Final
January 2013

Remedial Investigation Report
Reservoir No. 2 Burning Ground

Former Plum Brook Ordnance Works
Sandusky, Ohio

FUDS Project No. G05OH001812

US Army Corps of Engineers
Nashville District

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Reservoir No. 2 Burning Ground

Former Plum Brook Ordnance Works,
Sandusky, Ohio

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January 2013

Final

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List of Acronyms

2-ADNT	2-amino-4,6-dinitrotoluene
4-ADNT	4-amino-2,6-dinitrotoluene
amsl	above mean sea level
bgs	below ground surface
BHHRA	baseline human health risk assessment
BSC	background screening concentration
CD	compact disk
COPC	chemical of potential concern
COPEC	chemical of potential ecological concern
CSEM	conceptual site exposure model
DERP	Army Defense Environmental Restoration Program
DNT	dinitroluene
DoD	U.S. Department of Defense
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
FS	feasibility study
FUDS	Formerly Used Defense Sites
HI	hazard index
HQ	hazard quotient
ICI	International Consultants Incorporated
ILCR	incremental lifetime cancer risk
IT	IT Corporation
Jacobs	Jacobs Engineering Group, Inc.
LRD	Great Lakes and Rivers Division
µg/L	micrograms per liter
mg/L	milligrams per liter
NASA	National Aeronautics and Space Administration
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NOAEL	no-observed-adverse-effects level
NWI	National Wetland Inventory
ODNR	Ohio Department of Natural Resources
OEPA	Ohio Environmental Protection Agency
PAH	polycyclic aromatic hydrocarbon

List of Acronyms *(Continued)*

PBOW	Plum Brook Ordnance Works
PBS	Plum Brook Station
PCB	polychlorinated biphenyl
ppm	parts per million
PRG	preliminary remediation goal
R2BG	Reservoir No. 2 Burning Ground
RBC	risk-based criteria
RfD	reference dose
RI	remedial investigation
SCR	site characterization report
SDWR	Secondary Drinking Water Regulations
Shaw	Shaw Environmental, Inc.
SI	site investigation
SLERA	screening-level ecological risk assessment
SSAP	site-specific sampling and analysis plan
SVOC	semivolatile organic compound
T&E	threatened or endangered
TAL	target analyte list
TCDD	tetrachlorodibenzodioxin
TDS	total dissolved solids
TEQ	toxicity equivalent
TNT	trinitrotoluene
TNTA	TNT Area A
TNTB	TNT Area B
TNTC	TNT Area C
TRV	toxicity reference value
USACE	U.S. Corps of Engineers
VOC	volatile organic compound

Executive Summary

A remedial investigation (RI) was conducted for the Reservoir No. 2 Burning Ground (R2BG). The results of the RI have been previously reported in the following three finalized documents:

- Jacobs Engineering Group, Inc. (Jacobs), 2010, ***Revised Final Baseline Human Health Risk Assessment, Reservoir No. 2 Burning Ground, Former Plum Brook Ordnance Works, Sandusky, Ohio***, February.

- Jacobs Engineering Group, Inc. (Jacobs), 2010, ***Revised Final Screening Level Ecological Risk Assessment, Reservoir No. 2 Burning Ground, Former Plum Brook Ordnance Works, Sandusky, Ohio***, February, as updated by October 3, 2011 replacement pages.

- Jacobs Engineering Group, Inc. (Jacobs), 2006, ***Final Site Characterization Report, Remedial Investigation Part 1 at Reservoir No. 2 Burning Ground, Former Plum Brook Ordnance Works (PBOW), Sandusky, Ohio***, January.

This RI summarizes the findings of these three reports, which are appended. No additional investigation results, evaluation, or information is included in this RI. However, recommendations are provided based on this previously provided information. Thus, the purposes of this RI report are to1) place all RI-related reports under a single cover, and 2) record a recommendation as to whether or not performance of a feasibility study (FS) is warranted.

Site Characterization Report. Soil trenching was performed to identify the lateral and vertical extent of a layer of burned material. This lateral extent of the burn layer defines the boundary of the Burn Area. The burn layer was typically found at a depth of approximately 1 foot below ground surface and was typically about 1 foot thick. Groundwater was also investigated. Piezometers were installed in the overburden/shale unit, but the Project Delivery Team agreed not to install monitoring wells in this unit due to a lack of water. Three wells were installed in the bedrock limestone groundwater unit.

The following samples were collected and sent for laboratory analysis:

- Surface soil – 26 samples (4 inside the Burn Area and 22 outside the Burn Area)
- Subsurface soil – 24 samples (8 inside the Burn Area and 16 outside the Burn Area)
- Limestone bedrock monitoring wells – One sample each from 3 wells
- Sediment – Three samples from adjacent drainage ditch to the north.

No surface water was present in the drainage ditch, so no surface water samples were collected.

Chemicals detected in soils at concentrations exceeding screening levels include nitrotoluenes, polychlorinated biphenyls, polychlorinated dibenzodioxins/furans, polycyclic aromatic hydrocarbons (PAH), lead, and other metals. The highest concentrations were typically found within the burn layer. The only chemicals detected in sediment that exceeded screening values were PAHs. The groundwater monitoring wells contained little water and could thus not be developed or purged. The samples had to be collected by bailer, as there was too little water to sample using low-flow methods. Consequently, the samples were highly turbid. Chemicals that exceeded screening values in groundwater included various metals, benzene, xylene, and PAHs. Benzene and xylene are naturally occurring petroleum hydrocarbon-related components in the limestone bedrock groundwater, and the metals and PAHs are evidently associated with entrained sediment that resulted from the low water volume and sampling technique required. Groundwater flow direction in the overburden/shale unit was found to be toward the north. Although adequate water level measurements could not be collected from the R2BG limestone bedrock wells, the flow direction in this unit through the R2BG area is interpreted as being toward the southeast, following a linear northeast-to-southwest linear feature in this area.

Baseline Human Health Risk Assessment. A baseline human health risk assessment (Jacobs, 2010a) was performed using the RI analytical results and the analytical results from soil samples during the previous site investigation. These data were used to evaluate the following human receptors (media evaluated in parentheses):

- Current/future groundskeeper (surface soil)
- Future indoor worker (surface soil and bedrock groundwater)
- Current/future construction worker (surface soil, subsurface soil, and sediment)
- Future resident (surface soil, subsurface soil, sediment, and bedrock groundwater)
- Current/future adult hunter (surface soil, including venison pathway)
- Current/future hunter's child (surface soil [venison pathway only]).

Exposure to soils from inside the Burn Area and outside the Burn Area was evaluated separately. Cancer risks are calculated as incremental lifetime cancer risk (ILCR) values, and noncancer hazards are calculated as hazard index (HI) values. The overall HI and ILCR values are summarized by environmental medium and receptor in the following bullets. Exceedances of the PBOW cancer risk goal (ILCR>1E-5) are shown in bold type, and exceedances of the noncancer hazard criterion (HI>1) or the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) risk management range (1E-6 to 1E-4) are shown in bold italics. Receptors with

neither an ILCR nor HI value that exceeds the PBOW cancer risk goal or the HI criterion for a given medium are not shown.

Inside the Burn Area – Surface Soil

- Current/future groundskeeper: **ILCR = 8E-5**; ***HI = 12***
- Future indoor worker: **ILCR = 4E-5; *HI = 6***
- Current/future construction worker: ILCR = 4E-6; ***HI = 33***
- Future resident: ***ILCR = 3E-4***; ***child HI = 140***; ***adult HI = 15***

Inside the Burn Area – Subsurface Soil

- Current/future construction worker: **ILCR = 2E-5**; ***HI = 154***
- Future resident: ***ILCR = 4E-3***; ***child HI = 651***; ***adult HI = 70***

Outside the Burn Area – Surface Soil

- Current/future groundskeeper: **ILCR = 3E-5**; HI = 1
- Current/future construction worker: ILCR = 2E-6; ***HI = 3***
- Future resident: **ILCR = 1E-4**; ***child HI = 15***; ***adult HI = 2***

Outside the Burn Area – Subsurface Soil

- Current/future construction worker: ILCR = 1E-6; HI = 1
- Future resident: **ILCR = 8E-5**; ***child HI = 5***; adult HI = 0.6

Groundwater

- Future indoor worker: ***ILCR = 2E-3; HI = 15***
- Future resident: ***ILCR = 8E-3***; ***child HI = 101***; ***adult HI = 44***

Sediment

- No receptor had an ILCR or HI value that exceeded the PBOW cancer risk goal or noncancer hazard criterion.

The site-related cancer risk-driving chemicals in Burn Area surface soil were as follows: trinitrotoluene (TNT), dinitrotoluene (DNT) mixture, 2,3,7,8-tetrachlorodibenzodioxin (TCDD) toxicity equivalents (TEQ), and Aroclor 1260. TNT and lead were the noncancer hazard driving chemicals in Burn Area surface soil.

The site-related cancer risk driving chemicals in Burn Area subsurface soil were as follows: TNT, DNT mixture, 2,3,7,8-TCDD TEQ, Aroclor 1254, and Aroclor 1260. TNT, 2,4-DNT, 2,6-DNT, Aroclor 1254, and lead were the noncancer hazard-driving chemicals in subsurface soil inside the Burn Area.

The site-related cancer risk driving chemicals in surface soil outside of the Burn Area were as follows: TNT, DNT mixture, and Aroclor 1260. TNT and lead were the noncancer hazard-driving chemicals in surface soil outside of the Burn Area.

The cancer risks and noncancer hazards in subsurface soils outside of the Burn Area were driven by naturally occurring, non-site-related inorganic constituents. Site-related chemicals did not significantly contribute to cancer risks or noncancer hazards.

The risks and hazards associated with R2BG groundwater are regarded as implausible because exposure is unlikely due to low yield of the bedrock aquifer and the risk-driving chemicals in R2BG groundwater are naturally occurring inorganics and naturally occurring petroleum-related organic chemicals that are not associated with former PBOW activities.

The cancer risks for all receptors evaluated in the BHHRA for exposure to R2BG sediment are less than the PBOW cancer risk goal and are either within or less than the NCP risk management range. Noncancer hazards are regarded as negligible.

