

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List of Acronyms

µg/L	micrograms per liter
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	constituent of concern
D&M	Dames and Moore, Inc.
DNT	2,4-dinitrotoluene
DOD	U.S. Department of Defense
EPA	U.S. Environmental Protection Agency
FFS	focused feasibility study
FS	feasibility study
GSA	General Services Administration
GWI	groundwater investigation
HI	hazard index
HTF	Hypersonic Tunnel Facility
ICI	International Consultants Incorporated
ILCR	incremental lifetime cancer risk
IMS	Ion Mobility Spectrometer
IT	IT Corporation
LDR	land disposal restriction
MCL	maximum contaminant level
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MK	Morrison-Knudsen Ferguson Corporation
NASA	National Aeronautics and Space Administration
NCP	National Contingency Plan
O&M	operation and maintenance
OEPA	Ohio Environmental Protection Agency
PAH	polynuclear aromatic hydrocarbon
PBOW	Plum Brook Ordnance Works
PBS	Plum Brook Station
PCB	polychlorinated biphenyl

List of Acronyms *(Continued)*

PPE	personal protective equipment
PRG	preliminary remediation goal
RA	risk assessment
RAO	remedial action objective
RBC	risk-based concentration
RBRC	risk-based remedial criteria
RI	remedial investigation
ROD	record of decision
SLERA	Screening Level Ecological Risk Assessment
SMCL	secondary maximum contaminant level
SVOC	semivolatile organic compound
TNT	2,4,6-trinitrotoluene
TNTB	TNT Area B
TOC	total organic carbon
TSS	total suspended solids
USACE	U.S. Army Corps of Engineers
USACHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
UTS	Universal Treatment Standards
VOC	volatile organic compound

Executive Summary

This report presents the results of the focused feasibility study (FFS) performed for contaminated soils at TNT Area B (TNTB) located at the former Plum Brook Ordnance Works (PBOW) in Sandusky, Ohio. The U.S. Army Corps of Engineers (USACE) contracted IT Corporation (IT) to conduct this FFS under Delivery Order 034 of Contract Number DACA62-94-D-0030. The purpose of this FFS was to select, evaluate, compare, and recommend remedial alternatives that address the soil contamination at TNTB.

TNTB comprises an area of approximately 55 acres at the south-central portion of PBOW immediately north of West Sheid Road. All the buildings that were present during the TNT manufacturing period were demolished and the site regraded.

Field work for the remedial investigation (RI) was conducted in 1998 (IT, 2000). As part of the RI, nitroaromatic field screening analysis involved collection of 391 soil samples. To supplement the on-site screening analysis, 40 confirmation soil samples were collected for standard laboratory analysis. A human health risk assessment was conducted for TNTB. Twelve chemicals of concern (COC) were identified in surface and subsurface soil as shown on the table on the following page. Five of those COC are nitroaromatics (2-amino-4,6-DNT, 4-amino-2,6-dinitrotoluene (DNT), 2,4-DNT. 2,6-DNT, 2,4,6-TNT), and are clearly site-related. Their presence is consistent with the production and purification of explosives such as 2,4,6-TNT. The greatest cancer risk and noncancer hazard is associated with 2,4,6-TNT. The remaining seven COCs are polychlorinated biphenyls (PCBs) and polynuclear aromatic hydrocarbons (PAH). Risk-based remedial criteria were developed for all the COCs. No unacceptable risk was associated with exposure to surface water and sediment on site. In addition, a screening level ecological risk assessment was performed for TNTB. However, based on uncertainties of toxicity, limited aquatic habitat at the site, and the fact that no rare, threatened, and endangered species have been confirmed at the site, remedial action objectives (RAO) based on ecological risk were not recommended in the RI (IT, 2000).

Based on the results of the human health risk assessment, the following RAO was selected for soil. No RAOs were developed for groundwater because groundwater will be evaluated on a sitewide basis at a later date:

- Remedial actions will be taken to prevent human exposure via any exposure route (ingestion, inhalation, or dermal contact) to site soil containing any of the 12 COC at concentrations that exceed preliminary remediation goals. Preliminary remediation

goals are chemical- and receptor-specific risk-based remedial criteria that capture all the exposure assumptions and toxicological data used in the risk assessment.

Chemical of Concern	Preliminary Remediation Goal (mg/kg)
Nitroaromatics	
2-amino-4,6-DNT	0.40
4-amino-2,6-DNT	0.40
2,4-DNT	7.50
2,6-DNT	2.75
2-Nitrotoluene	74
2,4,6-TNT	3.36
Polychlorinated Biphenyls	
Aroclor 1254	0.16
Aroclor 1260	2.87
Polynuclear Aromatic Hydrocarbons	
Benzo(a)anthracene	5.43
Benzo(a)pyrene	0.54
Benzo(b)fluoranthene	5.43
Dibenz(a,h)anthracene	0.65
Indeno(1,2,3-cd)pyrene	5.43

In order to achieve the RAOs for soil, the following options and technologies were screened based on effectiveness, implementability, and cost:

- Capping
- Excavation
- Off-site disposal
- Ex-situ chemical stabilization
- In-situ chemical oxidation
- Windrow composting.

Based on the results of the technology screening, the following four alternatives were developed for detailed analysis:

- Alternative 1 – No Action.

- Alternative 2 – In-Situ Chemical Oxidation, Excavation, and Off-Site Disposal. In-situ chemical oxidation of all contaminated soil (3,300 cubic yards) using a 3 percent permanganate solution and excavation/disposal of soil contaminated with PCBs in a hazardous waste landfill (400 cubic yards).

- Alternative 3 – Excavation, Ex-Situ Stabilization, and Off-Site Disposal

Excavation of all contaminated soil (3,300 cubic yards), ex-situ stabilization of the soil classified as hazardous waste (960 cubic yards) followed by disposal of stabilized soil and nonhazardous soil in a nonhazardous waste landfill.

- Alternative 4 – Excavation, On-Site Composting, and Off-Site Disposal
  Excavation of all contaminated soil (3,300 cubic yards), windrow composting of soil classified as hazardous waste due to 2,4-DNT content (560 cubic yards), disposal of soil classified as hazardous waste due to lead content (400 cubic yards) at a hazardous waste landfill, and disposal of composted and nonhazardous soil (2,900 cubic yards) at a nonhazardous waste landfill.

All of the alternatives, with the exception of Alternative 1, would permanently treat/remove contaminated soil, thereby reducing human health risks to within levels considered acceptable by the EPA, and significantly reducing the ecological hazard quotients. All of the alternatives involving excavation and/or treatment of contaminated soil (Alternatives 2 through 4) may provide a corollary benefit to long-term groundwater and surface water quality by removing or mitigating the most significant source areas that contribute to contamination in these media. Alternative 1 does not employ removal, containment, or treatment response actions that would mitigate the impact of source areas on receptors or other environmental media. Therefore, Alternative 1, No Action, will not be considered the recommended alternative.

Alternative 2, in-situ chemical oxidation, is the only alternative that evaluates an in-situ treatment technology. In-situ treatment is preferred over ex-situ treatment because it avoids the possibility of generating large quantities of hazardous waste, and it eliminates, in most cases, the need for off-site disposal. Prior to recommending Alternative 2 over the other alternatives, a soil matrix demand test for the contaminated soil at TNTB needs to be conducted. The soil matrix demand determines the amount of potassium permanganate that would be consumed by the soil organic matter, and therefore has large implications on the overall capital cost of the alternative. In addition, a treatability study needs to be conducted to determine the ability of the chemical oxidant in achieving preliminary remediation goals, and to determine the exact ratio of chemical oxidant to COCs in soil. A main drawback to Alternative 2 is that chemical oxidation would not treat the recalcitrant PCBs detected in the soil at various locations. Therefore, soil portions contaminated with PCBs above the preliminary remediation goals will have to be excavated and disposed off-site (approximately 400 cubic yards). However, the soil might be classified as a hazardous waste due to the presence of 2,4-DNT and lead (both on the toxicity characteristic leaching procedure (TCLP) list) at high concentrations in soil. Treatment with potassium permanganate would not transform or decrease the toxicity of lead in the soil. Therefore, off-site disposal at a hazardous waste treatment and disposal facility might be required. This does not mean that Alternative 2 should not be recommended as the preferred alternative for achieving the

RAOs at TNTB. Alternatives 3 and 4 require the excavation of far more soil (3,300 cubic yards) compared to Alternative 2.

Alternatives 3 and 4 both require the excavation of the 3,300 cubic yards of contaminated soil at TNTB. This is followed by on-site ex-situ treatment of the excavated soil prior to off-site disposal. Under Alternative 3 the portion of the excavated soil classified as a hazardous waste is treated using stabilization. Based on 2,4-DNT concentrations across the site, it is estimated that 560 cubic yards would be classified as hazardous waste after subjecting soil samples from all the excavated soil to the TCLP test. The advantage of stabilization over other technologies is its ability to stabilize all the COCs in soil. Stabilization would immobilize nitroaromatics, PAHs, PCBs, and lead. No other treatment technology is required following stabilization, and the stabilized soil would most likely pass the TCLP test. Therefore, the stabilized soil can be disposed at a nonhazardous waste landfill. The main drawback to stabilization when compared to other technologies is that it does not destroy, transform, or remove the contaminants from the soil. It only alters their mobility and bioavailability. Therefore, it is not recommended to use the stabilized soil as fill (or backfill) material on site. In comparison to stabilization, composting would transform the nitroaromatics and PAHs (and to a lesser extent the PCBs) in soil to less toxic compounds. Composting will not reduce the toxicity of lead; hence the composted soil might fail the TCLP test thereby requiring further treatment or disposal at a hazardous waste landfill. Based on this comparison, Alternative 3 is recommended over Alternative 4.

A cost analysis comparison of all four alternatives is presented below. None of the alternatives require any long-term operation and maintenance (O&M) or monitoring.

Alternative 1	Alternative 2	Alternative 3	Alternative 4
$0	$814,000	$358,000	$828,000

In conclusion, Alternative 3 is the recommended alternative for achieving the RAOs for contaminated soil at TNTB. Alternative 3 is the most cost effective, it stabilizes all the COC (including lead) in soil, it treats all the hazardous waste generated as part of the excavation, it permanently reduces the health risk at the site, it is achievable in a short time period, and it is administratively and technically implementable.

1.0 Introduction

This report presents the results of the TNT Area B (TNTB) Focused Feasibility Study (FFS). The U.S. Army Corps of Engineers (USACE) is conducting studies under the Defense Environmental Restoration Program to determine the environmental impact of suspected hazardous waste sites at previously owned U.S. Department of Defense (DOD) properties. Plum Brook Ordnance Works (PBOW) is an Army Defense Environmental Restoration Program project currently managed and technically overseen by the Huntington, West Virginia and Nashville, Tennessee USACE District Offices, respectively. Work contracted to IT Corporation (IT) at PBOW includes this FFS, which is being conducted under Delivery Order No. 034 of Contract No. DACA62-94-D-0030.

The FFS was completed in a manner consistent with U.S. Environmental Protection Agency (EPA) remedial investigation (RI)/feasibility study (FS) study guidance, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988) and subsequent guidance materials, including *Guidance on Implementation of the Superfund Accelerated Cleanup Model (SACM) under CERCLA and the NCP* (EPA, 1992).

1.1 Purpose

The purpose of this FFS is to provide an evaluation of remediation alternatives to address contaminated soil at TNTB within the former PBOW. Groundwater at the TNTB will be addressed under future sitewide studies and is not addressed as part of this FFS.

1.2 Background Information

The following sections provide a summary of the site conditions, previous studies, and the nature and extent of contamination.

1.2.1 Summary of Site Conditions

The 9,009-acre PBOW site was built in early 1941 as a manufacturing plant for 2,4,6-trinitrotoluene (TNT), 2,4-dinitrotoluene (2,4-DNT), and pentolite (International Consultants Incorporated [ICI], 1995). The site of the former PBOW is located approximately 4 miles south of Sandusky, Ohio and 59 miles west of Cleveland (Figure 1-1). Although primarily in Perkins and Oxford Townships, the eastern edge of the site extends into Huron and Milan Townships. PBOW is bounded on the north by Bogart Road, on the south by Mason Road, on the west by

County Road 43, and on the east by U.S. Highway 250. The area surrounding PBOW is mostly agricultural and residential (IT, 1999).

The former PBOW site is currently owned by the National Aeronautics and Space Administration (NASA) and is operated as the Plum Brook Station (PBS) of the John Glenn Research Center at Lewis Field. Most of the aerospace testing facilities built in the 1960s at the site are in standby or inactive status. On April 18, 1978, NASA declared approximately 2,152 acres of PBOW as excess. The Perkins Township Board of Education acquired 46 acres of the excess acreage and uses this area as a bus transportation center. General Services Administration (GSA) retains the remaining acreage and currently has a use agreement with the Ohio National Guard for 604 acres of the land. NASA presently controls approximately 6,400 acres and is using the site to conduct space research as a satellite operation of the John Glenn Research Center at Lewis Field in Cleveland, Ohio. The details of these land transactions are listed in the site management plan (ICI, 1995) and can be found at the NASA PBS.

TNTB comprises an area of approximately 55 acres at the south-central portion of PBOW immediately north of West Sheid Road as shown on Figure 1-2. All the buildings that were present during the TNT manufacturing period were demolished and the site regraded. Figure 1-3 presents a site map showing the location of all the former buildings. Significant aboveground evidence of former PBOW facilities exists at TNTB in the form of roads, hydrants, and ditches. In addition, aboveground water valves indicate the presence of underground utilities. Two NASA facilities are present at the site and are currently active, the Hypersonic Tunnel Facility (HTF) and Nitrogen Dewar Tanks (Figure 1-3). The HTF is located in the northwest portion of TNTB and consists of a single building, above and below-ground piping and utilities, and paved parking areas. The Nitrogen Dewar Tanks are located in the center of TNTB with aboveground piping and underground utilities leading to the northwest and to the northeast offsite (Dames and Moore, Inc. [D&M], 1997).

1.2.2 Summary of Previous Environmental Studies

1.2.2.1 Surface Water, Sediment, and Soil Investigations

In 1993, Morrison-Knudsen Ferguson Corporation (MK) collected two surface water, two sediment, and two surface soil samples in the vicinity of TNTB. Each sample was analyzed for volatile organic compounds (VOC), semivolatile organic compounds (SVOC), nitroaromatics, and dissolved metals. The surface water and sediment locations were called SW07/SD07 and SW08/SD08. SW07 and SD07 were collected near the beginning of Ransom Brook approximately 250 feet north of Magazine Road near a former location of red water settling

tanks. SW08 and SD08 were collected north of TNTB approximately 200 feet south of Fox Road and approximately 3,000 feet downgradient of SW07 and SD07 (ICI, 1995). The surface water samples had no detections of VOCs or SVOCs. No metals were detected in the surface water that exceeded a maximum contaminant level (MCL) or a secondary maximum contaminant level (SMCL). The sediment sample collected at SD07 had detections of five VOCs and fourteen SVOC compounds. The only nitroaromatic compound detected was TNT at a concentration of 25 milligrams per kilogram (mg/kg). Sediment sample SD08 had eleven organic compounds, all detected at concentrations at or below 0.1 mg/kg. Detected organic compounds included two VOCs and nine SVOCs, eight of which were polynuclear aromatic hydrocarbons (PAH). The two surface soil sample locations were SB09 and SS13. SB09 was collected from the borehole for MK-MW17 shown on Figure 1-3. Sample SS13 was collected in the vicinity of the railroad tracks southwest of the Fortifier House, Building 463 (ICI, 1995). VOCs (toluene and xylenes), SVOCs (bis[2-ethylhexyl]phthalate) and nitroaromatics (TNT and 2,6-DNT) were detected in the surface soil. Nitroaromatics were present at SB09 with TNT detected at a concentration of 12 mg/kg. In October 1994, as part of the TNT Areas site investigation, D&M sampled the soil at twenty-six locations at TNTB at the points shown on Figure 1-3. Each sample was analyzed for nitroaromatics and metals. All the samples were collected between 0.5 and 3.5 feet below ground surface (bgs). Eighteen of the twenty-six locations were sampled at one depth and eight locations were sampled at two depths. Nitroaromatics were detected in eighteen of the twenty-six locations and most locations had at least one sample with concentrations greater than 1.0 mg/kg. Concentrations of nitroaromatics in excess of 10,000 mg/kg were present in soils at the Bi-Tri House for Line 5 (Building 452) and the DNT Sweating and Graining House (Building 412).

1.2.2.2 Groundwater Investigations

Overburden Water-Bearing Zone Results. Two overburden monitoring wells were installed at TNTB in July 1993 by MK. Well MK-MW16 is located upgradient and well MK-MW17 is located downgradient of TNTB at the locations shown on Figure 1-3. Samples collected from both wells were analyzed for VOCs, SVOCs, nitroaromatics, and dissolved metals. No VOCs or nitroaromatics were detected in either of the wells. Metals were not detected at levels that exceeded MCLs or SMCLs. One SVOC, bis(2-ethylhexyl)phthalate, was detected at a concentration of 12 micrograms per liter (µg/L) in MK-MW17.

In December 1994, D&M sampled both MK-MW16 and MK-MW17 as part of the TNT Areas site investigation. Samples from the wells were analyzed for nitroaromatics, nitrates, and total and dissolved concentrations of 14 metals, which consisted of the 13 priority pollutant metals

plus manganese. MK-MW16 did not exhibit any detections of nitroaromatics. The downgradient well MK-MW17 did have TNT at a concentration of 6.5 µg/l and 3-nitrotoluene at a concentration of 5.3 µg/L. Nitrates were detected, but at concentrations below risk-based concentrations (RBC). Ten metals were detected in overburden groundwater. These were antimony, arsenic, beryllium, cadmium, copper, lead, manganese, nickel, thallium, and zinc. Six of the metals, copper, lead, manganese, nickel, thallium, and zinc, were detected in both wells. Nickel, manganese, and thallium were the only metals that exceeded RBCs (D&M, 1997).

IT collected groundwater samples from MK-MW16 and MK-MW17 as part of the site-wide groundwater investigation (GWI). The first sampling event occurred in September and October 1996. Both samples from the two wells were analyzed for VOCs, SVOCs, metals, pesticides and polychlorinated biphenyls (PCB), cyanide, and nitroaromatics (IT, 1997). SVOCs, pesticides, PCBs, and cyanide were not detected and VOCs were not detected above RBCs. The metals detected above RBCs included aluminum, arsenic, iron, lead, and nickel. Five nitroaromatics were detected above RBCs at MK-MW17. The maximum concentration of any nitroaromatic detected in MK-MW17 was 11 µg/L of 2,6-DNT (IT, 1999).

In November 1997 and May 1998 as part of the semi-annual monitoring investigation portion of the GWI overburden wells MK-MW16 and MK-MW17 were sampled by IT (IT, 1999). Overburden groundwater samples were analyzed for VOCs, SVOCs, nitroaromatics, metals (total and dissolved), cyanide, and water quality parameters (alkalinity, chloride, hardness, sulfate, nitrate, total dissolved solids, total organic carbon [TOC], and total suspended solids [TSS]). No VOCs, SVOCs, cyanide, or water quality parameters were detected at concentrations exceeding RBCs. Dissolved overburden groundwater samples analyzed for dissolved metals exceeded RBCs for aluminum, arsenic, iron, lead, manganese, and nickel in MK-MW17 and iron, manganese, and nickel in downgradient Well MK-MW16. Only one nitroaromatic compound, 4-amino-2,6-DNT, was detected above RBCs. This exceedance occurred only in downgradient well MK-MW17 (IT, 1999).

Bedrock Water-Bearing Zone Results. In 1997, IT installed two bedrock wells near TNTB. TNTB-BED-GW001 was installed northwest of the site to monitor bedrock groundwater downgradient of TNTB and TNTB-BED-GW002 was installed southeast of TNTB to monitor bedrock groundwater upgradient of the site (Figure 1-3). Both bedrock wells were sampled in November 1997 and May 1998 as part of the semi-annual monitoring investigation portion of the GWI. Both wells were analyzed for VOCs, SVOCs, nitroaromatics, metals (total and dissolved), cyanide, and water quality parameters (alkalinity, chloride, hardness, sulfate, nitrate, total dissolved solids, TOC, and TSS). No SVOCs, cyanide, or water quality parameters were

detected at concentrations exceeding RBCs. One VOC, benzene, was detected at a concentration above the RBC in well TNTB-BED-GW001. No nitroaromatics were detected in either well. Filtered bedrock groundwater samples analyzed for metals exhibited RBC exceedances for barium, iron, and manganese (IT, 1999).

1.2.3 Nature and Extent of Contamination

The following sections discuss the findings of the TNTB RI (IT, 2000). All soil analytical results are presented in Figures 1-4 through 1-24.

1.2.3.1 Soil

Nitroaromatic field screening analysis involved collection of 391 soil samples. Field screening samples were analyzed using ion mobility spectroscopy (IMS) at an on-site mobile laboratory. On-site analytical data allowed for field screening, real-time interpretation, and the iterative selection of additional sampling locations necessary to delineate the extent of TNT contamination. The criteria for estimating contaminated soil volumes was to establish the points and depths at which all constituents analyzed were detected at concentrations exceeding cleanup levels; cleanup goals for soils at TNTB will be discussed in detail in Chapter 2.0. To ensure the effectiveness of the IMS data, approximately ten percent of the samples collected for IMS analysis were analyzed with colorimetric test kits using method SW-846 8515. Overall, there was a correlation between the TNT detections. There were several incidences of detects in the IMS that were not detected by the kit. Eight of those were concentrations substantially higher than the kit's detection limit. Where TNT was detected by both methods, there is variability in the concentrations. Relative percent differences between the concentration ranges from less than 1 percent to 138 percent.

To supplement the on-site screening analysis, forty confirmation soil samples were collected for standard laboratory analysis. Locations for confirmation soil sample collection were based on IMS results. Confirmation samples were selected to support IMS results and risk assessments. To further investigate possible contaminant migration, two surface water and five sediment samples were collected near TNTB. Both surface water and sediment samples were analyzed for nitroaromatic compounds, VOCs, SVOCs, target analyte list metals, and PCBs.

Findings from the current RI are summarized by TNT process line in the following sections.

DNT Process Buildings. Of the twenty-two surface and subsurface soil samples collected by IT at Building 412 (DNT Sweating and Graining Building), only four samples had nitroaromatics exceeding cleanup goals (Figure 1-4). Although contamination is only detected to a depth of 3

feet bgs, for remedial purposes it is assumed that contamination extends all the way to the bedrock at a depth of approximately 6 feet bgs. The detection of 2,4-DNT at this site is consistent with the historical use of this building, although 2,6-DNT, which was only detected in the historical samples collected by D&M, would also be expected to be present. Field screening results for Building 415 (DNT Nitrating Building; Figure 1-5) and the associated loading dock and ditch do not indicate detections of nitroaromatics that exceed the cleanup levels for soils.

Wastewater Settling Tanks and Associated Pipelines. Two limited areas of contamination exist to the north and south of the Wastewater Settling Tanks. North of building 417 (Figure 1-6) several nitroaromatics were detected at concentrations above cleanup levels. Numerous PAHs, PCBs, and lead were also detected in the samples collected. The PAHs and lead likely are the result of burning of the TNT process buildings and road runoff and/or atmospheric deposition. Lead only marginally exceeded the established background concentration for PBOW soils. * PCBs + Pb

Surface and subsurface samples collected from along the underground wastewater pipelines (Figure 1-7) indicate nitroaromatics are limited in extent, and were not detected above cleanup levels. Only one boring (SS370) in close proximity to Building 466 (Wash House) showed elevated concentrations of nitroaromatics. For the purpose of identifying areas requiring remediation, the area surrounding soil boring SS370 was lumped with building 466.

Process Line 5 Buildings. Six buildings (Buildings 451, 452, 453, 456, 459, and the Northeast Nail House) were investigated. Field screening and fixed base results indicate that detections of nitroaromatics in soil at Buildings 451 (Mono House; Figure 1-8) and Building 459 (Acid and Fume Recovery; Figure 1-9) did not exceed cleanup levels. On the other hand, field screening and fixed based results indicate nitroaromatic contamination exceeding cleanup levels at Building 452 (Bi-Tri House; Figure 1-10), Building 453 (Fortifier House; Figure 1-11), Building 456 (Wash House; Figure 1-12), and the Northeast Nail House (Figure 1-13). Confirmation sampling also indicates the presence of Aroclor-1260 (2.8 mg/kg) and lead (61.4 mg/kg) at Building 453 (Figure 1-11). Figures 1-10 through 1-13 also indicate the depth of contamination at each site. PCBs

Process Line 6 Buildings. Six buildings (Buildings 461, 462, 463, 466, 469, and the Northwest Nail House) were investigated. Field screening and fixed base results indicate that detections of nitroaromatics in soil at Buildings 461 (Mono House; Figure 1-14) and Building 469 (Acid and Fume Recovery; Figure 1-15) did not exceed cleanup levels. However, field screening and fixed based results indicate nitroaromatic contamination exceeding cleanup levels

at Building 462 (Bi-Tri House; Figure 1-16), Building 463 (Fortifier House; Figure 1-17), Building 466 (Wash House; Figure 1-18), and the Northwest Nail House (Figure 1-19). Confirmation data also indicate impacts by PAHs in surface soils at Building 462 (Figure 1-16). Figures 1-16 through 1-19 also indicate the depth of contamination at each site.

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Process Line 7 Buildings. Five buildings (Buildings 471, 472, 473, 476, and 479) were investigated. Field screening and fixed base results indicate that detections of nitroaromatics in soil at Buildings 471 (Mono House; Figure 1-20) and Building 479 (Acid and Fume Recovery; Figure 1-21) did not exceed cleanup levels. Conversely, field screening and fixed based results indicate nitroaromatic contamination exceeding cleanup levels at Building 472 (Bi-Tri House; Figure 1-22), Building 473 (Fortifier House; Figure 1-23), and Building 476 (Wash House; Figure 1-24). Figures 1-22 through 1-24 also indicate the depth of contamination at each site.

1.2.3.2 Ransom Brook Surface Water and Sediment

Surface Water. Analytical results indicate only VOCs and metals are present in surface water. Only three VOCs were detected, all at concentrations below 1.2 µg/L. Two of these compounds, 2-butanone and carbon disulfide, were also detected in TNTB soils. The detection of 2-butanone could be laboratory contamination introduced during extraction and sample analysis. However, based on the low concentrations in the soils and surface water, and the fact that these compounds are not attributable to former site activities, it is unlikely that TNTB is a major source of these constituents. In addition, the lack of nitroaromatics in surface water and sediment also suggest that TNTB is not a current source of contamination to Ransom Brook.

Sediment. Analytical results for sediment indicate that VOCs, SVOCs, and metals are present in sediment. As with surface water, VOCs were detected at low concentrations. In addition, the detection of acetone and 2-butanone could be laboratory contaminants introduced during analysis. Six SVOCs were detected in sediment. As with TNTB soils, most of these are PAHs, which result from incomplete combustion. It is most likely that the source of PAHs in both TNTB soils and Ransom Brook sediments is burning of the TNT-process buildings and atmospheric deposition and/or road runoff. However, if TNTB were the source of the SVOCs, nitroaromatic compounds detected at much higher concentrations in TNTB soils would also be expected to be present in the sediment.

1.2.4 Summary of Human Health Risks

A risk assessment (RA) was performed to evaluate the potential risk to plausible receptors exposed to contaminants in various media at TNTB (IT, 2000). The following receptors were selected to represent current and future land-use scenarios; a groundskeeper, an indoor worker, a construction worker, and an on-site resident. Environmental media evaluated in the RA include surface soil, subsurface soil, surface water and sediment. Groundwater was not included in this RA, because it will be evaluated on a site wide basis at a later date. Figure 1-25 presents a human health conceptual site exposure model, and Table 1-1 presents a summary of the human health risk characterization for TNTB.

Twelve chemicals of concern (COCs) were identified in total soil (surface and subsurface). Five of those COCs are nitroaromatics (2-amino-4,6-DNT, 4-amino-2,6-DNT, 2,4-DNT, 2,6-DNT, 2,4,6-TNT), and are clearly site-related. Their presence is consistent with the production and purification of explosives such as TNT. The greatest cancer risk and noncancer hazard is associated with TNT. Two of the COCs in total soil are PCBs (Aroclor 1254 and Aroclor 1260). PCBs are generally not associated with the production of nitroaromatic explosives, but their widespread occurrence in eighteen of twenty-eight surface soil samples strongly suggests they are site related at TNTB. The remaining five COCs in total soil are PAHs, which are generally ubiquitous in the environment, readily forming from the combustion of organic material. Their presence in TNTB soils is not surprising, particularly if buildings or waste has been burned on the site as part of the decontamination efforts in the 1960s (IT, 2000). The PAHs in soil are significant contributors to risk, and will be addressed in the remedial action objectives. Risk-based remedial criteria (RBRC) were developed for all the COCs in soil at TNTB, and are presented in Chapter 2.

Sediment

No COCs were identified for short-term (construction worker) or long-term (on-site resident) exposure to surface water based on limited detections in this medium. Arsenic was identified as a cancer-based COCs in sediment for the on-site resident, and arsenic, iron and manganese were identified as noncancer-based COCs in sediment for the construction worker. Background data were not available for sediment, so these metals were regarded as if they were site-related. Sediment concentrations of arsenic, however, were consistent with levels in background soil, suggesting that arsenic concentrations in sediment reflect background levels in the soil from which sediment is derived. Furthermore, its incremental lifetime cancer risk (ILCR) for the on-site resident is at the lower end of the risk management range. Therefore, sediment will not be considered in the remedial action objectives (RAO).

Construction Worker Hazards
Arsenic
iron
manganese
Noncancerous

1.2.5 Summary of Ecological Risks

A screening level ecological risk assessment (SLERA) has been performed as part of the RI for TNTB (IT, 2000). Results of the SLERA indicate the impact of contaminated soil on terrestrial plants is insignificant, and the limited aquatic habitat at the site reduces the concern for impact to aquatic biota. Terrestrial receptors (especially mice, rabbits, shrews, and wrens) are predicted to incur elevated hazards from exposure to TNT, 4-amino-2,6-DNT, 2-amino-4,6-DNT, and Aroclor 1260 in soil and from exposure to aluminum and iron in surface water. However, based on uncertainties of toxicity, limited aquatic habitat at the site, and the fact that no rare, threatened, and endangered species have been confirmed at the site, RAOs based on ecological risk were not recommended in the RI (IT, 2000). However, additional ecological discussions are presented in Section 2.2.

1.2.6 Contaminant Fate and Transport

The fate of a chemical in the environment is a function of the physical nature of the site and the chemical properties of the constituent. The potential for environmental transport was examined based on both a review of the topographic and hydrogeologic characteristics of the site and a review of the available physical constants and chemical characteristics of each COCs. The following most significant fate and transport processes for the COCs are summarized:

- Based on the chemical characteristics of the COCs (nitroaromatics, PAHs, PCBs) at the PBOW site, volatilization is not considered a significant pathway for constituent migration.

- The high concentration of nitroaromatics in some surface soils indicates that migration could occur via surface drainage. These constituents could be adsorbed to suspended particulates or dissolved as components of surface water runoff.

- Leaching of constituents to groundwater depends on the infiltration rate, each constituent's solubility, and the tendency of a constituent to sorb to soil particles. The significance of this migration route will be further evaluated in the future sitewide groundwater studies.

- Fugitive dust emissions are a potential migration pathway for this facility in areas where vegetation may be sparse or in disturbed areas. The majority of the PBOW TNTB is well vegetated which may mitigate the generation of fugitive dust.

- Bioaccumulation of constituents and/or biomagnification in the food chain is not expected to be a major exposure pathway. Based on the characteristics of the identified COCs, significant transfer to humans or biota through the food chain is not expected to occur.

2.0 Identification of Remedial Action Objectives at TNT Area B

2.1 Introduction

This chapter provides RAOs and other key parameters for TNTB. RAOs are cleanup objectives that are developed during the FFS and finalized in the record of decision (ROD) to protect human health and the environment. RAOs consist of site-specific, medium-specific, and location-specific goals for protecting human health and the environment based upon consideration of RBRC and regulatory-based applicable or relevant and appropriate requirements (ARAR). RAOs facilitate consideration of all practicable remedial alternatives. RAOs aimed at protecting human health and the environment specify the following:

- COCs to be addressed
- Relevant exposure route(s) and receptor(s)
- Chemical concentration limits specific to COCs, environmental media, and specific locations at the site, referred to as preliminary remediation goals (PRG).

The following sections discuss and identify PRGs for TNTB, and the resultant RAOs. These RAOs provide the basis for the identification, detailed analysis, and selection of remedial alternatives.

2.2 Remedial Action Objective for Soil

PRGs were developed for each COC in total soil at TNTB. The first step was to perform a comprehensive search for any chemical-specific ARARs for soil that should be considered as part of the RAO. No chemical-specific ARARs for soil were identified; therefore, the RBRCs developed as part of the baseline human health risk assessment (BHHRA) were considered. The RBRCs are COC-, receptor-, and medium-specific concentrations based on target cancer risk levels of 1E-6 or 1E-5, and target HI values of 0.1 or 1. The RBRCs incorporate all the exposure and toxicity assumptions and data used in the risk assessment. RBRCs based on a cancer risk of 1E-5 were selected as the PRGs for potential carcinogens to provide protection for the presumably additive nature of cancer risk. RBRCs based on an HI of 0.1 were selected as the PRGs for non-carcinogens to provide protection for the additivity of hazard associated with multiple chemicals with a common mechanism of toxicity. More detail regarding assumptions regarding the additivity of hazard are provided in the BHHRA. The PRGs are compiled in Table 2-1.

The PRGs are slightly over protective, at least for chemicals evaluated for noncancer effects, which includes all six nitroaromatics and Aroclor 1254. The critical effects associated with Aroclor 1254 include chloracne and immunological impairment, which are quite unlike the effects associated with the nitroaromatics. Therefore, the RBRC of 1.6 mg/kg, based on a target HI of 1, could be adopted and defended as the PRB for Aroclor 1254. All of the nitroaromatics, however, have at least one mechanism of toxicity in common – the oxidation of hemoglobin to methemoglobin, which is unable to release oxygen to the tissues and results in reduced erythrocyte longevity (hemolytic anemia). Setting the target HI for each COC at 1 would not be sufficiently protective because the total HI for the nitroaromatics would exceed the threshold limit of 1. On the other hand, setting the target HI at 0.1 yields PRGs that are slightly overly protective. Theoretically, PRGs could be established for each of the nitroaromatics based on an HI of 0.17. In fact there are in infinite number of combinations that would yield a total HI for all the nitroaromatics that meets but does not exceed the threshold limit of 1.

The RAO for total soil will focus on remediating the site to PRG levels. It should be noted, however, that the PRGs should be viewed as conservative estimates of average concentration rather than the maximum concentrations that should be allowed to remain. In other words, it is likely that some sampling locations could have soil concentrations substantially greater than the PRGs, but if a conservative estimate of average for the area of a reasonable exposure unit falls at or below the PRG, the site is judged to be in compliance.

The following is the RAO for soil at TNTB:

- Remedial actions will be taken to prevent human exposure via any exposure route (ingestion, inhalation, or dermal contact) to site soil containing any of the 12 COCs at concentrations that exceed PRGs presented in Table 2-1.

Elevated ecological hazards were estimated for the site (Section 1.2.5), and although these estimates were associated with a considerable degree of uncertainty, a further discussion of how the proposed remedial action is protective of the environment is necessary. Table 2-2 presents estimated ecological hazards for the residual concentrations of the human health COCs expected at the site following the proposed remedial action. As can be seen in the table, expected residual concentrations in soil are below the proposed human health PRG concentrations, due to the planned excavation of COCs hotspots. Using these estimated residual concentrations, resultant ecological hazards for critical ecological receptors were simply scaled, as described in the footnotes to Table 2-2. Ecological hazards for the site (following remediation) are expected to be reduced by an average of 750-fold for the COCs, as compared with the initial RI ecological

hazard estimates (IT, 2000). Most dramatically, TNT hazards for the shrew are expected to fall by almost 9,000-fold (Table 2-2). While many of the COCs are still estimated to have potential ecological hazards above 1.0, this finding is not considered significant for the following reasons:

- Many of the estimated ecological hazards above 1 are due to detection limit issues. Further reduction in the human health PRGs to protect ecological receptors is not warranted due to the fact that the PRGs are already near the analytical limit of detection (final column of Table 2-2).

- The potentially elevated ecological hazard for 4-amino-2,6-DNT is based on a very conservative toxicity reference value that over estimates the hazard. The bird toxicity value used in the RI (and in Table 2-2) was 0.032 mg/kg-day (based on a acute lethal dose of 3.2 mg/kg-day coupled with an uncertainty factor of 100). This toxicity value was originally used, as no other toxicity data were available for birds, including other nitroaromatics. More appropriate chronic data (USACHPPM, 2000) recommends an avian no observed adverse effect level (NOAEL) of 0.07 mg/kg-day and a lowest observed adverse effect level (LOAEL) of 1.8 mg/kg-day for TNT. Toxicity results for TNT may be used as a surrogate for the amino compound, due to general structural similarities between the two nitroaromatic compounds.

Use of these more appropriate wildlife toxicity values would result in an adjustment of 56-fold and 2-fold for the avian toxicity of 4-amino-2,6-DNT, giving revised scaled ecological hazard quotients of 22 to 628 in Table 2-2, as opposed to 1,256.

- The estimated ecological hazards in Table 2-2 incorporate additional safety factors, such as the use of an 8-fold modifying factor to account for species-to-species extrapolation, and a conservative site foraging factor of 100 percent. In reality, wildlife are not expected to spend 100 percent of their time at TNTB, and thus exposures to COCs would be reduced.

- Bioaccumulation of COCs in the food chain was estimated using simple empirical models, and actual uptake is expected to be less than estimated. For example, uptake of 4-amino-2,6-DNT in earthworms from soil was estimated to be 11.5-fold, however, actual uptake is likely much less. Earthworm-consuming wildlife, such as the wren used in the assessment (Table 2-2), would thus experience lower COCs exposures using more realistic COCs uptake factors.

In conclusion, given the reasons presented above, the proposed human health PRGs (Table 2-1) are expected to result in residual COCs soil concentrations that are protective of the environment. No additional aquatic PRGs are needed for surface water or sediment due to the fact that (1) there is very limited aquatic habitat at the site; and (2) the aquatic habitat that is present is of low quality and is not expected to support or attract fish or wildlife species.

2.3 Contaminated Soil Volume Estimates

The volume of contaminated soil was determined for individual sites at TNTB by estimating the aerial extent and depths of contamination that exceed the PRGs (Table 2-3 and Figures 1-4 through 1-16). The estimate for aerial extent of contamination for a soil sample exceeding PRGs was determined by assuming that contamination extends to the nearest sample(s) that were below PRGs. If samples were not available that adequately defined the lateral extent, it was assumed the contamination extends out approximately 10-ft beyond the detected PRG exceedance. To estimate depth of contamination exceeding PRGs, the top of the deepest sampling interval that had contamination below PRGs was used. For example, if a sample collected from 4 to 6 feet bgs exceeded PRGs but the 8 to 10 feet bgs sample was below PRGs, it was assumed that contamination extended down to 8 feet bgs. If all subsurface samples were contaminated at levels exceeding PRGs and bedrock was not encountered in any borings, the depth of contamination was assumed to be 10 feet, based on the construction worker exposure scenario presented in the RA. For areas where bedrock was encountered at depths less than 10 feet bgs, the total overburden thickness was used.

The total estimated volume of contaminated soil is approximately 3,300 cubic yards. The volume contributing to the total estimate at each of the individual locations at TNTB is presented in Figures 1-4 through 1-16, and summarized in Table 2-3. Careful inspection of the COCs concentrations in soil exceeding the PRGs indicates that about 560 cubic yards are contaminated with 2,4-DNT, and 2,520 cubic yards are contaminated with TNT (assuming no overlap between soils contaminated with 2,4-DNT and those contaminated with TNT). In addition, approximately 400 cubic yards are contaminated with PCBs at levels exceeding PRGs. The 400 cubic yards contaminated with PCBs are also contaminated with 2,4-DNT or TNT, and are associated with the highest hits for lead. Lead was not selected as a COCs in the RA, and it is not part of the soil RAOs. However, high lead concentrations might classify excavated soil as a hazardous waste based on the toxicity characteristic leaching procedure (TCLP) test.

2.4 Applicable or Relevant and Appropriate Requirements

ARARs are defined in the EPA CERCLA guidance document (EPA, 1988) as follows:

- Applicable requirements means those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances at a CERCLA site.

- Relevant and appropriate requirements means those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or

limitations promulgated under federal or state law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site.

A requirement may fall into one of these categories, but not both. There is more discretion in the determination of relevant and appropriate requirements. It is possible that only a specific part or parts of a requirement will be considered relevant and appropriate in a given case. When the analysis results in a determination that a requirement is both relevant and appropriate, compliance with that requirement is mandatory to the same extent as for applicable requirements.

According to the above definitions, ARARs can be separated into three categories, chemical-specific, action-specific, and location-specific ARARs. After a comprehensive analysis of ARARs, it was determined that no chemical-specific or location-specific ARARs were identified that need to be considered during the remediation of the soil at TNTB. However, some action-specific ARARs were identified that need to be considered for this site in the case that excavation of contaminated soil is part of the remedial alternative. Table A-1 in Appendix A presents the location-specific ARARs, and Table A-2 presents the action-specific ARARs. There is no table with chemical-specific ARARs because no such ARARs were identified that have to be considered for remediating contaminated soil at TNTB.

2.4.1 TCLP Limits

In the event that contaminated soil is excavated, classification of the generated waste (soil) needs to be determined. Samples from the excavated soil have to be analyzed using the TCLP test) and the results compared to the TCLP limits to determine whether the generated waste exhibits the characteristic of toxicity, and should thus be considered a hazardous waste (40 Code of Federal Regulations [CFR] Part 261.24). Of the 12 COCs present in soil, only 2,4-DNT is on the TCLP list at a regulatory level of 0.13 milligrams per liter (mg/L) of extract. Assuming that 100 percent of 2,4-DNT will leach during the TCLP and that the volume of extract is 20 times the volume of the sample, the 0.13 mg/L concentration in the extract translates to 2.6 mg/kg of 2,4-DNT in contaminated soil. Therefore, if the concentration of 2,4-DNT in the excavated soil exceeds 2.6 mg/kg, the TCLP needs to be performed to determine whether the waste (soil) is hazardous.

Chemicals present in site soil that are not COCs at TNTB, but appear on the TCLP list, were also evaluated. Several detected concentrations of lead in site soil exceeded 20 times the TCLP limit

for lead. Therefore, should soil at TNTB be excavated, it might be classified as a hazardous waste based on lead content.

2.4.2 Land Disposal Restrictions

Land disposal restrictions (LDRs) are applicable in the event that the excavated soil is a hazardous waste (40 CFR 268.49). Prior to land disposal, all non-metal hazardous constituents in contaminated soil must be treated to achieve a 90 percent capped by 10 times the universal treatment standard (UTS) (40 CFR 268.49). For soil contaminated with metals, treatment must achieve a 90 percent reduction in constituent concentrations as measured in leachate from the treated media (tested according to the TCLP) or 90 percent reduction in total constituent concentrations (when a metal removal treatment technology is used) capped by 10 x UTS (40 CFR 268.49). The UTSre identified in 40 CFR 268.48, Table UTS.

If the concentration of 2,4-DNT renders the excavated soil hazardous, and the concentration of all the COCs (and metals) is less than 10 times the UTS, the excavated soil can be land-disposed in a hazardous waste landfill. As presented in Table 2-4, the maximum detected concentrations of all the COCs indicate that there are no detections that exceed the 10 x UTS rule. However, the metals arsenic and lead might exceed 10 x UTS, thereby requiring a 90 percent reduction prior to land disposal. Therefore, for the purposes of this FFS, it is assumed that all hazardous waste generated during soil excavation will have to be treated to meet LDRs.

If the concentration of 2,4-DNT renders the excavated soil non-hazardous, then the UTS regulations do not apply to the waste.