Screening-Level Ecological Risk Assessment. A screening level ecological risk assessment (SLERA) was performed using the RI analytical results for soil and sediment, and the soil sample results from the previous site investigation. Only soil samples collected from depth intervals ranging from 0 to 7.6 feet below ground surface were used in the SLERA.

Ecological reconnaissance surveys were conducted as part of the SLERA. Vegetative communities at the Burn Area and the study area immediately west of the Burn Area are upland old field, dominated by grasses and herbs. The old field area may be irregularly mowed. In the vicinity of the southern boundary of the Burn Area, the vegetation is classified as shrub thicket. Areas farther to the south, north, and east are successional woods. Vegetative stress attributable to chemical contamination was not observed at R2BG. No wetlands or significant aquatic habitat was observed, and no water was present in the east-west ditch in the northern part of R2BG during the ecological surveys or field sampling events. No threatened or endangered plant or animal species were observed during site reconnaissance.

The following terrestrial species were evaluated for exposure to contaminants in R2BG soil: deer mouse (small omnivorous mammal), short-tailed shrew (small insectivorous mammal), Eastern cottontail rabbit (medium-sized terrestrial herbivorous mammal), marsh wren (small insectivorous bird), raccoon (medium-sized omnivorous mammal), white-tailed deer (large herbivorous mammal), and red-tailed hawk (large carnivorous bird). These were evaluated for direct (e.g., ingestion of soil) and food web exposure pathways. With respect to aquatic exposure pathways, only direct exposure to aquatic sediment-dwelling organisms was evaluated in the SLERA because of limited aquatic habitat.

Ecological hazards in a SLERA are characterized by the derivation of a hazard quotient (HQ) value, HQs less than or equal to 1 represent no probable hazard. Although the Ohio Environmental Protection Agency considers all HQs above 1 to be potentially significant, the HQ values include much uncertainty and are highly conservative. Therefore, it should be understood that HQs greater than 1 do not mean that adverse ecological effects are occurring at the site or may occur in the future.

Inside the Burn Area, terrestrial receptors are predicted to incur elevated hazards from exposure to 2,3,7,8-TCDD TEQ, explosives, and two PAHs (acenapthene and naphthalene), based on the no-observed-adverse-effect-level (NOAEL)-based HQ approach. Several metals had elevated HQs, but the metals concentrations are within the range of naturally occurring background. Estimated HQs are above 1,000 for some receptors using the NOAEL-approach. However, the estimated HQs that are above 1,000 using the NOAEL-based approach are considered unrealistic and toxicologically impossible. The white-tailed deer and red-tailed hawk had no HQ exceedances greater than 10 outside of the Burn Area and only an HQ greater than 10 for 2,4-DNT inside 2BG.

Outside the Burn Area, terrestrial receptors are predicted to incur elevated hazards from exposure to explosives only with TNT being the greatest risk driver for the raccoon only. The white-tailed deer and red-tailed hawk had no HQ exceedance greater than 10.

Sediment-dwelling aquatic receptors are predicted to have potentially elevated hazards from exposure to 2,3,7,8-TCDD TEQ and PAHs based on a comparison of sediment data to RBSLs. However, given the limited to poor quality aquatic habitat at the site, the potential for adverse impacts to aquatic biota is considered negligible.

Recommendations. Based on the RI results, including the BHHRA and SLERA, the U.S. Army Corps of Engineers recommends that an FS be performed for R2BG soils. This includes surface and subsurface soils inside the Burn Area and surface soil outside of the Burn Area.

1.0 Introduction

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

This remedial investigation (RI) has been performed to determine if there have been any environmental impacts associated with former DoD that present an unacceptable risk to human health or the environment associated with the former Reservoir No. 2 Burning Ground (R2BG), which comprises DERP-FUDS Project No. G05OH001812.

This RI report was conducted under Delivery Order No. DX09 of Contract No. W912QR-08-D-0013. It summarizes the information presented previously in the following reports:

- Jacobs Engineering Group, Inc. (Jacobs), 2010a, ***Revised Final Baseline Human Health Risk Assessment, Reservoir No. 2 Burning Ground, Former Plum Brook Ordnance Works, Sandusky, Ohio***, February.

- Jacobs Engineering Group, Inc. (Jacobs), 2010b, ***Revised Final Screening Level Ecological Risk Assessment, Reservoir No. 2 Burning Ground, Former Plum Brook Ordnance Works, Sandusky, Ohio***, February, as updated by October 3, 2011 replacement pages.

- Jacobs Engineering Group, Inc. (Jacobs), 2006, ***Final Site Characterization Report, Remedial Investigation Part 1 at Reservoir No. 2 Burning Ground, Former Plum Brook Ordnance Works (PBOW), Sandusky, Ohio***, January.

It should be noted that this RI report generally presents and summarizes information directly as it was conveyed in these final approved reports performed by Jacobs. No new data is presented in this RI. It is noted that Section 2.4 includes an updated evaluation of groundwater quality based on more recent PBOW documents (e.g., Shaw Environmental, Inc. [Shaw], 2008; 2012).

1.1 Report Organization

As part of the RI effort, the R2BG site was previously investigated and evaluated in a site characterization report (SCR), baseline human health risk assessment (BHHRA), and screening-level ecological risk assessment (SLERA). This RI report summarizes these three reports and presents recommendations based on their findings. The SCR, BHHRA, and SLERA are appended to this report in their entirety (Appendices A through C) in electronic format on compact disk (CD).

The remainder of this chapter provides a description and history of the PBOW facility and of the former R2BG. This description of R2BG discusses its relationship to the PBOW remedial activities and briefly describes the history and current associated conditions. More specific information is included in the respective SCR, BHHRA, and SLERA that are appended to this RI report. Chapter 2.0 of this report summarizes the physical setting of PBOW and R2BG. This discussion of physical setting includes the geography, topography, drainage, and geology, including hydrogeology and natural groundwater quality.

Chapter 3.0 summarizes the SCR, Chapter 4.0 summarizes the BHHRA, and Chapter 5.0 summarizes the SLERA results and conclusions. Chapter 6.0 presents site-specific recommendations for site management decisions. These recommendations primarily discuss whether or not a remedial action is warranted. These recommendations do not identify a specific technological approach, but are provided to help site managers form a basis for determining whether a feasibility study (FS) is required, or for proceeding directly to a no-action proposed plan. References used in the RI are listed in Chapter 7.0.

Additional details pertaining to the SCR, BHHRA, and SLERA for each of these four sites are provided in the three previously submitted final reports, which are included on CD as Appendices A through C.

1.2 Facility Location and Description

The former 9,000-acre PBOW facility was used for the manufacture of nitroaromatics during World War II. The National Aeronautics and Space Administration (NASA) operates and maintains the site as the Plum Brook Station (PBS), which is a satellite facility of the John H. Glenn Research Center, located at Lewis Field in Cleveland, Ohio. PBOW is located approximately 4 miles south of Sandusky, Ohio, and 59 miles west of Cleveland. Although primarily in Perkins and Oxford Townships, the eastern edge of PBOW extends into Huron and Milan Townships. PBOW is bounded on the north by Bogart Road, on the south by Mason Road, on the west by Patten Tract Road, and on the east by U.S Highway 250. The areas surrounding PBOW are mostly

agricultural and residential. Public access is prohibited at PBOW except during the annual deer hunting season, which is by permit only. Figure 1-1 shows the geographical location of the former PBOW site.

1.3 Facility History and Background

The PBOW facility was constructed on property comprising 9,009 acres in early 1941 as a manufacturing plant for 2,4,6-trinitrotoluene (TNT), 2,4-dinitroluene (DNT), and pentolite (International Consultants Incorporated [ICI], 1995). Production of explosives at PBOW began in December 1941 and continued until 1945. It is estimated that more than 1 billion pounds of nitroaromatic explosives were manufactured during the 4-year operating period. The three explosive manufacturing areas were designated TNT Area A (TNTA), TNT Area B (TNTB), and TNT Area C (TNTC). Twelve process lines were used in the manufacture of TNT: four lines at TNTA, three lines at TNTB, and five lines at TNTC.

After plant operations ceased, the manufacturing process lines were decontaminated by the Army in late 1945. During decontamination, all structures, equipment, and manufacturing debris were either removed and salvaged or removed and burned. After the property was certified as decontaminated, 3,230 acres of the property were initially transferred to the Ordnance Department, then to the War Assets Administration on September 6, 1946. In 1949, PBOW was transferred to the General Services Administration. This transfer did not include the Plum Brook Depot area, which consists of 2,800 acres. The Department of the Army reacquired the 3,230 acres in 1954. In 1955, the Army completed further decontamination of the manufacturing process lines. This effort included removal of contaminated surface and subsurface soil around the buildings and wooden and ceramic waste disposal lines containing TNT. Thousands of pounds of TNT were discovered in catch basins; this TNT was removed and burned at the burning grounds. The Army continued cleanup efforts until 1963.

Two property use agreements were entered into by the Army and the National Advisory Committee of Aeronautics, the predecessor of NASA, in 1956 and 1958, respectively. Accountability and custody for the entire portion of the former PBOW property (6,030 acres) that had been under the accountability and custody of the Department of the Army were transferred to NASA on March 15, 1963. NASA performed further decontamination efforts during 1964. The NASA decontamination process included removing contaminated surface soil above the drain tiles, flumes, etc.; destruction of all buildings by fire; then removal of all soil, debris, sumps, and above-grade portions of concrete foundations. Portions of the concrete foundations located below grade were left buried, and some that had been previously slightly

above grade were covered with fill material. All materials, including the soil in those areas, were flashed; the area was then rough-graded. The decontamination process was also to have included the burning of excavated nitroaromatic-filled pipelines (Dames & Moore, Inc., 1997a).

NASA has operated and maintained the former PBOW property since 1963, and the facility is currently the PBS, which supports the NASA John H. Glenn Research Center at Lewis Field, Cleveland, Ohio as a satellite operation. Most of the aerospace testing facilities built in the 1960s at PBOW are currently on standby or inactive status. However, NASA has constructed newer research facilities on site since the 1960s. On April 18, 1978, NASA declared approximately 2,152 acres of PBOW as excess. This excess included former buffer areas that had not been used by the Army and were thus not subject to decontamination efforts. The Perkins Township Board of Education acquired 46 acres of the excess acreage and uses this area as a bus transportation area. The General Services Administration retains ownership of the remaining excess acreage and currently has a use agreement with the Ohio National Guard for 604 acres of this land. The details of land transactions are listed in the site management plan (ICI, 1995).

1.4 Reservoir No. 2 Burning Ground Description and History

R2BG is one of five known burning grounds at PBOW. It is located in the northwestern portion of PBOW, approximately 400 feet south of Reservoir No. 2, between Ransom Road and Campbell Road (Figure 1-2). R2BG was used for destruction of process wastes (off-specification TNT, explosives, acids, solvents, asbestos, and waste oil) process wastes generated during explosives manufacturing operations. It is not known when the site was first used for burning; however, a 1950 aerial photograph clearly shows the site, and there is documentation showing ongoing operations up to 1962 (Jacobs, 2006). The quantity of waste destroyed at the burn grounds is unknown (Science Applications International Corporation, 1991). No building structures were present at R2BG.

Site restoration was performed in 1963, when the area was cleared of debris and the ground restored to proper grade. The R2BG site is currently a grass-covered open field with young hardwood trees and brush surrounding the area (Jacobs, 2006).

2.0 Physical Setting

2.1 Physiography and Topography

PBOW is located within the Eastern Lake section of the Central Lowland Province near the southwestern shore of Lake Erie. The region is characterized by lake plains, outwash plains, and till plains with occasional small hills produced during the retreat of the Wisconsinan ice sheet. Approximately two thirds of Erie County was once covered by a glacial lake. Processes associated with the lake produced features such as beach ridges and wave-cut cliffs.

The area was originally a flat lake bottom resulting from glacial melt waters. Across PBOW, the topography is relatively flat with a gentle north-northeast slope towards Lake Erie. The land surface at R2BG is flat. Elevations at the site range from 638.9 to 640.6 feet above mean sea level (amsl).

The R2BG site physical features include a former burning ground located in an open field and a drainage ditch at the northern end of the field. A paved service road is adjacent to the east side of the site. The ground surface is relatively flat, with minimal slope toward the north and northwest. Elevations at the site range from 639 to 641 feet amsl. The majority of the site is currently an open field; however, the southern portion of the site and areas to the west are wooded.

Geophysical surveys conducted during the 1996 site investigation (SI) (IT Corporation [IT], 1997a) indicated that debris remains in the subsurface; this was confirmed by the excavation of metallic debris during exploratory trenching. Excavated debris included piping, strapping, and plates. Additional soil descriptions recorded during trenching include reference to black cinder, ash, metal objects, broken tiles, tile fragments, and broken ceramics. The soil descriptions indicate the presence of a burn layer defined as black cinder and ash, ranging from 0.9 to 1.4 feet below ground surface (bgs) with thicknesses ranging from 0.5 to 1.2 feet. The soil descriptions for the overlying surface material indicate that the burning ground was covered with backfill material of unknown origin.

2.2 Geology

2.2.1 PBOW Geology

Most of the Erie County soil was formed from either glacial till or glacial melt water deposits. The dominant soil materials are derived from glacial till, outwash (gravel and sand), and

lacustrine (very fine sand, silt, and clay) deposits. Other soil types have been formed from more recent deposits of alluvium and weathering of parent rock. Within PBOW, the soil origins are listed as lacustrine. The glacial drift is less than 20 feet thick on average, with bedrock exposed in many places.

The bedrock formations in northern Ohio consist of Devonian and Silurian carbonates (limestone and dolomite) and clastics (shale, siltstone, and sandstone). The regional dip is to the southeast at approximately 35 feet per mile, with younger rocks subcropping to the east. The Silurian and Devonian Formations unconformably overlie sedimentary sequences of Ordovician and Cambrian age, which in turn unconformably overlie the Pre-Cambrian crystalline Greenville Basement.

At PBOW, four Devonian formations subcrop beneath glacial drift cover (Shaw, 2003). Form oldest to youngest these formations are Delaware Limestone, Plum Brook Shale, Prout Limestone, and the Huron Shale member of the Ohio Shale. Further details of PBOW-specific geology are presented in the SCR (Appendix A).

2.2.2 R2BG Geology

Overburden thicknesses at R2BG range from 20 to 23.5 feet, with greater thicknesses toward the north. The overburden is characterized as clay or silty clay with a fairly continuous layer of silt or clayey silt near the surface. The Plum Brook Shale subcrops beneath the unconsolidated deposits over R2BG. The thickness of this shale ranges from 1.8 to 11 feet, with thicknesses decreasing in the north and northwest. The Delaware Limestone underlies the Plum Brook Shale.

2.3 Hydrogeology

2.3.1 PBOW Groundwater

Groundwater at PBOW includes the shallow overburden/shale and the limestone bedrock aquifers. PBOW is located within a transition between the two aquifers; the shale is absent to the northeast. Both aquifers are overlain by a veneer of glacial drift, generally less than 20 feet thick, that is considered a poor source of groundwater. Flow in the overburden/shale is toward the local surface drainages, with a generally northerly trend. Groundwater flow in the Delaware Limestone is generally toward the north but is influenced by major fracture zones (Shaw, 2003).

2.3.2 R2BG Groundwater

Groundwater underlying R2BG includes both the overburden/shale and the limestone bedrock aquifers. Groundwater elevations in the overburden/shale unit range from 634.4 to 637.4 feet amsl. Depths to the shallow groundwater ranged from 2.4 to 6.2 feet bgs. Because of limited water encountered during piezometer installation, no monitoring wells were installed in the overburden/shale unit. The shallow groundwater underlying R2BG flows to the north, toward the drainage ditches. Adequate water level data could not be collected in the limestone unit to confirm flow directions. However, it is likely that limestone groundwater underlying R2BG flows in a southeastern direction toward a nearby northeast-southwest fracture.

2.4 Groundwater Quality and Use

2.4.1 Groundwater Quality

Two groundwater aquifer systems are utilized for drinking water in the region: a carbonate aquifer to the west and a shale aquifer to the east (Shaw, 2005). PBOW is located within the transition of the two systems. The limestone unit typically yields an adequate volume of groundwater for a drinking water source but is regionally regarded by the Ohio Department of Natural Resources (ODNR) (1962) as being of low quality because of high mineral content.

The two main water-bearing zones underlying the PBOW facility are located in the overburden/shale unit and the limestone bedrock and are thus called the overburden/shale and bedrock water-bearing zones. The overburden and shale groundwater units exhibit similar water levels, suggesting substantial vertical communication, and are considered one hydrogeologic unit.

Overburden/Shale Groundwater. Groundwater in the overburden is in discontinuous pockets during dry time periods (Shaw, 2005; IT, 1997b, 1999, 2001a). Also, the shallow overburden generally has low yields over most of PBOW due to the high percentage of silt and clay. Because of these conditions, the overburden/shale groundwater yields insufficient volume for potable use in many areas of the underlying PBOW. Particularly at R2BG, where overburden/shale groundwater was encountered at such an insufficient volume, no shallow wells could be installed (Jacobs, 2006). Additionally, groundwater from background wells in competent shale bedrock was found to have elevated concentrations of chloride, sulfate, iron, manganese, and total dissolved solids (TDS) (Shaw, 2006). Some of these concentrations, especially those of sulfate and TDS, were found at levels that far exceed the respective U.S. Environmental Protection Agency (EPA) Office of Groundwater Secondary Drinking Water

Regulations (SDWR) or health advisories (EPA, 2012). The SDWRs are nonenforceable levels that are based on aesthetic properties (e.g., taste, odor, or color) or cosmetic effects (e.g., skin or tooth discoloration). The following bulleted items compare concentrations of these analytes in samples from off-site upgradient background shale unit groundwater wells to the respective Office of Drinking Water SDWRs or health advisories.

- ***Chloride*** – 50 percent of the background wells exceeded the chloride SDWR of 250 milligrams per liter (mg/L) or parts per million (ppm). The maximum background concentration (3,540 ppm) was 14 times higher than the SDWR.
- ***Sulfate*** – 11 percent of the background wells exceeded the sulfate SDWR of 250 ppm. The maximum background concentration (514 ppm) was approximately twice the SDWR.
- ***Iron*** – 32 percent of the background wells exceeded the iron SDWR of 0.3 ppm. The maximum background concentration (1.55 ppm) was approximately 5 times higher than the SDWR.
- ***Manganese*** – 61 percent of the background wells exceeded the manganese SDWR of 0.05 ppm. The maximum background concentration (0.728 ppm) was over 14 times higher than the SDWR.
- ***Sodium*** – 100 percent of the background wells exceeded the sodium health advisory level of 20 ppm. The maximum background concentration (1,390 ppm) was approximately 70 times higher than the sodium health advisory level. (Note that no SDWR exists for sodium.)
- ***TDS*** – 82 percent of the background wells exceeded the TDS SDWR of 500 ppm. The maximum background concentration (6,850 ppm) was nearly 14 times higher than the SDWR.

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

This low yield in the overburden/shale groundwater generally found underlying much of PBOW was observed in the vicinity of R2BG. Five temporary piezometers were installed around the perimeter of R2BG and seven measurements were collected over a period of 2 months from May 22 through July 20, 2004. Shallow groundwater levels at the site ranged from 2.4 to 6.2 feet bgs during this period. Piezometer hydrographs show water levels reached a high point during mid-June, following a very rainy period during the month of May and first half of June. Water levels

then dropped an average of 2.2 feet from June 15 through July 20, 2004, which coincides with a relatively dry period (Jacobs, 2006).