2.4.3 PCB Waste

Solid waste contaminated with PCBs needs to comply with the Ohio Environmental Protection Agency (OEPA) regulations described in the Ohio administrative code section 3745-59-32. The regulations state that solid waste containing PCBs at concentrations above 50 mg/kg are prohibited from land disposal. If the total PCB concentration is below 50 mg/kg, then the soil can be disposed in a non-hazardous waste landfill. The Port Clinton non-hazardous waste landfill does not accept any soil contaminated with PCBs above a concentration of 25 mg/kg. The highest hit of PCBs at TNTB is 15 mg/kg of Aroclor 1260. Therefore, for the purpose of this FFS, it is assumed that non-hazardous soil contaminated with PCBs can be disposed in a non-hazardous waste landfill.

3.0 Screening of Remedial Action Technologies

3.1 Introduction

This section discusses the screening of the technologies and process options used to assemble the remedial alternatives for soil at TNTB. The steps involved in this screening are defined in *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988), and include:

- Identifying volumes or areas of contaminated soil, to which remedial actions might be applied, taking into account the RAO for soil and the chemical and physical characteristics of the site.
- Identifying and screening technology process options to eliminate those that cannot be implemented at the site.
- Assembling the representative technology process options into alternatives representing a range of treatment and disposal combinations, as appropriate (Chapter 4.0).

3.2 Identification of Soil Areas Requiring Remedial Action

A complete description of soil volumes requiring remediation is provided in Section 2.3, presented in Figures 1-4 through 1-16, and summarized in Table 2-3.

3.3 Screening of Technology Process Options

Technology process options were chosen to represent a wide array of possible technologies that could be used in site remediation, such as bioremediation, physical process options, chemical process options, and institutional controls. In the following subsections the technologies will be evaluated for their effectiveness in achieving RAOs, implementability, and relative cost. In Chapter 4.0 the most feasible technology options will be assembled into remedial alternatives.

3.3.1 Capping

3.3.1.1 Effectiveness

Capping was considered for this site because the RAOs are limited to soil. Caps are placed over contaminated soils to serve as a barrier to human and ecological receptors that may be exposed to the surface and subsurface soils. Also, a cap constructed with low-permeability materials would reduce the infiltration of precipitation through contaminated soils, thereby limiting the transport of contaminants to groundwater. Caps are effective in eliminating exposure to contaminated soil.

3.3.1.2 Implementability

The construction of caps over areas of contaminated soil is technically and administratively implementable at this site. However, caps limit future development or use of TNTB, including residential developments. In addition, numerous and discontinuous contaminated soil locations make capping less practical.

3.3.1.3 Cost

The costs associated with this option are moderate, and involve site grading and construction of caps at various locations on the site. The O&M costs are expected to be low.

3.3.1.4 Summary

Capping is effective in achieving the RAOs at TNTB, but it limits future development of the property. In addition, numerous and discontinuous contaminated soil locations make capping less practical. Therefore, it will not be included in any remedial alternatives.

3.3.2 Excavation

3.3.2.1 Effectiveness

This process could achieve the RAOs for soil by excavating the source of contamination. The excavation of contaminated materials would eliminate the contamination at the site, but it does not address the final disposition of the excavated material. Therefore, waste management of excavated materials will be required in order to meet the RAOs.

3.3.2.2 Implementability

Excavation of contaminated material is administratively and technically implementable at this site. This option involves using heavy equipment for effective removal of contaminated material from areas defined in Section 3.2.

3.3.2.3 Cost

The overall costs associated with this option would be low. The capital costs associated with this option would depend upon the extent of contaminated material present at the site. There are no O&M costs associated with this option, because it is a one-time event.

3.3.2.4 Summary

Excavation can be effective in achieving RAOs for soil by removing contaminated soil present at TNTB. This option is feasible and will be retained for inclusion in remedial action alternatives in Chapter 4.0.

3.3.3 Off-Site Disposal

3.3.3.1 Effectiveness

Off-site disposal would be an effective option for the management of treated and/or untreated soil that has been excavated from the site.

3.3.3.2 Implementability

This option is administratively and technically implementable at TNTB. Non-hazardous and hazardous waste disposal facilities have been identified in the area.

3.3.3.3 Cost

The cost for off-site disposal of contaminated soil would depend on the amount of fill material excavated, and on the cost per ton charged by the off-site landfill for disposal of the waste, which in turn depends on the characteristics of the waste. The cost would be moderate if the contaminated soil is classified as non-hazardous waste, and high if the contaminated soil is classified as hazardous waste.

3.3.3.4 Summary

Off-site disposal of contaminated soil is an effective and implementable process option to achieve RAOs for contaminated soil at TNTB. The process is retained for further development of alternatives in Chapter 4.0.

3.3.4 Ex-Situ Chemical Stabilization

3.3.4.1 Effectiveness

Chemical stabilization is effective in immobilizing COCs in soil. Contaminated soil is excavated and then mixed with stabilizing agents in a pugmill. A treatability study would be required to determine process parameters and confirm the effectiveness of the process before full-scale implementation. It is important to realize that stabilization does not transform or remove the COCs from soil, it only hinders its environmental transport. From the perspective of a risk assessment, the exposure parameters do not change. Therefore, stabilization needs to be combined with other options like off-site disposal in a non-hazardous waste landfill or capping of

the stabilized soil. In this case, off-site disposal will be more appropriate, because of potential future residential land uses of TNTB.

3.3.4.1 Implementability

This process is technically and administratively implementable at this site. A pugmill would be set up on-site to mix the excavated soil with the stabilizing agents. Stabilized soil would then be transported off-site to a non-hazardous waste landfill.

3.3.4.2 Cost

The cost associated with ex-situ stabilization is moderate, and it depends on the amount of excavated material requiring treatment, the amount of stabilizing agents required, and labor costs associated with the implementation.

3.3.4.3 Summary

The feasibility of this process option warrants further development in Chapter 4.0.

3.3.5 In-situ Chemical Oxidation

3.3.5.1 Effectiveness

Chemical oxidation would achieve the RAOs for soil by the application of an oxidizing chemical such as potassium permanganate to contaminated soil to convert the COCs into less toxic reaction products. Prior to full-scale implementation, treatability tests would have to be conducted to evaluate the effectiveness of the oxidizing agent in achieving cleanup levels for the COCs. A very important factor in determining the total amount of chemical oxidant needed is the soil matrix demand. A high soil matrix demand would increase the cost of in-situ oxidation.

3.3.5.2 Implementability

A full-scale oxidation process would be implemented by constructing soil berms around each contaminated area and applying a 3 percent potassium permanganate solution, and then allowing the solution to percolate through the soil. The treatment areas would be covered to protect ecological receptors from exposure to the treatment solution and prevent chemical washout from the treatment area due to incidental rainfall. A field test would be required to determine the practicality of treating soil. After PRGs are attained for COCs in soil, chemicals would be applied to the soil to quench the oxidation process.

3.3.5.3 Cost

The cost for treating soil in-situ using chemical oxidation would be high. The cost mainly depends on the quantity of chemical oxidant needed. The required quantity of oxidant is driven

by the concentration of COCs in soil, cleanup levels that need to be achieved, and soil matrix demand.

3.3.5.4 Summary

In-situ chemical oxidation at TNTB is a potentially feasible process option for attaining PRGs in site soil. Therefore, this option will be retained for inclusion in remedial action alternatives in Chapter 4.0.

3.3.6 Windrow Composting

3.3.6.1 Effectiveness

Windrow composting is an effective treatment process to achieve RAOs for soil at TNTB. Organic compounds are biodegraded or biotransformed into less toxic products. Composting of explosives such as TNT and 2,4-DNT in soil has been successfully demonstrated. Drawbacks to composting include the significant volume increase, the availability of the proper amendments, and the time required in achieving PRGs.

3.3.6.2 Implementability

This process is technically and administratively implementable at TNTB. It requires the construction of an enclosed structure to maintain constant temperature during the process, and the availability of the necessary amendments.

3.3.6.3 Cost

The cost for composting the soil would be moderate. The main factors contributing to the capital cost are the construction of an enclosed structure and the composting amendments. O&M costs are driven by the time required in achieving PRGs for the COCs in soil.

3.3.6.4 Summary

Composting of contaminated soil at TNTB is a potentially feasible process option for attaining PRGs in site soil. Therefore, this option will be retained for inclusion in remedial action alternatives in Chapter 4.0.

4.0 Development and Detailed Analysis of Remedial Alternatives

4.1 Introduction

The goal of this chapter is to introduce, assess, and communicate the relative costs and benefits of the remedial alternatives selected for careful consideration. Chapter 5.0 provides the comparison and recommendation of a preferred alternative for the site. The evaluation criteria for this analysis are provided by EPA in *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA, 1988). These criteria are based upon the *National Oil and Hazardous Substances Pollution Contingency Plan* (NCP), Title 40 CFR, Section 300.430 (EPA, 1990). The results of this analysis will likely be presented in the proposed plan and ROD, or other public information documents, following the consideration of state and federal regulatory and community input.

The RI/FS guidance provides nine evaluation criteria for assessing the alternatives within the context of a comprehensive FS. These criteria cover regulatory, technical, cost, institutional, and community considerations. Generally, the two threshold criteria are:

- Protection of human health and the environment
- Compliance with ARARs.

The five balancing criteria are:

- Long-term effectiveness and permanence
- Short-term effectiveness
- Reduction in toxicity, mobility, and volume
- Technical and administrative implementability
- Alternative cost including capital, O&M, and present value costs.

The final two criteria that often are evaluated subsequent to the initial publication of the FS are:

- State acceptance
- Community acceptance.

The first seven criteria will be evaluated in this FFS. The final two criteria will be evaluated through working-level discussions with state and federal regulators, as well as through the solicitation of community input from public outreach activities (i.e., publication and dissemination of a proposed plan or other public communication document). Once all of the FFS criteria have been adequately considered and a final remedy pathway is selected, a final remediation alternative will be presented in a ROD or other appropriate document. The ROD (or

alternative decision document) will serve as the basis for additional remedial design and action at TNTB.

The following four alternatives were selected for evaluation:

- Alternative 1 – No Action
- Alternative 2 – In-Situ Chemical Oxidation, Excavation, and Off-Site Disposal
- Alternative 3 – Excavation, Ex-Situ Stabilization, and Off-Site Disposal
- Alternative 4 – Excavation, On-Site Composting, and Off-Site Disposal

4.2 Alternative 1 - No Action

4.2.1 Description

A no action alternative is required by the NCP to be carried forward as a baseline for detailed comparison. Under this alternative no remedial action or monitoring would be conducted for contaminated soil at the site. Thus, this alternative fails to meet the RAOs for soil at TNTB.

4.2.2 Overall Protection of Human Health and the Environment

This alternative would not protect human health or the environment because no action would be taken to reduce the concentration of COCs in soil to acceptable levels or prevent current or future receptors from exposure to COCs.

4.2.3 Compliance with ARARs

No location-, chemical-, or action-specific ARARs were identified that need to be considered for this remedial alternative.

4.2.4 Long-Term Effectiveness

This alternative would not result in any permanent reduction of risk to human and ecological receptors at the site. No periodic review would take place to evaluate future site conditions.

4.2.5 Reduction of Toxicity, Mobility, or Volume

This alternative does not employ any remedial component that would permanently or significantly reduce the toxicity, mobility, or volume of contaminants in soil.

4.2.6 Short-Term Effectiveness

This alternative would not protect site workers or future residents from exposure to contaminants.

4.2.7 Implementability

There are no technical implementation issues associated with this alternative.

4.2.8 Cost

There is no cost impact associated with this alternative.

4.3 Alternative 2 – In-Situ Chemical Oxidation, Excavation, and Off-Site Disposal

4.3.1 Description

Alternative 2 combines in-situ chemical oxidation, excavation, and off-site disposal in order to achieve the RAOs for soil at TNTB. The proposed approach is to use in-situ chemical oxidation by applying a 3 percent potassium permanganate solution to all the areas that contain nitroaromatics or PAHs at concentrations above PRGs. Following treatment, all the areas with PCBs above their respective PRGs will be excavated and disposed off-site. PCBs are recalcitrant compounds, and do not undergo chemical oxidation when subjected to potassium permanganate.

As described in Section 2.3, the areas requiring remediation contain nitroaromatics at concentrations higher than PRGs. Chemical oxidation using permanganate is a successful technology used to transform the nitroaromatics into less toxic reaction products. The permanganate solution would be applied to the soil surface, percolate into the subsurface, and oxidize the contaminants. The maximum depth of contamination identified at TNTB is 10 feet. The lithology of the site does not pose any hindrances for the permanganate solution to percolate to the required depth. Confirmatory samples would be taken of the treated soil to ascertain that PRGs have been achieved. A second application of permanganate would be performed if deemed necessary.

The second stage involves remediating the areas where PCB contamination exceeds the PRGs. As described in Section 2.3, the estimated volume of soil contaminated with PCBs is 400 cubic yards. The contaminated soil would be excavated and disposed in a non-hazardous or hazardous waste landfill depending on the total concentrations of PCBs and the hazardous characteristics of the soil. The LDR stipulates that soil contaminated with PCBs above 50 mg/kg has to undergo treatment prior to land disposal. The RI report for TNTB indicates that the maximum detected concentration of Aroclor 1260 is only 15 mg/kg (IT, 2000). Therefore, it is unlikely that the excavated soil will not meet the LDR of 50 mg/kg. A non-hazardous waste landfill in Port Clinton, Ohio was contacted regarding the possible disposal of non-hazardous excavated soil. The maximum concentration of PCBs accepted by the landfill is 25 mg/kg, which is higher than the maximum detected concentration of PCBs at TNTB.

In addition, it has to be determined whether or not the excavated soil is a hazardous waste. Excavated soil is not classified as a listed hazardous waste because there is no definitive documentation regarding the dates of disposal. The TCLP test would be performed on representative samples of excavated soil to determine whether the concentration of 2,4-DNT (or other chemicals on the TCLP list such as lead) in the soil is higher than the TCLP limit. The areas with PCB concentrations above the PRGs do not contain 2,4-DNT at high concentrations, but they do contain lead at concentrations that exceed 20 times the TCLP limit. Therefore, should the excavated soil be classified as hazardous waste, the soil would need to be disposed at a hazardous waste landfill. It is important to note that although lead in soil was detected at high concentrations (maximum detected concentration is 245 mg/kg) compared to the TCLP limit of 5 mg/L, lead was not selected as a COCs in the RA because it did not exceed EPA's residential cleanup level of 400 mg/kg (IT, 2000). Therefore, lead cleanup is not part of the RAOs for soil at TNTB.

4.3.2 Overall Protection of Human Health and the Environment

In-situ chemical oxidation of the areas contaminated with nitroaromatics and PAHs followed by excavation of areas contaminated with PCBs would permanently treat/remove contaminated soil, thereby reducing human health risks to within levels considered acceptable by the EPA, and significantly reducing the ecological hazard quotients (Section 2.2 and Table 2-2).

4.3.3 Compliance with ARARs

The ARARs that need to be considered for Alternative 2 are presented in Appendix A. No location-specific ARARs (Table A-1) have been identified that need to be considered for this alternative. The remedial alternative would comply with all the action-specific ARARs (Table A-2), specifically the regulations that deal with the TCLP test and the storage/disposal of hazardous waste.

4.3.4 Long-Term Effectiveness

This alternative would result in the permanent reduction of contaminant concentrations in soil that currently exceed the PRGs. Human health risks caused by current (or future) human exposure to contaminated soil at the site would be reduced to within levels considered acceptable by the EPA and the OEPA.

4.3.5 Reduction of Toxicity, Mobility, or Volume

Alternative 2 would permanently reduce the toxicity, mobility, and volume of contaminants in soil by transforming and removing the COCs. The nitroaromatics and PAHs would be oxidized by the permanganate solution, while the PCBs would be excavated and disposed off-site.

4.3.6 Short-Term Effectiveness

This alternative would not pose any risk to the community or the environment during implementation. Measures would be taken to prevent excessive dust formation and the leaching of permanganate solution beyond contaminated areas. Remedial workers would be equipped with protective gear to prevent exposure.

The estimated time to complete the alternative is 18 to 24 months. This includes writing and review of work plans, health and safety plans, a treatability study, mobilization, in-situ chemical oxidation, confirmatory sampling, excavation of areas contaminated with PCBs (400 cubic yards), disposal of soil contaminated with PCBs, and demobilization.

4.3.7 Implementability

This alternative is technically and administratively implementable. No engineering or regulatory restrictions stand in the way of implementation. The chemicals and equipment needed for the remedial alternative are readily available. The non-hazardous waste would be disposed at a non-hazardous waste landfill if the maximum detected concentration of PCBs does not exceed 25 mg/kg. If the soil fails the TCLP test, then the hazardous soil would be sent to a hazardous waste treatment and disposal facility.

4.3.8 Cost

The detailed cost evaluation associated with the implementation of Alternative 2 is presented in Table 4-1. The estimated capital cost for Alternative 2 is $814,000. About 50 percent of the capital cost is attributed to the cost of the potassium permanganate needed to oxidize all the nitroaromatics and PAHs in soil. Appendix B provides the assumptions and calculations behind the estimated amount of permanganate needed. Determining the soil matrix demand of the soil at TNTB would increase the confidence level of the cost estimate. There are no long-term O&M costs associated with this alternative. Therefore, the present value of this alternative is the same as its capital cost.

4.4 Alternative 3 – Excavation, Ex-Situ Stabilization, and Off-Site Disposal

4.4.1 Description

Alternative 3 combines excavation, ex-situ stabilization, and off-site disposal in order to achieve the RAOs for soil at TNTB. The proposed approach is to excavate all the areas in which the concentration of the COCs in soil exceed the PRGs defined in Chapter 2.0. The estimated volume of contaminated soil from all over TNTB is 3,300 cubic yards. As described earlier, the number of COCs exceeding PRGs and their concentration ranges vary from area to area within TNTB. Therefore, following the excavation of the contaminated soil, representative soil samples from each area would be analyzed using the TCLP test. Using existing soil data, the estimated volume of excavated soil that would be classified as a characteristic hazardous waste based on 2,4-DNT concentrations is about 560 cubic yards (Table 3-1). An additional 400 cubic yards might be identified as hazardous waste due to the high lead concentrations. Section 2.4.1 lists the applicable regulations that identify the excavated soil as a hazardous waste. Based on the results of the TCLP tests, non-hazardous waste can be disposed in a non-hazardous landfill. Any soil identified as hazardous waste would be treated to achieve non-hazardous waste classification prior to land disposal in a non-hazardous waste landfill.

Assuming a successful treatability study, chemical stabilization would be used to treat the excavated soil classified as hazardous waste. Activated carbon and Portland cement would be mixed with the soil ex-situ to stabilize the chemical contaminants, thereby decreasing the mobility and bioavailability of the COCs in soil. A pugmill on-site would be used to mix the stabilizing agents with the contaminated soil. Representative samples of the stabilized soil would be taken for every 150 tons of soil treated. The samples would be tested for hazardous characteristics using the TCLP test. If the soil tests non-hazardous, it would be disposed in a non-hazardous waste landfill. If the soil tests hazardous, further stabilization would be needed or an alternate treatment would be required.

It is important to realize that stabilization does not reduce the concentration nor transform the COCs in the soil, it only alters the physical availability of contaminants. This does not change the assumptions used in the RA, and does not change the estimated hazard index (HI) and ILCR for the various receptor scenarios (IT, 2000). Therefore, it is not recommended that stabilized soil be used as fill material. Instead, the stabilized soil would be disposed in a non-hazardous waste landfill.

4.4.2 Overall Protection of Human Health and the Environment

Excavation of contaminated soil followed by treatment/disposal would permanently remove contaminated soil, thereby reducing human health risks to within levels considered acceptable by the EPA, and significantly reducing the ecological hazard quotients (Section 2.2 and Table 2-2).

4.4.3 Compliance with ARARs

The ARARs that need to be considered for Alternative 3 are presented in Appendix A. No location-specific ARARs (Table A-1) have been identified that need to be considered for this alternative. The remedial alternative would comply with all the action-specific ARARs (Table A-2), specifically the regulations that deal with the TCLP test and the storage/disposal of hazardous waste.

4.4.4 Long-Term Effectiveness

This alternative would result in the permanent removal of the COCs in soil that currently exceed PRGs. Human health risks caused by current (or future) human exposure to contaminated soil at the site would be reduced to within levels considered acceptable by the EPA and the OEPA.

4.4.5 Reduction of Toxicity, Mobility, or Volume

Alternative 3 would permanently reduce the toxicity and mobility of contaminants in soil by stabilizing the COCs in excavated site soil followed by disposal. No actual volume reductions would be achieved because COCs are transferred to another location.

4.4.6 Short-Term Effectiveness

This alternative would not pose any risk to the community or the environment during implementation. Measures would be taken to prevent excessive dust formation during excavation and stabilization activities. Remedial workers would be equipped with protective gear to prevent exposure.

The estimated time to complete the alternative is 18 to 24 months. This includes writing and review of work plans, health and safety plans, a treatability study, mobilization, excavation of 3,300 cubic yards of contaminated soil, ex-situ stabilization of excavated soil classified as hazardous waste (about 960 cubic yards), confirmatory sampling, disposal of treated and non-hazardous soil, and demobilization.

4.4.7 Implementability

This alternative is technically and administratively implementable. No engineering or regulatory restrictions stand in the way of implementation. The stabilizing agents and equipment needed for the remedial alternative are readily available.

4.4.8 Cost

The detailed cost evaluation associated with the implementation of Alternative 3 is presented in Table 4-2. The estimated capital cost for Alternative 3 is $358,000. There are no long-term O&M costs associated with this alternative. Therefore, the present value of this alternative is the same as its capital cost.

4.5 Alternative 4 – Excavation, On-Site Composting, and Off-Site Disposal

4.5.1 Description

Alternative 4 combines excavation, on-site composting, and off-site disposal in order to achieve the RAOs for soil at TNTB. The proposed approach is to excavate all the areas in which the concentration of the COCs in soil exceed the PRGs defined in Chapter 2.0. The estimated volume of contaminated soil from all over TNTB is 3,300 cubic yards. As described earlier, the number of COCs exceeding PRGs and their concentration ranges vary from area to area within TNTB. Therefore, following the excavation of the contaminated soil, representative soil samples from each pile will be analyzed using the TCLP test. Section 2.4.1 lists the applicable regulations that identify the excavated soil as a hazardous waste. Based on the results of the TCLP tests, non-hazardous waste can be disposed in a non-hazardous landfill. Any soil identified as hazardous waste needs to be treated to achieve non-hazardous waste classification prior to land disposal in a non-hazardous waste landfill. Based on existing soil data, it is expected that approximately 560 cubic yards of soil would be classified as hazardous waste due to the presence of 2,4-DNT, and therefore would require treatment prior to disposal in a non-hazardous waste landfill. An additional 400 cubic yards of excavated soil might be classified as hazardous waste due to the high lead concentrations. This portion of soil would be disposed at a hazardous waste treatment and disposal facility.

On-site windrow composting would be used to treat the excavated soil classified as hazardous waste. Windrow composting is a treatment process whereby organic compounds are biodegraded or biotransformed by mesophilic or thermophilic microorganisms. The composting process consists of mixing the waste material with bulking agents to increase porosity and thus enhance air mass transfer in the system. Composting of nitroaromatics (TNT and 2,4-DNT) in soil has been successfully demonstrated. The major parameters contributing to an efficient

composting process are temperature, pH, moisture content, explosive concentrations, heat production, and partial pressure of oxygen in the compost. Composting requires the construction of an enclosed structure to maintain constant temperature during the process.

Windrow composting offers several advantages over other treatment technologies. Depending on contaminant type and concentration, and amendment optimization, relatively rapid treatment can be achieved in individual windrows. The compost process is self-heating which allows for year-round treatment with minimal capital expense for heating of the treatment facilities. Due to the physical properties and high nutrient (nitrogen and phosphorous) value of the finished compost, the material could be used as a soil conditioner for revegetation activities. Drawbacks to the technology include the significant volume increase (up to twice the original volume) and the availability of the proper amendments. In addition to directly impacting treatment cost, difficulties with amendment selection and availability may produce ammonia gas during the composting process. The production of ammonia results in an increased treatment cost for air monitoring and treatment (if necessary) and increased cost for personnel protective equipment (PPE). Typical volume ratios of amendments and contaminated soils for composting range from 60 to 80 percent amendments and 20 to 40 percent soil.

Proper selection of amendments for windrow composting is critical to the success of the process. The amendments can be divided into the following general classifications: bulking agents, nutrient sources, and inoculum. The addition of bulking agents allows air movement through the compost and provides a measure of insulation for self-heating the windrow. Bulking agents may include wood chips, yard waste (a combination of grass clippings and wood chips), or other locally available products. Potential nutrient sources include alfalfa, starch (potato or corn), hay, silage, food processing wastes, or green wastes. Animal manure is an excellent source of a microbial inoculum for windrow composting. Selection of the amendment mixture entails a correct balance of bulk density, carbon: nitrogen: phosphorus ratio, pH, moisture content, and inoculum for rapid self-heating after blending. Bench-or pilot-scale windrow testing can be used to optimize amendment ratios and process performance if necessary.

Windrow operation includes aeration and mixing, process monitoring and moisture addition. In general, windrows would be turned three to seven times per week with a commercial windrow compost turner. The windrow turner straddles the windrow and travels the length of the windrow. A rotating drum with teeth or flails provides a high degree of mixing and aeration throughout the windrow. Process monitoring would include daily temperature readings throughout the windrow. Properly blended compost would achieve a thermophilic temperature within 1 to 3 days of construction. Because the self-heating process and mixing/aeration would

promote evaporation of the water from the compost, daily grab samples would be collected for on site moisture content analysis. Based on the analytical results water would be added to the windrow immediately before mixing to maintain optimal moisture content in the windrow. Composite samples would also be collected during the operation to provide data on the initial contaminant concentration in the compost and to determine when confirmation sampling is required. After the data have been validated and the windrow has been verified to meet the project requirements, the windrow would be removed from the treatment area. Rubber tire loaders would remove the windrow and direct load the treated compost into dump trucks for transport to a staging area. The next windrow would be constructed in that space.

Based on a windrow dimension of 100 by 18 by 6 feet, approximately 260 cubic yards (90 cubic yards of soil) of compost would be treated in each individual windrow with six windrows per 100 by 120 feet treatment enclosure. Assuming a 45-day cycle for each windrow including windrow construction, treatment, analytical confirmation and removal, the 560 cubic yards of DNT-contaminated, stockpiled soil would be treated in approximately 2 to 3 months.

Following composting, representative samples of the treated soil would be tested for hazardous characteristics using the TCLP tests. Once the soil is deemed non-hazardous, it would be disposed in a non-hazardous waste landfill. If the soil is still hazardous due to hazardous constituents other than the COCs (such as lead), an alternate treatment method would be required. Based on a maximum detected concentration of 15 mg/kg for Aroclor 1260 (IT, 2000), it is not expected that the PCB concentration in the excavated (and composted) soil will exceed the LDR of 50 mg/kg.

4.5.2 Overall Protection of Human Health and the Environment

Excavation of contaminated soil followed by composting and disposal would permanently remove contaminated soil, thereby reducing human health risks to within levels considered acceptable by the EPA, and significantly reducing the ecological hazard quotients (Section 2.2 and Table 2-2).

4.5.3 Compliance with ARARs

The ARARs that need to be considered for Alternative 4 are presented in Appendix A. No location-specific ARARs (Table A-1) have been identified that need to be considered for this alternative. The remedial alternative would comply with all the action-specific ARARs (Table A-2), specifically the regulations that deal with the TCLP test and the storage/disposal of hazardous waste.

4.5.4 Long-Term Effectiveness

This alternative would result in the permanent removal of the COCs above PRGs. Human health risks caused by current (or future) human exposure to contaminated soil at the site would be reduced to within levels considered acceptable by the EPA. All excavated soil would be disposed off-site thereby removing any risk associated with the site.

4.5.5 Reduction of Toxicity, Mobility, or Volume

Alternative 4 would permanently reduce the toxicity, mobility, and volume of contaminants in soil by removing the COCs in site soil. The toxicity would be reduced as a result of biological degradation during the composting process. All the excavated soil (composted and non-composted) would be disposed off-site in the appropriate landfill.

4.5.6 Short-Term Effectiveness

This alternative would not pose any risk to the community or the environment during implementation. Measures would be taken to prevent excessive dust formation during excavation and composting activities. Remedial workers would be equipped with protective gear to prevent exposure to toxic constituents during the composting. This includes protection against ammonia gas, which might be generated during the composting as a result of biological activities.

The estimated time to complete the alternative is 18 to 24 months. This includes writing and review of work plans, health and safety plans, a treatability study, mobilization, excavation, composting of the DNT contaminated soil, and disposal of the lead contaminated soil, disposal of composted material, confirmatory sampling, and demobilization.

4.5.7 Implementability

This alternative is technically and administratively implementable. No engineering or regulatory restrictions stand in the way of implementation. Implementation would involve amendment delivery and stockpiling, soil preparation and windrow construction, windrow operations, and treated residual management. The excavated soil (3,500 tons) and the composted soil (1,600 tons) would be disposed at a non-hazardous waste landfill if it is classified as a non-hazardous waste based on the TCLP test, and if the maximum detected concentration of PCBs does not exceed 25 mg/kg. The portion of the soil classified as hazardous waste (600 tons) due to the lead concentrations would be sent to a hazardous waste treatment and disposal facility.

Amendment delivery, stockpiling, and management are critical factors in the success of the windrow composting process. The required amendments would be procured from local sources to minimize transportation costs, and reduce odor and handling issues associated with onsite amendment stockpile. The amendments would be stored in individual bins constructed near the treatment area. Amendment bins would be covered to minimize precipitation infiltration and runoff from the stockpiles.

4.5.8 Cost

The detailed cost evaluation associated with the implementation of Alternative 4 is presented in Table 4-3. The estimated capital cost for Alternative 4 is $828,000. There are no long-term O&M costs associated with this alternative. Therefore, the present value of this alternative is the same as its capital cost.

5.0 Comparative Analysis of Remedial Alternatives

This chapter provides a comparative analysis of all four alternatives developed in Chapter 4.0. The comparison will be based on the evaluation criteria and the overall feasibility of the alternatives in achieving RAOs for contaminated soil at TNTB.

All of the alternatives, with the exception of Alternative 1, would permanently treat/remove contaminated soil, thereby reducing human health risks to within levels considered acceptable by the EPA, and significantly reducing the ecological hazard quotients. All of the alternatives involving excavation and/or treatment of contaminated soil (Alternatives 2 through 4) may provide a corollary benefit to long-term groundwater and surface water quality by removing or mitigating the most significant source areas that contribute to contamination in these media. Alternative 1 does not employ removal, containment, or treatment response actions that would mitigate the impact of source areas on receptors or other environmental media. Therefore, Alternative 1, No Action, will not be considered the recommended alternative.

Alternative 2, in-situ chemical oxidation, is the only alternative that evaluates an in-situ treatment technology. In-situ treatment is preferred over ex-situ treatment because it avoids the possibility of generating large quantities of hazardous waste, and it eliminates, in most cases, the need for off-site disposal. Prior to recommending Alternative 2 over other alternatives, a soil matrix demand test for the contaminated soil at TNTB needs to be conducted. The soil matrix demand determines the amount of potassium permanganate that would be consumed by the soil organic matter, and therefore has large implications on the overall capital cost of the alternative. In addition, a treatability study needs to be conducted to determine the ability of the chemical oxidant in achieving PRGs, and to determine the exact ratio of chemical oxidant to COCs in soil. A main drawback to Alternative 2 is that chemical oxidation would not treat the recalcitrant PCBs detected in the soil at various locations. Therefore, soil portions contaminated with PCBs above the PRGs would have to be excavated and disposed off-site (approximately 400 cubic yards). However, the soil might be classified as a hazardous waste due to the presence of 2,4-DNT and lead (both on the TCLP list) at high concentrations in soil. Treatment with potassium permanganate would not transform or decrease the toxicity of lead in the soil. Therefore, off-site disposal at a hazardous waste treatment and disposal facility might be required. This does not mean that Alternative 2 should not be recommended as the preferred alternative for achieving the RAOs at TNTB. Alternatives 3 and 4 require the excavation of far more soil (3,300 cubic yards) compared to Alternative 2.

Alternatives 3 and 4 both require the excavation of the 3,300 cubic yards of contaminated soil at TNTB. This is followed by on-site ex-situ treatment of the excavated soil prior to off-site disposal. Under Alternative 3 the soil portion of the excavated soil classified as a hazardous waste is treated using stabilization. Based on 2,4-DNT concentrations across the site, it is estimated that 560 cubic yards would be classified as hazardous waste after subjecting soil samples from all the excavated soil to the TCLP test. The advantage of stabilization over other technologies is its ability to stabilize all the COCs in soil. Stabilization would immobilize nitroaromatics, PAHs, PCBs, and lead. No other treatment technology is required following stabilization, and the stabilized soil would most likely pass the TCLP test. Therefore, the stabilized soil can be disposed at a non-hazardous waste landfill. The main drawback to stabilization when compared to other technologies is that it does not destroy, transform, or remove the contaminants from the soil. It only alters their mobility and bioavailability. Therefore, it is not recommended to use the stabilized soil as fill (or backfill) material on-site. In comparison to stabilization, composting would transform the nitroaromatics and PAHs (and to a lesser extent the PCBs) in soil to less toxic compounds. Composting will not reduce the toxicity of lead; hence the composted soil might fail the TCLP test thereby requiring further treatment or disposal at a hazardous waste landfill. Based on this comparison, Alternative 3 is recommended over Alternative 4.

A cost analysis comparison of Alternatives 2, 3, and 4 shows that Alternative 3 is the most cost-effective alternative with a capital cost of $358,000. Alternative 2 has a capital cost of $814,000, and Alternative 4 has a capital cost of $828,000. None of the alternatives require any long-term O&M or monitoring. Based on the cost analysis, Alternative 3 is the recommended alternative for achieving the soil RAOs at TNTB.

In conclusion, Alternative 3 is the recommended alternative for achieving the RAOs for contaminated soil at TNTB. Alternative 3 is the most cost effective, it stabilizes all the COCs (and lead) in soil, it treats all the hazardous waste generated as part of the excavation, it permanently reduces the health risk at the site, it significantly reduces the ecological hazard quotients, it is achievable in a short time period, and it is administratively and technically implementable.

6.0 References

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U.S. Environmental Protection Agency (EPA), 1990, ***National Oil and Hazardous Substances Pollution Contingency Plan,*** 40 CFR Part 300.430.

U.S. Environmental Protection Agency (EPA), 1988, ***Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA,*** EPA/540/9-89/004.

TABLES

Table 1-1

Summary of Total Hazard and Total Cancer Risk from Site-Related Chemicals of Concern
Feasibility Study
TNT Area B, Plum Brook Ordnance Works
Sandusky, Ohio

	Groundskeeper		Indoor Worker		Construction Worker		On-Site Resident	
Contaminant Source	Total HI	Total ILCR	Total HI	Total ILCR	Total HI	Total ILCR	Total HI	Total ILCR
Surface Soil	1.60E+01	1.07E-04	6.83E+00	4.59E-05	NA	NA	NA	NA
Total Soil	NA	NA	NA	NA	7.05E+01	1.55E-05	2.44E+02	1.15E-03
Surface Water	NA	NA	NA	NA	1.55E-01	4.23E-08	3.82E-02	4.03E-07
Sediment	NA	NA	NA	NA	1.94E+00	8.27E-07	1.58E-01	1.18E-06
Total across all media	**1.60E+01**	**1.07E-04**	**6.83E+00**	**4.59E-05**	**7.26E+01**	**1.63E-05**	**2.44E+02**	**1.16E-03**

HI = Hazard Index
ILCR = Incremental lifetime cancer risk
NA = not applicable

Table 2-1

Selection of Preliminary Remediation Goals
Feasibility Study
TNT Area B, Plum Brook Ordnance Works
Sandusky, Ohio

COC[a]	Unit	Resident RBRC	Groundskeeper RBRC	Construction Worker RBRC
Nitroaromatics				
2-amino-4,6-dinitrotoluene	mg/kg	0.40	NA	1.4
4-amino-2,6-dinitrotoluene	mg/kg	0.40	NA	1.4
2,4-dinitrotoluene	mg/kg	7.5	NA	54
2,6-dinitrotoluene	mg/kg	2.75	NA	27
2-Nitrotoluene	mg/kg	74	NA	NA
2,4,6-trinitrotoluene	mg/kg	3.36	44	12
PCBs				
Aroclor 1254	mg/kg	0.16	NA	NA
Aroclor 1260	mg/kg	2.87	13	NA
PAHs				
Benzo(a)anthracene	mg/kg	5.4	NA	NA
Benzo(a)pyrene	mg/kg	0.54	3.2	NA
Benzo(b)fluoranthene	mg/kg	5.4	NA	NA
Dibez(a,h)anthracene	mg/kg	0.65	3.5	NA
Indeno(1,2,3-cd)pyrene	mg/kg	5.4	NA	NA

ARARs - Applicable or Relevant and Appropriate Requirements
COC - Chemicals of Concern
NA - Not Applicable
PAHs - Polyaromatic Hydrocarbons
PCBs - Polychlorinated Biphenyls
PRGs - Preliminary Remediation Goals
RBRC - Risk-Based Remedial Criteria

[a] Chemicals of Concern were determined in the human health risk assessment for TNT Area B. (IT Corporation, TNT Area B Remedial Investigation, Volume II, Final August 2000).

Notes:

1) The RBRC concentrations reflect a cancer risk of 1E-5 or a noncancer hazard of 0.1, whichever is lower. The most conservative RBRC concentrations (resident - shaded) were selected as the PRGs.

2) Receptor assumptions for exposure to contaminated media at TNT Area B are presented in the human health risk assessment. (IT Corporation, TNT Area B Remedial Investigation, Volume II, Final August 2000).

3) No chemical-specific ARARs were identified that need to be considered in the remediation of contaminated soil at TNT Area B. The RBRCs were selected as the PRGs due to the absence of any chemical-specific ARARs..

Table 2-2

Ecological Implications of Human Health Soil PRGs
Feasibility Study
TNT Area B, Plum Brook Ordnance Works
Sandusky, Ohio

Human Health Chemical of Concern	Human Health PRG (mg/kg)	Expected Residual Conc.[a] (mg/kg)	Critical Ecological Hazard Quotient (and receptor)[b]	EPC for Critical[b] Ecological Receptor (mg/kg)	Scaled[c] Ecological Hazard Quotient Using Expected Residual Conc.	Estimated Reduction in Ecological Hazard[d]	Lowest Reported Detection Limit[b] (mg/kg)
2-amino-4,6-dinitrotoluene	0.4	< 0.25	13,600 wren	3.8	447	30	0.25
4-amino-2,6-dinitrotoluene	0.4	0.35	24,800 wren	6.91	1,256	20	0.25
2,4-dinitrotoluene	7.5	0.34	11.6 shrew	1.51	3	4	0.25
2,6-dinitrotoluene	2.75	< 0.25	8.92 shrew	0.83	1	7	0.25
2-nitrotoluene	74	–	(not in surface soil)	–	–	–	–
2,4,6-trinitrotoluene	3.36	0.78	15,900 shrew	6,900	2	8,846	0.25
Aroclor 1254	0.16	< 0.037	510 shrew	0.53	18	29	0.037
Aroclor 1260	2.67	1.1	2.43 hawk	0.852	3	1	0.037
Benzo(a)anthracene	5.43	0.049	124 shrew	2.4	3	49	0.36
Benzo(a)pyrene	0.54	0.077	108 shrew	2	4	26	0.36
Benzo(b)fluoranthene	5.43	0.1	97.6 shrew	1.8	5	18	0.36
Dibenzo(a,h)anthracene	0.65	< 0.36	176 shrew	0.55	58	3	0.36
Indeno(1,2,3-cd)pyrene	5.43	0.062	57.1 shrew	1	4	16	0.36

[a] Residual concentrations in surface soil were estimated by removing the 25 validated SO samples from the data base that were within the proposal excavation footprint (FS Figures 1-4, 1-6, 1-10, 1-11, 1-12, 1-13, 1-16, 1-17, 1-18, 1-19, 1-22, 1-23, and 1-24), and recalculating the exposure point concentration following the methodology used in the Remedial Investigation Report (Section 2.2.2 in Volume III - Ecological Risk Assessment; IT, 2000). Dilution from clean backfill not considered. Note: If the COC non detect, the lowest detection limit was used.

[b] From Ecological Risk Assessment (IT, 2000).

[c] Estimated using the following scaling relationship:

Scaled HQ = Residual Conc. x (pre-remediation HQ/pre-remediation EPC)

[d] Estimated by dividing pre-remediation HQ by estimated post-remediation HQ (rounded to 1 significant figure).

Notes:

PRG = preliminary remediation goal

Ecological Hazard Quotient from Ecological Risk Assessment [ERA]

EPC = exposure point concentration (original EPC used in ERA for surface soil exposure)

Table 2-3

Summary of Contaminated Soil Volume
Feasibility Study
TNT Area B, Plum Brook Ordnance Works
Sandusky, Ohio

Building Number	Area	Length (ft)	Width (ft)	Depth (ft)	Volume (ft^3)	Volume (yd^3)	Comments	Figure #
412	A	50	20	6	6000	222	Boring refusal on bedrock at 6 ft bgs. RBRCs exceeded in deepest samples collected (3.0 ft bgs). Assumed that contamination extends to bedrock.	Figure 1-4
	B	10	10	6	600	22		
	C	10	10	6	600	22		
417	A	20	25	3	1500	56	Bedrock estimated at 3 ft bgs.	Figure 1-6
	B	20	25	3	1500	56		
	C	45	25	3	3375	125		
	D	65	25	3	4875	181		
452	A	25	45	10	11250	417	Bedrock not encountered to a depth of 10 ft bgs.	Figure 1-10
	B	15	15	10	2250	83		
453	A	15	15	8.5	1912.5	71	Bedrock encountered at 8.5 ft bgs.	Figure 1-11
456	A	14	14	4	784	29	Boring refusal on bedrock at 4 ft bgs. Assumed that contamination extends to bedrock.	Figure 1-12
	B	24	24	4	2304	85		
	C	27	13	4	1404	52		
	D	20	10	4	800	30		
	E	10	10	4	400	15		
	F	10	10	4	400	15		
	G	10	10	4	400	15		
NENH	A	15	15	4	900	33	Borings not completed at this site but likely bedrock is present at about 4 ft bgs based on borings at Building 456. Assumed contamination is present to bedrock.	Figure 1-13
462	A	15	15	8	1800	67	Bedrock encountered at 8 ft bgs.	Figure 1-16
463	A	40	20	10	8000	296	Bedrock not encountered to a depth of 10 ft bgs.	Figure 1-17
468	A	35	20	7.5	5250	194	Bedrock encountered at 7.5 ft bgs.	Figure 1-18
	B	45	30	7.5	10125	375		
	C	50	20	4.5	4500	167	Bedrock encountered at 4.5 ft bgs.	
	D	10	10	4.5	450	17		
NWNH	A	20	30	3.5	2100	78	Bedrock encountered at 3.5 ft bgs.	Figure 1-19
472	A	15	15	5	1125	42	Bedrock encountered at 5 ft bgs.	Figure 1-22
	B	40	20	5	4000	148		
473	A	15	15	10	2250	83	Bedrock not encountered to a depth of 10 ft bgs.	Figure 1-23
476	A	35	15	3	1575	58	Bedrock estimated at 3 ft bgs.	Figure 1-24
	B	15	15	3	675	25		

NENH - Northeast Nail House
NWNH - Northwest Nail House

SUM	**3078**
Safety Factor	**8%**
Total	**3324**

Table 2-4

Comparison of Universal Treatment Standards to Maximum Detected Concentrations
TNT Area B, Plum Brook Ordnance Works
Sandusky, Ohio

Chemical[a]	UTS[b] (mg/kg)	10 x UTS (mg/kg)	MDC[c] (mg/kg)	Does MDC exceed 10 x UTS?[d]
Inorganics				
Aluminum	NA	NA	8400	—
Arsenic	1.4	14	29.4	Yes
Copper	NA	NA	445	—
Iron	NA	NA	32800	—
Lead	0.69	6.9	245	Yes
Manganese	NA	NA	504	—
Thallium	1.4	14	1.4	No
Nitroaromatics				
2-amino-4,6-dinitrotoluene	NA	NA	93	—
4-amino-2,6-dinitrotoluene	NA	NA	45	—
2,4-dinitrotoluene	140	1400	254.5	No
2,6-dinitrotoluene	28	280	180	No
2-Nitrotoluene	NA	NA	82	—
2,4,6-trinitrotoluene	NA	NA	6900	—
PCBs				
Total PCBs	10	100	15	No
PAHs				
Benzo(a)anthracene	3.4	34	2.4	No
Benzo(a)pyrene	0.34	3.4	2	No
Benzo(b)fluoranthene	6.8	68	1.8	No
Dibez(a,h)anthracene	8.2	82	0.55	No
Indeno(1,2,3-cd)pyrene	3.4	34	1	No

COC - Chemicals of Concern
MDC - Maximum detected concentration
NA - Not Applicable
PAHs - Polyaromatic Hydrocarbons
PCBs - Polychlorinated Biphenyls
UTS - Universal Treatment Standard

[a] Chemicals selected for screening are the COC in addition to inorganic constituents detected at elevated concentrations with respect to backgroung concentrations.

[b] The universal treatment standards are defined in 40 CFR 268.48 Table UTS.

[c] The maximum detected concentration (mg/kg) was selected as the greater of the field screening results and the fixed-base results. Historical data was not used in this table.

[d] If the MDC in contaminated soil (classified as a hazardous waste) exceeds the UTS, a 90% reduction in total concentration capped by 10 x UTS is required prior to land disposal (40 CFR 268.49).

Table 4-1

Cost Estimate for Alternative 2 - In-Situ Chemical Oxidation
Feasibility Study
TNT Area B, Plum Brook Ordnance Works
Sandusky, Ohio

Design + Workplan				Total Cost
Description	Cost ($/item)	Number	Total Cost ($)	
Conceptual Design	$12,000	1	$12,000.00	
Treatability Study	$12,000	1	$12,000.00	
Field Pilot Testing	$20,000	1	$20,000.00	
Health and Safety	$3,000	1	$3,000.00	
Permits	$1,000	1	$1,000.00	
Final Design	$17,000	1	$17,000.00	
Procurement	$3,500	1	$3,500.00	
		Task Total	**$68,500.00**	**$68,500.00**
Mobilization				
Labor	Cost ($/hr)	Hours	Total Cost ($)	
Eq. Operator	$60	8	$480.00	
Truck Driver	$40	8	$320.00	
Engineer	$80	8	$640.00	
			$1,440.00	
Equipment	Mobe Cost ($)	Number	Total Cost ($)	
Excavator	$500	1	$500.00	
Dump Truck	$200	2	$400.00	
Material Mixer	$1,000	1	$1,000.00	
			$1,900.00	
ODCs	Cost ($)	Number	Total Cost ($)	
Airfare	$500	3	$1,500.00	
Perdiem	$40	3	$120.00	
Hotel	$90	2	$180.00	
			$1,800.00	
		Task Total	**$5,140.00**	**$5,140.00**
Excavation of Soil Contaminated With PCBs				
Labor	Cost ($/hr)	Hours	Total Cost ($)	
Eq. Operator	$60	8	$480.00	
Truck Driver	$40	16	$640.00	
Engineer	$80	8	$640.00	
			$1,760.00	
Equipment	Cost ($/day)	Days	Total Cost ($)	
Excavator	$250	1	$250.00	
Dump Truck	$100	2	$200.00	
			$450.00	
ODCs	Cost ($)	Number	Total Cost ($)	
Analytical	$800	4	$3,200.00	
Perdiem	$40	4	$160.00	
Hotel	$90	2	$180.00	
			$3,540.00	
		Task Total	**$5,750.00**	**$5,750.00**

Table 4-1

Cost Estimate for Alternative 2 - In-Situ Chemical Oxidation
Feasibility Study
TNT Area B, Plum Brook Ordnance Works
Sandusky, Ohio

In-Situ Chemical Treatment				
Pre-Characterization Sampling			$5,000	
Chemical Costs	3300 lbs	$1.31/lb	$432,300.00	
	Freight	13000	$13,000.00	
Phase I Deployment			$34,000.00	
Phase I Monitoring			$3,000	
Phase II Deployment			$14,000.00	
Phase II Monitoring			$3,000	
		Task Total	$504,300.00	$504,300.00
Off-site Disposal (Hazardous Waste)				
Disposal Cost	Cost ($/ton)	Number	Total Cost ($)	
Transportation	$30.00	600	$18,000.00	
Disposal	$150	600	$90,000.00	
			$108,000.00	
		Task Total	$108,000.00	$108,000.00
Demobilization				
Labor	Cost ($/hr)	Hours	Total Cost ($)	
Eq. Operator	$60	8	$480.00	
Truck Driver	$40	8	$320.00	
Engineer	$80	8	$640.00	
			$1,440.00	
Equipment	Mobe Cost ($)	Number	Total Cost ($)	
Excavator	$500	1	$500.00	
Dump Truck	$200	2	$400.00	
			$900.00	
ODCs	Cost ($)	Number	Total Cost ($)	
Airfare	$500	4	$2,000.00	
			$2,000.00	
		Task Total	$4,340.00	$4,340.00

Total Capital Cost	$696,030.00
O&M Cost	$0.00
Contingency 10%	$69,603.00
PM Multiplier 7%	$48,722.10
Total Cost	$814,000

Table 4-1

Cost Estimate for Alternative 2 - In-Situ Chemical Oxidation
Feasibility Study
TNT Area B, Plum Brook Ordnance Works
Sandusky, Ohio

Assumptions:
3300 cubic yards of total treated soil
Cost of potassium permanganate is $1.31/lb
Excavate 400 cubic yards of soil contaminated with PCBs
Sample excavated soil every 150 tons (4 samples)
Cost estimate for analytical analysis per sample is $800
Assume excavated soil is hazardous due to lead content
1.5 tons/cubic yard density
600 tons of hazardous soil to be disposed off-site
Transportation Costs are $30/ton
Disposal Costs are $150/ton including disposal fees
Total cost is rounded to the nearest $1,000.
The presented cost is -30% to +50% of the actual project cost

Table 4-2

Cost Estimate for Alternative 3 - Stabilization
Feasibility Study
TNT Area B, Plum Brook Ordnance Works
Sandusky, Ohio

				Total Cost
	Design			
Description	Cost ($/item)	Number	Total Cost ($)	
Conceptual Design	$12,000	1	$12,000.00	
Treatability Study	$12,000	1	$12,000.00	
Health and Safety	$3,000	1	$3,000.00	
Permits	$1,000	1	$1,000.00	
Final Design	$17,000	1	$17,000.00	
Procurement	$3,500	1	$3,500.00	
		Task Total	**$48,500.00**	**$48,500.00**
	Mobilization			
Labor	Cost ($/hr)	Hours	Total Cost ($)	
Eq. Operator	$60	8	$480.00	
Truck Driver	$40	8	$320.00	
Engineer	$80	8	$640.00	
			$1,440.00	
Equipment	Mobe Cost ($)	Number	Total Cost ($)	
Excavator	$500	2	$1,000.00	
Dump Truck	$200	2	$400.00	
			$1,400.00	
ODCs	Cost ($)	Number	Total Cost ($)	
Airfare	$500	3	**$1,500.00**	
		Task Total	**$4,340.00**	**$4,340.00**
	Excavation			
Labor	Cost ($/hr)	Hours	Total Cost ($)	
Eq. Operator	$60	48	$2,880.00	
Truck Driver	$40	48	$1,920.00	
Engineer	$80	48	$3,840.00	
			$8,640.00	
Equipment	Cost ($/day)	Days	Total Cost ($)	
Excavator	$250	12	$3,000.00	
Dump Truck	$100	12	$1,200.00	
			$4,200.00	
ODCs	Cost ($)	Number	Total Cost ($)	
Analytical	$800	33	$26,400.00	
Perdiem	$40	36	$1,440.00	
Hotel	$90	12	$1,080.00	
			$28,920.00	
		Task Total	**$41,760.00**	**$41,760.00**

Table 4-2

Cost Estimate for Alternative 3 - Stabilization
Feasibility Study
TNT Area B, Plum Brook Ordnance Works
Sandusky, Ohio

	Treatment			
Labor	Cost ($/hr)	Hours	Total Cost ($)	
Eq. Operator	$60	48	$2,880.00	
Engineer	$80	48	$3,840.00	
			$6,720.00	
Equipment	Cost ($/day)	Days	Total Cost ($)	
Excavator	$250	6	$1,500.00	
			$1,500.00	
ODCs	Cost ($)	Number	Total Cost ($)	
Perdiem	$40	12	$480.00	
Hotel	$90	8	$720.00	
Carbon	$900	14.4	$12,960.00	
Cement	$90	72	$6,480.00	
Mix Box	$3,000	1	$3,000.00	
Analytical	$800	10	$8,000.00	
			$31,640.00	
		Task Total	**$39,860.00**	**$39,860.00**
	Off-site Disposal			
Labor	Cost ($/hr)	Hours	Total Cost ($)	
Eq. Operator	$60	48	$2,880.00	
Engineer	$80	48	$3,840.00	
			$6,720.00	
Equipment	Mobe Cost ($)	Number	Total Cost ($)	
Excavator	$500	6	$3,000.00	
			$3,000.00	
ODCs	Cost ($)	Number	Total Cost ($)	
Perdiem	$40	24	$960.00	
Hotel	$90	12	$1,080.00	
Transportation	$6.25	5000	$31,250.00	
Disposal Cost	$25	5000	$125,000.00	
			$158,290.00	
		Task Total	**$168,010.00**	**$168,010.00**

Table 4-2

Cost Estimate for Alternative 3 - Stabilization
Feasibility Study
TNT Area B, Plum Brook Ordnance Works
Sandusky, Ohio

	Demobilization			
Labor	Cost ($/hr)	Hours	Total Cost ($)	
Eq. Operator	$60	8	$480.00	
Truck Driver	$40	8	$320.00	
Engineer	$80	8	$640.00	
			$1,440.00	
Equipment	Mobe Cost ($)	Number	Total Cost ($)	
Excavator	$500	1	$500.00	
Dump Truck	$200	1	$200.00	
			$700.00	
ODCs	Cost ($)	Number	Total Cost ($)	
Airfare	$500	3	$1,500.00	
			$1,500.00	
		Task Total	**$3,640.00**	**$3,640.00**

Total Capital Cost	**$306,110.00**
O&M Cost	**$0.00**
Contingency 10%	**$30,611.00**
PM Multiplier 7%	**$21,427.70**
Total Cost	**$358,000**

Assumptions:

3300 cubic yards of total excavated soil
Sample excavated soil every 150 tons (33 samples)
Cost estimate for analytical analysis per sample is $800
960 cubic yards of hazardous soil that needs to be stabilized
1.5 tons/cubic yard density
1440 tons of hazardous soil
0.01 mix ratio carbon and 0.05 mix ratio Portland cement
Carbon cost $900 per ton
Cement cost $90 per ton
Need 1 ton of carbon for every 100 tons of soil
Need 5 tons of cement for every 100 tons of soil
Sample stabilized soil every 150 tons
Analyze samples for TCLP, Ignitability, PCBs, VOCs, and SVOCs.
Cost estimate for analytical analysis per sample is $800
Dispose of stabilized soil and non-stabilized non-hazardous soil at non-hazardous waste landfill
Total mass of soil (stabilized and non-stabilized) is roughly 5000 tons
Transportation Costs are $6.25/ton
Disposal Costs are $25/ton including disposal fees
Total cost is rounded to the nearest $1,000.
The presented cost is -30% to +50% of the actual project cost

Table 4-3

Cost Estimate for Alternative 4 - Composting
Feasibility Study
TNT Area B, Plum Brook Ordnance Works
Sandusky, Ohio

				Total Cost
	Design			
Description	Cost ($/item)	Number	Total Cost ($)	
Conceptual Design	$10,000	1	$10,000.00	
Health and Safety	$3,000	1	$3,000.00	
Permits	$1,000	1	$1,000.00	
Pilot Test	$12,000	1	$12,000.00	
Final Design	$17,000	1	$17,000.00	
		Task Total	**$43,000.00**	**$43,000.00**
	Mobilization			
Labor	Cost ($/hr)	Hours	Total Cost ($)	
Eq. Operator	$60	8	$480.00	
Truck Driver	$40	8	$320.00	
Engineer	$80	8	$640.00	
			$1,440.00	
Equipment	Mobe Cost ($)	Number	Total Cost ($)	
Backhoe	$250	1	$250.00	
Front End Loader	$500	1	$500.00	
Dump Truck	$200	2	$400.00	
Scarab	$750	1	$750.00	
			$1,900.00	
ODCs	Cost ($)	Number	Total Cost ($)	
Field Trailer	$4,300	1	$4,300.00	
Airfare	$500	5	$2,500.00	
			$6,800.00	
		Task Total	**$10,140.00**	**$10,140.00**
	Excavation, Characterization and Stockpiling			
Labor	Cost ($/hr)	Hours	Total Cost ($)	
Eq. Operator	$60	48	$2,880.00	
Truck Driver	$40	48	$1,920.00	
Engineer	$80	48	$3,840.00	
			$8,640.00	
Equipment	Cost ($/day)	Days	Total Cost ($)	
Backhoe	$250	6	$1,500.00	
Front End Loader	$500	6	$3,000.00	
Dump Truck	$200	6	$1,200.00	
			$5,700.00	
ODCs	Cost ($)	Number	Total Cost ($)	
Analytical	$800	33	$26,400.00	
Perdiem	$250	6	$1,500.00	
Hotel	$90	12	$1,080.00	
			$28,980.00	
		Task Total	**$43,320.00**	**$43,320.00**

Table 4-3

Cost Estimate for Alternative 4 - Composting
Feasibility Study
TNT Area B, Plum Brook Ordnance Works
Sandusky, Ohio

Windrow Composting				
Labor (3 months)	Cost ($/hr)	Hours	Total Cost ($)	
Eq. Operator	$60	520	$31,200.00	
Engineer	$80	130	$10,400.00	
Site Super	$50	130	$6,500.00	
Tech Manager	$90	40	$3,600.00	
Laborer	$40	520	$20,800.00	
			$72,500.00	
Equipment	Cost ($/day)	Days	Total Cost ($)	
Backhoe	$250	65	$16,250.00	
Front End Loader	$500	65	$32,500.00	
Scarab	$750	65	$48,750.00	
			$97,500.00	
Structures	Cost ($/ft^2)	ft^2	Total Cost ($)	
Fabric Building	$8	12000	$90,000.00	
			$90,000.00	
Amendments	Cost ($/cy)	Cubic Yard	Total Cost ($)	
	$25	1300	**$32,500.00**	
ODCs	Cost ($)	Number	Total Cost ($)	
Perdiem	$250	90	$22,500.00	
Hotel	$90	90	$8,100.00	
Analytical	$800	6	$4,800.00	
			$35,400.00	
		Task Total	**$327,900.00**	**$327,900.00**
Off-site Disposal				
Labor	Cost ($/hr)	Hours	Total Cost ($)	
Eq. Operator	$60	48	$2,880.00	
Engineer	$80	48	$3,840.00	
			$6,720.00	
Equipment	Cost ($/day)	Days	Total Cost ($)	
Backhoe	$250	6	$1,500.00	
			$1,500.00	
ODCs	Cost ($)	Number	Total Cost ($)	
Perdiem	$40	24	$960.00	
Hotel	$90	12	$1,080.00	
Non-hazardous Soil Disposal				
Transportation	$6.25	5100	$31,875.00	
Disposal Cost	$25	5100	$127,500.00	
Hazardous Soil Disposal				
Transportation	$30	600	$18,000.00	
Disposal Cost	$150	600	$90,000.00	
			$269,415.00	
		Task Total	**$277,635.00**	**$277,635.00**

Table 4-3

Cost Estimate for Alternative 4 - Composting
Feasibility Study
TNT Area B, Plum Brook Ordnance Works
Sandusky, Ohio

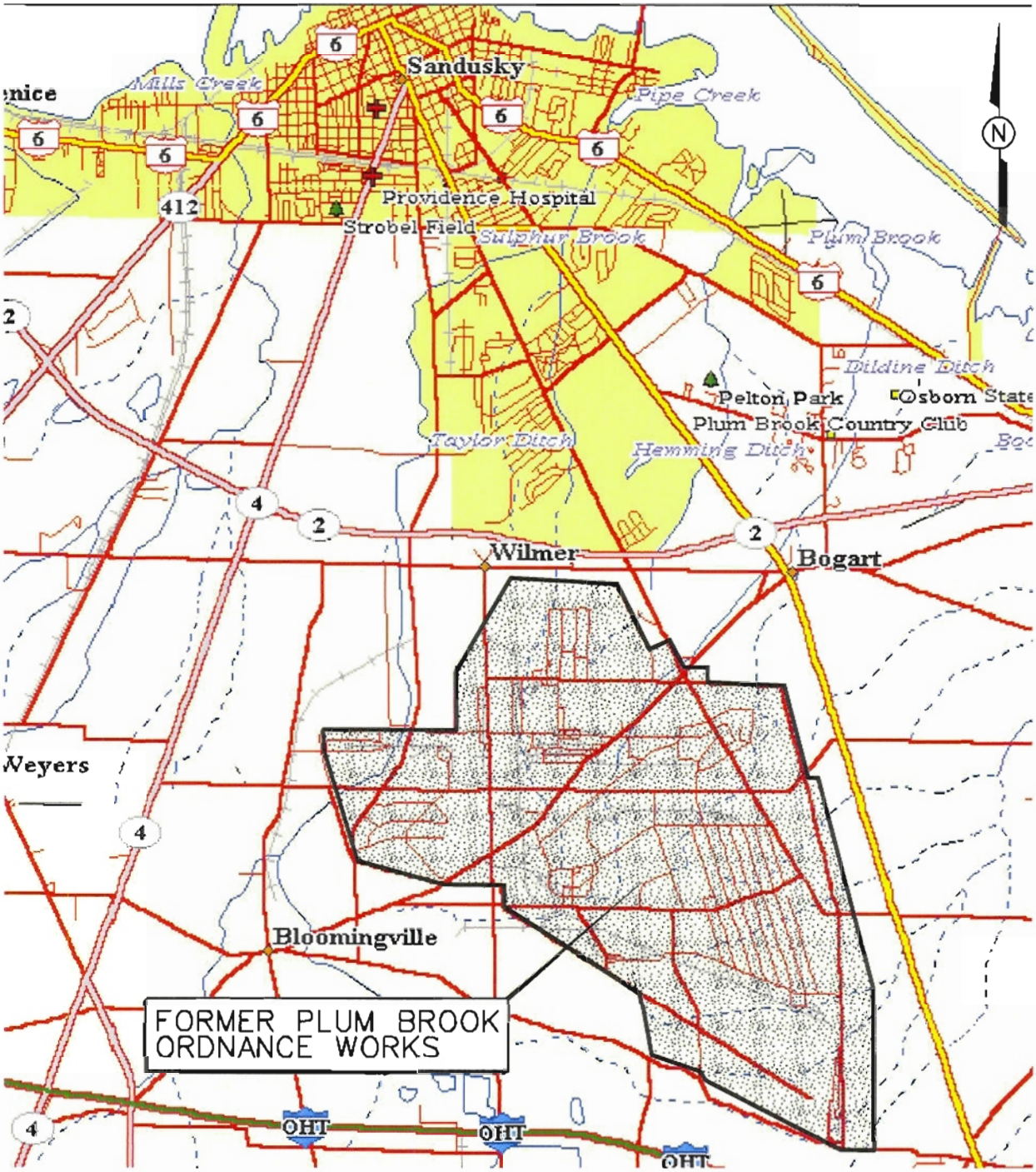
	Demobilization			
Labor	Cost ($/hr)	Hours	Total Cost ($)	
Eq. Operator	$60	8	$480.00	
Truck Driver	$40	8	$320.00	
Engineer	$80	8	$640.00	
			$1,440.00	
Equipment	Mobe Cost ($)	Number	Total Cost ($)	
Backhoe	$250	1	$250.00	
Front End Loader	$500	1	$500.00	
Dump Truck	$200	2	$400.00	
Scarab	$750	1	$750.00	
			$1,900.00	
ODCs	Cost ($)	Number	Total Cost ($)	
Airfare	$500	5	$2,500.00	
			$2,500.00	
		Task Total	$5,840.00	$5,840.00

Total Capital Cost	$707,835.00
O&M Cost	$0.00
Contingency 10%	$70,783.50
PM Multiplier 7%	$49,548.45
Total Cost	$828,000

Assumptions:

3300 cubic yards of total excavated soil
Sample excavated soil every 150 tons (33 samples)
Cost estimate for analytical analysis per sample is $800
560 cubic yards of hazardous soil that needs to be composted
400 cubic yards of hazardous soil that needs to be disposed at a hazardous waste landfill
1.5 tons/cubic yard density
840 tons of hazardous soil that needs to be composted
600 tons of hazardous soil that needs to be disposed at a hazardous waste landfill
Composting amendments available within 75 mile radius
Fabric structure area is 12,000 ft^2
Sample treated soil every 150 tons
Analyze samples for TCLP, Ignitability, PCBs, VOCs, and SVOCs.
Cost estimate for analytical analysis per sample is $800
Dispose of composted soil and non-composted non-hazardous soil at non-hazardous waste landfill.
Mass of composted soil is roughly 1600 tons (includes mass increase from amendments)
Mass of non-composted non-hazardous soil is roughly 4100 tons
Total soil mass disposed non-hazardous waste landfill is 5100 tons
Transportation Costs are $6.25/ton
Disposal Costs are $25/ton including disposal fees
Mass of hazardous waste disposed at hazardous waste landfill is 600 tons
Transportation Costs are $30/ton
Disposal Costs are $150/ton including disposal fees
Total cost is rounded to the nearest $1,000.
The presented cost is -30% to +50% of the actual project cost

FIGURES



NOT TO SCALE

FIGURE 1-1
VICINITY MAP

FORMER PLUM BROOK ORDNANCE WORKS
SANDUSKY, OHIO

IT CORPORATION
A Member of The IT Group

STARTING DATE: 12/16/97	DATE LAST REV.: 11/15/00	DRAFT. CHCK. BY:	INITIATOR: D. KESSLER	DWG. NO.: \773701es.001	09:43:34
DRAWN BY: D. BILLINGSLEY	DRAWN BY: bvanderg	ENGR. CHCK. BY: D. KESSLER	PROJ MGR: M.SPANGBERG	PROJ. NO.:773701	

bvanderg
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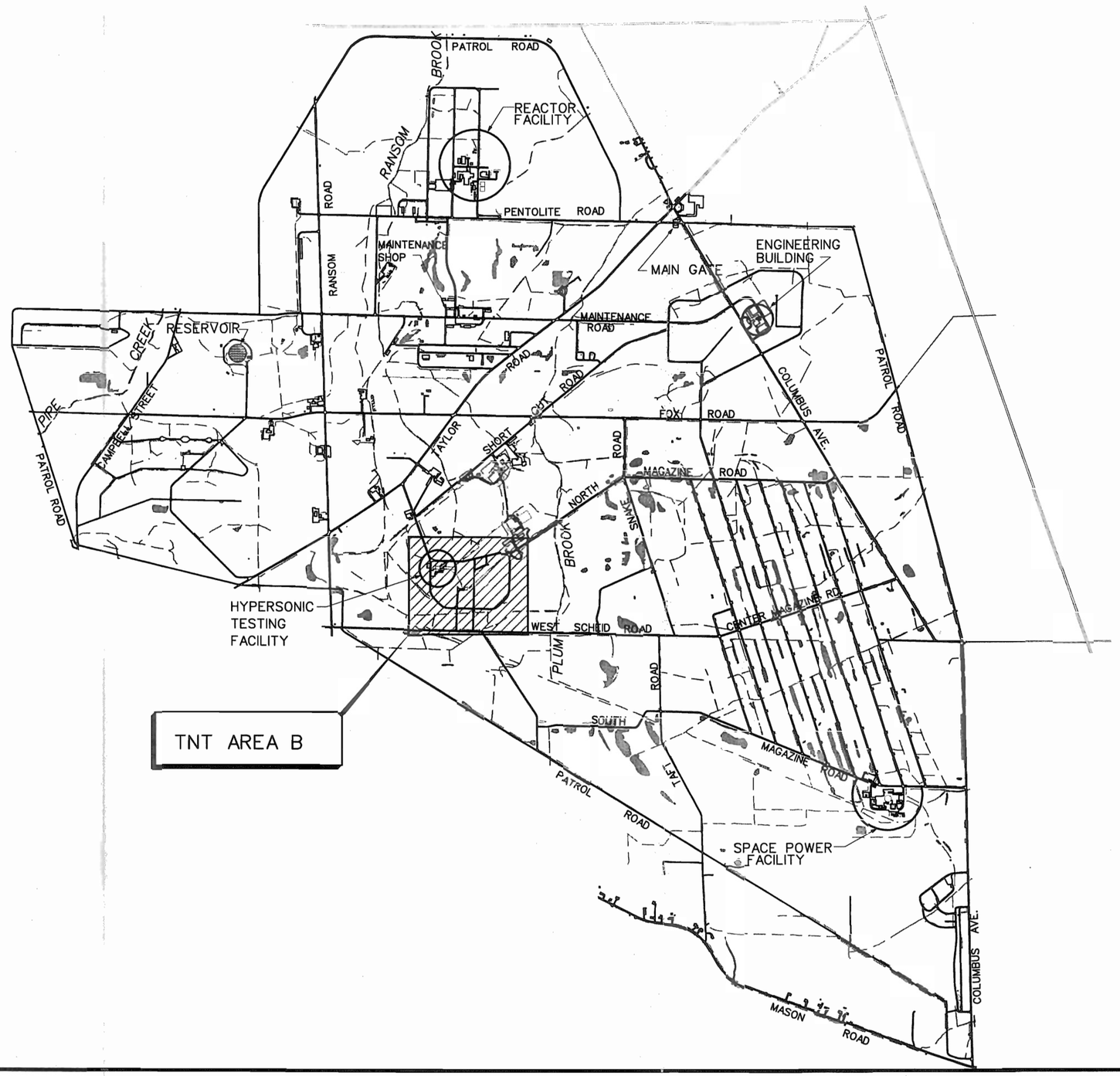

LEGEND:

- BUILDINGS
- STREAMS OR DITCHES
- ROAD
- SURFACE WATER
- AREA OF CONCERN

SCALE

0 2400 4800 FEET

FIGURE 1-2
TNT AREA B LOCATION MAP

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

IT CORPORATION
A Member of The IT Group

STARTING DATE: 12/16/97	DATE LAST REV.:	DRAFT. CHCK. BY:	INITIATOR: D. KESSLER
DRAWN BY: D. BILLINGSLEY	DRAWN BY:	ENGR. CHCK. BY: D. KESSLER	PROJ. MGR.:M.SPANGBERG
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PROJ. NO.: 773701

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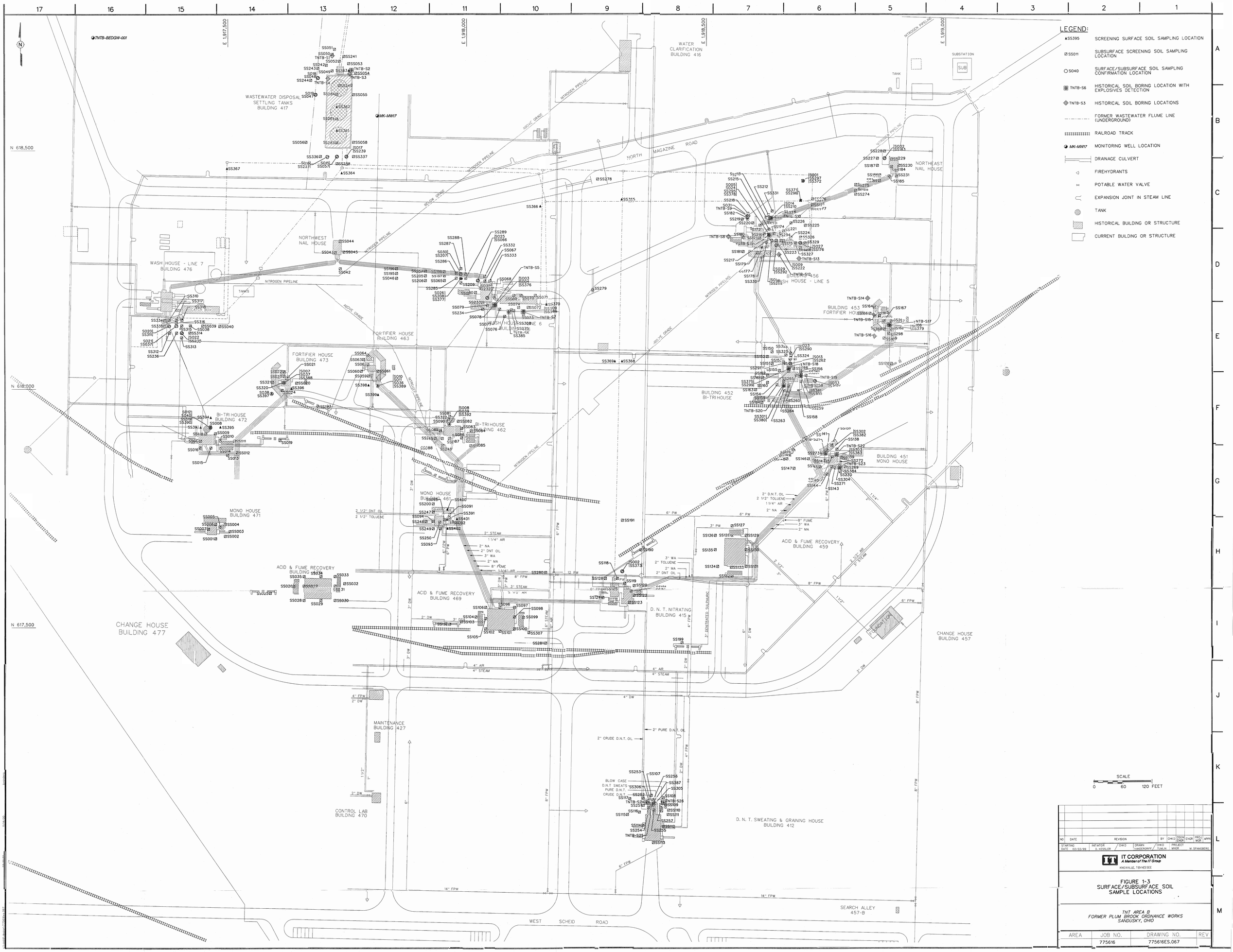
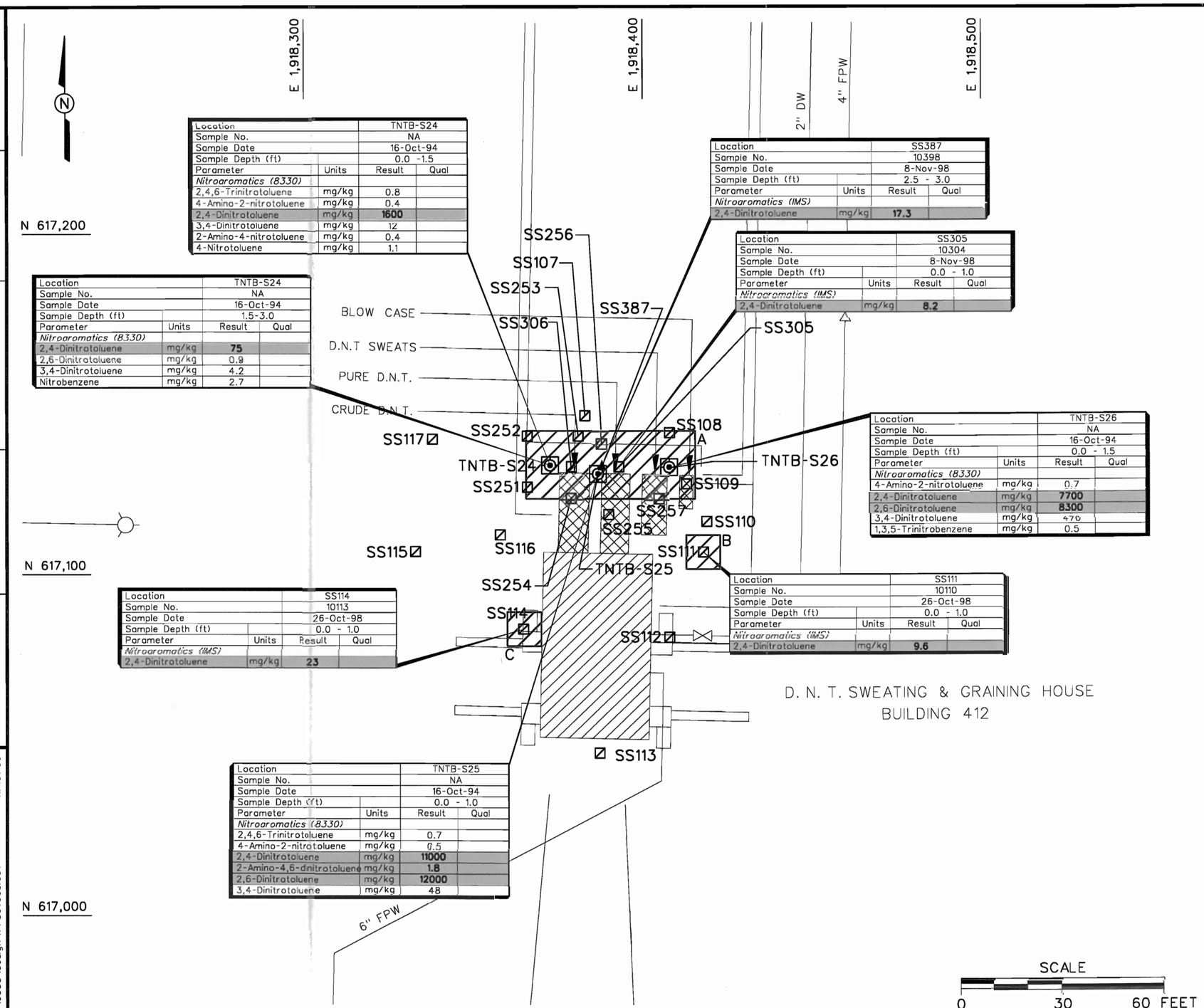

LEGEND:
SS395 SCREENING SURFACE SOIL SAMPLING LOCATION
SS011 SUBSURFACE SCREENING SOIL SAMPLING LOCATION
S040 SURFACE/SUBSURFACE SOIL SAMPLING CONFIRMATION LOCATION
TNTB-S6 HISTORICAL SOIL BORING LOCATION WITH EXPLOSIVES DETECTION
TNTB-S3 HISTORICAL SOIL BORING LOCATIONS
FORMER WASTEWATER FLUME LINE (UNDERGROUND)
RAILROAD TRACK
MK-MW17 MONITORING WELL LOCATION
DRAINAGE CULVERT
FIREHYDRANTS
POTABLE WATER VALVE
EXPANSION JOINT IN STEAM LINE
TANK
HISTORICAL BUILDING OR STRUCTURE
CURRENT BUILDING OR STRUCTURE
WASTEWATER DISPOSAL SETTLING TANKS BUILDING 417
WATER CLARIFICATION BUILDING 416
NORTH MAGAZINE ROAD
NORTHWEST NAIL HOUSE
NORTHEAST NAIL HOUSE
WASH HOUSE - LINE 7 BUILDING 476
WASH HOUSE - LINE 5 BUILDING 456
WASH HOUSE - LINE 6 BUILDING 475
FORTIFIER HOUSE BUILDING 463
FORTIFIER HOUSE BUILDING 473
BUILDING 453 FORTIFIER HOUSE
BUILDING 452 BI-TRI HOUSE
BI-TRI HOUSE BUILDING 472
BI-TRI HOUSE BUILDING 462
BUILDING 451 MONO HOUSE
MONO HOUSE BUILDING 461
MONO HOUSE BUILDING 471
ACID & FUME RECOVERY BUILDING 459
ACID & FUME RECOVERY BUILDING 469
ACID & FUME RECOVERY BUILDING 457
D. N. T. NITRATING BUILDING 415
CHANGE HOUSE BUILDING 477
CHANGE HOUSE BUILDING 457
MAINTENANCE BUILDING 427
CONTROL LAB BUILDING 470
D. N. T. SWEATING & GRAINING HOUSE BUILDING 412
SEARCH ALLEY 457-B
WEST SCHEID ROAD
SUBSTATION
NITROGEN PIPELINE
ABOVE GRADE
BELOW GRADE
N 618,500
N 618,000
N 617,500
E 1,917,500
E 1,918,000
E 1,918,500
E 1,919,000
SCALE
0 60 120 FEET
IT CORPORATION
A Member of The IT Group
KNOXVILLE, TENNESSEE
FIGURE 1-3
SURFACE/SUBSURFACE SOIL SAMPLE LOCATIONS
TNT AREA B
FORMER PLUM BROOK ORDNANCE WORKS
SANDUSKY, OHIO
AREA
JOB NO. 775616
DRAWING NO. 775616ES.067
REV



Location		TNTB-S24	
Sample No.		NA	
Sample Date		16-Oct-94	
Sample Depth (ft)		0.0 -1.5	
Parameter	Units	Result	Qual
Nitroaromatics (8330)			
2,4,6-Trinitrotoluene	mg/kg	0.8	
4-Amino-2-nitrotoluene	mg/kg	0.4	
2,4-Dinitrotoluene	mg/kg	**1600**	
3,4-Dinitrotoluene	mg/kg	12	
2-Amino-4-nitrotoluene	mg/kg	0.4	
4-Nitrotoluene	mg/kg	1.1	

Location		TNTB-S24	
Sample No.		NA	
Sample Date		16-Oct-94	
Sample Depth (ft)		1.5-3.0	
Parameter	Units	Result	Qual
Nitroaromatics (8330)			
2,4-Dinitrotoluene	mg/kg	**75**	
2,6-Dinitrotoluene	mg/kg	0.9	
3,4-Dinitrotoluene	mg/kg	4.2	
Nitrobenzene	mg/kg	2.7	

Location		SS387	
Sample No.		10398	
Sample Date		8-Nov-98	
Sample Depth (ft)		2.5 - 3.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4-Dinitrotoluene	mg/kg	**17.3**	

Location		SS305	
Sample No.		10304	
Sample Date		8-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4-Dinitrotoluene	mg/kg	**8.2**	

Location		TNTB-S26	
Sample No.		NA	
Sample Date		16-Oct-94	
Sample Depth (ft)		0.0 - 1.5	
Parameter	Units	Result	Qual
Nitroaromatics (8330)			
4-Amino-2-nitrotoluene	mg/kg	0.7	
2,4-Dinitrotoluene	mg/kg	**7700**	
2,6-Dinitrotoluene	mg/kg	**8300**	
3,4-Dinitrotoluene	mg/kg	470	
1,3,5-Trinitrobenzene	mg/kg	0.5	

Location		SS114	
Sample No.		10113	
Sample Date		26-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4-Dinitrotoluene	mg/kg	**23**	

Location		SS111	
Sample No.		10110	
Sample Date		26-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4-Dinitrotoluene	mg/kg	**9.6**	

Location		TNTB-S25	
Sample No.		NA	
Sample Date		16-Oct-94	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (8330)			
2,4,6-Trinitrotoluene	mg/kg	0.7	
4-Amino-2-nitrotoluene	mg/kg	0.5	
2,4-Dinitrotoluene	mg/kg	**11000**	
2-Amino-4,6-dinitrotoluene	mg/kg	**1.8**	
2,6-Dinitrotoluene	mg/kg	**12000**	
3,4-Dinitrotoluene	mg/kg	48	

LEGEND:

SS011	SCREENING SURFACE SOIL SAMPLING LOCATION
SS395	SUBSURFACE SCREENING SOIL SAMPLING LOCATION
TNTB-S6	HISTORICAL SOIL BORING LOCATION WITH EXPLOSIVES DETECTION
	FIRE HYDRANTS
	POTABLE WATER VALVE
	POTENTIAL REMEDIATION AREA

NOTES:

1. NITROAROMATICS (IMS) - IMS SCREENING RESULTS
2. OVERBURDEN THICKNESS ESTIMATED AT APPROXIMATELY 6 FT.
3. SHADED CONCENTRATIONS INDICATE DETECTIONS EXCEEDING PRGs.
4. TOTAL REMEDIATION VOLUME IS ESTIMATED AT 266 YD^3.