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

The presence of natural petroleum-derived hydrocarbon seeps are common along the walls of area quarries (Shaw, 2005). Petroleum hydrocarbons were observed at depth during the drilling of bedrock well 2BG-BEDGW-002. 2BG-BEDGW-002 was noted in the monitoring well borelog as petroliferous (petroliferous meaning bedrock exhibited hydrocarbon staining and a hydrocarbon odor). Due to tight fractures and the associated slow and reduced groundwater recharge rates, an incomplete suite of groundwater samples was collected from the bedrock wells without any purge prior to sample collection (Jacobs, 2006). These observations provide evidence that petroleum hydrocarbons are naturally occurring in this general area of PBOW. Consistent with the findings of naturally occurring petroleum hydrocarbons in the limestone wells, benzene was detected in two of the three wells at R2BG. Limestone bedrock groundwater samples had benzene concentrations of 2,460 and 1,510 micrograms per liter (µg/L), and both exceed the promulgated Safe Drinking Water Act maximum contaminant level of 5 µg/L for benzene (EPA, 2012).

The TDS concentrations in groundwater from both limestone monitoring wells sampled (3,310 and 2,870 mg/L) exceeded the Safe Drinking Water Act SDWR for TDS of 500 mg/L. The predominant components of TDS are common salts; very small particulates; ionic forms of common elements such as calcium, magnesium, sodium, iron, sulfate, and strontium; and elevated TDS (Ohio Environmental Protection Agency [OEPA], 2009). The elevated TDS within the limestone bedrock that underlies PBOW likely results from the reducing conditions that mobilize metals. In addition, naturally occurring long-chained petroleum hydrocarbon molecules may also contribute to TDS in PBOW bedrock groundwater.

In summary, the limestone unit generally provides an adequate quantity of groundwater for hypothetical potable use. However, the natural quality of this water would fail drinking water

standards with respect to naturally occurring benzene that consistently exceeds the maximum contaminant level and TDS limit. The elevated benzene is related to naturally occurring petroleum hydrocarbons, and the high TDS is likely associated with naturally occurring reducing conditions.

2.4.2 Groundwater Use

Upwards of 170 private drinking water wells permitted by the Erie County Health Department are located within 4 miles of PBOW. USACE conducted a private well survey for the area within 1 mile of the downgradient PBOW boundary. Only five private wells were identified within the 1-mile radius. Two of these were identified as being used for the irrigation of lawns and gardens and washing cars, and the other three were not used at all (Appendix A of Shaw [2006]). Groundwater is not used within the PBOW facility.

2.5 Surface Water

2.5.1 PBOW Surface Water

PBOW lies in the eastern region of the Pickeral Creek – Pipe Creek Basin, which in turn, lies within the St. Lawrence River drainage basin. The Huron River Basin lies approximately 3.5 miles east of PBOW. Sandusky Bay and Lake Erie are approximately 4.5 miles north of the site.

Eleven streams pass through or originate within PBOW and are a part of four drainage areas: 1) Sawmill Creek (southern PBOW); 2) Plum Brook (central (PBOW); 3) Pipe Creek (western PBOW); and 4) Storrs-Hemminger Ditch. All streams flow north or northeasterly into Sandusky Bay. Numerous ponds lie within and around PBOW.

The Erie County Health Department does not permit the use of surface water for private drinking water supply, and no surface water within PBOW is used as a drinking water supply.

2.5.2 R2BG Surface Water

The only surface water feature within the R2BG site is a drainage ditch that runs east to west and forms the north edge of the site. The drainage ditch is located 200 to 300 feet north of the former Burn Area and drains to the west across the site, then northwest to Pipe Creek. This drainage feature is approximately 4 feet wide and 6 to 7 feet deep. Elevations in the ditch range from 635 feet amsl upstream of the site to 633 feet amsl downstream. A less pronounced drainage ditch runs south to north along the eastern side of the service road and discharges into the main drainage ditch north of the site. This drainage system is ephemeral and flows only during the wet

season and following precipitation events, remaining essentially dry during the summer months. Flowing water was observed during a site reconnaissance in November 2003 and during the soil investigation in May 2004. Flow in the ditch began to dissipate in mid-June, with only small, disconnected pools observed at this time. By late June 2004, this stream channel was dry, and it remained so during investigation activities in late July 2004.

Reservoir No. 2 lies approximately 400 feet north of this drainage ditch. This reservoir is circular, has a surface area of less than 1 acre, and has an embankment approximately 5 feet above the natural ground surface (Jacobs, 2006).

3.0 Site Characterization and Evaluation

This chapter provides a summary of the sampling, analyses, results, and evaluation of the environmental media (i.e., soil, limestone bedrock groundwater, and sediment) associated with R2BG based chiefly on samples collected during the RI field activities. This information has been presented in the R2BG SCR (Jacobs, 2006), which is attached to this report as Appendix A. No overburden/shale monitoring well or surface water analytical data are available. Overburden/shale wells were not installed because of low yield, and surface water was not present during RI activities.

This chapter also includes references to the samples collected as part of the 1996 SI, as these data were also reviewed and evaluated with the RI data in the text of the SCR. These are briefly summarized in Section 3.1. Identification of the samples and the recommendations from the SI present a context for the performance of the RI and for some of the specific sampling locations selected and analyses performed in the RI.

Please note that this chapter provides no data or other information that have not been previously presented in the R2BG SCR (Appendix A).

3.1 Previous Investigation and Evaluation

Prior to the RI, a preliminary site assessment was conducted at R2BG confirming that the area was used as a burning ground (Science Applications International Corporation, 1991). In 1996, an SI was conducted by IT, which included a geophysical survey and excavation of four trenches to identify subsurface anomalies. To identify lithology, eight soil borings were drilled and the following soil samples were collected:

- Nine surface soil samples (0 to 0.5 foot), including one quality control sample
- Eighteen subsurface soil samples (2 to 3 and 6 to 7 feet), including two quality control samples.

Surface and subsurface soil samples were analyzed for nitroaromatics, volatile organic compounds (VOC), semivolatile organic compounds (SVOC), polychlorinated biphenyls (PCB), target analyte list (TAL) metals, and cyanide.

The analytical results were compared to risk-based criteria (RBC) derived from EPA Region 3 (EPA, 1996) as described in the SI (IT, 1997b). Based on this screening evaluation, an SVOC

(benzo[a]pyrene), metals, the PCB Aroclor 1260, and nitroaromatic compounds (one as great as 910,000 µg/kg) were present in shallow soils at concentrations greater than RBCs. Subsurface soils also exhibited nitroaromatics, metals, and the PCB Aroclor 1260 at concentrations greater than RBCs. Based upon analytical conclusions, further soil sampling was recommended. The SI results are summarized in the SCR (Appendix A) and were further evaluated in the BHHRA (Chapter 4.0 and Appendix B) and SLERA (Chapter 5.0 and Appendix C). The SI results are presented in Tables 4-7, 4-8, 4-19, and 4-20 of the attached SCR.

3.2 Remedial Investigation Characterization and Evaluation

This section summarizes the 2004 through 2005 RI sampling of environmental media at R2BG, the analytical results, and an evaluation of these results as presented in the SCR (Jacobs, 2006). Additional details are provided in the SCR, which is included as Appendix A.

3.2.1 Samples and Analyses

The RI samples were collected consistent with the sitewide sampling and analysis plan (Jacobs, 2004a), site-specific sampling and analysis plan (SSAP) (Jacobs, 2004b), and work plan addendum (Jacobs, 2005) for R2BG. Trench excavation and soil, groundwater, and sediment sampling locations are shown on Figure 3-1.

A total of 65 surface and subsurface soil samples were collected as part of the RI for screening analysis of the full analytical suite (VOCs, polycyclic aromatic hydrocarbons [PAH], PCBs, nitroaromatics, metals, polychlorinated dibenzodioxin/furans, and lead). This includes 26 surface soil, 24 subsurface soil, and 15 trench soil samples. Generally, surface soil is defined as samples collected from within the interval of 0 to 1 foot bgs, and subsurface soil is defined as samples collected from depths greater than 1 foot bgs. The objective of the soil sampling was to delineate the extent of the burn layer and to define the extent of the soil contamination outside of the Burn Area (Jacobs, 2006).

Five piezometers were installed following the guidelines listed in the SSAP (Jacobs, 2004b) to determine the depth, gradient, and seasonal variability of the shallow groundwater. No overburden/shale monitoring wells were installed due to insufficient shallow groundwater encountered during piezometer installation (Jacobs, 2006).

Three limestone bedrock monitoring wells (2BG-BEDMW-001, 2BG-BEDW-M002, and 2BG-BEDMW-003) were installed at R2BG according to the SSAP (Jacobs, 2004b). The work plan

was designed to include upgradient, on-site, and downgradient groundwater locations. According to Jacobs (2006), the bedrock wells were placed in upgradient, source area, and downgradient locations based upon other nearby bedrock wells and the 2002 Delaware Limestone groundwater flow map from the *2002 Groundwater Data Summary and Evaluation Report* (Shaw, 2003).

The collection of three collocated surface water and sediment samples had been planned at locations within the drainage ditches north and east of R2BG. However, surface water was not present in the ditches except immediately following rainfall events. Surface water samples were not collected from the ditches during these wet time periods because the water would not have been representative of R2BG. Therefore, no surface water samples were collected (Jacobs, 2006).

The following list summarizes the samples and analyses collected for the RI:

- Surface soil – 26 samples
  - Within Burn Area (four samples)
    - Three analyzed for VOCs, PAHs, PCBs, nitroaromatics, and metals
    - One sample analyzed for VOCs, PAHs, PCBs, nitroaromatics, metals, and dioxin/furans.
  - Outside Burn Area (22 samples)
    - Three analyzed for VOCs, PAHs, PCBs, nitroaromatics, metals, and dioxin/furans
    - Nine analyzed for VOCs, PAHs, PCBs, nitroaromatics, and metals
    - Ten analyzed for PAHs, PCBs, nitroaromatics, and lead.
- Subsurface soil – 24 samples (12 sampled 3 to 5 feet bgs and 12 sampled 8 to 10 feet bgs)
  - Within Burn Area (eight samples)
    - Eight (four sampled 3 to 5 feet bgs and four sampled 8 to 10 feet bgs) analyzed for VOCs, PAHs, PCBs, nitroaromatics, and metals.
  - Outside Burn Area (16 samples)
    - Eight (3 to 5 feet bgs) analyzed for VOCs, PAHs, PCBs, nitroaromatics, and metals
    - Eight (8 to 10 feet bgs) analyzed for VOCs, PAHs, nitroaromatics, and metals.
- Limestone bedrock monitoring wells – One sampling event for a total of three groundwater samples were collected during the wet season in January 2005.
  - 2BG-BEDMW-001 - Analyzed for nitroaromatics, TAL metals (unfiltered), PCBs, and VOCs

  - 2BG-BEDWM-002 - Analyzed for nitroaromatics, TAL metals (filtered and unfiltered), PCBs, VOCs, PAHs, cyanide, anions, hardness, turbidity/alkalinity, and TDS/total suspended solids.