AREA A:
ASSUMED DEPTH: 6 FT
ASSUMED DIMENSIONS: 50'X20'
VOLUME = 222 YD^3

AREA B:
ASSUMED DEPTH: 6 FT
ASSUMED DIMENSIONS: 10'X10'
VOLUME = 22 YD^3

AREA C:
ASSUMED DEPTH: 6 FT
ASSUMED DIMENSIONS: 10'X10'
VOLUME = 22 YD^3

SCALE
0 30 60 FEET

FIGURE 1-4
BUILDING 412 SWEATING AND GRAINING HOUSE SAMPLE LOCATIONS, ANALYTICAL RESULTS, AND POTENTIAL REMEDIATION AREAS

PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

IT CORPORATION
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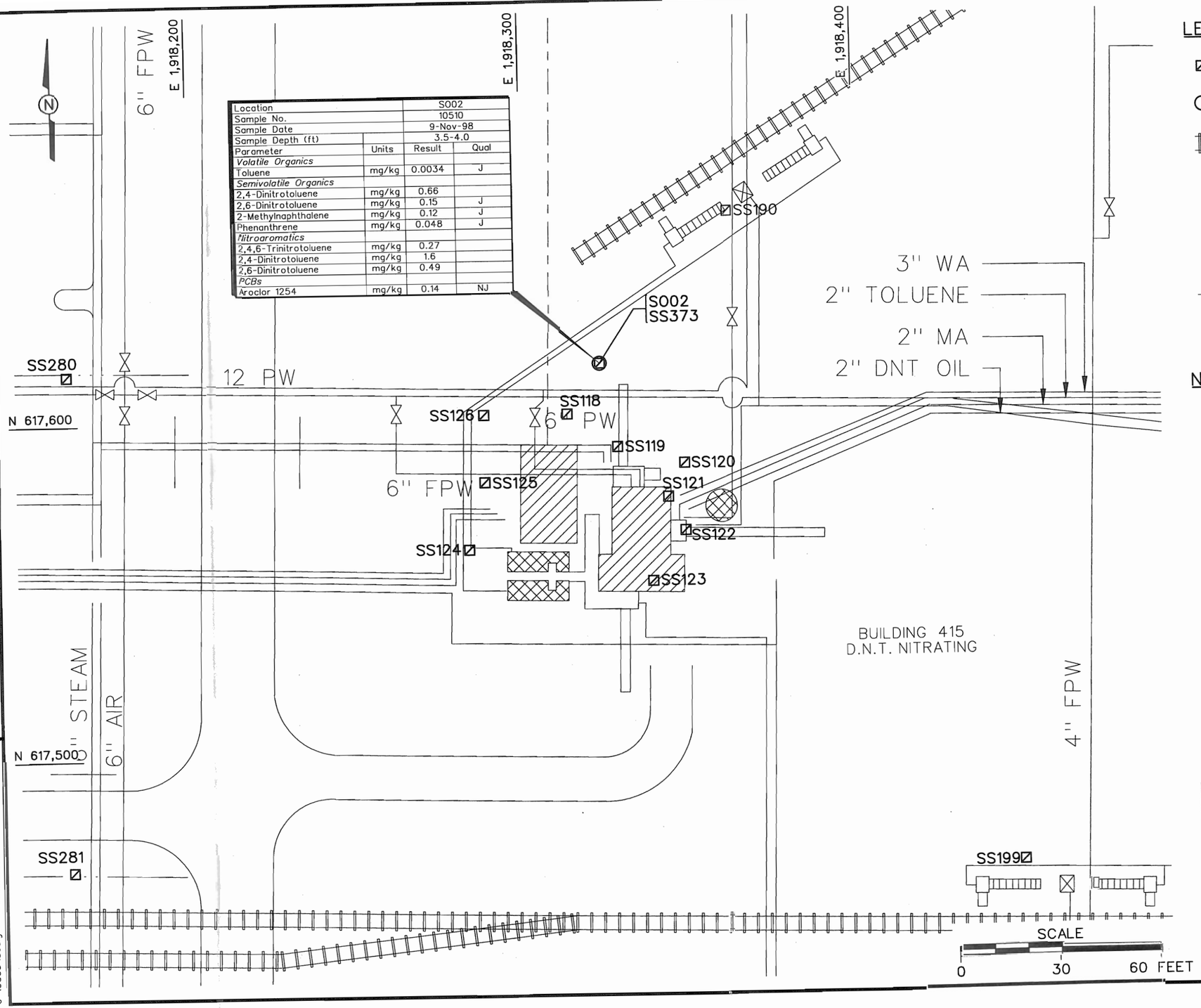
DWG. NO.: ...\775616es.061
PROJ. NO.: 775616
INITIATOR: GUNDERSON
PROJ. MGR.: SPANGBERG
DRAFT. CHCK. BY: C. TUMLIN
ENGR. CHCK. BY: S. MUFFLER
DATE LAST REV.:
DRAWN BY:
STARTING DATE: 03/15/99
DRAWN BY: B.VANDERGRIFF
11:32:05
11/10/00
bvanderg
c:\cadd\design\775616es.061



Location		S002	
Sample No.		10510	
Sample Date		9-Nov-98	
Sample Depth (ft)		3.5-4.0	
Parameter	Units	Result	Qual
Volatile Organics			
Toluene	mg/kg	0.0034	J
Semivolatile Organics			
2,4-Dinitrotoluene	mg/kg	0.66	
2,6-Dinitrotoluene	mg/kg	0.15	J
2-Methylnaphthalene	mg/kg	0.12	J
Phenanthrene	mg/kg	0.048	J
Nitroaromatics			
2,4,6-Trinitrotoluene	mg/kg	0.27	
2,4-Dinitrotoluene	mg/kg	1.6	
2,6-Dinitrotoluene	mg/kg	0.49	
PCBs			
Aroclor 1254	mg/kg	0.14	NJ

LEGEND:

- SS011 — SUBSURFACE SCREENING SOIL SAMPLING LOCATION
- S034 — SURFACE/SUBSURFACE SOIL SAMPLE CONFIRMATION LOCATION
- RAILROAD TRACK
- POTABLE WATER VALVE
- EXPANSION JOINT IN STEAM LINE
- TANK
- FORMER WASTEWATER FLUME LINE (UNDERGROUND)

NOTES:

1. NO CONTAMINATION EXCEEDING PRGs.

FIGURE 1-5
BUILDING 415
D.N.T. NITRATING SAMPLE LOCATIONS AND ANALYTICAL RESULTS

PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

IT CORPORATION
A Member of The IT Group

DRAFT. CHCK. BY: C. TUMLIN	INITIATOR: GUNDERSON	DWG. NO.:..\775616es.068	
ENGR. CHCK. BY: S. MUFFLER	PROJ. MGR.: SPANGBERG	PROJ. NO.: 775616	
STARTING DATE: 03/31/99	DATE LAST REV.:		
DRAWN BY: B.VANDERGRIFF	DRAWN BY:		

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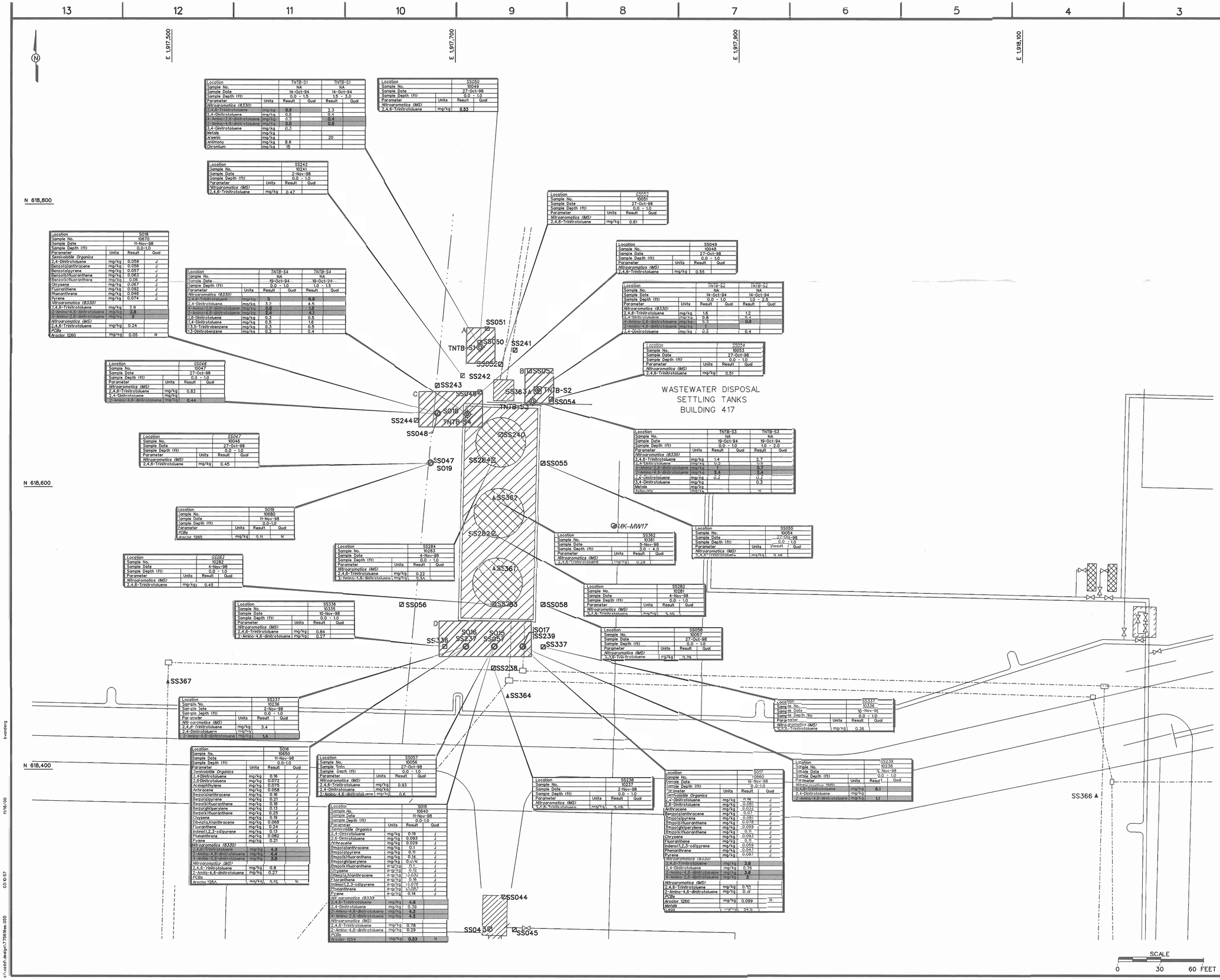

Location		TNTB-S1		TNTB-S1	
Sample No.		NA		NA	
Sample Date		14-Oct-94		14-Oct-94	
Sample Depth (ft)		0.0 - 1.5		1.5 - 3.0	
Parameter	Units	Result	Qual	Result	Qual
Nitroaromatics (8330)					
2,4,6-Trinitrotoluene	mg/kg	6.9		2.3	
2,4-Dinitrotoluene	mg/kg	0.6		0.4	
4-Amino-2,6-dinitrotoluene	mg/kg	2.3		0.4	
2-Amino-4,6-dinitrotoluene	mg/kg	0.8		0.8	
3,4-Dinitrotoluene	mg/kg	0.3			
Metals	mg/kg				
Arsenic	mg/kg			20	
Antimony	mg/kg	8.6			
Chromium	mg/kg	15			

Location		SS050	
Sample No.		10049	
Sample Date		27-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.53	

Location		SS242	
Sample No.		10241	
Sample Date		2-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.47	

Location		SS052	
Sample No.		10051	
Sample Date		27-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.61	

Location		SS018	
Sample No.		10670	
Sample Date		11-Nov-98	
Sample Depth (ft)		0.0-1.0	
Parameter	Units	Result	Qual
Semivolatile Organics			
2,4-Dinitrotoluene	mg/kg	0.059	J
Benzo(a)anthracene	mg/kg	0.056	J
Benzo(a)pyrene	mg/kg	0.057	J
Benzo(b)fluoranthene	mg/kg	0.063	J
Benzo(k)fluoranthene	mg/kg	0.05	J
Chrysene	mg/kg	0.067	J
Fluoranthene	mg/kg	0.092	J
Phenanthrene	mg/kg	0.048	J
Pyrene	mg/kg	0.074	J
Nitroaromatics (8330)			
2,4,6-Trinitrotoluene	mg/kg	2.9	
2-Amino-4,6-dinitrotoluene	mg/kg	3.8	
4-Amino-2,6-dinitrotoluene	mg/kg	2	
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.24	
PCBs			
Aroclor 1260	mg/kg	0.05	N

Location		TNTB-S4		TNTB-S4	
Sample No.		NA		NA	
Sample Date		19-Oct-94		19-Oct-94	
Sample Depth (ft)		0.0 - 1.0		1.0 - 1.5	
Parameter	Units	Result	Qual	Result	Qual
Nitroaromatics (8330)					
2,4,6-Trinitrotoluene	mg/kg	5		8.8	
2,4-Dinitrotoluene	mg/kg	3.2		4.5	
4-Amino-2,6-dinitrotoluene	mg/kg	0.8		1.3	
2-Amino-4,6-dinitrotoluene	mg/kg	2.4		4.1	
2,6-Dinitrotoluene	mg/kg	0.3		0.5	
3,4-Dinitrotoluene	mg/kg	0.5		1.6	
1,3,5-Trinitrobenzene	mg/kg	0.3		0.5	
1,3-Dinitrobenzene	mg/kg	0.3		0.4	

Location		SS049	
Sample No.		10048	
Sample Date		27-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.55	

Location		TNTB-S2		TNTB-S2	
Sample No.		NA		NA	
Sample Date		14-Oct-94		14-Oct-94	
Sample Depth (ft)		0.0 - 1.0		1.0 - 2.5	
Parameter	Units	Result	Qual	Result	Qual
Nitroaromatics (8330)					
2,4,6-Trinitrotoluene	mg/kg	1.6		1.2	
2,4-Dinitrotoluene	mg/kg	0.8		0.4	
4-Amino-2,6-dinitrotoluene	mg/kg	0.3		0.8	
2-Amino-4,6-dinitrotoluene	mg/kg	1			
3,4-Dinitrotoluene	mg/kg	0.5		0.4	

Location		SS054	
Sample No.		10053	
Sample Date		27-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.51	

Location		SS048	
Sample No.		10047	
Sample Date		27-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.83	
2,4-Dinitrotoluene	mg/kg		
2-Amino-4,6-dinitrotoluene	mg/kg	0.44	

Location		SS047	
Sample No.		10046	
Sample Date		27-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.45	

Location		TNTB-S3		TNTB-S3	
Sample No.		NA		NA	
Sample Date		19-Oct-94		19-Oct-94	
Sample Depth (ft)		0.0 - 1.0		1.0 - 2.0	
Parameter	Units	Result	Qual	Result	Qual
Nitroaromatics (8330)					
2,4,6-Trinitrotoluene	mg/kg	1.4		2.7	
2,4-Dinitrotoluene	mg/kg	0.3		0.6	
4-Amino-2,6-dinitrotoluene	mg/kg	1		0.7	
2-Amino-4,6-dinitrotoluene	mg/kg	2.6		3.4	
2,6-Dinitrotoluene	mg/kg	0.3		0.2	
3,4-Dinitrotoluene	mg/kg			0.3	
Metals	mg/kg				
Antimony	mg/kg			11	

Location		SS019	
Sample No.		10680	
Sample Date		11-Nov-98	
Sample Depth (ft)		0.0-1.0	
Parameter	Units	Result	Qual
PCBs			
Aroclor 1260	mg/kg	0.11	N

Location		SS284	
Sample No.		10283	
Sample Date		4-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.22	
2-Amino-4,6-dinitrotoluene	mg/kg	0.34	

Location		SS363	
Sample No.		10361	
Sample Date		5-Nov-98	
Sample Depth (ft)		3.0 - 4.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.28	

Location		SS055	
Sample No.		10054	
Sample Date		27-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.46	

Location		SS263	
Sample No.		10282	
Sample Date		4-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.45	

Location		SS282	
Sample No.		10281	
Sample Date		4-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.46	

Location		SS336	
Sample No.		10335	
Sample Date		10-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.84	
2-Amino-4,6-dinitrotoluene	mg/kg	0.27	

Location		SS058	
Sample No.		10057	
Sample Date		27-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.74	

Location		SS237	
Sample No.		10236	
Sample Date		2-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	3.4	
2,4-Dinitrotoluene	mg/kg		
2-Amino-4,6-dinitrotoluene	mg/kg	1.4	

Location		SS337	
Sample No.		10336	
Sample Date		10-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.36	

Location		SS016	
Sample No.		10650	
Sample Date		11-Nov-98	
Sample Depth (ft)		0.0-1.0	
Parameter	Units	Result	Qual
Semivolatile Organics			
2,4-Dinitrotoluene	mg/kg	0.16	J
2,6-Dinitrotoluene	mg/kg	0.072	J
Acenaphthylene	mg/kg	0.075	J
Anthracene	mg/kg	0.058	J
Benzo(a)anthracene	mg/kg	0.16	J
Benzo(a)pyrene	mg/kg	0.21	J
Benzo(b)fluoranthene	mg/kg	0.18	J
Benzo(ghi)perylene	mg/kg	0.13	J
Benzo(k)fluoranthene	mg/kg	0.25	J
Chrysene	mg/kg	0.19	J
Dibenz(a,h)anthracene	mg/kg	0.068	J
Fluoranthene	mg/kg	0.24	J
Indeno(1,2,3-cd)pyrene	mg/kg	0.13	J
Phenanthrene	mg/kg	0.082	J
Pyrene	mg/kg	0.21	J
Nitroaromatics (8330)			
2,4,6-Trinitrotoluene	mg/kg	4.3	
2-Amino-4,6-dinitrotoluene	mg/kg	4.4	
4-Amino-2,6-dinitrotoluene	mg/kg	3.5	
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.8	
2-Amino-4,6-dinitrotoluene	mg/kg	0.27	
PCBs			
Aroclor 1254	mg/kg	0.15	N

Location		SS057	
Sample No.		10056	
Sample Date		27-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.93	
2,4-Dinitrotoluene	mg/kg		
2-Amino-4,6-dinitrotoluene	mg/kg	0.6	

Location		SS238	
Sample No.		10237	
Sample Date		2-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.46	

Location		SS015	
Sample No.		10640	
Sample Date		11-Nov-98	
Sample Depth (ft)		0.0-1.0	
Parameter	Units	Result	Qual
Semivolatile Organics			
2,4-Dinitrotoluene	mg/kg	0.19	J
2,6-Dinitrotoluene	mg/kg	0.093	J
Anthracene	mg/kg	0.029	J
Benzo(a)anthracene	mg/kg	0.1	J
Benzo(a)pyrene	mg/kg	0.11	J
Benzo(b)fluoranthene	mg/kg	0.14	J
Benzo(ghi)perylene	mg/kg	0.076	J
Benzo(k)fluoranthene	mg/kg	0.1	J
Chrysene	mg/kg	0.12	J
Dibenz(a,h)anthracene	mg/kg	0.032	J
Fluoranthene	mg/kg	0.16	J
Indeno(1,2,3-cd)pyrene	mg/kg	0.078	J
Phenanthrene	mg/kg	0.057	J
Pyrene	mg/kg	0.14	J
Nitroaromatics (8330)			
2,4,6-Trinitrotoluene	mg/kg	4.8	
2,4-Dinitrotoluene	mg/kg	0.39	
2-Amino-4,6-dinitrotoluene	mg/kg	4.2	
4-Amino-2,6-dinitrotoluene	mg/kg	4.2	
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.78	
2-Amino-4,6-dinitrotoluene	mg/kg	0.29	
PCBs			
Aroclor 1254	mg/kg	0.53	N

Location		S017	
Sample No.		10660	
Sample Date		11-Nov-98	
Sample Depth (ft)		0.0-1.0	
Parameter	Units	Result	Qual
Semivolatile Organics			
2,4-Dinitrotoluene	mg/kg	0.18	J
2,6-Dinitrotoluene	mg/kg	0.081	J
Anthracene	mg/kg	0.032	J
Benzo(a)anthracene	mg/kg	0.07	J
Benzo(a)pyrene	mg/kg	0.081	J
Benzo(b)fluoranthene	mg/kg	0.078	J
Benzo(ghi)perylene	mg/kg	0.058	J
Benzo(k)fluoranthene	mg/kg	0.11	J
Chrysene	mg/kg	0.093	J
Fluoranthene	mg/kg	0.11	J
Indeno(1,2,3-cd)pyrene	mg/kg	0.058	J
Phenanthrene	mg/kg	0.047	J
Pyrene	mg/kg	0.097	J
Nitroaromatics (8330)			
2,4,6-Trinitrotoluene	mg/kg	3.8	
2,4-Dinitrotoluene	mg/kg	0.76	
2-Amino-4,6-dinitrotoluene	mg/kg	3.8	
4-Amino-2,6-dinitrotoluene	mg/kg	3	
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.40	
2-Amino-4,6-dinitrotoluene	mg/kg	0.18	
PCBs			
Aroclor 1260	mg/kg	0.099	N
Metals			
Lead	mg/kg	94.8	

Location		SS239	
Sample No.		10235	
Sample Date		2-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	6.1	
2,4-Dinitrotoluene	mg/kg		
2-Amino-4,6-dinitrotoluene	mg/kg	1.1	

LEGEND:

SS011	SCREENING SURFACE SOIL SAMPLING LOCATION
SS395	SUBSURFACE SCREENING SOIL SAMPLING LOCATION
SO40	SURFACE/SUBSURFACE SOIL SAMPLING CONFIRMATION LOCATION
TNTB-S6	HISTORICAL SOIL BORING LOCATION WITH EXPLOSIVES DETECTION
TNTB-S3	HISTORICAL SOIL BORING LOCATIONS
MK-MW17	MONITORING WELL LOCATION
	FORMER WASTEWATER FLUME LINE (UNDERGROUND)
	DRAINAGE CULVERT
	POTABLE WATER VALVE
	EXPANSION JOINT IN STEAM LINE
	DRAINAGE DITCH
	POTENTIAL REMEDIATION AREA

NOTES

1. NITROAROMATICS (IMS) - IMS SCREENING RESULTS
2. NITROAROMATICS (8330) - METHOD 8330 RESULTS
3. OVERBURDEN THICKNESS ESTIMATED TO BE APPROXIMATELY 3 FT.
4. SHADED CONCENTRATIONS INDICATE DETECTIONS EXCEEDING PRGs.
5. TOTAL REMEDIATION VOLUME IS ESTIMATED AT 300 YD^3.

AREA A:
ASSUMED DEPTH: 1.5 FT
ASSUMED DIMENSIONS: 20'X25'
VOLUME = 28 YD^3

AREA B:
ASSUMED DEPTH: 1.5 FT
ASSUMED DIMENSIONS: 20'X25'
VOLUME = 28 YD^3

AREA C:
ASSUMED DEPTH: 1.5 FT
ASSUMED DIMENSIONS: 45'X25'
VOLUME = 63 YD^3

AREA D:
ASSUMED DEPTH: 3 FT
ASSUMED DIMENSIONS: 65'X25'
VOLUME = 181 YD^3

SCALE
0 30 60 FEET

NO	DATE	REVISION	BY	CHKD	DSGN ENGR	ENGR	PROJ MGR	APPR

STARTING DATE 03/18/99 | INITIATOR M. GUNDERSON | CHKD MUFFLER | DRAWN VANDERGRIFF | CHKD C. TUMLIN | PROJECT MNGR M. SPANGBERG

IT CORPORATION
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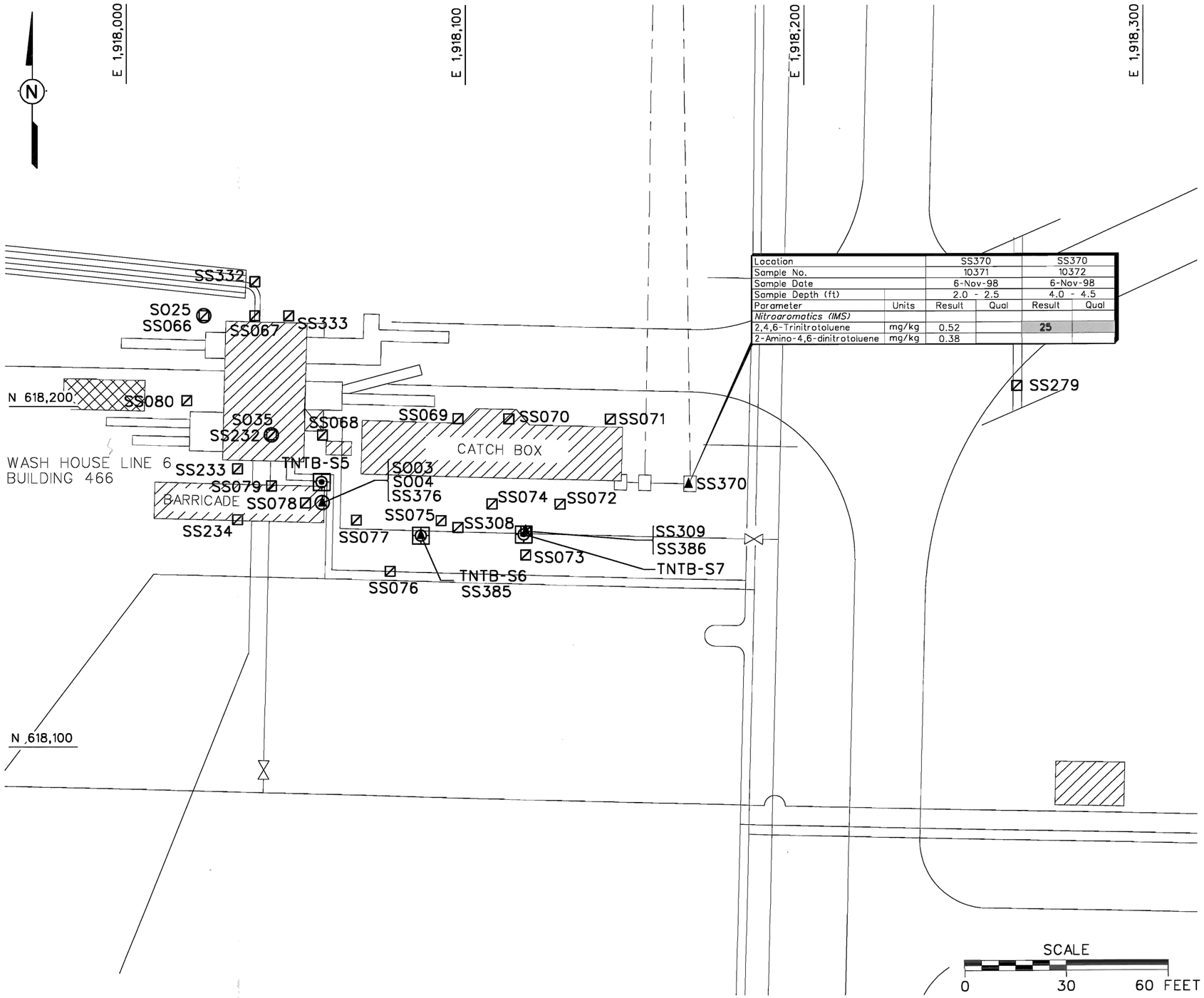
KNOXVILLE, TENNESSEE

FIGURE 1-6
BUILDING 417 WASTEWATER SETTLING TANKS SAMPLE LOCATIONS, ANALYTICAL RESULTS, AND POTENTIAL REMEDIATION AREAS

PLUMB ROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

AREA	JOB NO.	DRAWING NO.	REV
	775616	775616ES.055	

bvanderg 11/18/00 03:10:57 c:\cadd\design\775616es.055



Location		SS370		SS370	
Sample No.		10371		10372	
Sample Date		6-Nov-98		6-Nov-98	
Sample Depth (ft)		2.0 - 2.5		4.0 - 4.5	
Parameter	Units	Result	Qual	Result	Qual
Nitroaromatics (IMS)					
2,4,6-Trinitrotoluene	mg/kg	0.52		25	
2-Amino-4,6-dinitrotoluene	mg/kg	0.38			

LEGEND:

- SS017 — SCREENING SURFACE SOIL SAMPLING LOCATION
- SS390 — SUBSURFACE SCREENING SOIL SAMPLING LOCATION
- S040 — SURFACE/SUBSURFACE SOIL SAMPLING CONFIRMATION LOCATION
- TNTB-S7 — HISTORICAL SOIL BORING LOCATION WITH EXPLOSIVES DETECTION
- POTABLE WATER VALVE
- DRAINAGE CULVERT
- EXPANSION JOINT IN STEAM LINE
- FORMER WASTEWATER FLUME LINE (UNDERGROUND)

NOTES:

1. NITROAROMATICS (IMS) - IMS SCREENING RESULTS.
2. FIGURE IS INTENDED TO ONLY SHOW ANALYTICAL RESULTS FOR SS370, A SUBSURFACE SOIL SAMPLE LOCATION COLLECTED TO INVESTIGATE THE UNDERGROUND WASTEWATER PIPELINE. ALL OTHER SAMPLE LOCATIONS SHOWN FOR INFORMATION PURPOSES ONLY. ANALYTICAL RESULTS FOR OTHER SAMPLE LOCATIONS ARE SHOWN IN FIGURE 1-18.
3. CONTAMINATED AREA LUMPED WITH AREA ON FIGURE 1-18.

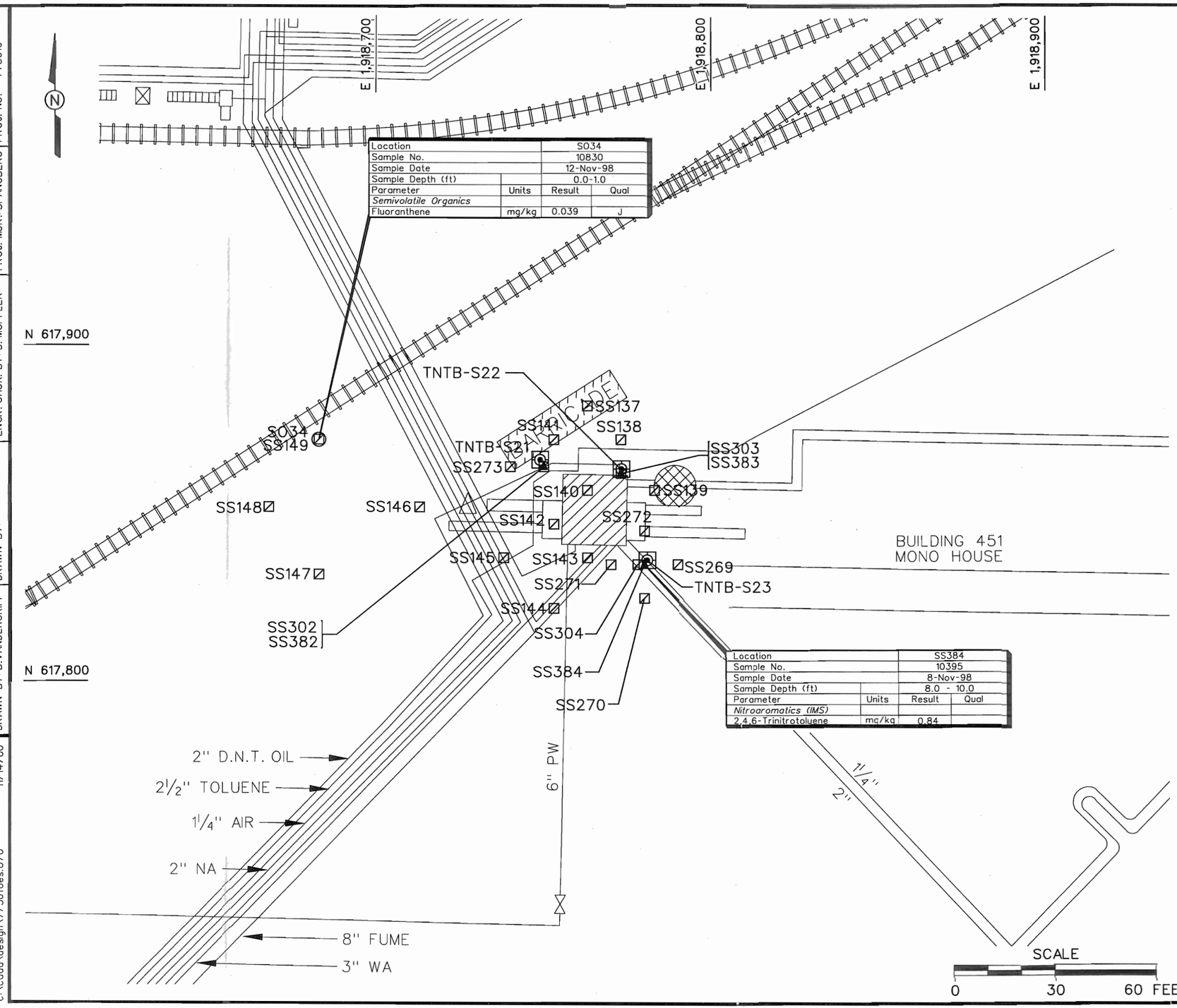
SCALE
0 30 60 FEET

FIGURE 1-7
WASTEWATER PIPELINE SAMPLE LOCATIONS AND ANALYTICAL RESULTS

PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

IT CORPORATION
A Member of The IT Group

DRAFT. CHCK. BY: C. TUMLIN | INITIATOR: GUNDERSON | DWG. NO.:..\775616es.069
ENGR. CHCK. BY: S. MUFFLER | PROJ. MGR.:SPANGBERG | PROJ. NO.: 775616
STARTING DATE: 03/23/99 | DATE LAST REV.:
DRAWN BY: B. VANDERGRIFF | DRAWN BY:
03:35:35 11/14/00
bvanderg c:\cadd\design\775616es.069



Location		S034	
Sample No.		10830	
Sample Date		12-Nov-98	
Sample Depth (ft)		0.0-1.0	
Parameter	Units	Result	Qual
Semivolatile Organics			
Fluoranthene	mg/kg	0.039	J

Location		SS384	
Sample No.		10395	
Sample Date		8-Nov-98	
Sample Depth (ft)		8.0 - 10.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.84	

LEGEND:

SS011	SCREENING SURFACE SOIL SAMPLING LOCATION
SS395	SUBSURFACE SCREENING SOIL SAMPLING LOCATION
S034	SURFACE/SUBSURFACE SOIL SAMPLE CONFIRMATION LOCATION
TNTB-S6	HISTORICAL SOIL BORING LOCATION WITH EXPLOSIVES DETECTION
	RAILROAD TRACK
	POTABLE WATER VALVE
	EXPANSION JOINT IN STEAM LINE
	TANK

NOTES:

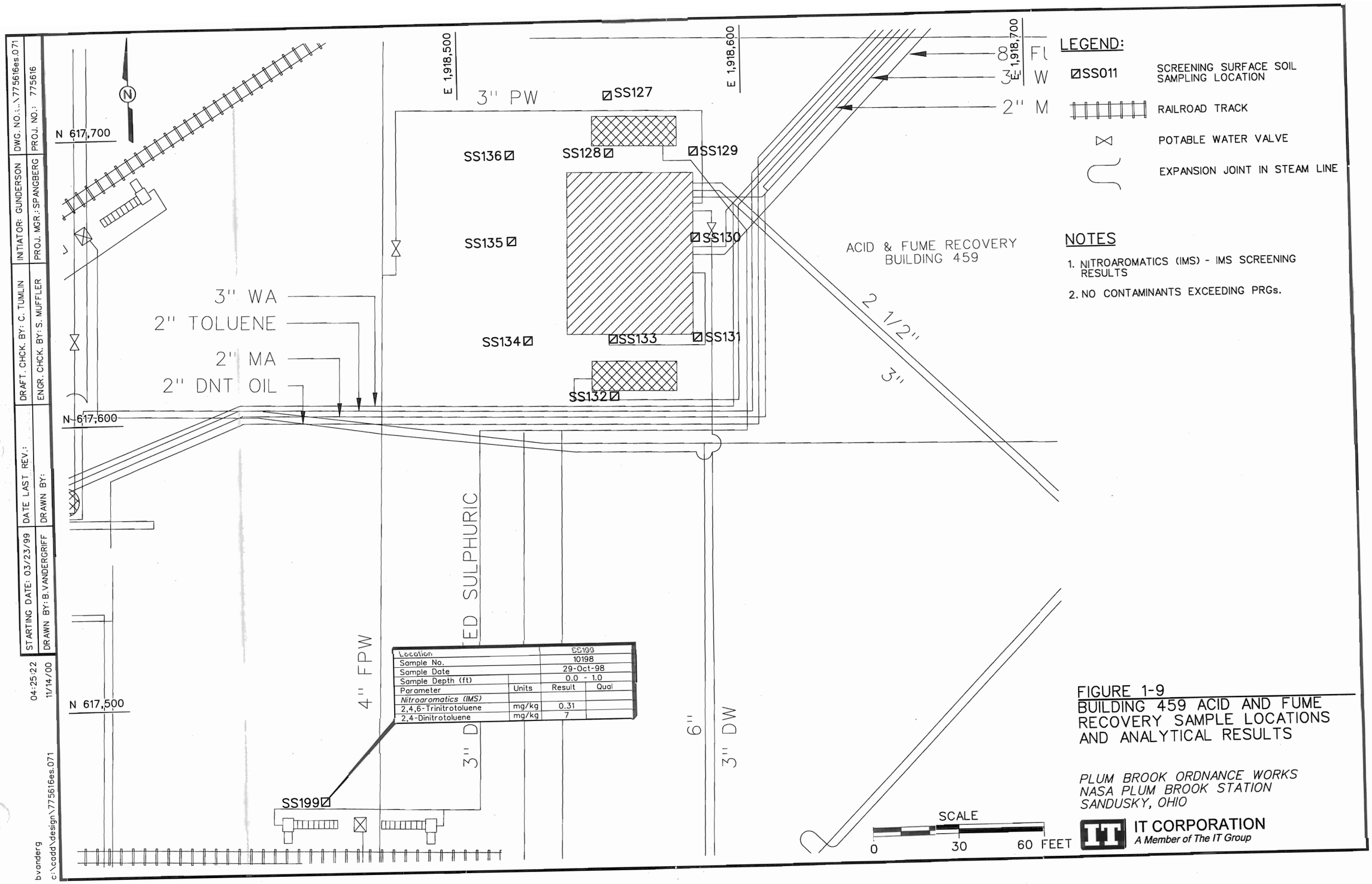
1. NITROAROMATICS (IMS) - IMS SCREENING RESULTS
2. NITROAROMATICS (8330) - METHOD 8330 RESULTS
3. NO CONTAMINANTS EXCEEDING PRGs.

FIGURE 1-8
BUILDING 451 MONO HOUSE
SAMPLE LOCATIONS AND
ANALYTICAL RESULTS

PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

IT CORPORATION
A Member of The IT Group

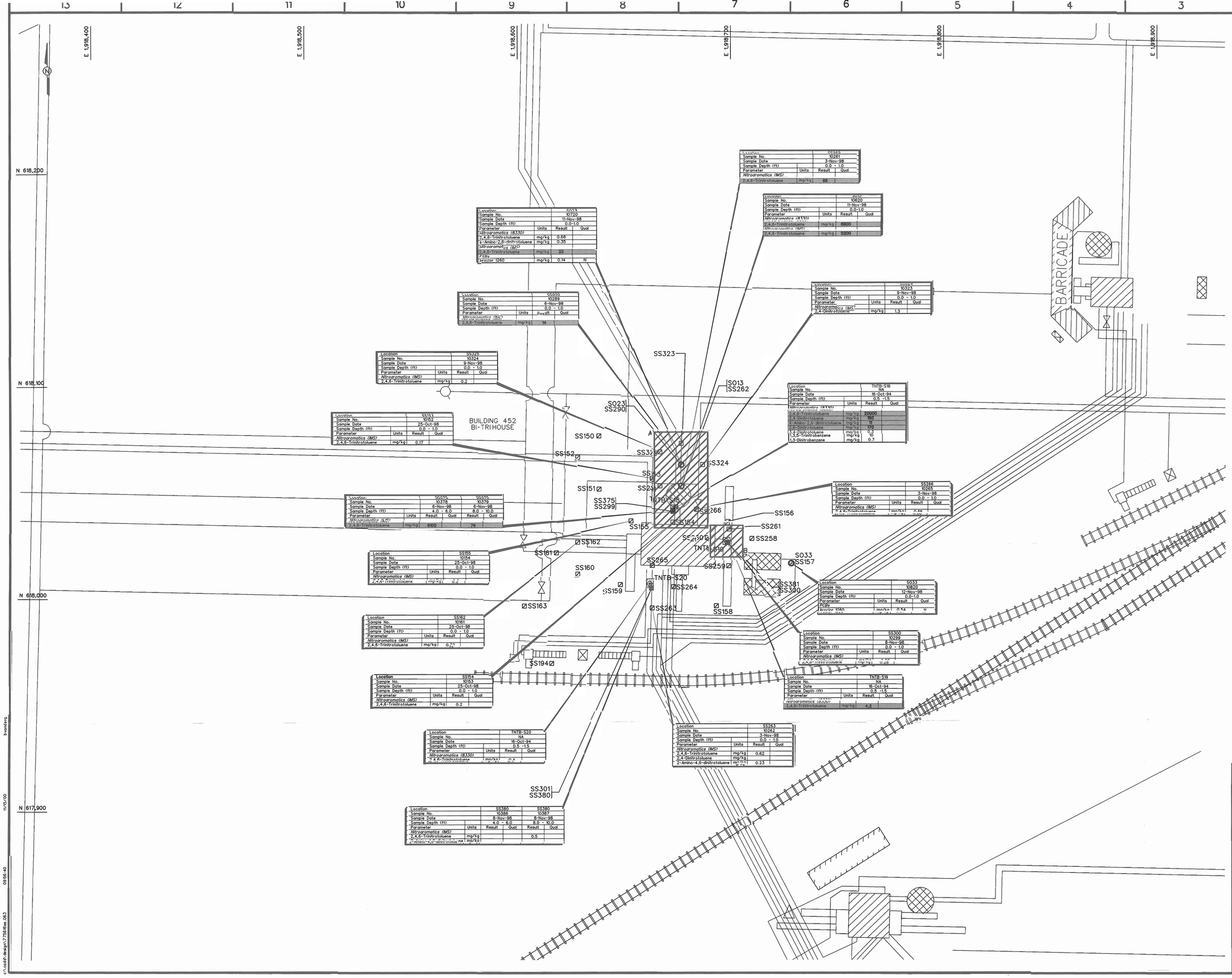
DWG. NO.: \775616es.070
PROJ. NO.: 775616
INITIATOR: GUNDERSON
PROJ. MGR.: SPANGBERG
DRAFT. CHCK. BY: C. TUMLIN
ENGR. CHCK. BY: S. MUFFLER
DATE LAST REV.:
DRAWN BY:
STARTING DATE: 03/19/99
DRAWN BY: B.VANDERGRIFF
03:39:32
11/14/00
bvanderg
c:\cadd\design\775616es.070



Location		SS199	
Sample No.		10198	
Sample Date		29-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.31	
2,4-Dinitrotoluene	mg/kg	7	

FIGURE 1-9
BUILDING 459 ACID AND FUME RECOVERY SAMPLE LOCATIONS AND ANALYTICAL RESULTS

PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO



Location		SS011	
Sample No.		10720	
Sample Date		11-Nov-98	
Sample Depth (ft)		0.0-1.0	
Parameter	Units	Result	Qual
Nitroaromatics (8330)			
2,4,6-Trinitrotoluene	mg/kg	0.68	
4-Amino-2,6-dinitrotoluene	mg/kg	0.35	
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	33	
PCBs			
Aroclor 1260	mg/kg	0.14	N

Location		SS395	
Sample No.		10261	
Sample Date		3-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	68	

Location		S010	
Sample No.		10620	
Sample Date		11-Nov-98	
Sample Depth (ft)		0.0-1.0	
Parameter	Units	Result	Qual
Nitroaromatics (8330)			
2,4,6-Trinitrotoluene	mg/kg	6900	
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	5200	

Location		SS005	
Sample No.		10289	
Sample Date		6-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	16	

Location		SS024	
Sample No.		10323	
Sample Date		9-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4-Dinitrotoluene	mg/kg	1.3	

Location		SS329	
Sample No.		10324	
Sample Date		9-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.2	

Location		TNTB-S16	
Sample No.		NA	
Sample Date		16-Oct-94	
Sample Depth (ft)		0.5 -1.5	
Parameter	Units	Result	Qual
Nitroaromatics (8330)			
2,4,6-Trinitrotoluene	mg/kg	20000	
2,4-Dinitrotoluene	mg/kg	150	
4-Amino-2,6-dinitrotoluene	mg/kg	11	
2,6-Dinitrotoluene	mg/kg	170	
1,4-Dinitrotoluene	mg/kg	0.3	
1,3,5-Trinitrobenzene	mg/kg	10	
1,3-Dinitrobenzene	mg/kg	0.7	

Location		SS015	
Sample No.		10152	
Sample Date		25-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.17	

Location		SS316		SS316	
Sample No.		10378		10379	
Sample Date		6-Nov-98		6-Nov-98	
Sample Depth (ft)		4.0 - 6.0		8.0 - 10.0	
Parameter	Units	Result	Qual	Result	Qual
Nitroaromatics (IMS)					
2,4,6-Trinitrotoluene	mg/kg	9100		78	

Location		SS266	
Sample No.		10265	
Sample Date		3-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.68	

Location		SS155	
Sample No.		10154	
Sample Date		25-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.2	

Location		S033	
Sample No.		10820	
Sample Date		12-Nov-98	
Sample Depth (ft)		0.0-1.0	
Parameter	Units	Result	Qual
PCBs			
Aroclor 1260	mg/kg	0.54	N

Location		SS162	
Sample No.		10361	
Sample Date		25-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.72	

Location		SS300	
Sample No.		10299	
Sample Date		8-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.69	

Location		SS154	
Sample No.		10153	
Sample Date		25-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.2	

Location		TNTB-S19	
Sample No.		NA	
Sample Date		16-Oct-94	
Sample Depth (ft)		0.5 -1.5	
Parameter	Units	Result	Qual
Nitroaromatics (8330)			
2,4,6-Trinitrotoluene	mg/kg	4.2	

Location		TNTB-S20	
Sample No.		NA	
Sample Date		16-Oct-94	
Sample Depth (ft)		0.5 -1.5	
Parameter	Units	Result	Qual
Nitroaromatics (8330)			
2,4,6-Trinitrotoluene	mg/kg	0.4	

Location		SS263	
Sample No.		10262	
Sample Date		3-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.62	
2,4-Dinitrotoluene	mg/kg		
2-Amino-4,6-dinitrotoluene	mg/kg	0.23	

Location		SS380		SS380	
Sample No.		10386		10387	
Sample Date		8-Nov-98		8-Nov-98	
Sample Depth (ft)		4.0 - 6.0		8.0 - 10.0	
Parameter	Units	Result	Qual	Result	Qual
Nitroaromatics (IMS)					
2,4,6-Trinitrotoluene	mg/kg			0.5	
2-Amino-4,6-dinitrotoluene	mg/kg				

LEGEND:

SS011	SCREENING SURFACE SOIL SAMPLING LOCATION
SS395	SUBSURFACE SCREENING SOIL SAMPLING LOCATION
S034	SURFACE/SUBSURFACE SOIL SAMPLE CONFIRMATION LOCATION
TNTB-S6	HISTORICAL SOIL BORING LOCATION WITH EXPLOSIVES DETECTION
	RAILROAD TRACK
	FIRE HYDRANTS
	POTABLE WATER VALVE
	EXPANSION JOINT IN STEAM LINE
	TANK
	POTENTIAL REMEDIATION AREA

NOTES

1. NITROAROMATICS (IMS) - IMS SCREENING RESULTS
2. NITORAROMATICS (8330) - METHOD 8330 RESULTS
3. OVERBURDEN THICKNESS GREATER THAN 10 FT.
4. SHADED CONCENTRATIONS INDICATE DETECTIONS EXCEEDING PRGs.
5. TOTAL REMEDIATION VOLUME IS ESTIMATED AT 500 YD^3.