  - 2BG-BEDMW-003 - Analyzed for nitroaromatics, TAL metals (filtered and unfiltered), PCBs, VOCs, cyanide, anions, hardness, turbidity/alkalinity, and TDS/total suspended solids.

- Sediment – Three samples were collected and analyzed for VOCs, dioxins/furans, PAHs, and metals.

All analytical data from these samples were reviewed for accuracy and completeness. One hundred percent of the data analyzed were subjected to data validation following the guidelines in the EPA *Contract Laboratory Program National Functional Guidelines for Organic Data Review* (EPA, 1999) and EPA *Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (EPA, 1994a) and is sampling and analysis plans (Jacobs, 2004a,b). Data were evaluated against specific criteria to verify the achievement of precision, accuracy, representativeness, completeness, and comparability goals established to meet the project data quality objectives (DQO). The criteria for blank evaluation were based on those detailed in *Region 3 Modifications to National Functional Guidelines for Evaluating Organic Analyses* (EPA, 1994b) and *Region 3 Modifications to the Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* (EPA, 1993a). Additional information on data evaluation, data validation, and data quality are provided in the SCR (Appendix A).

3.2.2 Characterization of R2BG

3.2.2.1 Local Soils

At many PBOW sites, following closure and removal of the manufacturing structures, tanks, and equipment, a local fill sand was brought to the areas to cover the remaining concrete building foundations and demolition scars and provide a natural landscape appearance. Based on drilling and sampling logs, no fill sand is documented to be present at R2BG, consistent with the lack of aboveground structures and buildings. Within the burning ground area are remnants of the former burning ground. This material consists of a black clay with cinders, ash, gravel, and burned debris (glass fragments and metal pieces). The burn layer is approximately 1 to 2 feet in thickness. Soil immediately below the burned layer is typically a discolored (dark brown to black), firm, low-plasticity clay. A silt with clay layer was encountered at a depth of approximately 6 to 8 feet below the discolored clay. The silt/clay layer was light brown in color, soft, and wet. Below the silt with clay layer is a clay layer with variable amounts of silt. At a

depth of approximately 8 feet bgs, a firm, soft, light gray clay was encountered until refusal (refusal at 22.5 feet in boring 2BG-BEDGW-002).

Outside but near the former burning ground, a dark brown clay was encountered over burn debris (cinders) in two borings (BH09 and BH10) between depths of 1.3 to 1.6 and 2 to 2.5 feet, respectively. The grading of the former berm is also suspected to be evident in these two borings. In other borings away from the Burn Area, native surface soil also consists of dark brown, soft, low-plasticity clay. Clay with variable silt content to bedrock is the main constituent in all R2BG borings. Signs of a glacial till (angular sand and gravel) are seen in some borings (BH10 and BH11) at a depth of 9.5 to 10 feet bgs. The main description of the clay below 10 feet in most of the borings varies in a gray color, is soft to firm, and ranges from low to high plasticity. Angular sand, gravel, and rock fragments are typically seen at depth as the borings near bedrock.

3.2.2.2 Local Geology

Bedrock units in the R2BG consist of the Plum Brook Shale (member of the Olentangy Shale) and the underlying Delaware Limestone, both of Devonian age. The Plum Brook Shale at R2BG was encountered at an average depth of 22.5 feet bgs. In general, the shale was light gray in color, weathered, friable, and soft. Thickness of the shale in the three bedrock monitoring well locations averaged 7 feet. Below the shale, the Delaware Limestone was encountered. It was found at depths ranging from 25.3 feet (614.4 feet amsl) in bedrock well 2BG-BEDGW-001 to 30.6 feet bgs (610.3 feet amsl) in well 2BG-BEDGW-003. The limestone was typically light gray in color, massive, fossiliferous, and hard. Hydrocarbon was noted on the borelog in boring 2BG-BEDGW-002 at a depth of 67 to 71.5 feet bgs (569.4 to 579.9 feet amsl).

3.2.2.3 Local Hydrogeology

Overburden/shale groundwater at R2BG was encountered at depths ranging from 6 feet bgs (PZ-01, PZ-02, and PZ-03) to 7.8 feet bgs (PZ-05) in May 2004 (wet season) during soil boring drilling/piezometer installation. During bedrock monitoring well installation conducted in June 2004 (wet season), overburden/shale groundwater was encountered at depths of 7 feet bgs (2BG-BEDGW-001) to 8 feet bgs (2BG-BEDGW -003). As shown by the June 2004 overburden/shale groundwater elevation contour map based on piezometer elevations and surface water (when present) elevations in the drainage ditch, groundwater flow is in a northerly direction (Figure 3-2). Overburden/shale groundwater flow depicted on this contour map indicates that groundwater flow generally mimics the surface topography.

Three bedrock wells were installed at R2BG in June 2004 during the RI. Depth of water-producing bedrock fractures in the borings could not be determined due to minimal water located during drilling. Groundwater recharge was also limited in each of the bedrock wells (2BG-BEDGW-001, 2BG-BEDGW-002, and 2BG-BEDGW-003) and did not allow a complete well development. Although adequate water level data could not be collected from the three R2BG wells to confirm flow direction, the groundwater flow direction in the limestone water unit was interpreted to be toward the southeast in the vicinity of R2BG. This flow direction is based on the presence of a linear northeast-to-southwest feature that may represent a fracture system and/or karst development.

3.2.2.4 Summary of Analytical Results

The analytical results of the RI samples, described in Section 3.2.1, are summarized in this section. As part of this evaluation, analytes detected in the respective environmental media were compared to PRG and background screening concentrations (BSC) as points of reference only. Analytes detected in R2BG RI soil samples are presented in Tables 4-1 through 4-6 and Tables 4-9 through 4-16 of the SCR (Appendix A). Tables 4-21 through 4-23 of the SCR present the analytes detected in limestone bedrock groundwater. Analytes detected in sediment are presented in Tables 6-1 through 6-4 of the SCR. The respective PRG values are included in these tables. PRGs do not infer a regulatory limit or mandated cleanup level, nor is the identification of an exceedance intended to indicate an unacceptable human health risk or a need for remedial action. A formal evaluation of human health risks was performed in the BHHRA (Appendix B), which includes further information on PRGs.

The evaluation of the analytical results of the samples and analyses (Section 3.2.1), as presented in the SCR, are summarized below for each medium.

Soil Within Burn Area (1996, 2004, and 2005)

Surface Soil (0 to 1 foot):

A total of seven surface soil samples have been collected inside of the Burn Area. Analytical results of detected chemicals are included in SCR Tables 4-1 through 4-8 (Appendix A). One of the surface soil samples collected during the 2004 investigation included analysis for dioxin/furans (BH-17). Distributions and concentrations of contaminants exceeding the PRGs in the surface soil are presented on Figure 3-3. Specific compounds exceeding the EPA Region 9 October 1994 residential preliminary remediation goals (PRG) (EPA, 2004) and established background values for inorganics include the following (Jacobs, 2006):

- 2,3,7,8-Tetrachlorodibenzo-p-dioxin - one location
- PCB-1260 (Aroclor 1260) - six locations
- TNT - five locations
- Benzo(a)pyrene - two locations
- Lead - seven locations.

Burn Layer Soil (1 to 2 feet):

A total of 10 samples were collected from the burn layer material, five of which were analyzed for dioxins/furans only. Analytical results of detected chemicals are shown in SCR Tables 4-9 through 4-14 (Appendix A). Distributions and concentrations of compounds exceeding the PRGs and the established background values for inorganics in burn layer material are presented on Figure 3-4. Specific compounds exceeding the EPA Region 9 residential PRGs (October 2004) and established background values for inorganics include the following (Jacobs, 2006):

- PCB-1254 (Aroclor 1254) - two of five locations
- PCB-1260 (Aroclor 1260) - four of five locations
- 2,4 -Dinitrotoluene - all five locations
- 2,6-Dinitrotoluene - four of five locations
- TNT - all five locations
- 2-Nitrotoluene - two of five locations
- 1,3-Dinitrobenzene - one of five locations
- Benzo(a)pyrene - one of five locations
- Dibenz(a,h)anthracene - one of five locations
- Napthalene - three of five locations
- Lead - all five locations
- Thallium - all five locations
- Barium - one of five locations
- Copper - one of five locations.

Concentrations of TNT at trench locations TR05, TR07, TR08, and TR09 are two to three orders of magnitude higher than the PRGs. Concentrations of DNT compounds at trench locations TR08 and TR09 are one to two orders of magnitude higher than the PRGs. Based on these concentrations, the burn layer material sampled from trenches TR08 and TR09 is composed of 3.6 to 4.5 percent explosives (Jacobs, 2006).

Subsurface Soil (2 to 10 feet):

A total of 17 subsurface soil samples were collected from beneath the burn layer. Analytical results of detected chemicals are included in SCR Tables 4-15 through 4-20 (Appendix A). Six samples collected during the 1996 SI were collected from three locations at two intervals: 2 to 3 and 6 to 7 feet bgs. The 1996 SI sample collected from the 2 to 3 feet interval at location

2BGSO-03 included material from the burn layer, which may account for the high explosives concentrations (Figure 3-5). The burn layer at this location was encountered from 2.0 to 2.5 ft bgs. Three samples collected during the 2004 trenching program were analyzed for dioxins/furans only and represent the only locations where soil beneath the burn layer was analyzed for dioxins/furans. Eight samples collected during the 2004 DPT investigation were collected from four locations at two intervals: 3 to 5 and 8 to 10 feet bgs. Distributions and concentrations of compounds exceeding the PRGs in soil beneath the burn layer are presented on Figure 3-5. Specific compounds exceeding the October 2004 EPA Region 9 residential PRGs (EPA, 2004) include the following (Jacobs, 2006):

- 2,4,6-TNT - two locations
- 2,4-DNT - three locations
- 2,6 -DNT - one location
- PCB-1260 (Aroclor 1260) - one location
- Thallium - five locations
- Aluminum - four locations.

Soil Outside Burn Area

Surface Soil (0 to 1 foot):

A total of 27 surface soil samples were collected outside of the Burn Area. Analytical results of detected chemicals are included in SCR Tables 4-1 through 4-8 (Appendix A). Three of the surface soil samples collected during the 2004 investigation included analysis for dioxin/furans (BH-09, BH-10, and BH-11). Distributions and concentrations of compounds exceeding the PRGs in surface soil are presented on Figure 3-3. Specific compounds exceeding the October 2004 EPA Region 9 Residential PRGs (EPA, 2004) and established background values for inorganics include the following (Jacobs, 2006):

- 2,3,7,8-Tetrachlorodibenzo-p-dioxin - one of three locations sampled
- PCB-1260 (Aroclor 1260) - 11 of 27 locations
- 2,4,6-Trinitrotoluene - 5 of 27 locations
- Benzo(a)pyrene - 11 of 27 locations
- Dibenz(a,h)anthracene - 1 of 27 locations
- Benzo(b)fluoranthene - 1 of 27 locations
- Lead - 20 of 27 locations.

Half of the additional surface soil locations sampled in April 2005 had PRG exceedances for one or more compounds.

Subsurface Soil (2 to 10 feet):

A total of 28 subsurface soil samples have been collected outside of the Burn Area. Analytical results of detected chemicals are included in SCR Tables 4-15 through 4-20 (Appendix A). Ten samples collected during the 1996 SI were collected from five locations at two intervals: 2 to 3 and 6 to 7 feet bgs. Two samples collected during the 2004 trenching program were analyzed for dioxins/furans only and represent the only locations where subsurface soil outside of the Burn Area was analyzed for dioxins/furans. Sixteen samples collected during the 2004 DPT investigation were collected from eight locations at two intervals: 3 to 5 and 8 to 10 feet bgs. Compounds exceeding the October 2004 EPA Region 9 Residential PRGs (EPA, 2004) and established background values for inorganics are limited to metals. Distributions and concentrations of compounds exceeding the PRGs in subsurface soil are presented on Figure 3-5 (Jacobs, 2006).

Piezometer Overburden/Shale Groundwater Summary:

Five temporary piezometers were installed from May 20 through 25, 2004 around the perimeter of R2BG to determine the depth, gradient, and seasonal variability of the shallow overburden groundwater. No overburden/shale groundwater samples were collected (Jacobs, 2006).

Monitoring Well Overburden/Shale Groundwater Sample Summary:

Shallow overburden monitoring wells were not installed due to insufficient permeable material in the subsurface. OEPA and the USACE Nashville District geologist concurred with this decision (Jacobs, 2006).

Bedrock Groundwater Sample Summary:

Due to low porosity and associated low recharge rates, only one round of groundwater samples was collected from bedrock monitoring wells. Groundwater samples were collected in January 2005 (wet season) using a disposable bailer and without purging the well prior to sample collection. Since wells exhibited limited volumes of water, no groundwater water quality measurements were recorded.

Contaminants detected include PAHs, metals, and VOCs. The analytical results of detected chemicals are shown in SCR Tables 4-21 through 4-23.

The distribution of detections that exceed the PRGs are shown on Figure 3-6. Specific compounds exceeding the October 2004 EPA Region 9 Residential PRGs (EPA, 2004) and established background values (Shaw, 2005) for inorganics include the following (Jacobs, 2006):

- Acenaphthene - one well (PAH analysis performed for one well only)
- Benzo(a)anthracene - one well (PAH analysis performed for one well only)
- Napthalene - one well (PAH analysis performed for one well only)
- Arsenic - all three wells
- Iron - two of three wells
- Manganese - one of three wells
- Benzene - two of three wells
- Xylene - all three wells.

Sediment Summary

Three sediment samples were collected and analyzed for VOCs, PAHs, PCBs, nitroaromatics, metals, and dioxin/furans. Contaminants detected include dioxins, furans, PAHs, metals, and VOCs. Analytical results of chemicals detected in sediment are shown in SCR Tables 6-1 through 6-4 (Appendix A). The distribution of detections that exceed the PRGs is shown on Figure 3-7. Specific compounds exceeding the October 2004 EPA Region 9 residential PRGs (EPA, 2004) include the following (Jacobs, 2006):

- Benzo(a)pyrene - all locations
- Benzo(a)anthracene - upstream location only
- Benzo(b)fluoranthene - upstream location only
- Indeno(1,2,3-c,d)pyrene - upstream location only.

4.0 Baseline Human Health Risk Assessment

This chapter provides a summary of the R2BG BHHRA report (Jacobs, 2010a), which is included as Appendix B. It is important to note that this site-specific risk assessment, including the evaluation of future land use and groundwater use, was performed to satisfy administrative requirements. This chapter provides no data or other information that has not been previously presented in the full BHHRA or SCR (Appendix A) reports.

The BHHRA evaluates potential human health risks associated with exposure to soil, bedrock groundwater, and sediment associated with R2BG at the former PBOW. Environmental media evaluated in the BHHRA include surface soil, subsurface soil, limestone bedrock groundwater, and sediment. Because of a lack of water, no groundwater samples could be collected from the overburden unit, and representative surface water was not present in the adjacent drainage ditches from which sediment samples were collected. Human health risks associated with soil inside of the Burn Area and outside of the Burn Area were evaluated separately.

This summary identifies the chemicals of potential concern (COPC); summarizes the receptors, media, and exposure pathways evaluated; summarizes the risk characterization; and presents the BHHRA conclusions. The BHHRA was performed consistent with EPA guidance and with the procedures established in the BHHRA for TNTA and TNTC soil (IT, 2001b), the BHHRA for groundwater at PBOW (Shaw, 2006) and, most specifically, the R2BG BHHRA work plan (Jacobs, 2008).

4.1 Identification of Chemicals of Potential Concern

A screening procedure was conducted on the RI and SI (IT, 1997b) analytical data from each R2BG environmental medium. This screening process is used to identify COPCs, which are the detected chemical analytes carried through the full risk assessment process. The objectives of COPC screening are to focus the risk assessment on those chemicals that may contribute significantly to overall risk and to remove from quantification those chemicals whose contribution is clearly inconsequential. COPC screening includes a risk-based screen which also considers status as a human nutrient, a frequency-of-detection evaluation, and a background screen.

The COPC screening process resulted in the generation of a data summary table that includes each medium quantitatively evaluated in the BHHRA. This table generated during the BHHRA

is included as Table 4-1 of this RI report. Table 4-1 includes the following information for each chemical detected in surface soil inside the Burn Area, subsurface soil inside of the Burn Area, surface soil outside of the Burn Area, subsurface soil outside of the Burn Area, limestone bedrock groundwater, and sediment:

- Chemical name
- Frequency of detection
- Range of detected concentrations
- Range of detection limits
- Arithmetic mean of site concentrations
- Appropriate risk-based screening concentration
- Appropriate BSC
- Selection/exclusion of chemical as a COPC.

Additional details of this data summary, including the estimation of the upper confidence limit values and exposure point concentrations for COPCs, are discussed in the BHHRA (Appendix B).

- ***Inside the Burn Area Surface Soil*** – 2,3,7,8-tetrachlorodibenzodioxin (TCDD) toxicity equivalent (TEQ), TNT, 2,4-DNT, 2,6-DNT, 2-amino-4,6-dinitrotoluene (2-ADNT), 4-amino-2,6-dinitrotoluene (4-ADNT), lead, thallium, acenaphthylene, benzo(a)pyrene, benzo(g,h,i)perylene, naphthalene, phenanthrene, and Aroclor 1260

- ***Inside the Burn Area Subsurface Soil*** –TCDD TEQ, 1,3-dinitrobenzene, TNT, 2,4-DNT, 2,6-DNT, 2-ADNT, 4-ADNT, 2-nitrotoluene, aluminum, barium, chromium, copper, lead, thallium, acenaphthylene, benzo(a)pyrene, benzo(g,h,i)perylene, dibenz(a,h)anthracene, naphthalene, phenanthrene, Aroclor 1254, Aroclor 1260

- ***Outside the Burn Area Surface Soil*** – TNT, 2,4-DNT, 2,6-DNT, 2-ADNT, 4-ADNT, 2-nitrotoluene, cadmium, copper, lead, acenaphthylene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, dibenz(a,h)anthracene, phenanthrene, 2-methylnaphthalene, Aroclor 1260

- ***Outside the Burn Area Subsurface Soil*** –2,4-DNT, TNT, 4-ADNT, cadmium, chromium, cobalt, copper, lead, manganese, thallium, vanadium, acenaphthylene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, indeno(1,2,3-c,d)pyrene, phenanthrene

- ***Bedrock Groundwater*** – Aluminum, antimony, arsenic, iron, manganese, thallium, vanadium, cyanide, acenaphthene, benzo(a)anthracene, naphthalene, benzene, carbon disulfide, chloromethane, xylenes.

- ***Sediment*** – TCDD TEQ, acenaphthylene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, dibenz(a,h)anthracene, naphthalene, phenanthrene.

4.2 Exposure Assessment

Exposure is the contact of a receptor with a chemical or physical agent. An exposure assessment estimates the type and magnitude of potential exposure of a receptor to COPCs found at or migrating from a site (EPA, 1989). The R2BG BHHRA characterizes potential exposures to COPCs in WWTP1 environmental media as portrayed by the conceptual site exposure model (CSEM). These environmental media include soil, sediment, and groundwater.