AREA A:
ASSUMED DEPTH: 10 FT
ASSUMED DIMENSIONS: 25'X45'
VOLUME = 417 YD^3

AREA B:
ASSUMED DEPTH: 10 FT
ASSUMED DIMENSIONS: 15'X15'
VOLUME = 83 YD^3

SCALE
0 20 40 FEET

NO	DATE	REVISION	BY	CHKD	DSGN ENGR	ENGR	PROJ MGR	APPR

STARTING DATE	INITIATOR	CHKD	DRAWN	CHKD	PROJECT MNGR
11/13/00	M. GUNDERSON	MG	RKV	TUMLIN	M. SPANGBERG

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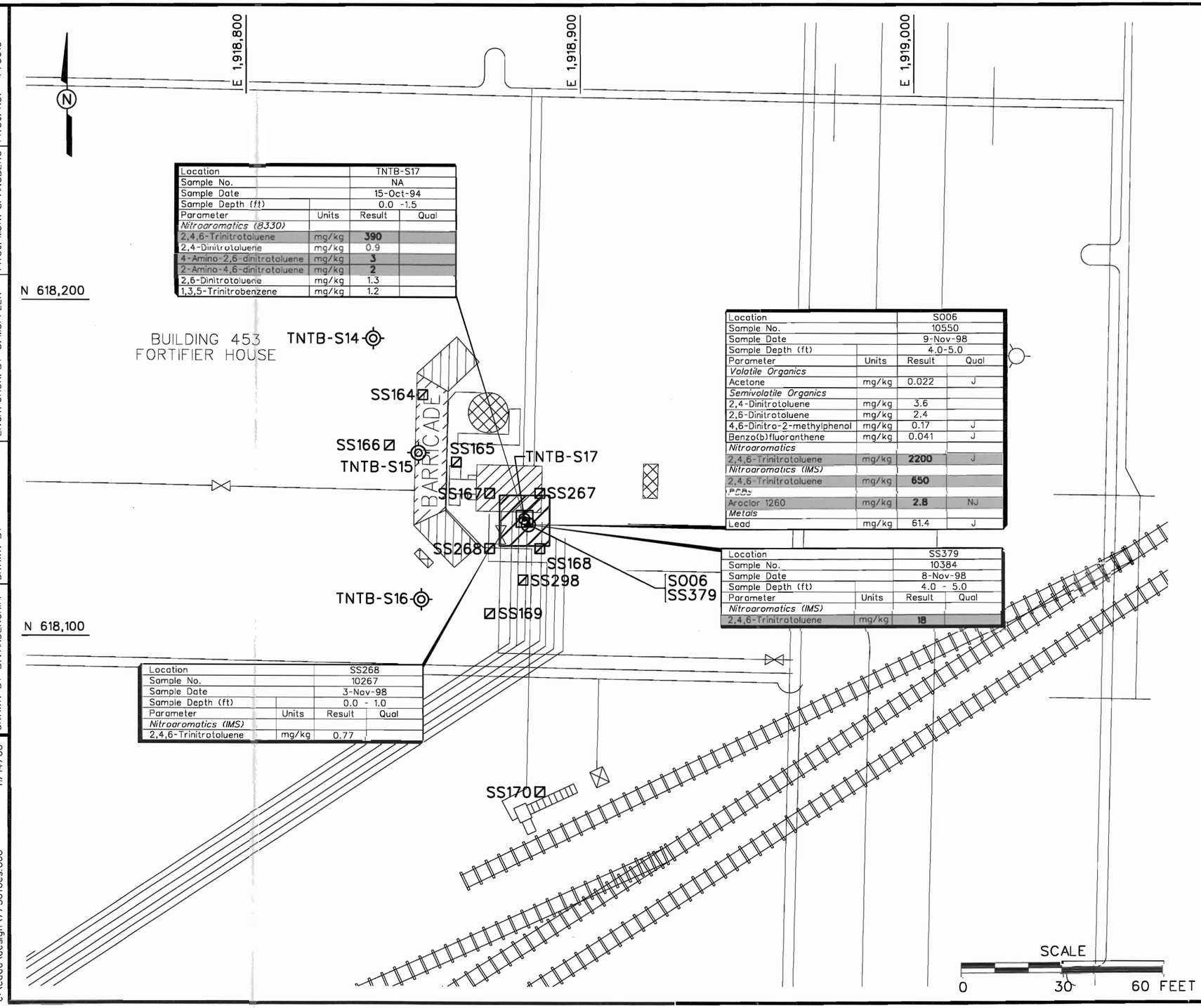
FIGURE 1-10
BUILDING 452 BI-TRI HOUSE, SAMPLE LOCATIONS, ANALYTICAL RESULTS, AND POTENTIAL REMEDIATION AREAS

PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

AREA	JOB NO.	DRAWING NO.	REV
	775616	775616ES.063	

c:\cadd\design\775616es.063 09:56:40 11/15/00 bondberg



Location		TNTB-S17	
Sample No.		NA	
Sample Date		15-Oct-94	
Sample Depth (ft)		0.0 -1.5	
Parameter	Units	Result	Qual
Nitroaromatics (8330)			
2,4,6-Trinitrotoluene	mg/kg	**390**	
2,4-Dinitrotoluene	mg/kg	0.9	
4-Amino-2,6-dinitrotoluene	mg/kg	**3**	
2-Amino-4,6-dinitrotoluene	mg/kg	**2**	
2,6-Dinitrotoluene	mg/kg	1.3	
1,3,5-Trinitrobenzene	mg/kg	1.2	

Location		S006	
Sample No.		10550	
Sample Date		9-Nov-98	
Sample Depth (ft)		4.0-5.0	
Parameter	Units	Result	Qual
Volatile Organics			
Acetone	mg/kg	0.022	J
Semivolatile Organics			
2,4-Dinitrotoluene	mg/kg	3.6	
2,6-Dinitrotoluene	mg/kg	2.4	
4,6-Dinitro-2-methylphenol	mg/kg	0.17	J
Benzo(b)fluoranthene	mg/kg	0.041	J
Nitroaromatics			
2,4,6-Trinitrotoluene	mg/kg	**2200**	J
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	**650**	
PCBs			
Aroclor 1260	mg/kg	**2.8**	NJ
Metals			
Lead	mg/kg	61.4	J

Location		SS379	
Sample No.		10384	
Sample Date		8-Nov-98	
Sample Depth (ft)		4.0 - 5.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	**18**	

Location		SS268	
Sample No.		10267	
Sample Date		3-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.77	

LEGEND:

- ▲SS395 — SCREENING SURFACE SOIL SAMPLING LOCATION
- ⊠SS011 — SUBSURFACE SCREENING SOIL SAMPLING LOCATION
- ○S034 — SURFACE/SUBSURFACE SOIL SAMPLE CONFIRMATION LOCATION
- TNTB-S6 — HISTORICAL SOIL BORING LOCATION WITH EXPLOSIVES DETECTION
- TNTB-S3 — HISTORICAL SOIL BORING LOCATIONS
- RAILROAD TRACK
- FIRE HYDRANTS
- POTABLE WATER VALVE
- EXPANSION JOINT IN STEAM LINE
- TANK
- POTENTIAL REMEDIATION AREA

NOTES

1. NITROAROMATICS (IMS) - IMS SCREENING RESULTS
2. NITORAROMATICS (8330) - METHOD 8330 RESULTS
3. OVERBURDEN THICKNESS ESTIMATED AT APPROXIMATELY 8.5 FT.
4. SHADED CONCENTRATIONS INDICATE DETECTIONS EXCEEDING PRGs.
5. REMEDIATION AREA:

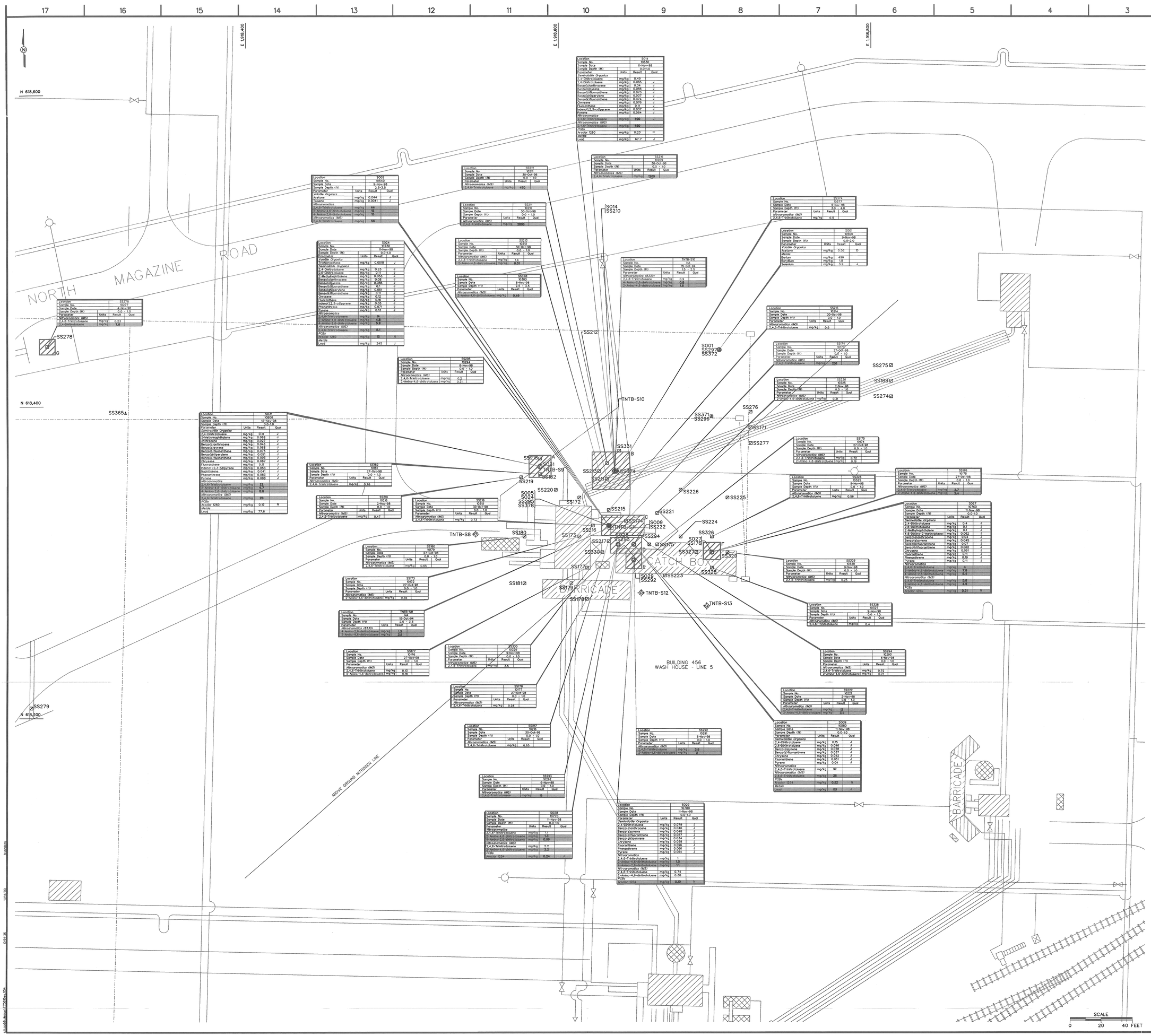
   ASSUMED DEPTH: 8.5 FT
   ASSUMED DIMENSIONS: 15'X15'
   VOLUME = 71 YD^3

FIGURE 1-11
BUILDING 453 FORTIFIER HOUSE SAMPLE LOCATIONS, ANALYTICAL RESULTS, AND POTENTIAL REMEDIATION AREAS

PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

IT CORPORATION
A Member of The IT Group

DWG. NO.:..\775616es.060 | PROJ. NO.: 775616
INITIATOR: GUNDERSON | PROJ. MGR.: SPANGBERG
DRAFT. CHCK. BY: C. TUMLIN | ENGR. CHCK. BY: S. MUFFLER
DATE LAST REV.: | DRAWN BY:
STARTING DATE: 03/22/99 | DRAWN BY: B.VANDERGRIFF
02:05:15 11/14/00
bvanderg c:\cadd\design\775616es.060



LEGEND:

- SS011 — SCREENING SURFACE SOIL SAMPLING LOCATION
- SS395 — SUBSURFACE SCREENING SOIL SAMPLING LOCATION
- SO34 — SURFACE/SUBSURFACE SOIL SAMPLE CONFIRMATION LOCATION
- TNTB-S6 — HISTORICAL SOIL BORING LOCATION WITH EXPLOSIVES DETECTION
- TNTB-S3 — HISTORICAL SOIL BORING LOCATIONS
- FORMER WASTEWATER FLUME LINE (UNDERGROUND)
- RAILROAD TRACK
- FIREHYDRANTS
- POTABLE WATER VALVE
- EXPANSION JOINT IN STEAM LINE
- POTENTIAL REMEDIATION AREA

NOTES:

1. NITROAROMATICS (IMS) - IMS SCREENING RESULTS
2. NITROAROMATICS (8330) - METHOD 8330 RESULTS
3. OVERBURDEN THICKNESS ESTIMATED TO BE APPROXIMATELY 4 FT.
4. SHADED CONCENTRATIONS INDICATE DETECTIONS EXCEEDING PRGs.
5. TOTAL REMEDIATION VOLUME IS ESTIMATED AT 161 YD^3.

AREA A:
ASSUMED DEPTH: 4 FT
ASSUMED DIMENSION: 14'X14'
VOLUME = 29 YD^3

AREA B:
ASSUMED DEPTH: 4 FT
ASSUMED DIMENSION: 24'X24'
VOLUME = 85 YD^3

AREA C:
ASSUMED DEPTH: 4 FT
ASSUMED DIMENSION: 27'X13'
VOLUME = 52 YD^3

AREA D:
ASSUMED DEPTH: 4 FT
ASSUMED DIMENSION: 20'X10'
VOLUME = 30 YD^3

AREA E:
ASSUMED DEPTH: 4 FT
ASSUMED DIMENSION: 10'X10'
VOLUME = 15 YD^3

AREA F:
ASSUMED DEPTH: 4 FT
ASSUMED DIMENSION: 10'X10'
VOLUME = 15 YD^3

AREA G:
ASSUMED DEPTH: 4 FT
ASSUMED DIMENSION: 10'X10'
VOLUME = 15 YD^3

NO	DATE	REVISION	BY	CHKD	DSGN ENGR	ENGR	PROJ MGR	APPR

STARTING DATE	INITIATOR	CHKD	DRAWN	CHKD	PROJECT MNGR
03/22/99	M. GUNDERSON	MUFFLER	VANDERGRIFF/ C. TUMLIN		M. SPANGBERG

IT CORPORATION
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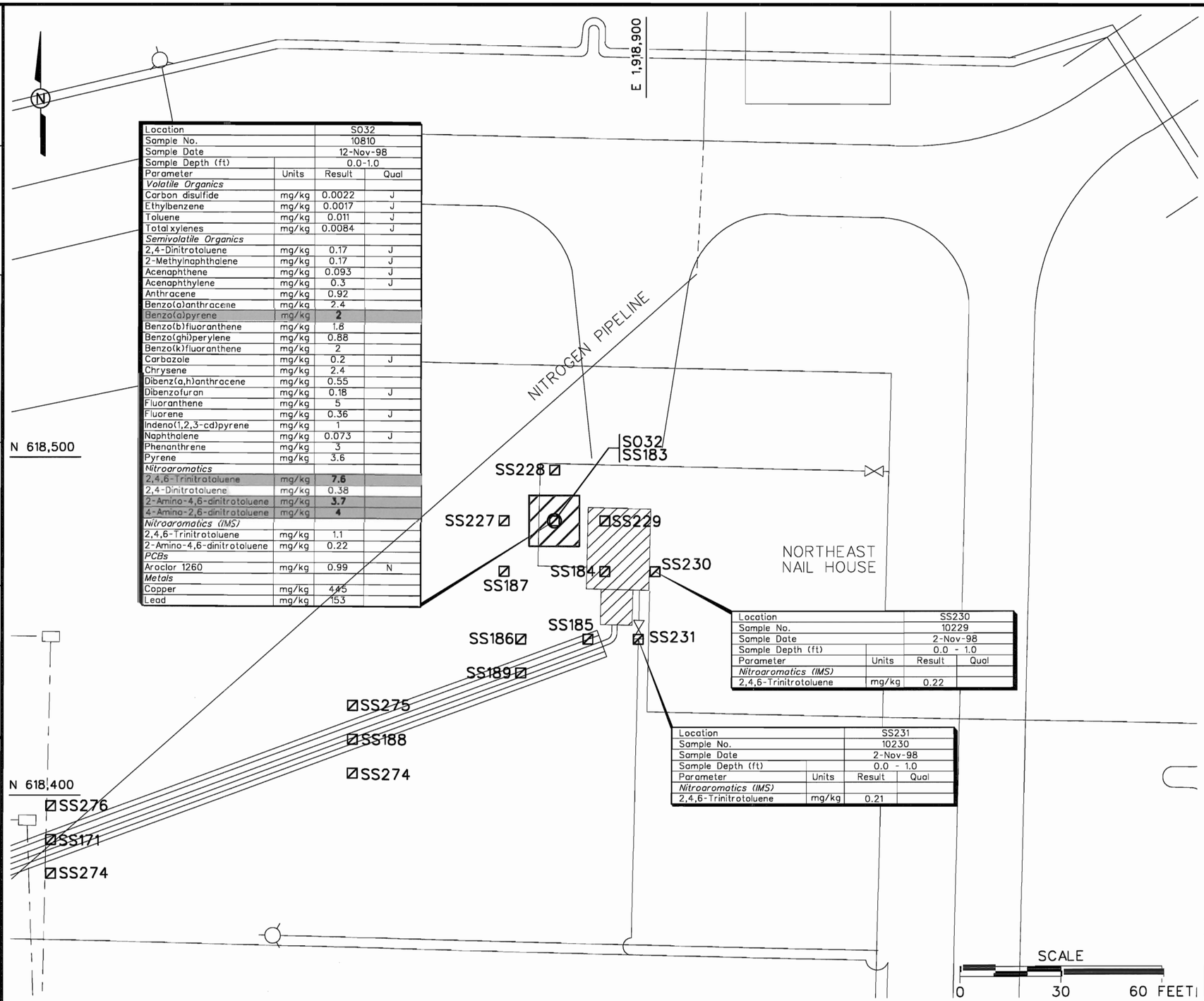
KNOXVILLE, TENNESSEE

FIGURE 1-12
BUILDING 456 WASH HOUSE SAMPLE LOCATIONS, ANALYTICAL RESULTS, AND POTENTIAL REMEDIATION AREAS

PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

AREA	JOB NO.	DRAWING NO.	REV
	775616	775616ES.054	



Location		S032	
Sample No.		10810	
Sample Date		12-Nov-98	
Sample Depth (ft)		0.0-1.0	
Parameter	Units	Result	Qual
Volatile Organics			
Carbon disulfide	mg/kg	0.0022	J
Ethylbenzene	mg/kg	0.0017	J
Toluene	mg/kg	0.011	J
Total xylenes	mg/kg	0.0084	J
Semivolatile Organics			
2,4-Dinitrotoluene	mg/kg	0.17	J
2-Methylnaphthalene	mg/kg	0.17	J
Acenaphthene	mg/kg	0.093	J
Acenaphthylene	mg/kg	0.3	J
Anthracene	mg/kg	0.92	
Benzo(a)anthracene	mg/kg	2.4	
Benzo(a)pyrene	mg/kg	**2**	
Benzo(b)fluoranthene	mg/kg	1.8	
Benzo(ghi)perylene	mg/kg	0.88	
Benzo(k)fluoranthene	mg/kg	2	
Carbazole	mg/kg	0.2	J
Chrysene	mg/kg	2.4	
Dibenz(a,h)anthracene	mg/kg	0.55	
Dibenzofuran	mg/kg	0.18	J
Fluoranthene	mg/kg	5	
Fluorene	mg/kg	0.36	J
Indeno(1,2,3-cd)pyrene	mg/kg	1	
Naphthalene	mg/kg	0.073	J
Phenanthrene	mg/kg	3	
Pyrene	mg/kg	3.6	
Nitroaromatics			
2,4,6-Trinitrotoluene	mg/kg	**7.6**	
2,4-Dinitrotoluene	mg/kg	0.38	
2-Amino-4,6-dinitrotoluene	mg/kg	**3.7**	
4-Amino-2,6-dinitrotoluene	mg/kg	**4**	
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	1.1	
2-Amino-4,6-dinitrotoluene	mg/kg	0.22	
PCBs			
Aroclor 1260	mg/kg	0.99	N
Metals			
Copper	mg/kg	445	
Lead	mg/kg	153	

Location		SS230	
Sample No.		10229	
Sample Date		2-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.22	

Location		SS231	
Sample No.		10230	
Sample Date		2-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.21	

LEGEND:

- SS011 — SCREENING SURFACE SOIL SAMPLING LOCATION
- SS395 — SUBSURFACE SCREENING SOIL SAMPLING LOCATION
- S034 — SURFACE/SUBSURFACE SOIL SAMPLE CONFIRMATION LOCATION
- FIRE HYDRANTS
- POTABLE WATER VALVE
- FORMER WASTEWATER FLUME LINE (UNDERGROUND)
- POTENTIAL REMEDIATION AREA

NOTES

1. NITROAROMATICS (IMS) - IMS SCREENING RESULTS
2. NITROAROMATICS (8330) - METHOD 8330 RESULTS
3. BENZO(A)PYRENE ASSUMED TO BE PRESENT ONLY IN SURFACE SOIL.
4. SHADED CONCENTRATIONS INDICATE DETECTIONS EXCEEDING PRGs.
5. REMEDIATION AREA:

   ASSUMED DEPTH: 4 FT
   ASSUMED DIMENSIONS: 15'X15'
   VOLUME = 33 YD^3

FIGURE 1-13
NORTHEAST NAIL HOUSE SAMPLE LOCATIONS, ANALYTICAL RESULTS, AND POTENTIAL REMEDIATION AREAS

PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

IT CORPORATION
A Member of The IT Group

DWG. NO.: \775616es.059
PROJ. NO.: 775616
INITIATOR: GUNDERSON
PROJ. MGR.: SPANGBERG
DRAFT. CHCK. BY: C. TUMLIN
ENGR. CHCK. BY: S. MUFFLER
DATE LAST REV.:
DRAWN BY:
STARTING DATE: 03/23/99
DRAWN BY: B.VANDERGRIFF
02:01:58
11/14/00
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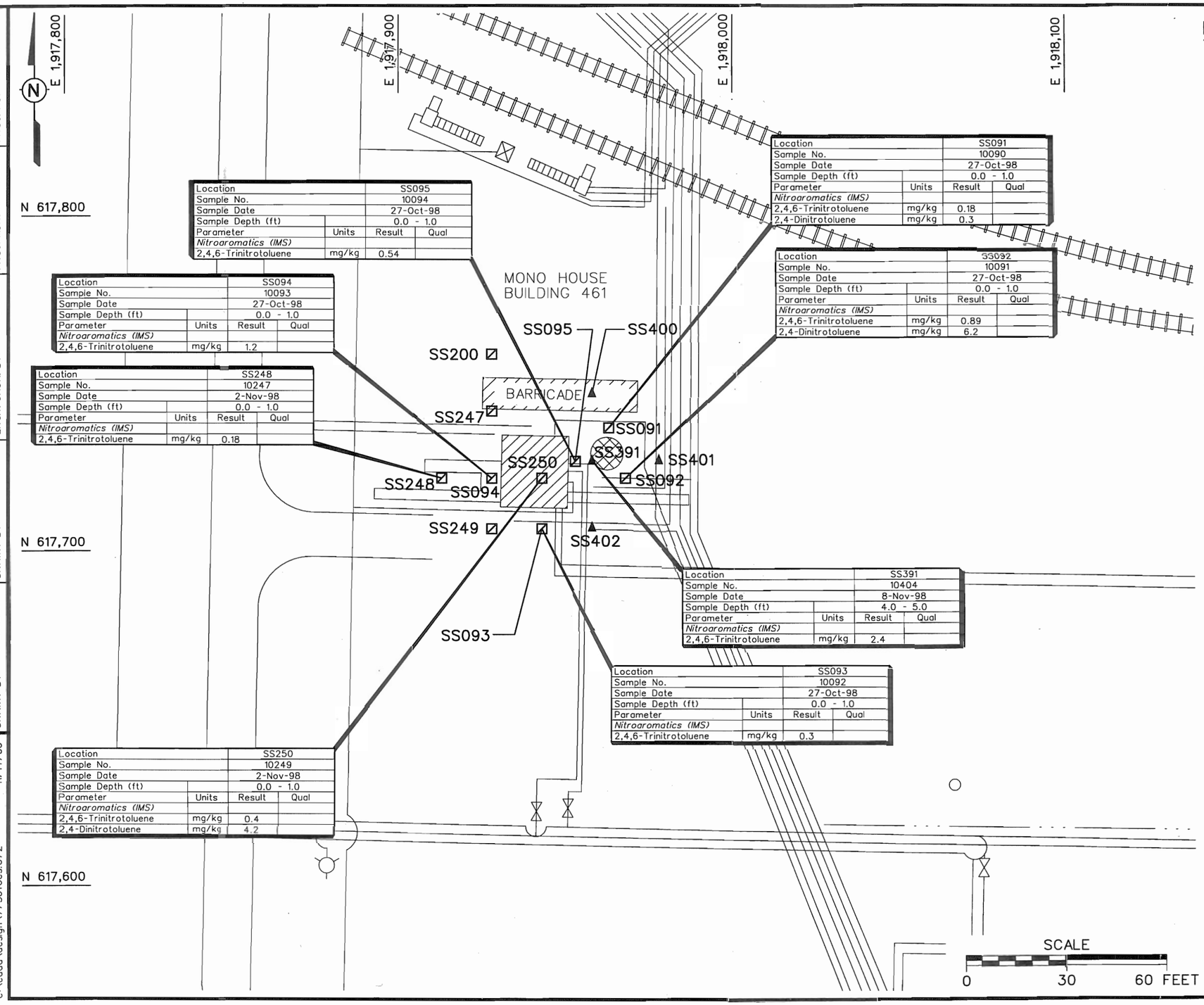

Location		SS095	
Sample No.		10094	
Sample Date		27-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.54	

Location		SS094	
Sample No.		10093	
Sample Date		27-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	1.2	

Location		SS248	
Sample No.		10247	
Sample Date		2-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.18	

Location		SS091	
Sample No.		10090	
Sample Date		27-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.18	
2,4-Dinitrotoluene	mg/kg	0.3	

Location		SS092	
Sample No.		10091	
Sample Date		27-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.89	
2,4-Dinitrotoluene	mg/kg	6.2	

Location		SS391	
Sample No.		10404	
Sample Date		8-Nov-98	
Sample Depth (ft)		4.0 - 5.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	2.4	

Location		SS093	
Sample No.		10092	
Sample Date		27-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.3	

Location		SS250	
Sample No.		10249	
Sample Date		2-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.4	
2,4-Dinitrotoluene	mg/kg	4.2	

LEGEND:

- SS017 — SCREENING SURFACE SOIL SAMPLING LOCATION
- SS390 — SUBSURFACE SCREENING SOIL SAMPLING LOCATION
- RAILROAD TRACK
- POTABLE WATER VALVE
- FIRE HYDRANTS
- TANK
- DRAINAGE DITCH

NOTES:

1. NITROAROMATICS (IMS) - IMS SCREENING RESULTS.
2. NO CONTAMINANTS EXCEEDING PRGs.

SCALE

0 30 60 FEET

FIGURE 1-14
BUILDING 461 MONO HOUSE
SAMPLE LOCATIONS AND
ANALYTICAL RESULTS

PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

IT CORPORATION
A Member of The IT Group

STARTING DATE: 03/23/99	DATE LAST REV.:	DRAFT. CHCK. BY: C. TUMLIN	INITIATOR: GUNDERSON	DWG. NO.:\775616es.072
DRAWN BY: T. BRADSHAW	DRAWN BY:	ENGR. CHCK. BY: S. MUFFLER	PROJ. MGR.: SPANGBERG	PROJ. NO.: 775616

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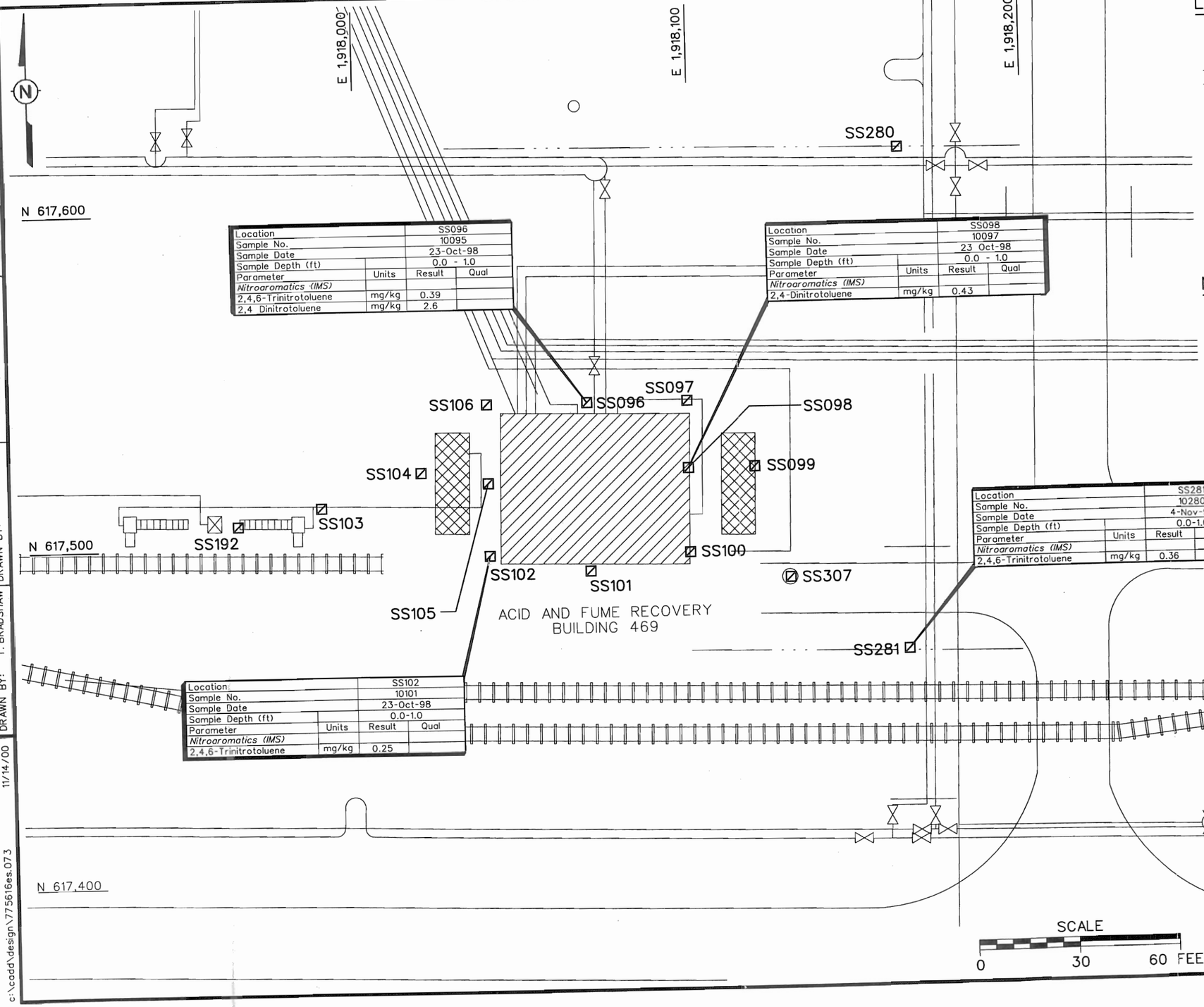

Location		SS096	
Sample No.		10095	
Sample Date		23-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.39	
2,4 Dinitrotoluene	mg/kg	2.6	

Location		SS098	
Sample No.		10097	
Sample Date		23 Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4-Dinitrotoluene	mg/kg	0.43	

Location		SS281	
Sample No.		10280	
Sample Date		4-Nov-98	
Sample Depth (ft)		0.0-1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.36	

Location		SS102	
Sample No.		10101	
Sample Date		23-Oct-98	
Sample Depth (ft)		0.0-1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.25	

LEGEND:

- SS011 — SURFACE SCREENING SOIL SAMPLING LOCATION
- RAILROAD TRACK
- POTABLE WATER VALVE
- EXPANSION JOINT IN STEAM LINE
- DRAINAGE DITCH
- MANHOLE

NOTES:

1. NITROAROMATICS (IMS) - IMS SCREENING RESULTS
2. NO CONTAMINANTS EXCEEDING PRGs.

SCALE
0 30 60 FEET

FIGURE 1-15
BUILDING 469
ACID AND FUME RECOVERY
SAMPLE LOCATIONS AND
ANALYTICAL RESULTS

PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

IT CORPORATION
A Member of The IT Group

DWG. NO.: \775616es.073
PROJ. NO.: 775616
INITIATOR: GUNDERSON
PROJ. MGR.: SPANGBERG
DRAFT. CHCK. BY: C. TUMLIN
ENGR. CHCK. BY: S. MUFFLER
DATE LAST REV.:
DRAWN BY:
STARTING DATE: 03/22/99
DRAWN BY: T. BRADSHAW
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11/14/00
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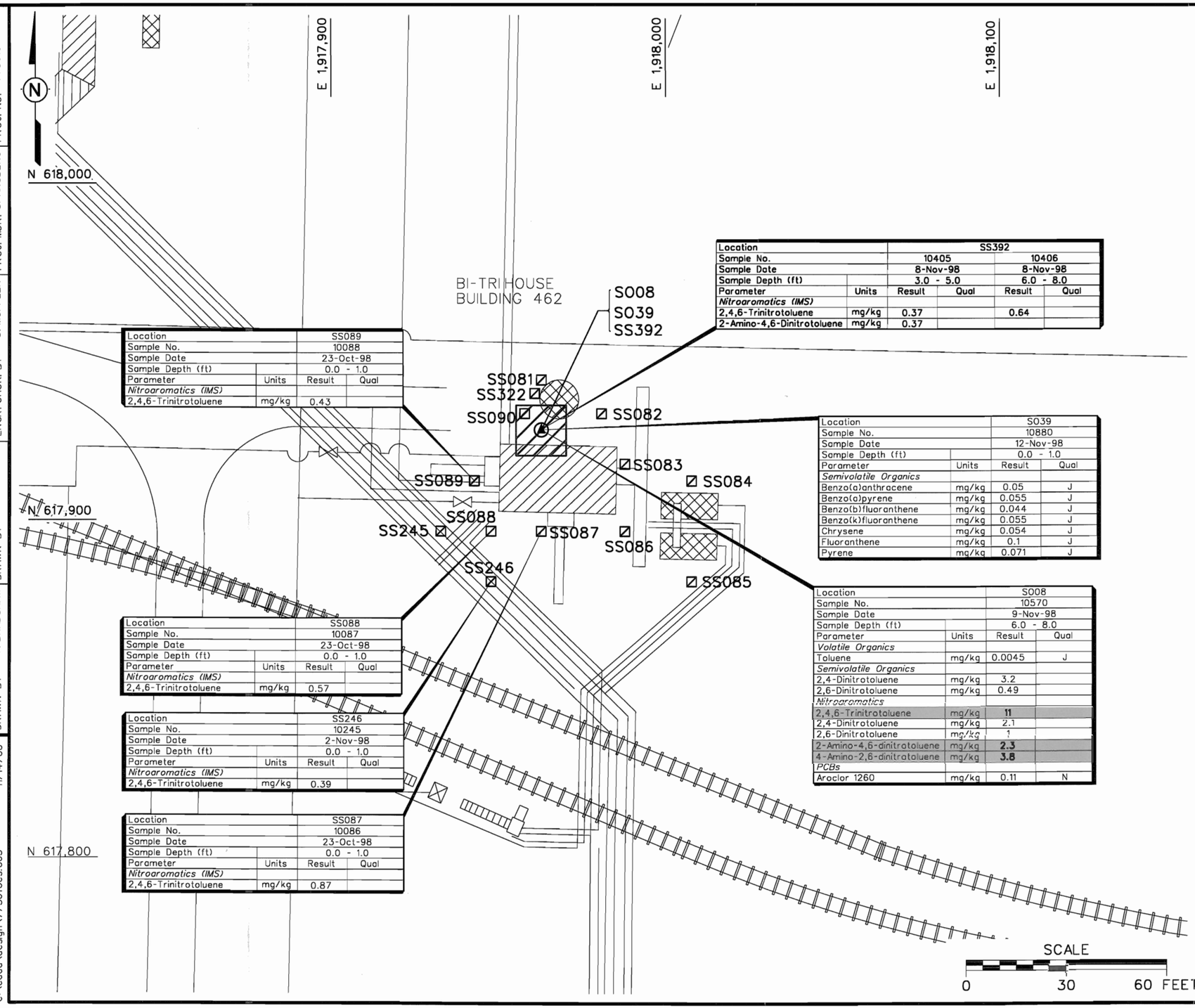


Location		SS089	
Sample No.		10088	
Sample Date		23-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.43	

Location		SS392			
Sample No.		10405		10406	
Sample Date		8-Nov-98		8-Nov-98	
Sample Depth (ft)		3.0 - 5.0		6.0 - 8.0	
Parameter	Units	Result	Qual	Result	Qual
Nitroaromatics (IMS)					
2,4,6-Trinitrotoluene	mg/kg	0.37		0.64	
2-Amino-4,6-Dinitrotoluene	mg/kg	0.37			

Location		S039	
Sample No.		10880	
Sample Date		12-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Semivolatile Organics			
Benzo(a)anthracene	mg/kg	0.05	J
Benzo(a)pyrene	mg/kg	0.055	J
Benzo(b)fluoranthene	mg/kg	0.044	J
Benzo(k)fluoranthene	mg/kg	0.055	J
Chrysene	mg/kg	0.054	J
Fluoranthene	mg/kg	0.1	J
Pyrene	mg/kg	0.071	J

Location		S008	
Sample No.		10570	
Sample Date		9-Nov-98	
Sample Depth (ft)		6.0 - 8.0	
Parameter	Units	Result	Qual
Volatile Organics			
Toluene	mg/kg	0.0045	J
Semivolatile Organics			
2,4-Dinitrotoluene	mg/kg	3.2	
2,6-Dinitrotoluene	mg/kg	0.49	
Nitroaromatics			
2,4,6-Trinitrotoluene	mg/kg	**11**	
2,4-Dinitrotoluene	mg/kg	2.1	
2,6-Dinitrotoluene	mg/kg	1	
2-Amino-4,6-dinitrotoluene	mg/kg	**2.3**	
4-Amino-2,6-dinitrotoluene	mg/kg	**3.8**	
PCBs			
Aroclor 1260	mg/kg	0.11	N

Location		SS088	
Sample No.		10087	
Sample Date		23-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.57	

Location		SS246	
Sample No.		10245	
Sample Date		2-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.39	

Location		SS087	
Sample No.		10086	
Sample Date		23-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.87	

LEGEND:

- SS017 — SCREENING SURFACE SOIL SAMPLING LOCATION
- SS390 — SUBSURFACE SCREENING SOIL SAMPLING LOCATION
- S040 — SURFACE/SUBSURFACE SOIL SAMPLING CONFIRMATION LOCATION
- RAILROAD TRACK
- POTABLE WATER VALVE
- TANK
- POTENTIAL REMEDIATION AREA

NOTES:

1. NITROAROMATICS (IMS) - IMS SCREENING RESULTS.
2. OVERBURDEN THICKNESS ESTIMATED AT 8 FT.
3. SHADED CONCENTRATIONS INDICATE DETECTIONS EXCEEDING PRGs.
4. REMEDIATION AREA:

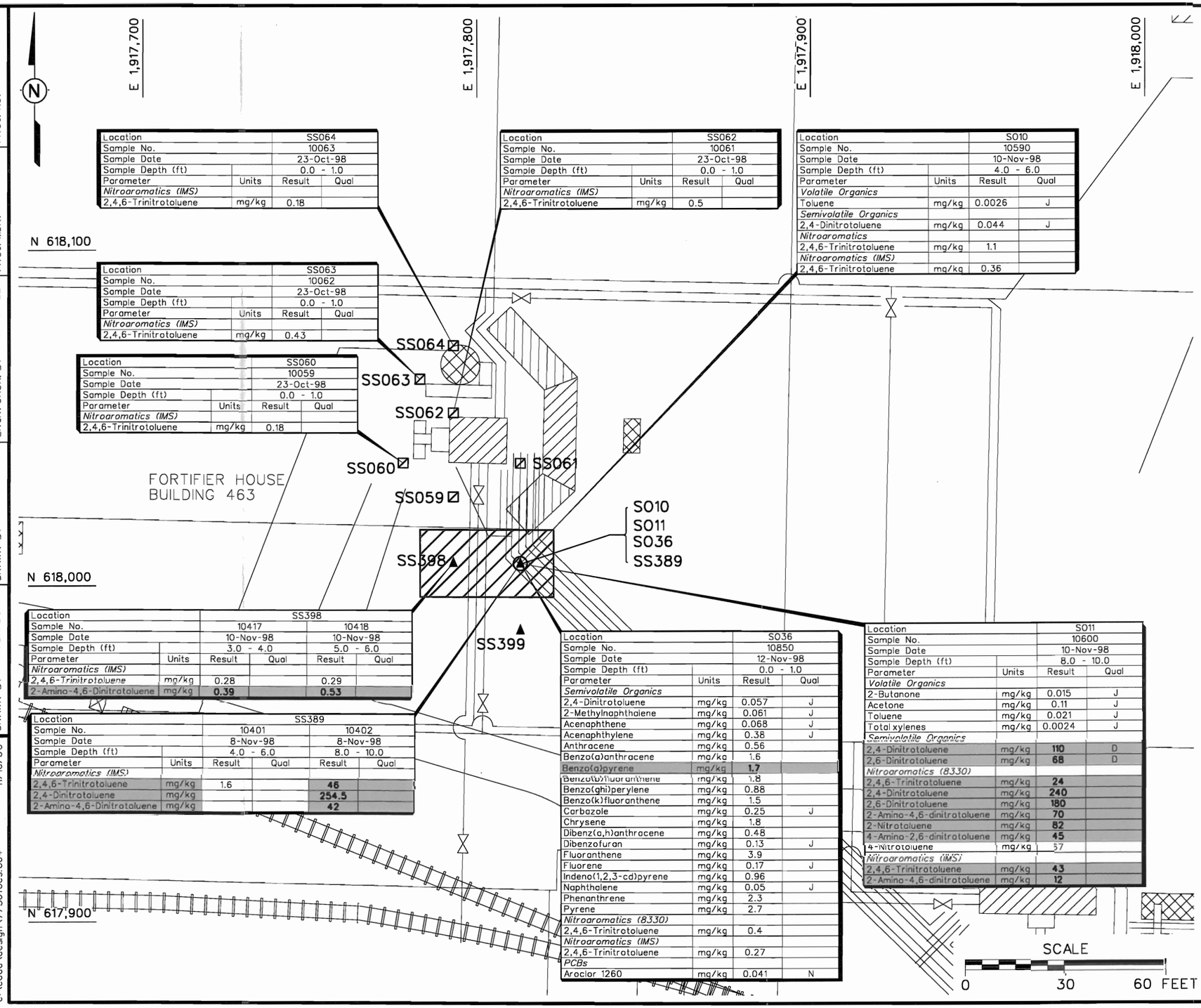
   ASSUMED DEPTH: 8 FT
   ASSUMED DIMENSIONS: 15'X15'
   VOLUME = 67 YD^3

FIGURE 1-16
BUILDING 462 BI-TRI HOUSE SAMPLE LOCATIONS AND ANALYTICAL RESULTS

PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

IT CORPORATION
A Member of The IT Group

DRAFT. CHCK. BY: C. TUMLIN | INITIATOR: GUNDERSON | DWG. NO.: \775616es.065
ENGR. CHCK. BY: S. MUFFLER | PROJ. MGR.: SPANGBERG | PROJ. NO.: 775616
DATE LAST REV.: | STARTING DATE: 03/23/99
DRAWN BY: | DRAWN BY: T. BRADSHAW
02:23:20 11/14/00
bvanderg c:\cadd\design\775616es.065



Location		SS064	
Sample No.		10063	
Sample Date		23-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.18	

Location		SS062	
Sample No.		10061	
Sample Date		23-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.5	

Location		SO10	
Sample No.		10590	
Sample Date		10-Nov-98	
Sample Depth (ft)		4.0 - 6.0	
Parameter	Units	Result	Qual
Volatile Organics			
Toluene	mg/kg	0.0026	J
Semivolatile Organics			
2,4-Dinitrotoluene	mg/kg	0.044	J
Nitroaromatics			
2,4,6-Trinitrotoluene	mg/kg	1.1	
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.36	