The CSEM provides the basis for identifying and evaluating the potential risks to human health in the BHHRA. The CSEM, graphically depicted on Figure 4-1, includes the receptors appropriate to all plausible site-use scenarios and the potential exposure pathways. This presentation of all possible pathways by which a potential receptor may be exposed, including all sources, release and transport pathways, and exposure routes; facilitates consistent and comprehensive evaluation of risk to human health; and helps to ensure that potential pathways are not overlooked. The elements of a CSEM include the following:

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

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

The receptors and pathways on Figure 4-1 reflect scenarios developed from information regarding site background and history, topography, climate, and demographics as presented by Dames and Moore, Inc. (1997b) and the sitewide groundwater investigation (IT, 1997b). No current or future exposure by off-site residents is evaluated. Most of the off-site residents are serviced by municipal water from surface water sources. Although there are numerous private groundwater wells in the vicinity, including several within 1 mile of the facility boundary, none of these is used as a potable source. Based on the investigations of other PBOW sites, natural hydrocarbons and hydrogen sulfide are known to be present within the bedrock limestone, and shale formation groundwater generally provides low yields and is of low quality (Shaw, 2008); however, the groundwater underlying R2BG was not summarily excluded for consideration as a tap water source based on natural water quality parameters or general assumptions concerning

yield. Therefore, given the presence of numerous off-site wells and the assumption of unrestricted future land use on the site, the development of groundwater for on-site residential (or on-site worker) use as tap water was evaluated for purposes of this BHHRA. Groundwater quality and use are discussed further in Section 2.4.

Exposure associated with the COPCs were evaluated using the following receptors. The media that were quantitatively evaluated for each receptor are listed in parentheses:

- Current/future groundskeeper (surface soil)
- Future indoor worker (surface soil, bedrock groundwater)
- Current/future construction worker (surface soil, subsurface soil, sediment)
- Future resident (surface soil, subsurface soil, sediment, bedrock groundwater)
- Current/future adult hunter (surface soil, including venison pathway)
- Current/future hunter's child (surface soil [venison pathway only]).

The resident was evaluated for noncancer hazards separately for the young child (ages 1 through 6 years) and adult life stages, and the noncancer hazard results are presented separately for the child and adult residents. Cancer risk results for the child and adult resident were evaluated separately but are combined in this report to present cancer risks associated with the 30-year residential child/adult exposure duration.

Based on the groundwater investigation (Jacobs, 2006), the limestone bedrock groundwater unit underlying R2BG would not provide an adequate quantity of groundwater, and the quality of this water would fail drinking water standards due to the presence of naturally occurring compounds that are unrelated to former site activities. Also, the bedrock groundwater wells installed at R2BG (and other areas of PBOW) emit notable amounts of naturally occurring hydrogen sulfide gas, which may result in nuisance odors and, at elevated levels, potential health concerns. The presence of hydrogen sulfide gas, which has direct and indirect corrosive effects, results in the rapid deterioration of metal components of well materials, pumps, and plumbing. Therefore, groundwater from the limestone unit underlying the R2BG is regarded as nonpotable, despite the assumption made in the BHHRA that it may be developed as a drinking water source. The assumption of potability for the limestone bedrock groundwater was made in the BHHRA because OEPA maintained that this assumption should initially be made under baseline conditions where no prior use restrictions are in place. Overburden groundwater monitoring wells were not installed because of a lack of groundwater in this unit underlying R2BG. Therefore, the overburden/shale groundwater could not be evaluated with respect to potential exposure, but its paucity indicates that exposure to groundwater from this unit is not plausible.

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

4.3 Risk Characterization

Risk characterization is the process of applying numerical methods and professional judgment to determine the potential for adverse human health effects to result from the presence of site-specific chemicals. This is done by combining the intake rates estimated during the exposure assessment with the appropriate toxicity information identified in the toxicity assessment (see Chapter 4.0 of the BHHRA in Appendix B). Noncancer hazards and cancer risks are characterized separately, including COPCs that induce both types of effects.

Quantitative expressions are calculated during risk characterization that describe the probability of developing cancer (i.e., incremental lifetime cancer risk [ILCR]), or the nonprobabilistic comparison of estimated dose with an reference dose (RfD) for noncancer effects (i.e., hazard quotients [HQ] and hazard index [HI]). Quantitative estimates are developed for individual chemicals, exposure pathways, and exposure media for each receptor. These quantitative risk characterization expressions, in combination with qualitative information, are used to guide risk management decisions. Risk characterization is applied only to COPCs.

4.3.1 Cancer Risk

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

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

4.3.2 Noncancer Effects of Chemicals

The hazards associated with noncancer effects of chemicals are evaluated by comparing an exposure level or intake with an RfD. The HQ, defined as the ratio of intake to RfD, is estimated by dividing the intake of a chemical by the RfD as described in the BHHRA (Appendix B). Chemical noncancer hazards are evaluated using chronic RfD values. An HQ of unity indicates that the estimated intake equals the RfD. If the HQ is greater than unity, there may be concern for potential adverse health effects. In the case of simultaneous exposure of a receptor to multiple chemicals, or to a given chemical by multiple pathways, an HI is calculated as the sum of the HQs.

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

4.3.3 Risk Characterization Results

Cancer and noncancer risk characterization results were evaluated in the BHHRA for each environmental medium and each receptor scenario using the methods summarized in Sections 4.3.1 and 4.3.2 and described in Appendix B. The cancer risks and noncancer hazards are presented for each receptor exposed to R2BG media inside the Burn Area are shown in Table 4-2, and those for receptors exposed to media outside the Burn Area are shown in Table 4-3.

The overall HI and ILCR values are summarized by environmental medium and receptor in the following bullets. Exceedances of the PBOW cancer risk goal (ILCR>1E-5) are shown in bold type, and exceedances of the noncancer hazard criterion (HI>1) or the NCP risk management range (1E-6 to 1E-4) are shown in bold italics:

Inside the Burn Area – Surface Soil

- Current/future groundskeeper: **ILCR = 8E-5**; ***HI = 12***
- Future indoor worker: **ILCR = 4E-5; *HI = 6***
- Current/future construction worker: ILCR = 4E-6; ***HI = 33***
- Future resident: ***ILCR = 3E-4***; ***child HI = 140***; ***adult HI = 15***
- Current/future hunter: ILCR = 6E-6; HI = 0.7
- Current/future hunter's child: ILCR = 5E-10; HI = 0.0002.

Inside the Burn Area – Subsurface Soil

- Current/future construction worker: **ILCR = 2E-5**; ***HI = 154***
- Future resident: ***ILCR = 4E-3***; ***child HI = 651***; ***adult HI = 70***

Outside the Burn Area – Surface Soil

- Current/future groundskeeper: **ILCR = 3E-5**; HI = 1
- Future indoor worker: ILCR = 1E-5; HI = 0.6
- Current/future construction worker: ILCR = 2E-6; ***HI = 3***
- Future resident: **ILCR = 1E-4**; ***child HI = 15***; ***adult HI = 2***
- Current/future hunter: ILCR = 2E-6; HI = 0.1
- Current/future hunter's child: ILCR = 4E-10; HI = 0.0002.

Outside the Burn Area – Subsurface Soil

- Current/future construction worker: ILCR = 1E-6; HI = 1
- Future resident: **ILCR = 8E-5**; ***child HI = 5***; adult HI = 0.6

Groundwater

- Future indoor worker: ***ILCR = 2E-3; HI = 15***
- Future resident : ***ILCR = 8E-3***; ***child HI = 101***; ***adult HI = 44***

Sediment

- Current/future construction worker: ILCR = 2E-7; HI is negligible
- Future resident: ILCR = 3E-6; child and adult are negligible.

4.3.4 BHHRA Conclusions

The conclusions are presented separately in this section for receptors exposed to soil inside the Burn Area and outside the Burn Area.

Inside the Burn Area – Surface Soil. Among the current potential receptors evaluated for exposure to R2BG inside the Burn Area surface soil (i.e., groundskeeper, construction worker, hunter, and hunter's child), the PBOW cancer risk goal is exceeded only for the groundskeeper. None of these potential current receptors have a surface soil ILCR that exceeds the NCP risk management range. However, both the groundskeeper and construction worker have HI values that exceed the HI criterion of 1, indicating that adverse noncancer health effects cannot be regarded as unlikely under these scenarios. Please note that there are no current or planned construction activities at R2BG, and no groundskeeping activities are known or apparent based on current site conditions but may occur infrequently. Thus, the current groundskeeper scenario,

which assumes a full-time, 25-year employee who works exclusively at R2BG for 8 hours per day, 250 days per year (refer to Chapter 3.0 in Appendix B), appears to greatly overestimate the exposure levels of any current on-site worker or other current receptor. Therefore, it is doubtful that any individual is currently exposed to R2BG Burn Area surface soil at a level that may result in adverse noncancer health effects.

Under potential future surface soil exposure scenarios (i.e., resident, indoor worker, groundskeeper, construction worker, hunter, and hunter's child), the future resident has an ILCR that exceeds both PBOW ILCR goal and the NCP risk management range, and both the indoor worker and groundskeeper have surface soil ILCR values that exceed the PBOW cancer risk goal, but not the NCP risk management range. The following potential future receptors have HI values that exceed the HI criterion of 1: resident, indoor worker, construction worker, and groundskeeper.

The following site-related cancer risk-driving chemicals in Burn Area surface soil were identified in the BHHRA: TNT, DNT mixture, 2,3,7,8-TCDD TEQ, and Aroclor 1260. TNT and lead were the noncancer hazard-driving chemicals in surface soil inside the Burn Area.

Inside the Burn Area – Subsurface Soil. Both of the receptors evaluated in the BHHRA for exposure to subsurface soil (i.e., future resident and future/current construction worker) were found to have associated ILCR values that exceed the PBOW cancer risk goal. Only the resident had an ILCR that exceeds the NCP risk management range. Both of these receptors had HI values that exceed the HI criterion of 1. As stated above with respect to surface soil, there is currently no construction ongoing or planned at R2BG, so there is currently no exposure to subsurface soil within R2BG.