Location		SS063	
Sample No.		10062	
Sample Date		23-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.43	

Location		SS060	
Sample No.		10059	
Sample Date		23-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.18	

Location		SS398			
Sample No.		10417		10418	
Sample Date		10-Nov-98		10-Nov-98	
Sample Depth (ft)		3.0 - 4.0		5.0 - 6.0	
Parameter	Units	Result	Qual	Result	Qual
Nitroaromatics (IMS)					
2,4,6-Trinitrotoluene	mg/kg	0.28		0.29	
2-Amino-4,6-Dinitrotoluene	mg/kg	**0.39**		**0.53**	

Location		SS389			
Sample No.		10401		10402	
Sample Date		8-Nov-98		8-Nov-98	
Sample Depth (ft)		4.0 - 6.0		8.0 - 10.0	
Parameter	Units	Result	Qual	Result	Qual
Nitroaromatics (IMS)					
2,4,6-Trinitrotoluene	mg/kg	1.6		**46**	
2,4-Dinitrotoluene	mg/kg			**254.5**	
2-Amino-4,6-Dinitrotoluene	mg/kg			**42**	

Location		SO36	
Sample No.		10850	
Sample Date		12-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Semivolatile Organics			
2,4-Dinitrotoluene	mg/kg	0.057	J
2-Methylnaphthalene	mg/kg	0.061	J
Acenaphthene	mg/kg	0.068	J
Acenaphthylene	mg/kg	0.38	J
Anthracene	mg/kg	0.56	
Benzo(a)anthracene	mg/kg	1.6	
Benzo(a)pyrene	mg/kg	**1.7**	
Benzo(b)fluoranthene	mg/kg	1.8	
Benzo(ghi)perylene	mg/kg	0.88	
Benzo(k)fluoranthene	mg/kg	1.5	
Carbazole	mg/kg	0.25	J
Chrysene	mg/kg	1.8	
Dibenz(a,h)anthracene	mg/kg	0.48	
Dibenzofuran	mg/kg	0.13	J
Fluoranthene	mg/kg	3.9	
Fluorene	mg/kg	0.17	J
Indeno(1,2,3-cd)pyrene	mg/kg	0.96	
Naphthalene	mg/kg	0.05	J
Phenanthrene	mg/kg	2.3	
Pyrene	mg/kg	2.7	
Nitroaromatics (8330)			
2,4,6-Trinitrotoluene	mg/kg	0.4	
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.27	
PCBs			
Aroclor 1260	mg/kg	0.041	N

Location		SO11	
Sample No.		10600	
Sample Date		10-Nov-98	
Sample Depth (ft)		8.0 - 10.0	
Parameter	Units	Result	Qual
Volatile Organics			
2-Butanone	mg/kg	0.015	J
Acetone	mg/kg	0.11	J
Toluene	mg/kg	0.021	J
Total xylenes	mg/kg	0.0024	J
Semivolatile Organics			
2,4-Dinitrotoluene	mg/kg	**110**	D
2,6-Dinitrotoluene	mg/kg	**68**	D
Nitroaromatics (8330)			
2,4,6-Trinitrotoluene	mg/kg	**24**	
2,4-Dinitrotoluene	mg/kg	**240**	
2,6-Dinitrotoluene	mg/kg	**180**	
2-Amino-4,6-dinitrotoluene	mg/kg	**70**	
2-Nitrotoluene	mg/kg	**82**	
4-Amino-2,6-dinitrotoluene	mg/kg	**45**	
4-Nitrotoluene	mg/kg	57	
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	**43**	
2-Amino-4,6-dinitrotoluene	mg/kg	**12**	

LEGEND:

- SS017 — SCREENING SURFACE SOIL SAMPLING LOCATION
- SS390 — SUBSURFACE SCREENING SOIL SAMPLING LOCATION
- SO40 — SURFACE/SUBSURFACE SOIL SAMPLING CONFIRMATION LOCATION
- POTABLE WATER VALVE
- RAILROAD TRACK
- TANK
- POTENTIAL REMEDIATION AREA

NOTES:

1. NITROAROMATICS (IMS) - IMS SCREENING RESULTS
2. NITROAROMATICS (8330) - METHOD 8330 RESULTS
3. OVERBURDEN THICKNESS EXCEEDS 10 FT.
4. SHADED CONCENTRATIONS INDICATE DETECTIONS EXCEEDING PRGs.
5. REMEDIATION AREA:

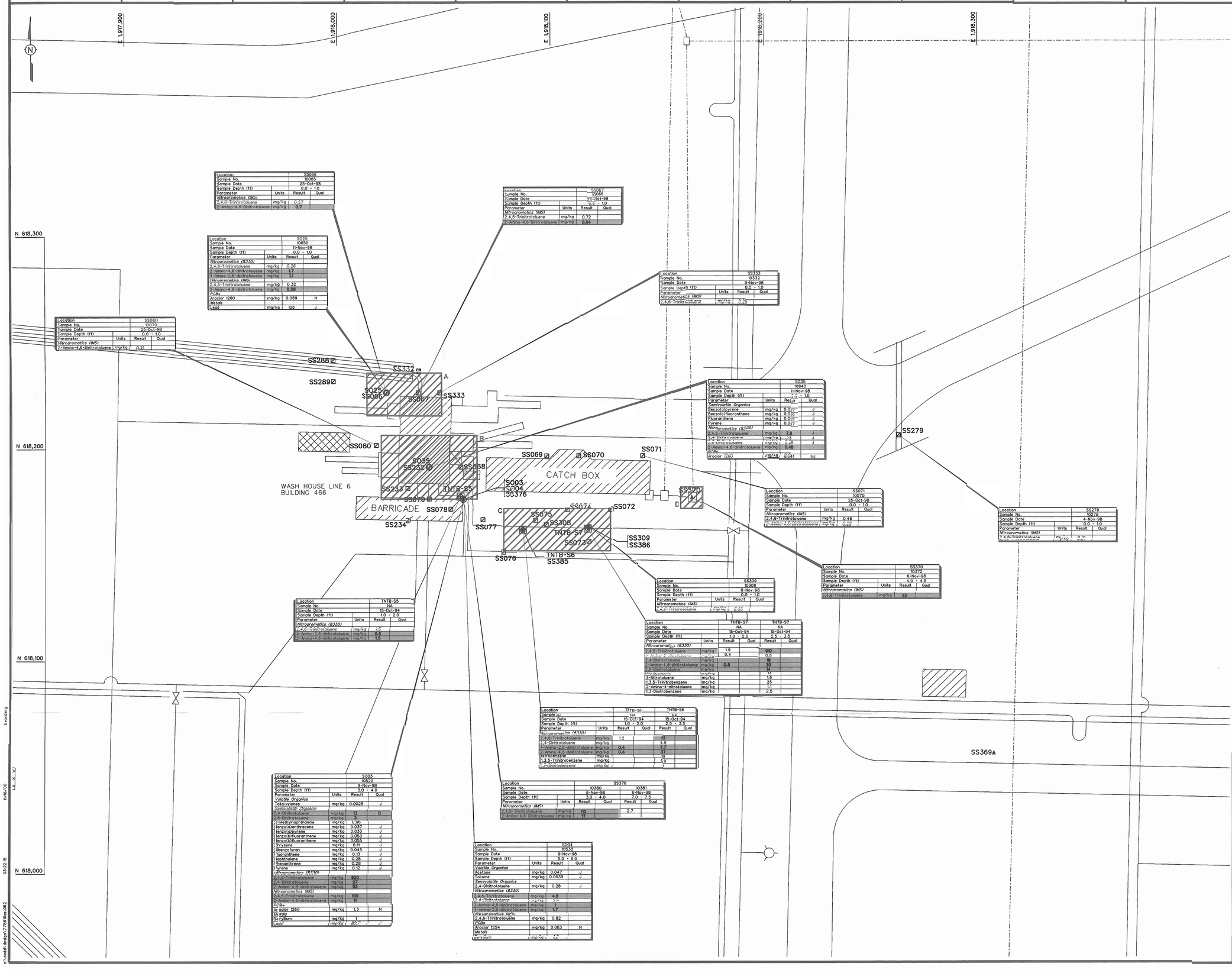
   ASSUMED DEPTH: 10 FT
   ASSUMED DIMENSIONS: 40'X20'
   VOLUME = 296 YD^3

FIGURE 1-17
BUILDING 463 FORTIFIER HOUSE SAMPLE LOCATIONS, ANALYTICAL RESULTS, AND POTENTIAL REMEDIATION AREAS

PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

IT CORPORATION
A Member of The IT Group

DWG. NO.: \775616es.064 | PROJ. NO.: 775616
INITIATOR: GUNDERSON | PROJ. MGR.: SPANGBERG
DRAFT. CHCK. BY: C. TUMLIN | ENGR. CHCK. BY: S. MUFFLER
DATE LAST REV.: | DRAWN BY:
STARTING DATE: 03/23/99 | DRAWN BY: T. BRADSHAW
03:07:46 11/16/00
bvanderg
c:\cadd\design\775616es.064



Location		SS066	
Sample No.		10065	
Sample Date		25-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.27	
2-Amino-4,6-Dinitrotoluene	mg/kg	0.7	

Location		SS067	
Sample No.		10066	
Sample Date		25-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.72	
2-Amino-4,6-Dinitrotoluene	mg/kg	0.84	

Location		SS025	
Sample No.		10650	
Sample Date		11-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (8330)			
2,4,6-Trinitrotoluene	mg/kg	0.26	
2-Amino-4,6-dinitrotoluene	mg/kg	1.7	
4-Amino-2,6-dinitrotoluene	mg/kg	1.1	
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.32	
2-Amino-4,6-dinitrotoluene	mg/kg	0.28	
PCBs			
Aroclor 1260	mg/kg	0.089	N
Metals			
Lead	mg/kg	126	J

Location		SS080	
Sample No.		10079	
Sample Date		26-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2-Amino-4,6-Dinitrotoluene	mg/kg	0.21	

Location		SS333	
Sample No.		10332	
Sample Date		9-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.25	

Location		SS035	
Sample No.		10840	
Sample Date		11-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Semivolatile Organics			
Benzo(a)pyrene	mg/kg	0.017	J
Benzo(b)fluoranthene	mg/kg	0.016	J
Fluoranthene	mg/kg	0.015	J
Pyrene	mg/kg	0.017	J
Nitroaromatics (8330)			
2,4,6-Trinitrotoluene	mg/kg	7.8	J
2,4-Dinitrotoluene	mg/kg	3.3	J
2,6-Dinitrotoluene	mg/kg	0.28	J
2-Amino-4,6-dinitrotoluene	mg/kg	0.48	
PCBs			
Aroclor 1260	mg/kg	0.041	NJ

Location		SS071	
Sample No.		10070	
Sample Date		25-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.48	
2-Amino-4,6-dinitrotoluene	mg/kg	0.22	

Location		SS279	
Sample No.		10278	
Sample Date		4-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.21	

Location		SS370	
Sample No.		10372	
Sample Date		6-Nov-98	
Sample Depth (ft)		4.0 - 4.5	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	25	

Location		SS309	
Sample No.		10308	
Sample Date		8-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	2.22	
2,4-Dinitrotoluene	mg/kg	0.03	

Location		TNTB-S5	
Sample No.		NA	
Sample Date		15-Oct-94	
Sample Depth (ft)		1.0 - 2.0	
Parameter	Units	Result	Qual
Nitroaromatics (8330)			
2,4,6-Trinitrotoluene	mg/kg	2.5	
4-Amino-2,6-dinitrotoluene	mg/kg	0.8	
2-Amino-4,6-dinitrotoluene	mg/kg	1.5	

Location		TNTB-S7		TNTB-S7	
Sample No.		NA		NA	
Sample Date		15-Oct-94		15-Oct-94	
Sample Depth (ft)		1.0 - 2.0		2.5 - 3.5	
Parameter	Units	Result	Qual	Result	Qual
Nitroaromatics (8330)					
2,4,6-Trinitrotoluene	mg/kg	1.9		910	
4-Amino-2,6-dinitrotoluene	mg/kg	0.4		0.5	
2,4-Dinitrotoluene	mg/kg			18	
2-Amino-4,6-dinitrotoluene	mg/kg	0.5		30	
2,6-Dinitrotoluene	mg/kg			14	
Nitrobenzene	mg/kg			13	
3-Nitrotoluene	mg/kg			1.6	
1,3,5-Trinitrobenzene	mg/kg			25	
2-Amino-4-nitrotoluene	mg/kg			1.1	
1,3-Dinitrobenzene	mg/kg			2.5	

Location		TNTB-S6		TNTB-S6	
Sample No.		NA		NA	
Sample Date		15-Oct-94		15-Oct-94	
Sample Depth (ft)		1.0 - 2.0		2.5 - 3.5	
Parameter	Units	Result	Qual	Result	Qual
Nitroaromatics (8330)					
2,4,6-Trinitrotoluene	mg/kg	1.2		21	
2,4-Dinitrotoluene	mg/kg			4.9	
4-Amino-2,6-dinitrotoluene	mg/kg	0.4		7.7	
2-Amino-4,6-dinitrotoluene	mg/kg	0.4		37	
Nitrobenzene	mg/kg			.5	
1,3,5-Trinitrobenzene	mg/kg			5.9	
2,6-Dinitrotoluene	mg/kg				

Location		SS003	
Sample No.		10520	
Sample Date		9-Nov-98	
Sample Depth (ft)		3.0 - 4.0	
Parameter	Units	Result	Qual
Volatile Organics			
Total xylenes	mg/kg	0.0025	J
Semivolatile Organics			
2,4-Dinitrotoluene	mg/kg	13	D
2,6-Dinitrotoluene	mg/kg		
2-Methylnaphthalene	mg/kg	UJb	
Benzo(a)anthracene	mg/kg	0.037	J
Benzo(a)pyrene	mg/kg	0.033	J
Benzo(b)fluoranthene	mg/kg	0.053	J
Benzo(k)fluoranthene	mg/kg	0.055	J
Chrysene	mg/kg	0.11	J
Dibenzofuran	mg/kg	0.045	J
Fluoranthene	mg/kg	0.13	J
Naphthalene	mg/kg	0.28	J
Phenanthrene	mg/kg	0.28	J
Pyrene	mg/kg	0.12	J
Nitroaromatics (8330)			
2,4,6-Trinitrotoluene	mg/kg	620	
2,4-Dinitrotoluene	mg/kg	27	
2-Amino-4,6-dinitrotoluene	mg/kg	93	
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	100	
2-Amino-4,6-dinitrotoluene	mg/kg	11	
PCBs			
Aroclor 1260	mg/kg	1.3	N
Metals			
Beryllium	mg/kg	1	
Lead	mg/kg	667	J

Location		SS376			
Sample No.		10380		10381	
Sample Date		6-Nov-98		6-Nov-98	
Sample Depth (ft)		3.0 - 4.0		7.0 - 7.5	
Parameter	Units	Result	Qual	Result	Qual
Nitroaromatics (IMS)					
2,4,6-Trinitrotoluene	mg/kg	110		2.7	
2-Amino-4,6-Dinitrotoluene	mg/kg	17			

Location		SS004	
Sample No.		10530	
Sample Date		9-Nov-98	
Sample Depth (ft)		5.0 - 6.0	
Parameter	Units	Result	Qual
Volatile Organics			
Acetone	mg/kg	0.047	J
Toluene	mg/kg	0.0039	J
Semivolatile Organics			
2,4-Dinitrotoluene	mg/kg	0.28	J
Nitroaromatics (8330)			
2,4,6-Trinitrotoluene	mg/kg	4.8	
2,4-Dinitrotoluene	mg/kg	0.5	
2-Amino-4,6-dinitrotoluene	mg/kg	1	
4-Amino-2,6-dinitrotoluene	mg/kg	1.7	
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.82	
PCBs			
Aroclor 1254	mg/kg	0.083	N
Metals			
Beryllium	mg/kg	0.6	

LEGEND:

⊠ SS017	SCREENING SURFACE SOIL SAMPLING LOCATION
▲ SS390	SUBSURFACE SCREENING SOIL SAMPLING LOCATION
○ S040	SURFACE/SUBSURFACE SOIL SAMPLING CONFIRMATION LOCATION
⋈	POTABLE WATER VALVE
	DRAINAGE CULVERT
	FORMER WASTEWATER FLUME LINE (UNDERGROUND)
	POTENTIAL REMEDIATION AREA

NOTES:

1. NITROAROMATICS (IMS) - IMS SCREENING RESULTS
2. NITROAROMATICS (8330) - METHOD 8830 RESULTS
3. OVERBURDEN THICKNESS ESTIMATED AT APPROXIMATELY 7 FT.
4. SHADED CONCENTRATIONS INDICATE DETECTIONS EXCEEDING PRGs.
5. TOTAL REMEDIATION VOLUME ESTIMATED AT APPROXIMATELY 753 YD^3.

AREA A:
ASSUMED DEPTH: 7.5 FT
ASSUMED DIMENSIONS: 35'X20'
VOLUME = 194 YD^3

AREA B:
ASSUMED DEPTH: 7.5 FT
ASSUMED DIMENSIONS: 45'X30'
VOLUME = 378 YD^3

AREA C:
ASSUMED DEPTH: 4.5 FT
ASSUMED DIMENSIONS: 50'X20'
VOLUME = 167 YD^3

AREA D:
ASSUMED DEPTH: 4.5 FT
ASSUMED DIMENSIONS: 10'X10'
VOLUME = 17 YD^3

SCALE
0 20 40 FEET

NO	DATE	REVISION	BY	CHKD	DSGN ENGR	ENGR	PROJ MGR	APPR

STARTING DATE	INITIATOR	CHKD	DRAWN	CHKD	PROJECT MNGR
03/22/99	M. GUNDERSON	MG	RKV	TUMLIN	M. SPANGBERG

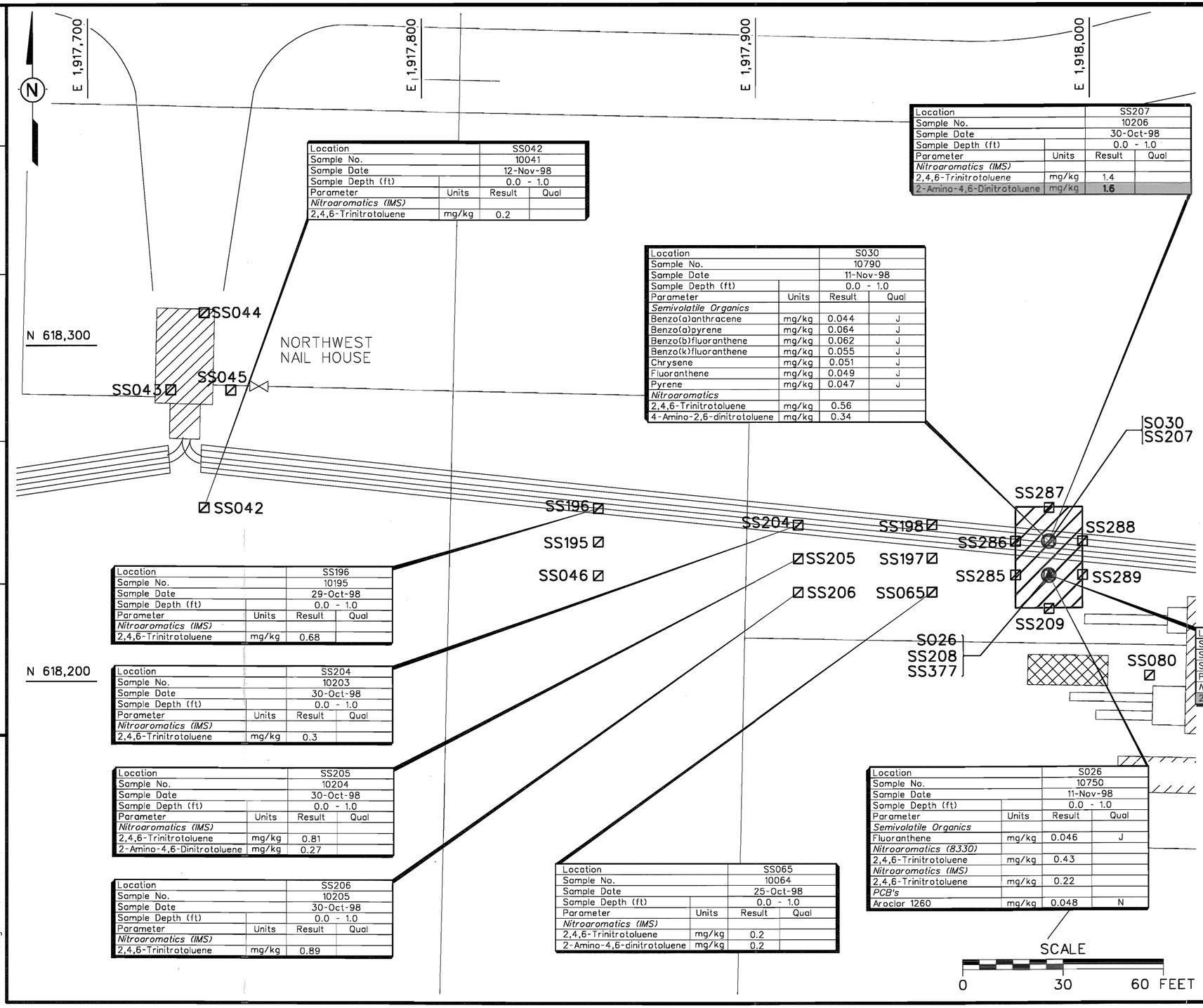
IT CORPORATION
A Member of The IT Group
KNOXVILLE, TENNESSEE

FIGURE 1-18
BUILDING 466, WASH HOUSE SAMPLE LOCATIONS, ANALYTICAL RESULTS, AND POTENTIAL REMEDIATION AREAS

PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

AREA	JOB NO.	DRAWING NO.	REV
	775616	775616es.062	

c:\cadrb\design\775616es.062 03/22/15 11/16/00 bwadsing



Location		SS042	
Sample No.		10041	
Sample Date		12-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.2	

Location		SS207	
Sample No.		10206	
Sample Date		30-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	1.4	
2-Amino-4,6-Dinitrotoluene	mg/kg	**1.6**	

Location		S030	
Sample No.		10790	
Sample Date		11-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Semivolatile Organics			
Benzo(a)anthracene	mg/kg	0.044	J
Benzo(a)pyrene	mg/kg	0.064	J
Benzo(b)fluoranthene	mg/kg	0.062	J
Benzo(k)fluoranthene	mg/kg	0.055	J
Chrysene	mg/kg	0.051	J
Fluoranthene	mg/kg	0.049	J
Pyrene	mg/kg	0.047	J
Nitroaromatics			
2,4,6-Trinitrotoluene	mg/kg	0.56	
4-Amino-2,6-dinitrotoluene	mg/kg	0.34	

Location		SS196	
Sample No.		10195	
Sample Date		29-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.68	

Location		SS204	
Sample No.		10203	
Sample Date		30-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.3	

Location		SS205	
Sample No.		10204	
Sample Date		30-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.81	
2-Amino-4,6-Dinitrotoluene	mg/kg	0.27	

Location		SS206	
Sample No.		10205	
Sample Date		30-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.89	

Location		SS065	
Sample No.		10064	
Sample Date		25-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.2	
2-Amino-4,6-dinitrotoluene	mg/kg	0.2	

Location		S026	
Sample No.		10750	
Sample Date		11-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Semivolatile Organics			
Fluoranthene	mg/kg	0.046	J
Nitroaromatics (8330)			
2,4,6-Trinitrotoluene	mg/kg	0.43	
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.22	
PCB's			
Aroclor 1260	mg/kg	0.048	N

Location		SS208	
Sample No.		10207	
Sample Date		30-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	**23**	

LEGEND:

- ⊠ SS017 — SCREENING SURFACE SOIL SAMPLING LOCATION
- ▲ SS390 — SUBSURFACE SCREENING SOIL SAMPLING LOCATION
- ○ S040 — SURFACE/SUBSURFACE SOIL SAMPLING CONFIRMATION LOCATION
- ⋈ — POTABLE WATER VALVE
- ▨ — POTENTIAL REMEDIATION AREA

NOTES:

1. NITROAROMATICS (IMS) - IMS SCREENING RESULTS.
2. NITROAROMATICS (8330) - METHOD 8330 RESULTS.
3. OVERBURDEN THICKNESS ESTIMATED AT APPROXIMATELY 3.5 FT.
4. SHADED CONCENTRATIONS INDICATE DETECTIONS EXCEEDING PRGs.
5. REMEDIATION AREA:

   ASSUMED DEPTH: 3.5 FT
   ASSUMED DIMENSIONS: 20'X30'
   VOLUME = 78 YD^3

SCALE

0 30 60 FEET

FIGURE 1-19
NORTHWEST NAIL HOUSE SAMPLE LOCATIONS AND ANALYTICAL RESULTS

PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

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DRAFT. CHCK. BY: C. TUMLIN | INITIATOR: GUNDERSON | DWG. NO.:\775616es.066
ENGR. CHCK. BY: S. MUFFLER | PROJ. MGR.: SPANGBERG | PROJ. NO.: 775616
STARTING DATE: 03/22/99 | DATE LAST REV.:
DRAWN BY: T. BRADSHAW | DRAWN BY:
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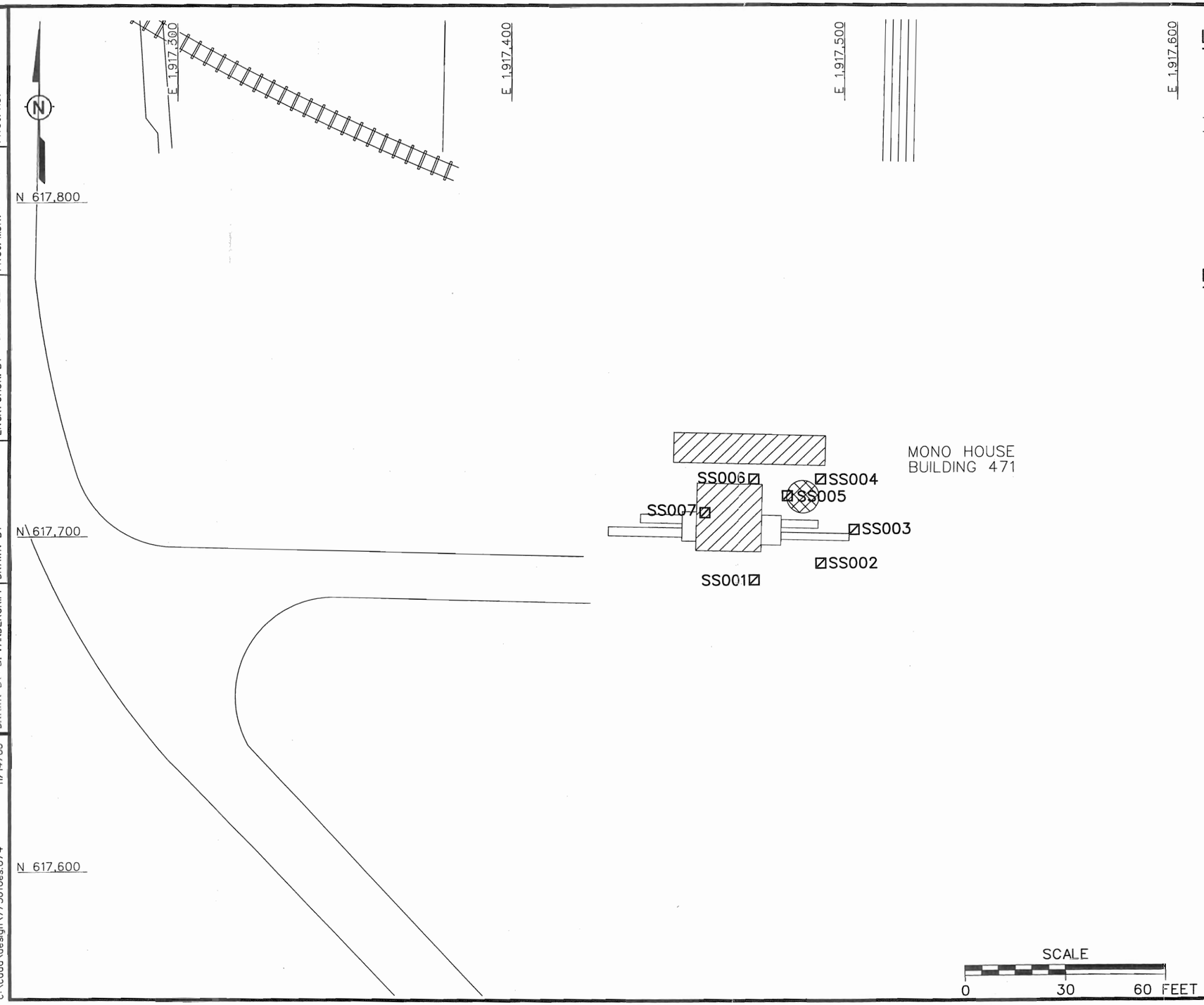

LEGEND:

⊠ SS039	SUBSURFACE SCREENING SOIL SAMPLING LOCATION
	RAILROAD
	TANK

NOTES:

1. NO CONTAMINANTS EXCEEDING PRGs.

FIGURE 1-20
BUILDING 471 MONO HOUSE
SAMPLE LOCATIONS

PLUM BROOK ORDNANCE WORKS
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STARTING DATE:04/23/99	DATE LAST REV.:	DRAFT. CHCK. BY: C. TUMLIN	INITIATOR: GUNDERSON	DWG. NO.:\775616es.074
DRAWN BY: B. VANDERGRIFF	DRAWN BY:	ENGR. CHCK. BY: S. MUFFLER	PROJ. MGR.:SPANGBERG	PROJ. NO.: 775616

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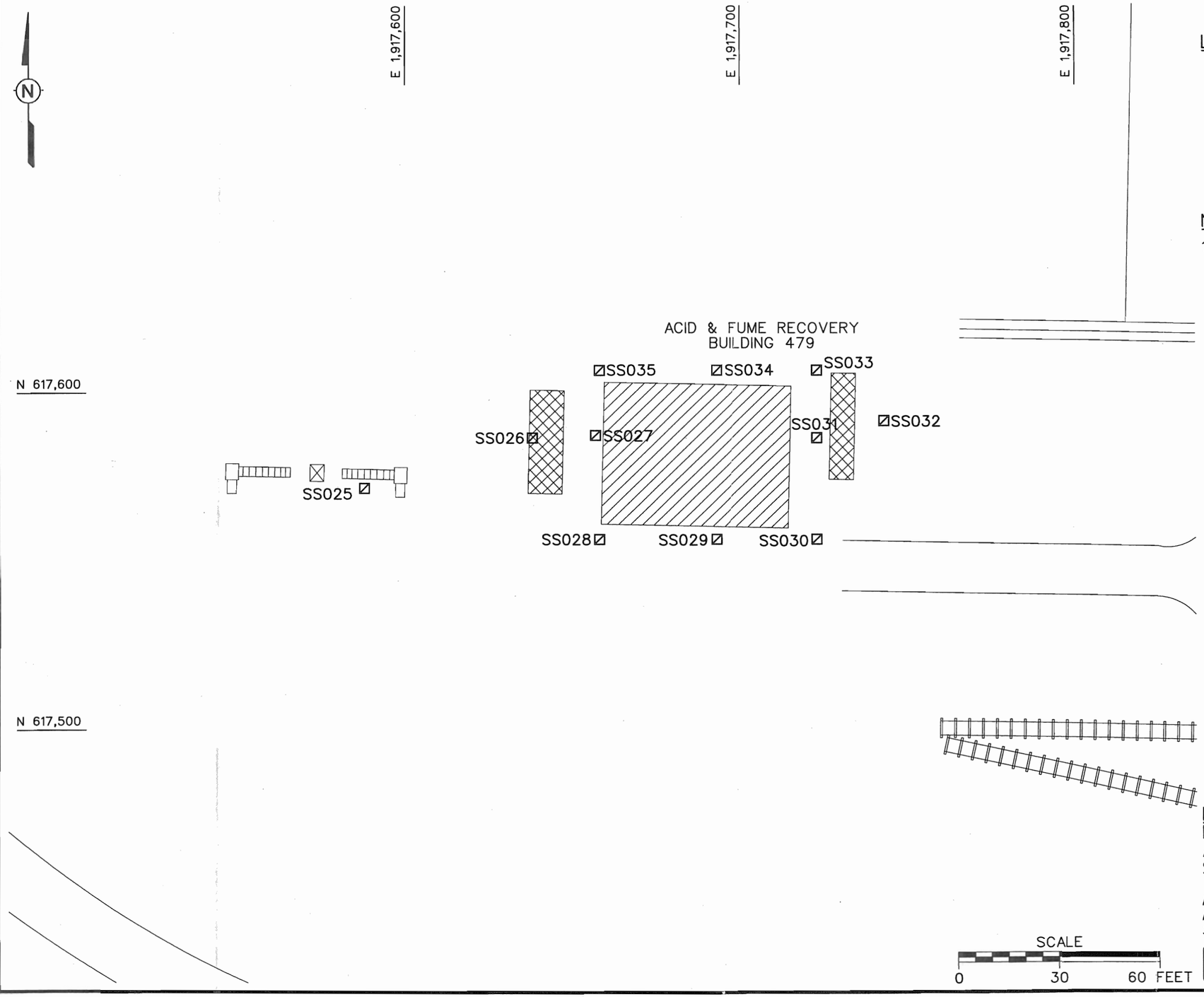

LEGEND:

SS011 — SUBSURFACE SCREENING SOIL SAMPLING LOCATION

RAILROAD TRACK

NOTES:

1. NO CONTAMINANTS EXCEEDING PRGs.

FIGURE 1-21
BUILDING 479
ACID AND FUME RECOVERY
SAMPLE LOCATIONS

PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

IT CORPORATION
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STARTING DATE: 03/18/99	DATE LAST REV.:	DRAFT. CHCK. BY: C. TUMLIN	INITIATOR: GUNDERSON	DWG. NO.:\775616es.075
DRAWN BY: T. BRADSHAW	DRAWN BY:	ENGR. CHCK. BY: S. MUFFLER	PROJ. MGR.:SPANGBERG	PROJ. NO.: 775616

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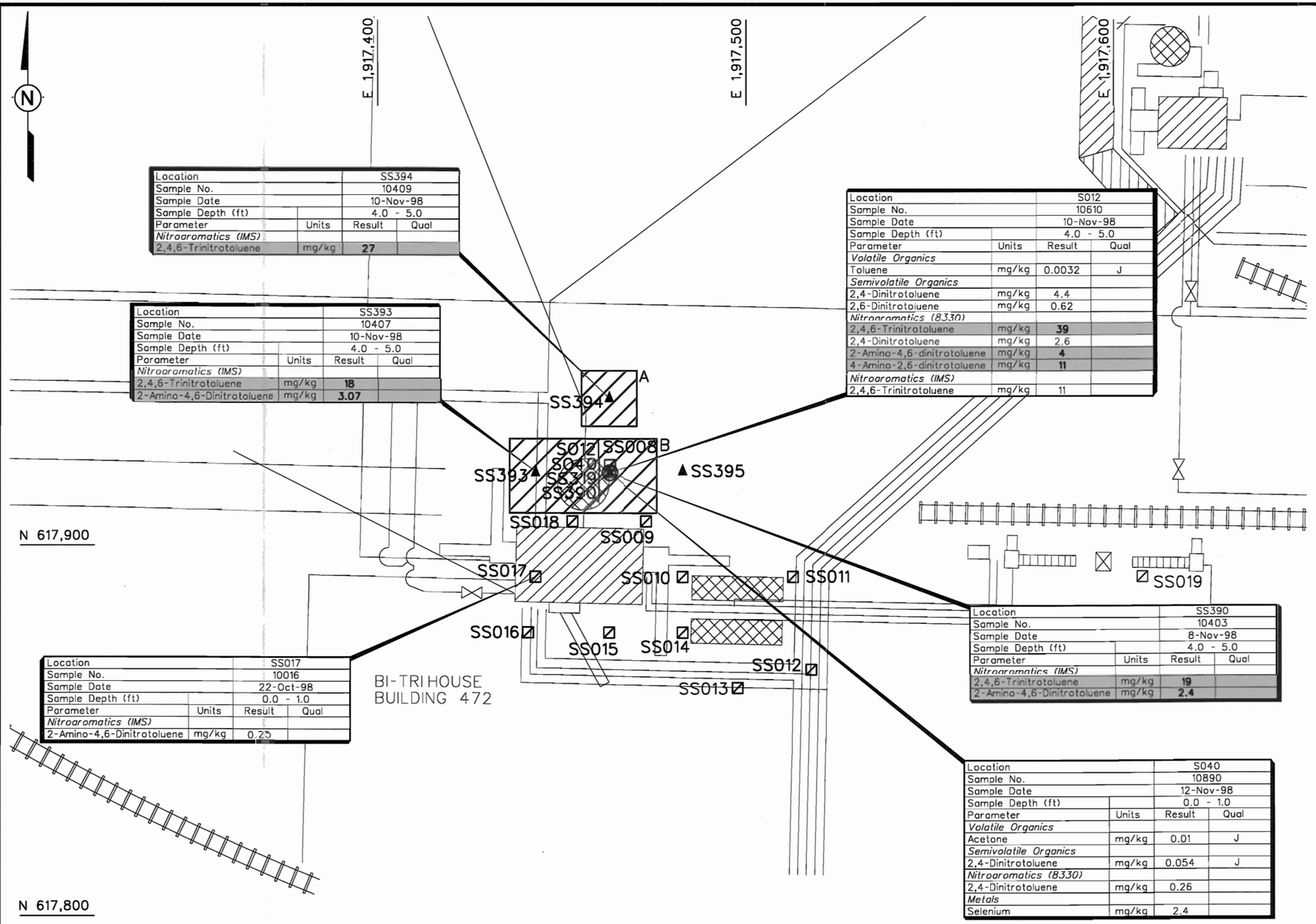

Location		SS394	
Sample No.		10409	
Sample Date		10-Nov-98	
Sample Depth (ft)		4.0 - 5.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	**27**	

Location		SS393	
Sample No.		10407	
Sample Date		10-Nov-98	
Sample Depth (ft)		4.0 - 5.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	**18**	
2-Amino-4,6-Dinitrotoluene	mg/kg	**3.07**	

Location		S012	
Sample No.		10610	
Sample Date		10-Nov-98	
Sample Depth (ft)		4.0 - 5.0	
Parameter	Units	Result	Qual
Volatile Organics			
Toluene	mg/kg	0.0032	J
Semivolatile Organics			
2,4-Dinitrotoluene	mg/kg	4.4	
2,6-Dinitrotoluene	mg/kg	0.62	
Nitroaromatics (8330)			
2,4,6-Trinitrotoluene	mg/kg	**39**	
2,4-Dinitrotoluene	mg/kg	2.6	
2-Amino-4,6-dinitrotoluene	mg/kg	**4**	
4-Amino-2,6-dinitrotoluene	mg/kg	**11**	
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	11	

Location		SS017	
Sample No.		10016	
Sample Date		22-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2-Amino-4,6-Dinitrotoluene	mg/kg	0.25	

Location		SS390	
Sample No.		10403	
Sample Date		8-Nov-98	
Sample Depth (ft)		4.0 - 5.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	**19**	
2-Amino-4,6-Dinitrotoluene	mg/kg	**2.4**	

Location		S040	
Sample No.		10890	
Sample Date		12-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Volatile Organics			
Acetone	mg/kg	0.01	J
Semivolatile Organics			
2,4-Dinitrotoluene	mg/kg	0.054	J
Nitroaromatics (8330)			
2,4-Dinitrotoluene	mg/kg	0.26	
Metals			
Selenium	mg/kg	2.4	

LEGEND:

- SS017 — SCREENING SURFACE SOIL SAMPLING LOCATION
- SS390 — SUBSURFACE SCREENING SOIL SAMPLING LOCATION
- S040 — SURFACE/SUBSURFACE SOIL SAMPLING CONFIRMATION LOCATION
- RAILROAD TRACK
- POTABLE WATER VALVE
- TANK
- POTENTIAL REMEDIATION AREA

NOTES:

1. NITROAROMATICS (IMS) - IMS SCREENING RESULTS
2. NITROAROMATICS (8330) - METHOD 8330 RESULTS
3. OVERBURDEN THICKNESS ESTIMATED AT 5 FT.
4. SHADED CONCENTRATIONS INDICATE DETECTIONS EXCEEDING PRGs.
5. TOTAL REMEDIATION VOLUME IS ESTIMATED AT 190 YD^3.

AREA A:
ASSUMED DEPTH: 5 FT
ASSUMED DIMENSIONS: 15'X15'
VOLUME = 42 YD^3

AREA B:
ASSUMED DEPTH: 5 FT
ASSUMED DIMENSIONS: 20'X40'
VOLUME = 148 YD^3

SCALE
0 30 60 FEET

FIGURE 1-22
BUILDING 472 BI-TRI HOUSE SAMPLE LOCATIONS, ANALYTICAL RESULTS, AND POTENTIAL REMEDIATION AREAS

PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

IT CORPORATION
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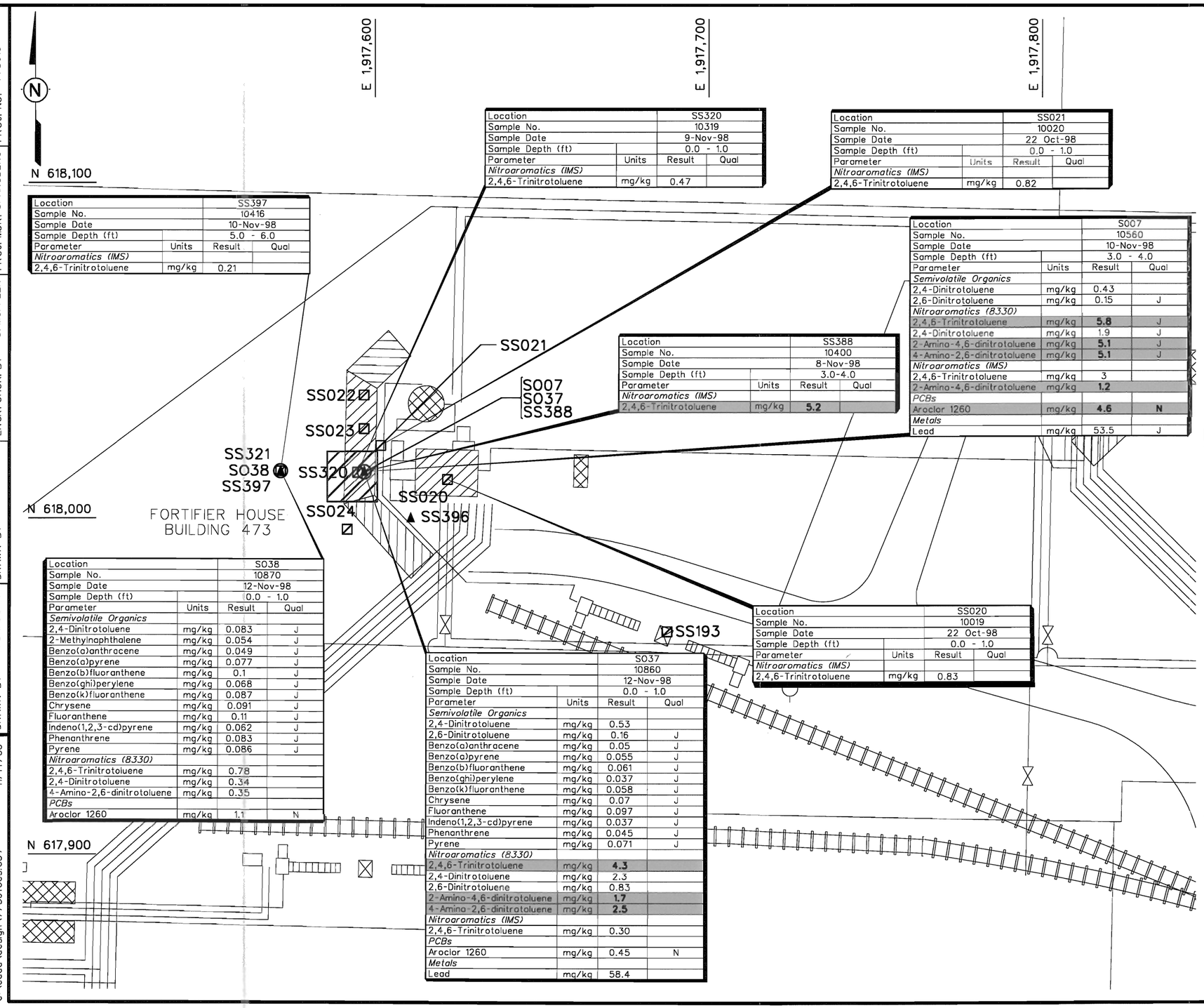
DRAFT. CHCK. BY: C. TUMLIN | DWG. NO.: \775616es.058
ENGR. CHCK. BY: S. MUFFLER | PROJ. NO.: 775616
INITIATOR: GUNDERSON
PROJ. MGR.: SPANGBERG
STARTING DATE: 03/22/99 | DATE LAST REV.:
DRAWN BY: T. BRADSHAW | DRAWN BY:
02:00:27 11/14/00
bvanderg c:\cadd\design\775616es.058



Location		SS320	
Sample No.		10319	
Sample Date		9-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.47	

Location		SS021	
Sample No.		10020	
Sample Date		22 Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.82	

Location		SS397	
Sample No.		10416	
Sample Date		10-Nov-98	
Sample Depth (ft)		5.0 - 6.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.21	

Location		SS388	
Sample No.		10400	
Sample Date		8-Nov-98	
Sample Depth (ft)		3.0-4.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	**5.2**	

Location		S007	
Sample No.		10560	
Sample Date		10-Nov-98	
Sample Depth (ft)		3.0 - 4.0	
Parameter	Units	Result	Qual
Semivolatile Organics			
2,4-Dinitrotoluene	mg/kg	0.43	
2,6-Dinitrotoluene	mg/kg	0.15	J
Nitroaromatics (8330)			
2,4,6-Trinitrotoluene	mg/kg	**5.8**	J
2,4-Dinitrotoluene	mg/kg	1.9	J
2-Amino-4,6-dinitrotoluene	mg/kg	**5.1**	J
4-Amino-2,6-dinitrotoluene	mg/kg	**5.1**	J
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	3	
2-Amino-4,6-dinitrotoluene	mg/kg	**1.2**	
PCBs			
Aroclor 1260	mg/kg	**4.6**	N
Metals			
Lead	mg/kg	53.5	J

Location		SO38	
Sample No.		10870	
Sample Date		12-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Semivolatile Organics			
2,4-Dinitrotoluene	mg/kg	0.083	J
2-Methylnaphthalene	mg/kg	0.054	J
Benzo(a)anthracene	mg/kg	0.049	J
Benzo(a)pyrene	mg/kg	0.077	J
Benzo(b)fluoranthene	mg/kg	0.1	J
Benzo(ghi)perylene	mg/kg	0.068	J
Benzo(k)fluoranthene	mg/kg	0.087	J
Chrysene	mg/kg	0.091	J
Fluoranthene	mg/kg	0.11	J
Indeno(1,2,3-cd)pyrene	mg/kg	0.062	J
Phenanthrene	mg/kg	0.083	J
Pyrene	mg/kg	0.086	J
Nitroaromatics (8330)			
2,4,6-Trinitrotoluene	mg/kg	0.78	
2,4-Dinitrotoluene	mg/kg	0.34	
4-Amino-2,6-dinitrotoluene	mg/kg	0.35	
PCBs			
Aroclor 1260	mg/kg	1.1	N

Location		SO37	
Sample No.		10860	
Sample Date		12-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Semivolatile Organics			
2,4-Dinitrotoluene	mg/kg	0.53	
2,6-Dinitrotoluene	mg/kg	0.16	J
Benzo(a)anthracene	mg/kg	0.05	J
Benzo(a)pyrene	mg/kg	0.055	J
Benzo(b)fluoranthene	mg/kg	0.061	J
Benzo(ghi)perylene	mg/kg	0.037	J
Benzo(k)fluoranthene	mg/kg	0.058	J
Chrysene	mg/kg	0.07	J
Fluoranthene	mg/kg	0.097	J
Indeno(1,2,3-cd)pyrene	mg/kg	0.037	J
Phenanthrene	mg/kg	0.045	J
Pyrene	mg/kg	0.071	J
Nitroaromatics (8330)			
2,4,6-Trinitrotoluene	mg/kg	**4.3**	
2,4-Dinitrotoluene	mg/kg	2.3	
2,6-Dinitrotoluene	mg/kg	0.83	
2-Amino-4,6-dinitrotoluene	mg/kg	**1.7**	
4-Amino-2,6-dinitrotoluene	mg/kg	**2.5**	
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.30	
PCBs			
Aroclor 1260	mg/kg	0.45	N
Metals			
Lead	mg/kg	58.4	

Location		SS020	
Sample No.		10019	
Sample Date		22 Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.83	

LEGEND:

- SS011 — SCREENING SURFACE SOIL SAMPLING LOCATION
- SS395 — SUBSURFACE SCREENING SOIL SAMPLING LOCATION
- SO40 — SURFACE/SUBSURFACE SOIL SAMPLING CONFIRMATION LOCATION
- RAILROAD TRACK
- FIRE HYDRANTS
- POTABLE WATER VALVE
- TANK
- POTENTIAL REMEDIATION AREA

NOTES:

1. NITROAROMATICS (IMS) - IMS SCREENING RESULTS
2. NITROAROMATICS (8330) - METHOD 8330 RESULTS
3. OVERBURDEN THICKNESS GREATER THAN 10 FT.
4. SHADED CONCENTRATIONS INDICATE DETECTIONS EXCEEDING PRGs.
5. REMEDIATION AREA:

   ASSUMED DEPTH: 10 FT
   ASSUMED DIMENSIONS: 15'X15'
   VOLUME = 83 YD^3

SCALE

0 30 60 FEET

FIGURE 1-23
BUILDING 473 FORTIFIER HOUSE SAMPLE LOCATIONS, ANALYTICAL RESULTS, AND POTENTIAL REMEDIATION AREAS

PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

IT CORPORATION
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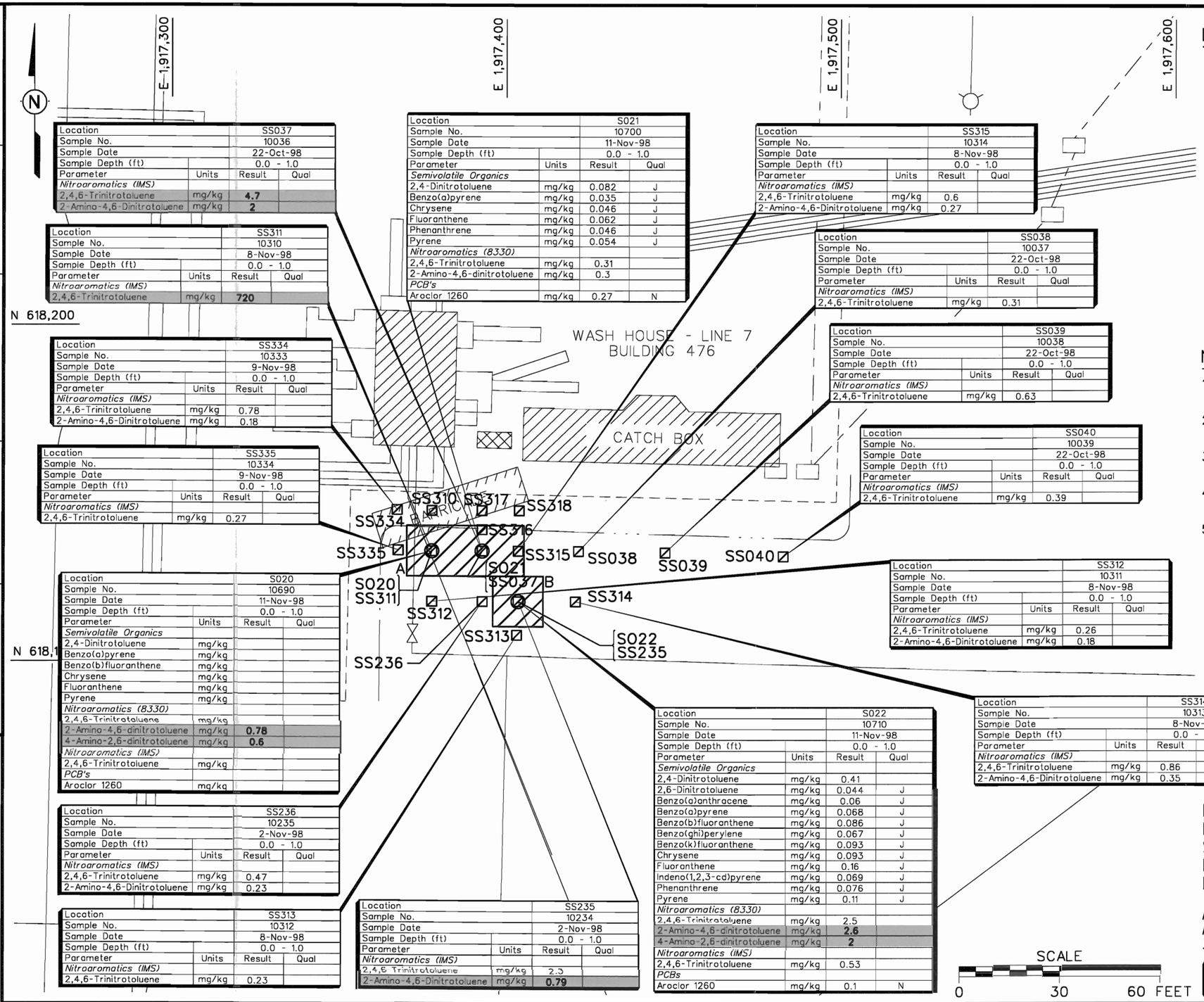
DWG. NO.: \775616es.057 | PROJ. NO.: 775616
INITIATOR: GUNDERSON | PROJ. MGR.: SPANGBERG
DRAFT. CHCK. BY: C. TUMLIN | ENGR. CHCK. BY: S. MUFFLER
DATE LAST REV.: | DRAWN BY:
STARTING DATE: 03/19/99 | DRAWN BY: T. BRADSHAW
01:59:07 11/14/00
bvanderg
c:\cadd\design\775616es.057



Location		SS037	
Sample No.		10036	
Sample Date		22-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	**4.7**	
2-Amino-4,6-Dinitrotoluene	mg/kg	**2**	

Location		SS311	
Sample No.		10310	
Sample Date		8-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	**720**	

Location		SS334	
Sample No.		10333	
Sample Date		9-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.78	
2-Amino-4,6-Dinitrotoluene	mg/kg	0.18	

Location		SS335	
Sample No.		10334	
Sample Date		9-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.27	

Location		S020	
Sample No.		10690	
Sample Date		11-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Semivolatile Organics			
2,4-Dinitrotoluene	mg/kg		
Benzo(a)pyrene	mg/kg		
Benzo(b)fluoranthene	mg/kg		
Chrysene	mg/kg		
Fluoranthene	mg/kg		
Pyrene	mg/kg		
Nitroaromatics (8330)			
2,4,6-Trinitrotoluene	mg/kg		
2-Amino-4,6-dinitrotoluene	mg/kg	**0.78**	
4-Amino-2,6-dinitrotoluene	mg/kg	**0.6**	
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg		
PCB's			
Aroclor 1260	mg/kg		

Location		SS236	
Sample No.		10235	
Sample Date		2-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.47	
2-Amino-4,6-Dinitrotoluene	mg/kg	0.23	

Location		SS313	
Sample No.		10312	
Sample Date		8-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.23	

Location		S021	
Sample No.		10700	
Sample Date		11-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Semivolatile Organics			
2,4-Dinitrotoluene	mg/kg	0.082	J
Benzo(a)pyrene	mg/kg	0.035	J
Chrysene	mg/kg	0.046	J
Fluoranthene	mg/kg	0.062	J
Phenanthrene	mg/kg	0.046	J
Pyrene	mg/kg	0.054	J
Nitroaromatics (8330)			
2,4,6-Trinitrotoluene	mg/kg	0.31	
2-Amino-4,6-dinitrotoluene	mg/kg	0.3	
PCB's			
Aroclor 1260	mg/kg	0.27	N

Location		SS235	
Sample No.		10234	
Sample Date		2-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	2.3	
2-Amino-4,6-Dinitrotoluene	mg/kg	**0.79**	

Location		S022	
Sample No.		10710	
Sample Date		11-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Semivolatile Organics			
2,4-Dinitrotoluene	mg/kg	0.41	
2,6-Dinitrotoluene	mg/kg	0.044	J
Benzo(a)anthracene	mg/kg	0.06	J
Benzo(a)pyrene	mg/kg	0.068	J
Benzo(b)fluoranthene	mg/kg	0.086	J
Benzo(ghi)perylene	mg/kg	0.067	J
Benzo(k)fluoranthene	mg/kg	0.093	J
Chrysene	mg/kg	0.093	J
Fluoranthene	mg/kg	0.16	J
Indeno(1,2,3-cd)pyrene	mg/kg	0.069	J
Phenanthrene	mg/kg	0.076	J
Pyrene	mg/kg	0.11	J
Nitroaromatics (8330)			
2,4,6-Trinitrotoluene	mg/kg	2.5	
2-Amino-4,6-dinitrotoluene	mg/kg	**2.6**	
4-Amino-2,6-dinitrotoluene	mg/kg	**2**	
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.53	
PCBs			
Aroclor 1260	mg/kg	0.1	N

Location		SS315	
Sample No.		10314	
Sample Date		8-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.6	
2-Amino-4,6-Dinitrotoluene	mg/kg	0.27	

Location		SS038	
Sample No.		10037	
Sample Date		22-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.31	

Location		SS039	
Sample No.		10038	
Sample Date		22-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.63	

Location		SS040	
Sample No.		10039	
Sample Date		22-Oct-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.39	

Location		SS312	
Sample No.		10311	
Sample Date		8-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.26	
2-Amino-4,6-Dinitrotoluene	mg/kg	0.18	

Location		SS314	
Sample No.		10313	
Sample Date		8-Nov-98	
Sample Depth (ft)		0.0 - 1.0	
Parameter	Units	Result	Qual
Nitroaromatics (IMS)			
2,4,6-Trinitrotoluene	mg/kg	0.86	
2-Amino-4,6-Dinitrotoluene	mg/kg	0.35	

LEGEND:

- SS039 — SURFACE SCREENING SOIL SAMPLING LOCATION
- S022 — SURFACE/SUBSURFACE SOIL SAMPLING CONFIRMATION LOCATION
- FIRE HYDRANTS
- POTABLE WATER VALVE
- DRAINAGE DITCH
- APPROXIMATE EXTENT OF ASPHALT PAVEMENT
- FORMER WASTEWATER FLUME LINE (UNDERGROUND)
- POTENTIAL REMEDIATION AREA

NOTES:

1. NITROAROMATICS (IMS) - IMS SCREENING RESULTS
2. NITROAROMATICS (8330) - METHOD 8330 RESULTS
3. OVERBURDEN THICKNESS ESTIMATED AT APPROXIMATELY 3 FT.
4. SHADED CONCENTRATIONS INDICATE DETECTIONS EXCEEDING PRGs.
5. TOTAL REMEDIATION VOLUME IS ESTIMATED AT 83 YD^3.

   AREA A:
   ASSUMED DEPTH: 3 FT
   ASSUMED DIMENSIONS: 35'X15'
   VOLUME = 58 YD^3

   AREA B:
   ASSUMED DEPTH: 3 FT
   ASSUMED DIMENSIONS: 15'X15'
   VOLUME = 25 YD^3

SCALE
0 30 60 FEET

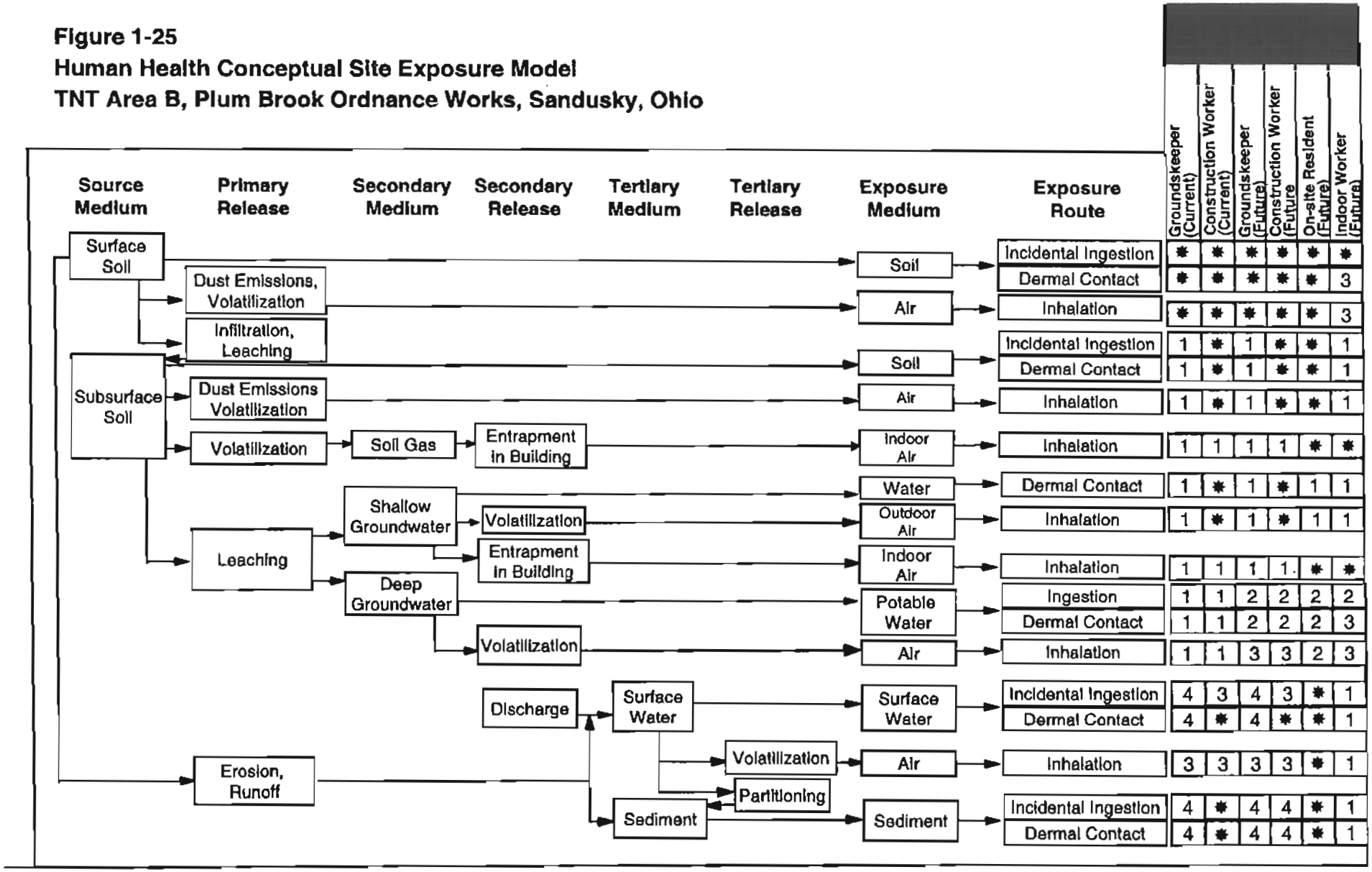
FIGURE 1-24
BUILDING 476 WASH HOUSE SAMPLE LOCATIONS, ANALYTICAL RESULTS, AND POTENTIAL REMEDIATION AREAS

PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

IT CORPORATION
A Member of The IT Group

DWG. NO.: \775616es.056 | PROJ. NO.: 775616
INITIATOR: GUNDERSON | PROJ. MGR.: SPANGBERG
DRAFT. CHCK. BY: C. TUMLIN | ENGR. CHCK. BY: S. MUFFLER
DATE LAST REV.: | DRAWN BY:
STARTING DATE: 03/18/99 | DRAWN BY: T. BRADSHAW
01:56:56 11/14/00
bvanderg c:\cadd\design\775616es.056

Figure 1-25
Human Health Conceptual Site Exposure Model
TNT Area B, Plum Brook Ordnance Works, Sandusky, Ohio



✱ = Complete exposure route quantified in the risk assessment
1 = There is no plausible pathway for exposure to this medium.
2 = Although a complete pathway, no groundwater data are available. Future groundwater exposures will be assessed when data become available.
3 = Although theoretically complete, this pathway is not quantified as explained in text.
4 = Contact with this medium, although plausible, is not part of this receptor's normal or expected activities; therefore contact would be sporadic and is not quantified.

APPENDIX A

Table A-1

Location-Specific Applicable or Relevant and Appropriate Requirements
Feasibility Study
TNT Area B, Plum Brook Ordnance Works
Sandusky, Ohio

Location Characteristics	Requirement(s)	Prerequisite(s)	Federal Citation	Ohio Citation	Alternatives Applicable	Comments
Floodplains/Wetlands						
Presence of floodplain [as defined in 40 CFR 6, Appendix A, Section 4.0 (d)]	Avoid, as practicable, the long- and short-term adverse effects associated with occupancy and modification of floodplains. Measures to mitigate adverse effects of actions in a floodplain include, but are not limited to: minimum grading requirements, runoff controls, design and construction constraints, and protection of ecologically sensitive areas.	Federal actions with potential to impact or occur within flood plains - **Applicable**	40 CFR 6, Appendix A	NA	NA	No floodplains were identified near TNT Area B.
	Potential effects of any action taken in a floodplain shall be evaluated. Identify, evaluate, and implement alternative actions that may avoid or mitigate adverse impacts on floodplains.		40 CFR 6, Appendix A			
	Design or modify selected alternatives to minimize harm to or within floodplains and restore and preserve floodplain values.		40 CFR 6, Appendix A			
Presence of wetlands as defined in 40 CFR 6, Appendix A, Section 4.0(j).	Avoid, to the extent possible, the long- and short-term adverse effects associated with destruction, occupancy and modification of wetlands. Measures to mitigate adverse effects or actions in a wetland include, but are not limited to: minimum grading requirements, runoff controls, design and construction constraints, and protection of ecology-sensitive areas.	Federal actions that involve potential impacts to, or take place within wetlands - **Applicable**	40 CFR 6, Appendix A	NA	NA	No wetlands were identified near TNT Area B.
	Take action, to the extent practicable, to minimize destruction, loss or degradation of wetlands, and to preserve, restore, and enhance the natural and beneficial values of wetlands.		40 CFR 6, Appendix A			
	Potential effects of any new construction in wetlands that are not in a floodplain shall be evaluated. Identify, evaluate, and as appropriate, implement alternative actions that may avoid or mitigate adverse impacts on wetlands.		10 CFR 1022.3(c) and (d)			

Table A-1

Location-Specific Applicable or Relevant and Appropriate Requirements
Feasibility Study
TNT Area B, Plum Brook Ordnance Works
Sandusky, Ohio

Location Characteristics	Requirement(s)	Prerequisite(s)	Federal Citation	Ohio Citation	Alternatives Applicable	Comments
Aquatic Resources						
Within area impacting stream or any other body of water - and – presence of wildlife resources (e.g. fish)	The effects of water-related projects on fish and wildlife resources and their habitat should be considered with a view to the conservation of fish and wildlife resources by preventing loss of and damage to such resources.	Action that impounds, modifies, diverts, or controls waters including navigation and drainage activities - **Relevant and appropriate**	Fish and Wildlife Coordination Act (16 USC 661 et seq.)	NA	NA	Remedial activities are not anticipated to impact fish and wildlife resources.
Location encompassing aquatic ecosystem as defined in 40 CFR 230.3(c)	Except as provided under Section 404(b)2 of the Clean Water Act, no discharge of dredged or fill material into an aquatic ecosystem is permitted if there is a practicable alternative that would have less adverse impact. No discharge of dredged or fill material shall be permitted unless appropriate and practicable steps per 40 CFR 230.70 et seq. have been taken which will minimize potential adverse impacts of the discharge on the aquatic ecosystem.	Action that involves the discharge of dredged or fill material into "waters of the U.S.", including jurisdictional wetlands - **Applicable**	40 CFR 230.10(a) 40 CFR 230.10(d)		NA	No wetlands were identified at TNT Area B.
Cultural Resources						
Presence of archaeological resources	May not excavate, remove, damage, or otherwise alter or deface such resources unless by permit or exception.	Action that would impact archaeological resources on public land - **Applicable**	43 CFR 7.4(a)		NA	Cultural resources have not been discovered within PBOW.
	Must protect any such archaeological resources if discovered.	Excavation activities that inadvertently discover archaeological resources - **Applicable**	40 CFR 7.5(b)(1)		NA	Cultural resources have not been discovered within PBOW.

Table A-1

Location-Specific Applicable or Relevant and Appropriate Requirements
Feasibility Study
TNT Area B, Plum Brook Ordnance Works
Sandusky, Ohio

Location Characteristics	Requirement(s)	Prerequisite(s)	Federal Citation	Ohio Citation	Alternatives Applicable	Comments
Presence of archaeological resources (continued)	Must stop activities in the area of discovery and make a reasonable effort to secure and protect the objects discovered.	Excavation activities that inadvertently discover such resources on federal lands or under federal control - **Applicable**	43 CFR 10.4(c)		NA	Cultural resources have not been discovered within PBOW.
	Must consult with Indian tribe likely to be affiliated with the objects to determine further disposition per 40 CFR 10.5(b)	Same as above - **Applicable**	43 CFR 10.4(d)		NA	Cultural resources have not been discovered within PBOW.
Within area where action may cause irreparable harm, loss, or destruction of significant artifacts.	Must take action to recover and preserve artifacts.	Alteration of terrain that threatens significant scientific, prehistoric, or archaeological data.	National Archaeological and Historical Preservation Act (16 USC Section 469); 35 CFR Part 65	NA	NA	Cultural resources have not been discovered within PBOW.
Endangered, threatened or rare species						
Areas harboring Endangered Species	Current conditions and potential remedial activities at PBOW must not destroy or adversely impact critical habitat	Threatened and endangered species were identified at PBOW, but not at TNT Area B.	16 USC 1531 et. seq., 50 CFR 17.21, 17.31, 17.61, 17.71, 17.94, 50 CFR 402.	NA	NA	No endangered species identified at TNT Area B.
	May not knowingly destroy the habitat of such wildlife species.	Same as above - **Relevant and Appropriate**		NA	NA	No endangered species identified at TNT Area B.
	Upon good cause shown and where necessary to protect human health or safety, endangered or threatened species may be removed, captured, or destroyed.	Same as above - **Relevant and appropriate**		NA	NA	

Table A-2

Action-Specific Applicable or Relevant and Appropriate Requirements
Feasibility Study
TNT Area B, Plum Brook Ordnance Works
Sandusky, Ohio

Action/Requirement	Requirement(s)	Prerequisite(s)	Federal Citation	Ohio Citation	Alternative Applicable	Comments
Waste generation/management						
Characterization of solid waste (e.g. contaminated PPE, equipment, wastewater)	Must determine if the waste is hazardous waste or if waste is excluded under 40 CFR 261.4; and	Generation of solid waste as defined in 40 CFR 261.2 - Applicable	40 CFR 262.11(a)	3745-52-11(a)	2-4	Remedial activities might generate hazardous waste.
	Must determine if waste is listed under 40 CFR Part 261; or		40 CFR 262.11(b)	3745-52-11(b)	2-4	Excavated contaminated soil is not classified as a listed hazardous waste because there is no definitive documentation regarding the dates of disposal.
	Must characterize waste by using prescribed testing methods or applying generator knowledge based on information regarding material or processes used. If waste is determined to be hazardous, it must be managed in accordance with pertinent provisions of 40 CFR 261 through 268.		40 CFR 262.11(c) and (d)	3745-52-11(c) through (e)	2-4	Remedial activities might generate hazardous waste.
Characterization of hazardous waste	Must obtain a detailed chemical and physical analysis of a representative sample of the waste(s) which at a minimum contains all of the information which must be known to treat, store, or dispose of the waste in accordance with 40 CFR 264 and 268.	Generation of RCRA hazardous waste for storage, treatment or disposal - Applicable	40 CFR 264.13(a)(1)	3745-54-13(a)(1)	2-4	Remedial activities might generate hazardous waste.
	Must determine if the waste is restricted from land disposal under 40 CFR 268 et seq. by testing in accordance with prescribed methods or use of generator knowledge of waste.		40 CFR 268.7	3745-59-07	2-4	Remedial activities might generate hazardous waste.
	Must determine alternative land disposal restrictions under 40 CFR 268.49 by treating soil to 10x UTS levels prior to land disposal.	Generation of RCRA hazardous waste for storage, treatment or disposal – Applicable	40 CFR 268.49		2-4	Remedial activities might generate hazardous waste.

Table A-2

Action-Specific Applicable or Relevant and Appropriate Requirements
Feasibility Study
TNT Area B, Plum Brook Ordnance Works
Sandusky, Ohio

Action/Requirement	Requirement(s)	Prerequisite(s)	Federal Citation	Ohio Citation	Alternative Applicable	Comments
Storage						
Accumulation of hazardous waste in containers (e.g. PPE, rags, etc.)	A generator may accumulate hazardous waste at the facility provided that: • Waste is placed in containers that comply with 40 CFR 265.171 through 173 (Subpart I); and • container is marked with the words "hazardous waste" or; • container may be marked with other words that identify the contents.	Accumulation of RCRA hazardous waste on site as defined in 40 CFR 260.10 - **Applicable** Accumulation of 55 gallons or less of RCRA hazardous waste at or near any point of generation – **Applicable**	40 CFR 262.34(a) 40 CFR 262.34(c)(1)	3745-52-34(a) 3745-52-34(c)(1)	2-4	This applies to accumulation in 55-gallon drums at or near the point of generation, before the drum is filled. Upon filling the drum, it must be moved within 3 days to a designated container storage area. Upon a drum's placement in the container storage area, if a temporary storage area, it must be disposed within allowed time frame.
Temporary storage of hazardous waste in containers	Except as noted below, a generator may accumulate (store) hazardous waste on-site for 90 days or less without a permit or without having interim status: • A generator who generates greater than 100 kg but less than 1000 kg of hazardous waste in a calendar month may accumulate hazardous waste onsite for 180 days or less without need to meet long-term storage requirements (40 CFR 262.34(d)). • A generator who generates greater than 100 kg but less than 1000 kg of hazardous waste in a calendar month and who must transport his waste, or offer his waste for transportation, over a distance of 200 miles or more for off-site treatment, storage or disposal may accumulate hazardous waste on-site for 270 days without need to meet long-term storage requirements (40 CFR 262.34(d)). • A generator who generates greater than 100 kg but less than 1000 kg of hazardous waste in a calendar month and who accumulates hazardous waste in a quantity less than 6000 kg or for fewer than 180 days (or for less than 270 days if he must transport his waste, or offer his waste for transportation, over a distance of 200 miles or more), is not required to meet long-term storage requirements (40 CFR 262.34(f)).	A generator providing temporary storage pending off-site treatment, storage, and disposal	40 CFR 262.34	3745-52-34	2-4	Remedial activities might generate hazardous waste. On-site storage prior to disposal/treatment might be necessary.

Table A-2

Action-Specific Applicable or Relevant and Appropriate Requirements
Feasibility Study
TNT Area B, Plum Brook Ordnance Works
Sandusky, Ohio

Action/Requirement	Requirement(s)	Prerequisite(s)	Federal Citation	Ohio Citation	Alternative Applicable	Comments
Requirements for temporary storage of hazardous waste in containers	Except as noted above, a generator may accumulate hazardous waste on-site for 90 days or less without the need to meet requirements for long-term storage, provided that:	Temporary storage of RCRA hazardous waste pending off-site treatment, storage, and disposal.	40 CFR 262.34(a)(1)(i)	3745-52-34(a)(1)(a)	2-4	Remedial activities might generate hazardous waste.
	• The waste is placed in containers and the generator complies with Subpart I of 40 CFR Part 265.		40 CFR 262.34(a)(1)(i)	3745-52-34(a)(1)(a)	2-4	Remedial activities might generate hazardous waste.
Requirements for temporary storage of hazardous waste in containers	• The date upon which each period of accumulation begins is clearly marked and visible for inspection on each container.		40 CFR 262.34(a)(2)	3745-52-34(a)(2)	2-4	Remedial activities might generate hazardous waste.
	• While being accumulated on-site, each container and tank is labeled or marked clearly with the words, "Hazardous Waste"; and		40 CFR 262.34(a)(3)	3745-52-34(a)(3)	2-4	Remedial activities might generate hazardous waste.
	• The generator complies with the requirements for owners and operators in Subparts C (Emergency Preparedness), and Subpart D (Contingency Plan) in 40 CFR 265, with 265.16 (closure survey plat), and with 268.7(a)(4) [testing and documentation for disposal].		40 CFR 262.34(a)(4)	3745-52-34(a)(4)	2-4	Remedial activities might generate hazardous waste.
Use and management of hazardous waste in containers	If container is not in good condition (e.g. severe rusting, structural defects) or if it begins to leak, must transfer waste into container in good condition.	Storage of RCRA hazardous waste in containers - Applicable	40 CFR 264.171	3745-55-71	2-4	Remedial activities might generate hazardous waste.
	use container made or lined with materials compatible with waste to be stored so that the ability of the container is not impaired		40 CFR 264.172	3745-55-72	2-4	Remedial activities might generate hazardous waste.
	Keep containers closed during storage, except to add/remove waste.		40 CFR 264.173(a)	3745-55-73(a)	2-4	Remedial activities might generate hazardous waste.
	Open, handle and store containers in a manner that will not cause containers to rupture or leak		40 CFR 264.173(b)	3745-55-73(b)	2-4	Remedial activities might generate hazardous waste.
Design and operation of a RCRA container storage area (no free liquids)	Area must be sloped or otherwise designed and operated to drain liquid from precipitation, or containers must be elevated or otherwise protected from contact with accumulated liquid	Long-term storage of RCRA hazardous waste in containers that do not contain free liquids-Applicable	40 CFR 264.175(c)	3745-55-75(c)	2-4	Remedial activities might generate hazardous waste.

Table A-2

Action-Specific Applicable or Relevant and Appropriate Requirements
Feasibility Study
TNT Area B, Plum Brook Ordnance Works
Sandusky, Ohio

Action/Requirement	Requirement(s)	Prerequisite(s)	Federal Citation	Ohio Citation	Alternative Applicable	Comments
Design and operation of a RCRA container storage area (contains free liquids)	Area must have a containment system designed and operated as follows	Long-term storage of RCRA hazardous waste with free liquids - Applicable	40 CFR 264.175(a)	3745-55-75(a)	2	Remedial activities might generate liquid hazardous waste.
	• a base must underlie the containers which is free of cracks or gaps and is sufficiently impervious to contain leaks, spills and accumulated precipitation until the collected material is detected and removed.				2	Remedial activities might generate liquid hazardous waste.
Design and operation of a RCRA container storage area (contains free liquids) (Continued)	• base must be sloped or the containment system must be otherwise designed and operated to drain and remove liquids resulting from the leaks spills or precipitation, unless the containers are elevated or are otherwise protected from contact with accumulated liquids.	-	-		2	Remedial activities might generate liquid hazardous waste.
	• must have sufficient capacity to contain 10% of the volume of containers or the volume of the largest container, whichever is greater.	-	-		2	Remedial activities might generate liquid hazardous waste.
	• runoff into the system must be prevented unless the collection system has sufficient capacity to contain along with volume required for containers	-	-		2	Remedial activities might generate liquid hazardous waste.
Waste Treatment						
Onsite treatment of RCRA hazardous waste in a NPDES treatment system	Wastewater treatment units (WWTUs), as defined in 260.10, are exempt from the requirements for permitting and interim status treatment, storage, and disposal facilities, which are codified in 40 CFR Parts 264 and 265 All applicable hazardous waste management standards apply to the waste prior to treatment in the WWTU and to any residue generated by the treatment of that waste. In other words, solid waste resulting from the treatment of a listed waste, and solid waste resulting from the treatment of a characteristic hazardous waste in an exempt wastewater treatment unit will remain hazardous as long as the solid waste continues to exhibit a characteristic as defined in 261.3 (3) and (d).	Treatment of RCRA hazardous wastewater	40 CFR 264.1(g)(6), 265.1(c)(10), and 270.1(c)(2)(v)	3745-54(g)(5) and 3745-65(c)(8)	NA	Remedial activities are not expected to generate wastewater
Wastewater Treatment and Discharge						

Table A-2

Action-Specific Applicable or Relevant and Appropriate Requirements
Feasibility Study
TNT Area B, Plum Brook Ordnance Works
Sandusky, Ohio

Action/Requirement	Requirement(s)	Prerequisite(s)	Federal Citation	Ohio Citation	Alternative Applicable	Comments
Classification of local water bodies for discharge of treated waters	Discharge quality of treated waters from the site must attain the criteria for which the segment of the water body is classified.	Point source discharge of treated wastewater - Applicable	NA	3745-1-01	NA	Remedial activities are not expected to generate wastewater
Discharge of Toxic Pollutants identified by the State of Ohio pursuant to Section 307(a)(1) of the Federal Water Pollution Control Act	Concentrations of identified toxic pollutants in Ohio waters shall not exceed the criteria indicated in this regulation	Point source discharge of treated wastewater - Applicable	NA	3745-1-07	NA	Remedial activities are not expected to generate wastewater
General Facility Requirements						
Emissions of hazardous air pollutants from TNT Area B operations	The steps necessary to indicate that the remediation systems are in compliance with the Ohio Environmental Protection Agency requirements are as follows: • Model each new or modified source of an air toxic using the SCREEN 3 model. • Compare predicted 1-hour concentrations against 1/40 of the Threshold Limit Value (TLV). The guidance specifically calls for evaluation against the time-weighted average (TWA), TLVs published by the American Conference of Governmental Industrial Hygienist (ACGIH) and Biological Exposure Indices; Threshold Limit Values and Biological Exposure Indices, ACGIH, 1998. • If this comparison shows that the predicted 1-hour concentration is greater than 1/40 of the TLV, further assessment is required. • Applies to controlled or uncontrolled sources.	Emissions of potentially toxic air contaminants	Clean Air Act Amendments of 1990, Appendix G	3745-15 et. seq.	NA	Remedial activities are not expected to result in the emission of hazardous air pollutants.
Security System	Must prevent the unknowing entry and minimize the possibility for unauthorized entry of persons or livestock onto active portion of the facility or comply with provisions of 40 CFR 264.14(b) and (c).	Operation of long-term (>90) container storage – Relevant and Appropriate	40 CFR 264.14	3745-54-14	2-4	Land use restrictions will be implemented as part of remedial activities.
General Inspections	Must inspect facility for malfunctions and deterioration, operator errors, and discharges, often enough to identify and correct any problems.	Operation of long-term (>90 day) container storage - Relevant and Appropriate	40 CFR 264.15(a)	3745-54-15(a)	2-4	Inspections are part of O&M activities.

Table A-2

Action-Specific Applicable or Relevant and Appropriate Requirements
Feasibility Study
TNT Area B, Plum Brook Ordnance Works
Sandusky, Ohio

Action/Requirement	Requirement(s)	Prerequisite(s)	Federal Citation	Ohio Citation	Alternative Applicable	Comments
Personnel Training	Must ensure personnel adequately trained in hazardous waste, emergency response, monitoring equipment maintenance, alarm system procedures, etc.	Operation of long-term (>90 day) container storage - **Relevant and Appropriate**	40 CFR 264.16	3745-54-16	2-4	
Contingency Plan	Must have a contingency plan, designed to minimize hazards to human health and the environment from fires, explosions or other unplanned sudden releases of hazardous waste to air, soil, or surface water in accordance with 40 CFR 264.62	Operation of long-term (>90 day) container storage - **Relevant and Appropriate**	40 CFR 264.51	3745-54-51	2-4	Requirement for both temporary and long-term storage.
	Must be at least one emergency coordinator on the facility premises responsible for coordinating emergency response measures in accordance with 40 CFR 264.56.	Operation of long-term (>90 day) container storage - **Relevant and Appropriate**	40 CFR 264.55	3745-54-55	2-4	Contingency plan can refer to PBOW site wide, not TNT Area B alone.
Preparedness and Prevention	Facilities must be designed, constructed, maintained, and operated to prevent any unplanned release of hazardous waste or hazardous waste constituents into the environment and minimize the possibility of fire or explosion. All facilities must be equipped with communication and fire suppression equipment and undertake additional measures as specified in 40 CFR 264.30 et seq.	Operation of long-term (>90 day) container storage - **Relevant and Appropriate**	40 CFR 264.30-264.37	3745-54-30 through 37	2-4	Requirement for both temporary and long-term storage of hazardous waste.
Closure of RCRA Container Storage						
Clean closure of RCRA container storage area	Must close the facility in a manner that: • minimizes the need for further maintenance • controls, minimizes or eliminates potential hazards to human health and the environment, post-closure escape of hazardous waste, hazardous constituents, contaminated runoff or hazardous waste decomposition products to ground or surface waters or to the atmosphere; and • complies with closure requirements of 40 CFR 264.178.	Management of RCRA hazardous waste in long-term storage (> 90 days) facility - **Relevant and Appropriate**	40 CFR 264.111	3745-66-11	2-4	
Monitoring and Extraction Wells						
Monitoring/Extraction Well Construction	Monitoring and extraction wells shall be constructed in accordance with EPA Region V Standard Operating Procedures.	Installation of groundwater monitoring or extraction wells	EPA Region V SOPs		NA	No additional monitoring wells or extraction wells are anticipated.
Monitoring/Extraction Well Abandonment	Monitoring and extraction wells shall be abandoned in accordance with requirements specified in EPA Region V Standard Operating Procedures.	Closure or abandonment of groundwater monitoring or extraction wells.	EPA Region V SOPs		NA	No action alternative results in monitoring well abandonment.

Table A-2

Action-Specific Applicable or Relevant and Appropriate Requirements
Feasibility Study
TNT Area B, Plum Brook Ordnance Works
Sandusky, Ohio

Action/Requirement	Requirement(s)	Prerequisite(s)	Federal Citation	Ohio Citation	Alternative Applicable	Comments
Transportation of Hazardous Materials and Wastes						
Transportation of hazardous waste off-site	Must comply with the generator requirements of 40 CFR 262.20-23 for manifesting, Section 262.30 for packaging, Section 262.31 for labeling, Section 262.32 for marking, Section 262.33 for placarding, and Section 262.40, 262.41(a) for record keeping requirements and Section 262.12 to obtain EPA ID number.	Off-site transportation of RCRA hazardous waste - **Applicable**	40 CFR 262.10(h)	3745-52-10(f)	2-4	Off-site disposal of hazardous waste might be part of remedial alternative.
	Must comply with the requirements of 40 CFR 263.11-263.31.	Transportation of hazardous waste within United States requiring a manifest - **Applicable**	40 CFR 263.10(a)	3745-53-10(a)	2-4	Off-site disposal of hazardous waste might be part of remedial alternative.
	A transporter who meets all applicable requirements of 49 CFR 171-179 and the requirements of 40 CFR 263.11 and 263.31 will be deemed in compliance with 40 CFR 263.	Transportation of hazardous waste within United States requiring a manifest - **Applicable**	40 CFR 263.10(a)	3745-53-10(a)	2-4	Off-site disposal of hazardous waste might be part of remedial alternative.
Transportation of hazardous materials	Shall be subject to and must comply with all applicable provisions of the HMTA and HMR (49 CFR 171-180).	Any person, who under contract with a department or agency of the federal government, transports "in commerce", or causes to be transported or shipped, a hazardous material - **Applicable**	49 CFR 171.1(c)	NA	2-4	Transportation of hazardous waste might be part of remedial alternative.

APPENDIX B

Permanganate Usage Rate Calculations

IT CORPORATION

Site: PBOW

Date: 10/26/00

1. Determine Volumes of Contaminated Zone(s):

Zone A	TNT Source Area
Zone B	DNT Source Area (no overlap to Zone A)
Zone C	
Zone D	

Zone E
Zone F
Zone G
Zone H

DRAFT

	Zone A	Zone B	Zone C	Zone D	Total	
Top Elevation	2	2				ft bls
Bottom Elevation	10	10				ft bls
Zone Length	83	48				ft
Zone Width	85	40				ft
Area of Zone	7,072	1,900	0	0		ft^2
Soil Volume	56,576	15,200	0	0		ft^3
	2,095	563	0	0		yd^3
Porosity	32%	32%	32%	35%		
Soil Bulk Density	110	110	110	118		lb/ft^3
TOC			1,000			mg/kg
Soil Mass	2,828,800	760,000	0	0		kg
Groundwater Volur	135,420	36,383	0	0		gal
	513,243	137,891	0	0		L

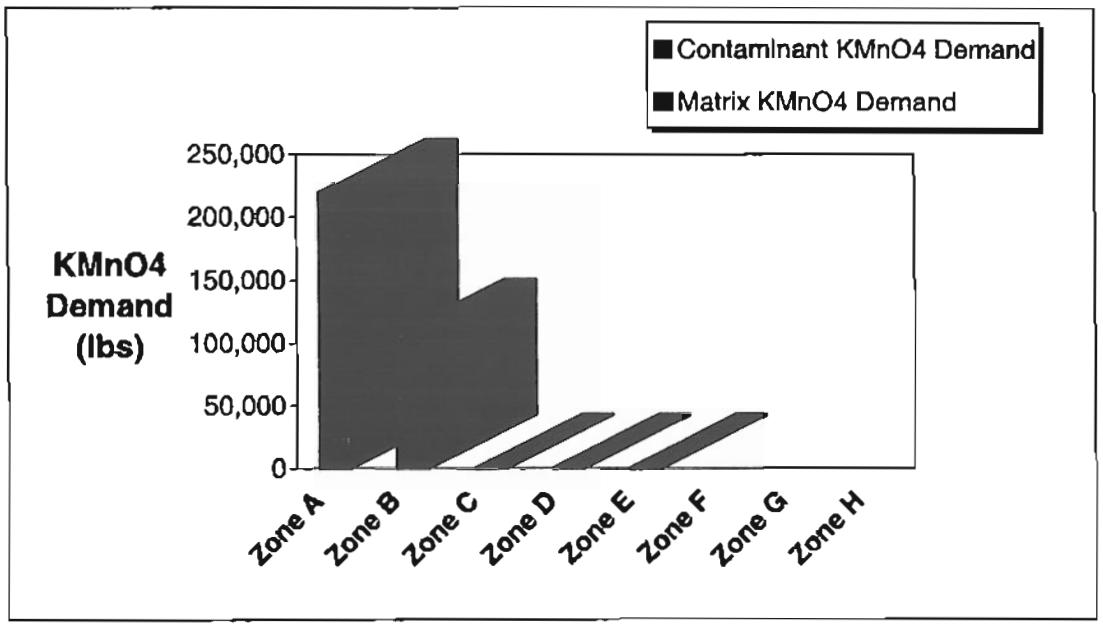
	Zone E				Total	
Top Elevation						ft bls
Bottom Elevation						ft bls
Zone Length						ft
Zone Width						ft
Area of Zone	0	0	0	0	8,972	ft^2
Soil Volume	0	0	0	0	71,776	ft^3
	0	0	0	0	2,658	yd^3
Porosity	35%	33%	33%	33%		
Soil Bulk Density	118	118	110	110		lb/ft^3
TOC						mg/kg
Soil Mass	0	0	0	0	3,588,800	kg
Groundwater Volur	0	0	0	0	171,803	gal
	0	0	0	0	651,133	L

Permanganate Usage Rate Calculations

FBOW

Area	Contaminant		Groundwater Avg Conc (mg/L)	Gw Mass lbs	Soil Avg Conc (mg/kg)	Soil Excavation Factor (%)	Soil Avg Mass lbs	Unsaturated Soil Avg Mass lbs	Total Avg Mass lbs	Total Max Mass lbs	Stoich Ratio lb KMnO4 / lb contam	Matrix Demand mg KMnO4 / kg soil	Matrix Demand lb KMnO4 / kg soil	Matrix Demand lb KMnO4	Avg Matrix Usage Factor lb KMnO4 / lb contam	Efficiency Factor ()	Total Avg KMnO4 lb KMnO4 / lb contam	Avg KMnO4 Contaminant Demand lb KMnO4	Total Avg KMnO4 Demand lb KMnO4	Total Max KMnO4 Demand lb KMnO4
Zone A	1A	2,4,6-TNT		0.0	935	☐	5825.8		5825.8	0.0	8.35	4,000.0	8.81E-03	24,923	4.28	4	33.4	194,583	219,506	0
	2A			0.0		☐	0.0		0.0	0.0	0.00				0.00		0.0	0		
	3A			0.0		☐	0.0		0.0	0.0	0.00				0.00		0.0	0		
	4A			0.0		☐	0.0		0.0	0.0	0.00				0.00		0.0	0		
	5A			0.0		☐	0.0		0.0	0.0	0.00				0.00		0.0	0		
	6A			0.0		☐	0.0		0.0	0.0	0.00				0.00		0.0	0		
	7A			0.0		☐	0.0		0.0	0.0	0.00				0.00		0.0	0		
	8A			0.0		☐	0.0		0.0	0.0	0.00				0.00		0.0	0		
	9A			0.0		☐	0.0		0.0	0.0	0.00				0.00		0.0	0		
	10A			0.0		☐	0.0		0.0	0.0	0.00				0.00		0.0	0		
	SubTotal (AVG):			0.0			5825.8		5825.8	0.0							33.4	194,583		
Zone B	1B	2,4-DNT		0.0	1,450	☐	2,427		2427.3	0.0	10.41	4,000.0	8.81E-03	6,696.0	2.76	4	41.6	101,073	107,769	0
	2B			0.0		☐	0.0		0.0	0.0	0.00				0.00		0.0	0		
	3B			0.0		☐	0.0		0.0	0.0	0.00				0.00		0.0	0		
	4B			0.0		☐	0.0		0.0	0.0	0.00				0.00		0.0	0		
	5B			0.0		☐	0.0		0.0	0.0	0.00				0.00		0.0	0		
	6B			0.0		☐	0.0		0.0	0.0	0.00				0.00		0.0	0		
	7B			0.0		☐	0.0		0.0	0.0	0.00				0.00		0.0	0		
	8B			0.0		☐	0.0		0.0	0.0	0.00				0.00		0.0	0		
	9B			0.0		☐	0.0		0.0	0.0	0.00				0.00		0.0	0		
	10B			0.0		☐	0.0		0.0	0.0	0.00				0.00		0.0	0		
	SubTotal (AVG):			0.0			2427.3		2427.31	0.00							41.6	101,073		

Zone	Soil Volume (yd3)	Groundwater Volume (gal)	Average VOC Mass (lbs)	Matrix KMnO4 Demand lb KMnO4	Average Contaminant KMnO4 Demand lb KMnO4	Average KMnO4 Demand lb KMnO4	Max KMnO4 Demand lb KMnO4
Zone A	2,095	135,420	5,826	24,923	194,583	219,506	0
Zone B	563	137,891	2,427	6,696	101,073	107,769	0
Zone C	0	0	0	0	0	0	0
[illegible]	0	0	0	0	0	0	0
Zone E	0	0	0	0	0	0	0
Zone F	0	0	0			0	0
Zone G	0	0	0			0	0
Zone H	0	0	0			0	0
	2,658	273,311	8,253	31,619	295,656	327,275	0



EQUATIONS:

Soil Volumes

Ho = bottom elevation (ft)
H = top elevation (ft)
A = zone area (ft^2)
Vs = soil volume (ft^3)
p = soil density (lb/ft^3)
Vgw = volume of groundwater (gal)
e = porosity

TOC = soil organic carbon content (mg/L)
KOC = soil equilibrium constant (octanol-H2O)

$$Vs = \frac{Ho-H\ (ft)}{} \cdot \frac{A\ (ft^2)}{}$$

$$Ms = \frac{Vs\ (ft^3)}{} \cdot \frac{p\ (lb)}{(ft^3)} \cdot \frac{kg}{2.2\ lb}$$

$$Vgw = \frac{Vs\ (ft^3)}{} \cdot \frac{7.48\ gal}{ft^3} \cdot \frac{e}{}$$

Mass Use Calculations

COC = contaminant of concern
Ce = COC groundwater concentration (ug/L)
Mgw = mass of COC in groundwater (lb)

$$Mg = \frac{Ce\ (ug)}{L} \cdot \frac{Vgw\ (gal)}{} \cdot \frac{3.79\ L}{gal} \cdot \frac{g}{1000\ mg} \cdot \frac{lb}{454\ g}$$

Msoil = mass of COC in soil (lb)
Cs = concentration of COC in soil (mg/kg)

$$Msoil = \frac{Cs\ (mg)}{kg} \cdot \frac{Vs\ (ft^3)}{} \cdot \frac{p\ (lb)}{ft^3} \cdot \frac{kg}{2.2\ (lb)} \cdot \frac{g}{1000\ mg} \cdot \frac{lb}{454\ g}$$

Mt = mass total (lb)
Mnapl = mass of residual NAPL (lb)

$$Mt = Mgw + Ms + Mnapl$$

MD = matrix demand (lb KMnO4)
NOM = soil matrix demand ratio (lbs KMnO4/kg soil)

$$MD = \frac{Ms\ (kg\ soil)}{} \cdot \frac{NOM\ (lb\ KMnO4)}{kg\ soil}$$

UF = matrix usage factor (lb KMnO4 /lb COC)

$$UF = \frac{1}{Mt\ (lbs)} \cdot \frac{MD\ (lb\ KMnO4)}{}$$

SUR = stoichiometric use ratio (lb KMnO4/lb COC)
Sr = stoichiometric ratio (lb KMnO4/lb COC)
eff = efficiency factor (Sr multiplier)

$$SUR = \frac{Sr\ (lb\ KMnO4)}{lb\ COC} \cdot \frac{eff}{}$$

CD = contaminat demand (lb $KMnO_4$)

$$CD = \frac{Mt\ (lb\ COC) \cdot SUR\ (lb\ KMnO_4)}{lb\ COC}$$

TOD = total oxidant demand

$$TOD = MD\ (lb\ KMnO_4) + CD\ (lb\ KMnO_4)$$

Cox = oxidant concentration (%)
Q = oxidant solution feedrate (gpm)
t = time of injection (hrs/day)
n = number of days
p = number of injection points
r = number of reinjection periods

$$Mox\ ((KMnO_4) = \frac{Cox\ (\%)}{} \cdot \frac{10{,}000\ (mg)}{(L)\ (\%)} \cdot \frac{g}{1000\ mg} \cdot \frac{lb}{454\ g} \cdot \frac{3.79\ (L)}{gal} \cdot \frac{Q\ (gal)}{min} \cdot \frac{1440\ min}{day} \cdot n\ (days) \cdot p \cdot r$$

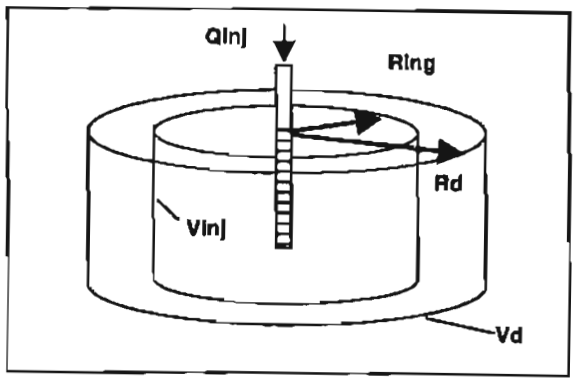
$$Mox\ ((NaMnO_4) = \frac{Cox\ (\%)}{} \cdot \frac{Y13}{} \cdot \frac{g}{1000\ mg} \cdot \frac{lb}{454\ g} \cdot \frac{3.79\ (L)}{gal} \cdot \frac{Q\ (gal)}{min} \cdot \frac{1440\ min}{day} \cdot n\ (days) \cdot p \cdot r$$

Mox = total mass of injected oxidant (lbs)

Vox-inj = total volume of oxidant solution injected (gal)

d = days of injection (days)

$$Vox\text{-}inj = \frac{Q\ (gal)}{min} \cdot \frac{1440\ min}{day} \cdot \frac{t\ (hr/d)}{24\ (hr/d)} \cdot n\ (days) \cdot p$$



Vinj = volume injected per point (gal)

$$Vinj = \frac{Q\ (gal)}{min} \cdot \frac{1440\ min}{day} \cdot \frac{t\ (hr/d)}{24\ (hr/d)} \cdot n\ (days)$$

l/v = lateral to vertical flow ratio for injected solution

Rinj = injection displacement radius (ft)

Vd = volume displaced per point (gal)

Rd = radius of displaced water (ft)

$$R_{inj} = \left[\frac{V_{inj}\,(gal)}{} \cdot \frac{ft^3}{7.48\,gal} \cdot \frac{}{e} \cdot \frac{}{3.14} \cdot \frac{}{(H-H_o)\,ft} \cdot \frac{}{l/v} \right]^{0.5}$$

$$V_d = V_{inj}$$

$$R_d = \left[\frac{2 * V_{inj}\,(gal)}{} \cdot \frac{ft^3}{7.48\,gal} \cdot \frac{}{e} \cdot \frac{}{3.14} \cdot \frac{}{(H-H_o)\,ft} \cdot \frac{}{l/v} \right]^{0.5}$$

Potassium Permanganate Feedrate Calculations

PBOW

DRAFT

4. Determine Approximate Feed Flowrate and Mass Delivery

Zone		Average Estimated Cont Mass (lbs)	NaMnO4 Oxidant Required (lbs)	Oxidant Injected (lbs)	Injection Concentration (% w/v)	Average Injection Flowrate (gpm)	Injection Time Per Day (hrs)	Time of Injection Per Interval (hours)	# of Simultaneous Injections	# of Intervals (zone layers)	# of Injection Locations
Zone A	TNT Source Area	5,826	219,506 ☐	220,438	3.0	3.0	8.0	16.3	30	5	60
Zone B	DNT Source Area (no overlap to Zone A)	2,427	107,769 ☐	106,838	3.0	3.0	8.0	7.9	30	5	60
Zone C		0	0 ☐	0	0.00	0.0	0.0	0.0	1		
Zone D		0	0 ☐	0	0.00	0.0	0.0	0.0	1		
Zone E		0.0	0 ☐	0	0.00	0.0	0.0	0.0	1		
Zone F		0	0 ☐	0	0.01	0.0	0.0	0.00	1		
Zone G		0	0 ☐	0	0.00	0.0	0.0	0.00	1		
Zone H		0	0 ☐	0	0.00	0.0	0.0	0.00	1		
		8,253	327,275	327,276				24.20			

Zone	Total Mass of KMnO4 Injected (lbs)	Mass Percent Injected	Average Mass Injected Per Day (lbs)	Volume Injected Per Interval (gals)	All Pores Volume Injected (gals)	Time of Injection Per Interval (hrs)	(workdays)	Dry Flush Time Between Intervals (min)	Total Dry Flush Time (hrs)	Relocate DP Rig (# of moves)	Time for Rig Move and Dry Flush (min/move)	DP Rig Relocation Time Total (hrs)	Total Time Per Zone (workdays)
Zone A	220,438	100%	7,287	2,934	880,200	163	20.4	10.0	1.7	☐ 0		0.0	20.6
Zone B	106,838	99%	3,532	1,422	426,600	79	9.9	10.0	1.7	☐ 0		0.0	10.1
Zone C	0	0%	0	0	0	0	0.0	0.0	0.0	☐ 0		0.0	0.0
Zone D	0	0%	0	0	0	0	0.0	0.0	0.0	☐ 0		0.0	0.0
Zone E	0	0%	0	0	0	0	0.0	0.0	0.0	☐ 0		0.0	0.0
Zone F	0	0%	0	0	0	0	0.0	0.0	0.0	☐ 0		0.0	0.0
Zone G	0	0%	0	0	0	0	0.0	0.0	0.0	☐ 0		0.0	0.0
Zone H	0	0%	0	0	0	0	0.0	0.0	0.0	☐ 0		0.0	0.0
	327,276		5,410		1,306,800	242	30		3			0.0	31

Total # of 1500 kg Cycle Bins: 99.2

Number of 1500 kg KMnO4 Cycle Bins per Day: 1.64

Total # of NaMnO4 Drums: Zone A

Number of drums of NaMnO4 per Day: Zone A

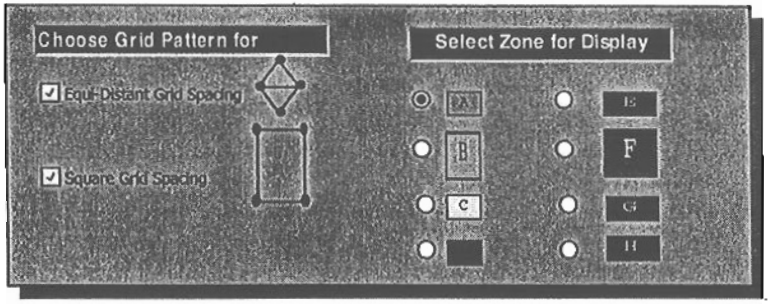
Total # of Injection Intervals: 600

5. Check Average Displacement and Pore Volumes Injected

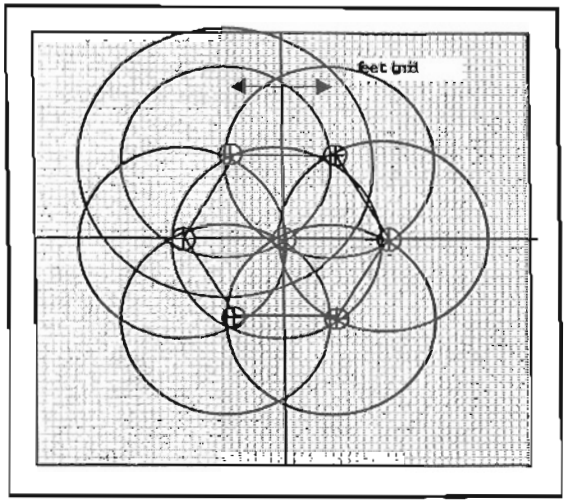
Zone	Zone Volume	Bank of Injection	Permanganate Displacement Stations	Volume of Injected Solution	Maximum Radius of Influence	# of Pore Volumes	Square Grid Spacing X Axis	Y Axis	Average Grid	Equil Distance Grid Spacing Average Grid	X Axis	Y Axis	Grid Spacing

	Thickness (ft)	Vertical Flow	Rate Injection (ft)	Per Zone (gal)	Displacement (ft)	Injected	# of Columns	# of Rows	Spacing (ft)	Spacing (ft)	# of Rows	# of Columns	Locations
Zone A	8.0	1	15.6	14,670	22.1		7.8	7.7	10.86	12.0	6.9	7.1	59.3
Zone B	8.0	1	10.9	7,110	15.4	11.73	7.1	8.4	5.63	12.0	4.0	3.3	54.3
Zone C	0.0	1	0.0	0		0.00				8.0		0.0	
	0.0	1	0.0	0		0.00				8.0		0.0	
Zone E	0.0	1	0.0	0		0.00				8.0		0.0	
Zone F	0.0	1	0.0	0		0.00				8.0		0.0	
Zone G	0.0	1	0.0	0		0.00				8.0		0.0	
Zone H	0.0	1	0.0	0		0.00				8.0		0.0	

assumes x-grid spacing = y-grid spacing



Zone A



6. **Oxidant Cost Estimate**

Zone	Chemical Cost Per lb VOC Treated	Chemical Cost / 1000 Gallons Treated	Chemical Cost /yd^3 Soil	Chemical Cost for KMnO4	Chemical Cost for KMnO4
A	$49	$2,123	$137	$288,773	$288,773
B	$58	$3,880	$251	$139,958	$139,958
C				$0	$0
				$0	$0
E				$0	$0
F				$0	$0
G				$0	$0
H				$0	$0
				$428,731	$428,731

Cost of Permanganate (delivered):	$ 1.31	per lb
Total Volume Treated	171,803	gallons
Total Soil Volume Treated	71,776	ft^3
	2,658	yd^3

RESPONSE TO COMMENTS
FROM U.S. ARMY CORPS OF ENGINEERS
ON THE DRAFT TNT AREA B FEASIBILITY STUDY
FORMER PLUM BROOK ORDNANCE WORKS, SANDUSKY, OHIO
DATED DECEMBER 2000

Reference: Comments by Mr. Larry Tannenbaum, Environmental Health Risk Assessment and Risk Communication

Comment 1: Page ES-2, Executive Summary. Here and later in the document, the technical basis of Preliminary Remediation Goals (PRGs) are not provided. Are these PRGs taken from another source, such as USEPA Region IX? It is also not clear, what exposure assessment assumptions give rise to the PRGs.

<u>Recommendation</u>: In the revised report, provide all the supportive information (e.g., source(s), technical bases).

Response: Agreed, the term preliminary remediation goals (PRG), in the context of the FS, is confusing. The PRGs are risk-based remedial criteria selected to represent a certain target cancer risk or noncancer hazard. They capture all the exposure assumptions and toxicological data used in the risk assessment. The following will be added to the first bullet in the ES: "Preliminary remediation goals are chemical- and receptor-specific risk-based remedial criteria that capture all the exposure assumptions and toxicological data used in the risk assessment." Section 2.2 will be revised in response to Comment No. 3. The basis for the PRGs will be explained as part of the revision.

Comment 2: Page ES-4, Executive Summary. In the last paragraph, the parenthetical "and lead" should be changed to "including lead". Also, the phrase "it significantly reduces the ecological hazard quotients" appears unnecessary.

<u>Recommendation</u>: Please make the wording change in the parentheses. Consider dropping the highlighted phrase, since ecological hazard quotients were not problematic to begin with.

Response: The recommended changes have been incorporated.

Comment 3: Page 2-1, Section 2.2, Remedial Action Objective for Soil. This Section poses a few difficulties. How was the decision made to establish the target (cancer) risk level of 1 x 10^{-5} as opposed to the more conventionally applied1 x 10^{-6}? Similarly, setting the target hazard (quotient) at 0.1 as opposed to 1.0 introduces a complication. Given the page's last paragraph, where it is stated that RBRCs were chosen as the PRGs, and further, that "the focus will be on remediating the site to PRG levels", the implication is that a hazard quotient of 1.0 is not acceptable. This is not correct. It is only when hazard quotients exceed 1.0 that there is a level of concern that may need to be

addressed. Furthermore, with the intention to remediate to the PRG, the assumption here is that the hazard quotient scale is linear, and this is also not true. Because the scale is not linear, determining cleanup numbers by "back-scaling" hazard quotients is a much frowned-upon process.

<u>Recommendation</u>: Please address all the points in the comment. Ensure that the shortcomings of deriving PRGs and cleanup numbers through back-scaling of hazard quotients are fully articulated in the revised report. Ensure also that a cleanup level on the basis of noncancer hazard equates with a hazard quotient of 1.0 and not any more stringent than that.

Response: This comment can be reduced to four separate issues. A response is provided for each. Finally, a revision of the first three paragraphs of Section 2.2 is proposed that addresses the issues raised by the reviewer in this comment as well as in Comment No. 1. The issues and their responses are:

"How was the decision made to establish the target (cancer) risk level of 1E-5 as opposed to the more conventionally applied 1E-6?"

The decision to set cancer-based PRGs at a target risk of 1E-5 reflects an evolution in OEPA risk management. Whereas OEPA once held to a more restrictive policy, they now generally conform to the NCP policy that cancer risks below 1E-6 are minimal, 1E-6 is a point of departure, 1E-6 to 1E-4 is a risk management range, and greater than 1E-4 is clearly unacceptable. The decision to set the target cancer risk for PRGs at 1E-5 allows using the largest RBRC that does not result in total cancer risk (summed across exposure routes, chemicals and media) for a given receptor (in this case the resident) exceeding the upper end of the risk management range. The total cancer risk for the resident, with the relevant chemicals present at concentrations equivalent to a cancer risk of 1E-5, would be below 1E-4. Further protection against cancer is provided by the fact that the PRG for TNT, the major cancer risk driver, is based on noncancer effects, which yields a more restrictive value than a PRG based on a cancer risk of 1E-5.

How was the decision made to establish the target HQ of 0.1 as opposed to the more conventionally applied value of 1?

First, it is necessary to clarify the terms hazard quotient (HQ) and hazard index (HI). An HQ is the result of dividing an estimated intake rate by a reference dose (RfD). An HI is the sum of two or more HQ values. Intake rates and RfDs are exposure route-specific. As an example, consider the evaluation of residential exposure to TNT in soil (Table 5-7 in Volume II of the RI). The source-term concentration in soil is 6900 mg/kg. Exposure routes include incidental ingestion of TNT in soil, dermal uptake of TNT from soil, and inhalation of TNT in airborne dust from soil. The HQ for incidental ingestion is 159; the HQ for dermal uptake is 46; the HQ for inhalation of dust was not estimated because there is no inhalation RfD for TNT. The HI (sum of the HQ values across

incidental ingestion, dermal uptake and inhalation of dust) for residential exposure to TNT in soil is 205.

The decision to set noncancer-based PRGs at a target HI of 0.1 rather than 1.0 reflects the assumed additivity for chemicals that operate by the same mechanism of toxicity. All of the noncancer COCs, except Aroclor 1254, are nitroaromatics. All the nitroaromatics (there are six of them) have at least one mechanism of toxicity in common – the oxidation of hemoglobin to methemoglobin, which is unable to release oxygen to the tissues and results in reduced erythrocyte longevity (hemolytic anemia). Setting the target HI for each COC at 1 would not be sufficiently protective because the total HI for the site would exceed the threshold limit of 1. Setting the target HI at 0.1 yields PRGs that are sufficiently protective.

"...the implication is that a hazard quotient of 1.0 is not acceptable. This is not correct."

The text in question will be revised for clarity.

"...the assumption here is that the hazard quotient scale is linear, and this is also not true."

The HQ scale, in fact, is linear. Consider the example of TNT in soil described above. If the source-term concentration were 3450 mg/kg instead of 6900 mg/kg, the HQ for incidental ingestion would be 79.5 instead of 159, the HQ for dermal uptake would be 23 instead of 46, and the HI for exposure to TNT in soil would be 102.5 instead of 205. It is likely that the reviewer means, correctly, that the interpretation or application of the HI is not linear. An HI of 1 is not twice as "bad" as an HI of 0.5. Both are acceptable because neither exceeds the threshold limit of 1. It is the existence of thresholds that makes back-scaling difficult, because compliance can be achieved in an infinite number of ways. The approach taken in Section 2.2 was simply to adopt the RBRCs based on a target HI of 0.1 as the PRGs. It is understood that the numbers would be slightly overly protective. The limitations associated with back-scaling will be included in the revision below.

Following is the proposed revision of the first three paragraphs of Section 2.2:

"PRGs were developed for each COC in total soil at TNTB. The first step was to perform a comprehensive search for any chemical-specific ARARs for soil that should be considered as part of the RAO. No chemical-specific ARARs for soil were identified; therefore, the RBRCs developed as part of the baseline human health risk assessment (BHHRA) were considered. The RBRCs are COC-, receptor-, and medium-specific concentrations based on target cancer risk levels of 1E-6 or 1E-5, and target HI values of 0.1 or 1. The RBRCs incorporate all the exposure and toxicity assumptions and data used in the risk assessment. RBRCs

based on a cancer risk of 1E-5 were selected as the PRGs for potential carcinogens to provide protection for the presumably additive nature of cancer risk. RBRCs based on an HI of 0.1 were selected as the PRGs for non-carcinogens to provide protection for the additivity of hazard associated with multiple chemicals with a common mechanism of toxicity. More detail regarding assumptions regarding the additivity of hazard are provided in the BHHRA. The PRGs are compiled in Table 2-1.

The PRGs are slightly over protective, at least for chemicals evaluated for noncancer effects, which includes all six nitroaromatics and Aroclor 1254. The critical effects associated with Aroclor 1254 include chloracne and immunological impairment, which are quite unlike the effects associated with the nitroaromatics. Therefore, the RBRC of 1.6 mg/kg, based on a target HI of 1, could be adopted and defended as the PRG for Aroclor 1254. All of the nitroaromatics, however, have at least one mechanism of toxicity in common – the oxidation of hemoglobin to methemoglobin, which is unable to release oxygen to the tissues and results in reduced erythrocyte longevity (hemolytic anemia). Setting the target HI for each COC at 1 would not be sufficiently protective because the total HI for the nitroaromatics would exceed the threshold limit of 1. On the other hand, setting the target HI at 0.1 yields PRGs that are slightly overly protective. Theoretically, PRGs could be established for each of the nitroaromatics based on an HI of 0.17. In fact there are an infinite number of combinations that would yield a total HI for all the nitroaromatics that meets but does not exceed the threshold limit of 1.

"The RAO for total soil will focus on remediating the site to PRG levels. It should be noted, however, that the PRGs should be viewed as conservative estimates of average concentration rather than the maximum concentrations that should be allowed to remain. In other words, it is likely that some sampling locations could have soil concentrations substantially greater than the PRGs, but if a conservative estimate of average for the area of a reasonable exposure unit falls at or below the PRG, the site is judged to be in compliance."

RESPONSE TO COMMENTS
FROM STATE OF OHIO ENVIRONMENTAL PROTECTION AGENCY
ON THE DRAFT TNT AREA B FEASIBILITY STUDY
FORMER PLUM BROOK ORDNANCE WORKS, SANDUSKY, OHIO
DATED DECEMBER 2000

Reference: Comments by Mr. Ron Nabors, Site Coordinator, Division of Emergency and Remedial Response, dated June 12, 2001.

Comment 1: General Comment – Based upon the information provided within this document, the Ohio EPA, DERR concurs with the proposed Alternative 3. It appears that Alternative 3 would achieve the remedial action objectives as established in the report.

Response: No response required.

Comment 2: Section 2.2, page 2-1: IT Corp. has incorrectly noted a hazard quotient of 0.1 within the feasibility study report. Hazard quotients are established at unity or a value of 1.0. IT Corp. should revise the report accordingly.

Response: Please see response to comment # 3 from Mr. Larry Tannenbaum, U.S. Army Center for Health Promotion and Preventive Medicine.

Response to Internal Technical Review Comments
Feasibility Study
TNT Area B, Plum Brook Ordnance Works
Sandusky, Ohio

Comments from Mike Spangberg, IT-PM (11/15/2000):

Comment 1. Change Table 4-1 to match the format and level of detail for cost estimates presented in Tables 4-2 and 4-3. Also, include a PM multiplier factor and a contingency factor in the cost estimates for the remedial alternatives.

Response 1. Agree. Table 4-1 was modified to match the format and level of detail for cost estimates presented in Tables 4-2 and 4-3. In addition, a 7% PM multiplier factor and a 10% contingency factor were added to the total costs in Tables 4-1 through 4-3.

Comment 2. [Page ES-1; fourth paragraph] Mention that groundwater will be evaluated on a site-wide basis at a later date.

Response 2. Agree. Text added throughout the document.

Comment 3. [Page 1-5; third full paragraph] Change "ion mobility spectrometry" to "ion mobility spectroscopy".

Response 3. Agree. Text has been modified.

Comment 4. [Page 2-2; first paragraph in Section 2.3] Add the following to line 6 "...it was assumed the contamination extends out approximately 10-ft *beyond the detected PRG exceedances*".

Response 4. Agree. Text has been added.

Comments from Mike Gunderson, IT (11/16/00)

Comment 1. [Executive Summary, page ES-1, third paragraph]: Revise the sentence as follows – "Fieldwork for the remedial investigation (RI) was conducted in 1998 (IT, 2000)."

Response 1. Agree. Sentence modified.

Comment 2. [Executive Summary, page ES-1, third paragraph, fifth sentence]: Suggest that we eliminate the reference to "total soil" and also include a reference to the table included in the Executive Summary. Suggest the sentence be revised to "Twelve chemicals of potential concern (COC) were identified in surface and subsurface soil as shown on the table on the following page."

Response 2. Agree. Sentence modified.

Comment 3. [Executive Summary, page ES-4, first paragraph, third sentence]: Revise to "Under Alternative 3 the portion of the excavated soil . . . ".

Response 3. Agree. Sentence modified.

Comment 4. [Section 1.2.4, page 8, second paragraph]: Suggest this be reworded to eliminate the statement that the surface water is "essentially clean" since this is a subjective statement and there were limited detections of VOCs and metals. Suggest "No COC were identified for short-term (construction worker) or long-term (on-site resident) exposure to surface water based on limited detections in this medium."

Response 4. Agree. Sentence modified.

Comment 5. [Section 1.2.6]: Change "COPC" to "COC".

Response 5. Agree. Text was modified throughout Section 1.2.6.

Comment 6. [Section 1.2.6, page 9, second bullet]: Change to "The high concentration of nitroaromatics in some surface soils indicates . . . ".

Response 6. Agree. Sentence modified.

Comment 7. [Section 3.3.1.2, page 3-2]: Delete the last sentence that states this is eliminated from further consideration. This is included in the summary and seems out of place here.

Response 7. Agree. Sentence deleted.

Comment 8. [Section 3.3.1.4, page 3-2]: Suggest we include that capping the small areas would also be impractical.

Response 8. Agree. Sentence added.

Comments from Bill Hedberg, IT – Senior Technical Reviewer (11/16/00)

Comment 1. There is no figure depicting the detections of contaminants in surface water and sediment.

Response 1. According to the human health risk assessment in Volume II of this RI report, there is no risk associated with exposure to surface water or sediment at TNT Area B. Therefore, no RAOs were developed for these two environmental media, and no figures were presented depicting contaminant detections.

Comment 2. What is the reference for the lead background values used in the FS

Response 2. Lead background values were referenced from Volume II of this RI report.

Comments from Patrick Gray (11/17/2000)

No substantive comments.

Response to Comments
Feasibility Study
TNT Area B, Plum Brook Ordnance Works
Sandusky, Ohio

Response to Comments from Doug Mullendore (received on November 27th, 2000)

Comment 1: **Page ES-2, Bullet for Alternative 2 – There seems to be a typographical error associated with the volume of material to be treated.**

Response 1: Agree. Total volume of contaminated soil to be treated is 3,300 cubic yards and not 300 cubic yards. Text will be modified accordingly.

Comment 2: **Page ES-2, Bullet for Alternative 2 – 3 percentum permanganate solution should be 3 percent potassium permanganate solution.**

Response 2: Agree. Sentence will be changed to read "...using a 3 percent permanganate solution...".

Comment 3: **Page ES-3, Bullet for Alternative 3 – There seems to be a typographical error associated with the volume of material treated.**

Response 3: Agree. Total volume of contaminated soil to be treated is 3,300 cubic yards and not 300 cubic yards. Text will be modified accordingly.

Comment 4: **Page ES-3, Bullet for Alternative 4 – There seems to be a typographical error associated with the volume of material to be treated.**

Response 4: Agree. Total volume of contaminated soil to be treated is 3,300 cubic yards and not 300 cubic yards. Text will be modified accordingly.

Response to Comments
Feasibility Study
TNT Area B, Plum Brook Ordnance Works
Sandusky, Ohio

Response to Comments from Becky Terry (received on November 29th, 2000)

Comment 1: **Page ES-2, Bullet for Alternative 2 – Number in parentheses needs to be corrected. Alternative 2 – Correct spelling of the "percentum".**

Response 1: Agree. Total volume of contaminated soil to be treated is 3,300 cubic yards and not 300 cubic yards. Text will be modified accordingly. Also, sentence will be changed to read "...using a 3 percent permanganate solution...".

Comment 2: **Page ES-3, Bullet for Alternative 3 – Number in parentheses needs correcting.**

Response 2: Agree. Total volume of contaminated soil to be treated is 3,300 cubic yards and not 300 cubic yards. Text will be modified accordingly.

Comment 3: **Page ES-3, Bullet for Alternative 4 – See previous comment.**

Response 3: Agree. Total volume of contaminated soil to be treated is 3,300 cubic yards and not 300 cubic yards. Text will be modified accordingly.

Comment 4: **Page 1-2, Section 1.2.2.1, first sentence. Provide an approximate location for surface water/sediment samples (SW07/SD07 and SW08/SD08).**

Response 4: Approximate location of the surface water/sediment samples is provided on Page 1-2, Section 1.2.2.1, third and fourth sentences.

Comment 5: **Page 1-5, Section 1.2.3.1, first paragraph. Include a discussion of the results from the test kits used for nitroaromatic confirmation.**

Response 5: Agree. The following paragraph will be added after the first paragraph in Section 1.2.3.1.

To ensure the effectiveness of the IMS data, approximately ten percent of the samples collected for IMS analysis were analyzed with colorimetric test kits using method SW-846 8515. Overall, there was a correlation between the TNT detections. There were several incidences of detects in the IMS that were not detected by the kit. Eight of those were concentrations substantially higher than the kit's detection limit. Where TNT was detected by both methods, there is variability in the

concentrations. Relative percent differences between the concentration ranges from less than 1 percent to 138 percent.

Comment 6: **Page 2-3, Section 2.4, paragraph in middle of page. Should this discussion include a table that provides chemical specific ARARs?**

Response 6: No table with chemical-specific ARARs was included in the document, because no chemical-specific ARARs were identified that have to be considered for remediating contaminated soil at TNTB. The following sentence will be added at the end of the second paragraph on Page 2-3. "There is no table with chemical-specific ARARs because no such ARARs were identified that have to be considered for remediating contaminated soil at TNTB".

Comment 7: **Page 3-2, Section 3.3.1.3, second sentence. Edit spelling.**

Response 7: Sentence will be edited to read: "The O&M costs are expected to be low".

Response to Comments
Feasibility Study
TNT Area B, Plum Brook Ordnance Works
Sandusky, Ohio

Response to Comments from Lannae Long (received on November 29th, 2000)

Comment 1: **Section 1.2.5, Ecological Assessment Summary. The ecological assessment in the RI should be considered a screening level ecological risk assessment (SLERA) that fulfills EPA's Step 1 and 2 of the ecological Guidance for Superfund (1997), not a full ecological risk assessment. The text should reflect that this is a summary of the SLERA from the RI.**

Response 1: Agree. The first paragraph in Section 1.2.5 will be modified to read "A screening level ecological risk assessment (SLERA) has been performed as part of the RI for TNTB (IT, 2000). Results of the SLERA indicate...".

Comment 2: **Generally, remedial goals do not get drafted from a SLERA because of the uncertainties involved in the preliminary level ecological process. Generally the SLERA can determine if there is very low likelihood of ecological impact, or if there is a potential for concern where further action (not necessarily remedial goal development) should be considered. The meaning of the RI SLERA conclusions seems to reflect this sentiment (confirmed with a phone call to the RI author 11/28/00). In the Draft FS, there appears to be a misinterpretation as seen in the last sentence. The last sentence should be deleted.**

Response 2: Agree. Last sentence will be modified to read "However, based on uncertainties of toxicity, limited aquatic habitat at the site, and the fact that no rare, threatened, and endangered species have been confirmed at the site, RAOs based on ecological risk were not recommended in the RI (IT, 2000). However, additional ecological discussions are presented in Section 2.2."

Comment 3: **The SLERA RI indicates HQs greater than 1000 for a few indicator species, and the highest calculated HQ of 40,000 for the wren. HQs greater than 1 may indicate that there is a potential for ecological concern, and there should be further ecological consideration at the site. Because there was no further ecological consideration programmed into the CELRH's site plan, creative ecological consideration that supports protection of the environment needs to be conducted. I suggest including a statement that remedial goals in soil, based on human health concerns are protective of the environment, and that new HQs for certain indicator receptors are calculated from remedial goal values, and the resulting HQs should be within a**

manageable range. I suggest re-calculating HQs using the derived human health remedial goals, showing the results in a table, and reference the table from this section. (Note: In soil, TNT and the Amino-DNTs are the major contributors to the calculated HQs, and these should be the focus for protection of the environment.)

Response 3: Agree. The following insert will be added to Section 2.2, page 2-2, immediately before Section 2.3, and a new table (Table 2-2) will be included in the document. Existing Tables 2-2 and 2-3 will be renumbered to Tables 2-3 and 2-4, respectively.

Elevated ecological hazards were estimated for the site (Section 1.2.5), and although these estimates were associated with a considerable degree of uncertainty, a further discussion of how the proposed remedial action is protective of the environment is necessary. Table 2-2 presents estimated ecological hazards for the residual concentrations of the human health COCs expected at the site following the proposed remedial action. As can be seen in the table, expected residual concentrations in soil are below the proposed human health PRG concentrations, due to the planned excavation of COC hotspots. Using these estimated residual concentrations, resultant ecological hazards for critical ecological receptors were simply scaled, as described in the footnotes to Table 2-2. Ecological hazards for the site (following remediation) are expected to be reduced by an average of 750-fold for the COCs, as compared with the initial RI ecological hazard estimates (IT, 2000). Most dramatically, TNT hazards for the shrew are expected to fall by almost 9,000-fold (Table 2-2). While many of the COCs are still estimated to have potential ecological hazards above 1.0, this finding is not considered significant for the following reasons:

- Many of the estimated ecological hazards above 1 are due to detection limit issues. Further reduction in the human health PRGs to protect ecological receptors is not warranted due to the fact that the PRGs are already near the analytical limit of detection (final column of Table 2-2).

- The potentially elevated ecological hazard for 4-amino-2,6-DNT is based on a very conservative toxicity reference value that over estimates the hazard. The bird toxicity value used in the RI (and in Table 2-2) was 0.032 mg/kg-day (based on a acute lethal dose of 3.2 mg/kg-day coupled with an uncertainty factor of 100). This toxicity value was originally used, as no other toxicity data were available for

birds, including other nitroaromatics. More appropriate chronic data (USACHPPM, 2000) recommends an avian no observed adverse effect level (NOAEL) of 0.07 mg/kg-day and a lowest observed adverse effect level (LOAEL) of 1.8 mg/kg-day for TNT. Toxicity results for TNT may be used as a surrogate for the amino compound, due to general structural similarities between the two nitroaromatic compounds.

Use of these more appropriate wildlife toxicity values would result in an adjustment of 56-fold and 2-fold for the avian toxicity of 4-amino-2,6-DNT, giving revised scaled ecological hazard quotients of 22 to 628 in Table 2-2, as opposed to 1,256.

- The estimated ecological hazards in Table 2-2 incorporate additional safety factors, such as the use of an 8-fold modifying factor to account for species-to-species extrapolation, and a conservative site foraging factor of 100 percent. In reality, wildlife are not expected to spend 100 percent of their time at TNTB, and thus exposures to COCs would be reduced.

- Bioaccumulation of COCs in the food chain was estimated using simple empirical models, and actual uptake is expected to be less than estimated. For example, uptake of 4-amino-2,6-DNT in earthworms from soil was estimated to be 11.5-fold, however, actual uptake is likely much less. Earthworm-consuming wildlife, such as the wren used in the assessment (Table 2-2), would thus experience lower COC exposures using more realistic COC uptake factors.

In conclusion, given the reasons presented above, the proposed human health PRGs (Table 2-1) are expected to result in residual COC soil concentrations that are protective of the environment. No additional aquatic PRGs are needed for surface water or sediment due to the fact that (1) there is very limited aquatic habitat at the site; and (2) the aquatic habitat that is present is of low quality and is not expected to support or attract fish or wildlife species.

References (to be added to Section 6.0):

U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM), 2000, ***Standard Practice for Wildlife Toxicity Reference Values***, Technical Guide No. 254, Environmental Assessment Program, Health Effects Research Program, October.

Comment 4: **In Section 4, there are "Over all Protectiveness of Human Health and the Environment" statements. I suggest referencing the re-calculated HQs to show that the remedial goals are protective of the environment.**

Response 4: Agree. Sections 4.3.2, 4.4.2, and 4.5.2 will be modified to reference Table 2-2 when referring to ecological risks at the site. The text in the aforementioned sections will be modified to read "*...remedial action* would permanently treat/remove contaminated soil, thereby reducing human health risks to within levels considered acceptable by the EPA, and significantly reducing the ecological hazard quotients (Section 2.2 and Table 2-2)." The executive summary will also be modified.

Comment 5: **It should be noted that a baseline Eco Risk Assessment (BERA) is probably not warranted if the remedial goal calculations in the indicator species exposure models show little to no concern.**

Response 5: Agree. See response to comment 3.

Comment 6: **Human Health Remedial Goals, Table 2-1: I believe that tables should be developed for other likely scenarios including the trespasser and the industrial worker to give perspective to the residential based remedial goals. It is a possibility that Ohio EPA will want to discuss the choice of the residential scenario based remedial goals.**

Response 6: Agree. Table 2-1 was modified to include a total of three receptor scenarios: resident, groundskeeper, and construction worker. RBRC were taken directly from the human health risk assessment for TNTB (IT, 2000). The footnotes in Table 2-1 describe the selection of PRGs for soil at TNTB.