The following site-related cancer risk-driving chemicals in Burn Area subsurface soil were identified in the BHHRA: TNT, DNT mixture, 2,3,7,8-TCDD TEQ, Aroclor 1254, and Aroclor 1260. TNT, 2,4-DNT, 2,6-DNT, Aroclor 1254, and lead were the noncancer hazard-driving chemicals in subsurface soil inside the Burn Area.

Outside the Burn Area – Surface Soil. Among the current potential receptors evaluated for exposure to R2BG outside the Burn Area surface soil (i.e., groundskeeper, construction worker, hunter, and hunter's child), the PBOW cancer risk goal is exceeded only for the groundskeeper. None of these potential current receptors have a surface soil ILCR that exceeds the NCP risk management range. Only the construction worker has an HI value that exceeds the HI criterion

of 1, indicating that adverse noncancer health effects cannot be regarded as unlikely under this scenario. Please note that there are no current or planned construction activities at R2BG.Therefore, it is doubtful that any individual is currently exposed to R2BG surface soil outside of the Burn Area at a level that may result in adverse noncancer health effects.

Under potential future subsurface soil exposure scenarios (i.e., resident, indoor worker, groundskeeper, construction worker, hunter, and hunter's child), only the groundskeeper and future resident have a ILCR values that exceed the PBOW ILCR goal. None of these receptors has an ILCR value that exceeds the NCP risk management range. Only the construction worker and resident have HI values associated with exposure to soil outside of the Burn Area that exceed the HI criterion of 1, indicating that adverse noncancer health effects cannot be regarded as unlikely under these two scenario.

The following site-related cancer risk-driving chemicals in surface soil outside of the Burn Area were identified in the BHHRA: TNT, DNT mixture, and Aroclor 1260. TNT and lead were the noncancer hazard-driving chemicals in surface soil outside of the Burn Area.

Outside the Burn Area – Subsurface Soil. The cancer risk associated with subsurface soil outside of the Burn Area exceeded the PBOW cancer risk goal, but not the NCP risk management range, only for the resident. Similarly, residential exposure yields an HI value for the child resident only that exceeds the PBOW noncancer hazard criterion of 1. However, the cancer risks and noncancer hazards were driven by naturally occurring, non-site-related inorganic constituents (i.e., aluminum, arsenic, and iron). Site-related chemicals did not significantly contribute to cancer risks or noncancer hazards associated outside of the Burn Area.

Groundwater. The PBOW cancer risk goal and the NCP risk management range were exceeded by the ILCR values associated with R2BG bedrock groundwater for each of the receptors evaluated (i.e., future resident and future indoor worker) in the BHHRA. Similarly, the HI values exceeded the HI criterion for each receptor. However, the risks and hazards associated with R2BG groundwater are regarded as implausible because exposure is unlikely due to low yield of the bedrock aquifer. In addition, the data quality of the samples was low due to high turbidity associated with the bailer sampling method, which had to be used due to low water yield. The risk-driving chemicals in R2BG groundwater are naturally occurring metals (i.e., arsenic, iron, and thallium) and naturally occurring petroleum-related organic chemicals (i.e., benzene) that are not associated with former PBOW activities. In summary, exposure is regarded as implausible and, regardless, the risk-driving analytes are not related to former site activities.

Sediment. The cancer risks for all receptors evaluated in the BHHRA for exposure to R2BG sediment (i.e., current/future construction worker and future resident) are less than the PBOW cancer risk goal and are either within or less than the NCP risk management range. Noncancer hazards are regarded as negligible, as no COPCs were identified based on noncancer effects.

5.0 Screening-Level Ecological Risk Assessment

This chapter provides a summary of the SLERA report (Jacobs, 2010b), which is included as Appendix C. It is important to note that this site-specific ecological risk assessment was performed to satisfy administrative requirements. This chapter provides no data or other information that has not been previously presented in the full SLERA or SCR (Appendix A) report.

The SLERA was performed to evaluate and provide an estimate of current and future ecological hazard associated with exposure to potential releases to soil, groundwater, and sediment associated with R2BG. This SLERA summary provides an ecological site description, identifies chemicals of potential ecological concern (COPEC), identifies ecological receptors, characterizes exposure, characterizes ecological risks, and presents the conclusions of the SLERA.

The SLERA is consistent with EPA guidance and with the procedures established in the SLERA for TNTA and TNTC soil (IT, 2001c) and, most specifically, the R2BG SLERA work plan (Jacobs, 2008).

5.1 Ecological Site Description

This ecological site description includes a general discussion of site background and the area of concern, surface water resources, wetlands, and vegetative communities; a species inventory; and a discussion of threatened and endangered species. Ecological characterization of the study area was based on a compilation of existing ecological information and site reconnaissance activities discussed in Sections 5.1.1 and 5.1.2. Information was obtained on the presence of state- and federally listed, threatened, and endangered species; species of special concern; and wildlife and fisheries resources. A botanist searched for threatened and endangered plant species during the reconnaissance visits. A checklist of biological species present at the site was developed using existing SI reports, environmental data sources, and information gathered during the site reconnaissance. Information on unique and special-concern habitats, preserves, wildlife refuge parks, and natural areas within the general vicinity was also obtained.

5.1.1 Site Background

PBOW is part of the Lake Plains region. Across PBOW, the land slopes gently to the north-northeast towards Lake Erie. The Lake Plains region itself is over 69 percent cropland, 2.7 percent pasture land, and 10.5 percent forest (ODNR, 1985). However, since the U.S. Army

acquired the site in 1941 and removed the land from agricultural production, undeveloped portions of the former PBOW have become second generation forest and open fields. This has resulted in PBOW becoming an island of forest and open fields within the greater context of primarily agricultural land in north-central Ohio.

R2BG is approximately 2 acres in size, and approximately 0.5 acre of this comprises the Burn Area. The ground surface is relatively flat, with minimal slope to the north and northwest. The majority of the site is an open field, and an east-west, ephemeral drainage ditch is at the northern boundary of the R2BG. This ditch, which contained no water during the RI sampling event, eventually flows to Pipe Creek. Areas to the south and west that are now wooded appear on historical photographs as being void of trees (Appendix A).

5.1.2 Site Reconnaissance

Jacobs ecological scientists performed site reconnaissance visits to R2BG in the spring and fall of 2008. These visits were performed at different times of year to identify early- and late-blooming plant species (especially threatened and endangered species) and to identify migrating and nesting bird species. These site visits were also used to compile lists of other fauna observed at the site. No federally or state-listed species were observed. A full species list is presented in the SLERA (Appendix C).

Prior to arrival at PBOW, site personnel obtained maps and other relevant site information and determined the locations of potential ecological units such as streams, creeks, ponds, grasslands, forest, and wetlands on or near the site. Additionally, the biological inventory performed in 1994 at PBOW (ODNR, 1995) that identifies and indicates the locations of threatened and endangered species at the installation was reviewed. The locations of known or potential contaminant sources affecting the site and the probable gradient of the pathway by which contaminants may be released from the site to the surrounding environment were identified. Reconnaissance personnel used the site visit to evaluate the site for more subtle clues of potential effects from contaminant release. Information obtained during the reconnaissance trips was used to select representative receptors, refine exposure scenarios for the risk assessment, and identify protected species or habitats of special concern in the study area. General habitat maps showing the types and extent of vegetation communities present within the immediate vicinity of the site were prepared based on information collected during the site reconnaissance.

5.1.3 Surface Water

No surface water was encountered in the ephemeral east-west ditch in the northern portion of R2BG.

5.1.4 Wetlands

No wetlands or significant aquatic habitats were observed during the spring and fall ecological surveys. According to the National Wetland Inventory (NWI) maps for the area (U.S. Fish and Wildlife Service, 1977), there are no designated wetlands at the R2BG site. It should be noted that the accuracy of NWI maps is limited, especially in relatively flat landscapes (such as PBOW), because minor depressions often contain isolated wetlands not easily identified through aerial photograph interpretation (the process used by the U.S. Fish and Wildlife Service in preparing NWI maps). NASA is currently performing a wetland delineation study at PBOW that will better identify locations and extent of sensitive wetland habitat throughout the installation.

5.1.5 Vegetative Communities

Vegetative communities at the site were classified during spring and fall 2008 site reconnaissance trips. The vegetation community map shown on Figure 5-1 was generated based on information obtained during these reconnaissance visits. Plant species identified are listed in Table 2-1 of the SLERA (Appendix C). The Burn Area and the study area immediately west of the Burn Area are upland old field, dominated by grasses and herbs. In the vicinity of the southern boundary of the Burn Area, the vegetation is classified as shrub thicket, dominated by gray dogwood (*Cornus racemosa*). Areas farther to the south, north, and east are successional woods, composed primarily of green ash (*Fraxinus pennsylvanica*), box elder (*Acer negundo*), and cottonwood (*Populus deltoids).*

Vegetative stress attributable to chemical contamination was not observed at R2BG. Based on site reconnaissance information, the northern portion of R2BG consists of a “pocket” of old field and dense shrub thicket dominated by gray dogwood surrounded by successional woods. The old field area may be irregularly mowed. The southern portion of R2BG is covered by successional woods.

5.1.6 Species Inventory

Based on information from ODNR (1995) and collected during the site reconnaissance, species lists were prepared for plants, mammals, birds, reptiles, amphibians, and fish. Note that no reptiles, amphibians, or fish were observed during reconnaissance at R2BG; the ditches at R2BG

are only occasionally inundated and are not expected to contain fish. These species lists are included in the SLERA.

A total of 85 plant species were documented at R2BG during the early summer and fall vegetation surveys. This comprises approximately 20 percent of the total number of species documented at PBOW either during the 1994 biological inventory (ODNR, 1995) or during vegetation surveys at other sites at the former PBOW.

Signs of 2 of the 43 species of mammals that may be found in the region based on species range maps were observed at R2BG during site visits, including raccoon and white-tailed deer. It is likely that other species are present but were not observed due to the short duration of the field visits.

A total of 130 species of birds are likely to be found in the region based on species range maps and field observations, and 105 species have been recorded at the former PBOW by the ODNR during their multiyear studies. During the 2008 spring and fall site reconnaissance, 23 bird species were documented at R2BG.

No threatened or endangered (T&E) plant or animal species were observed during site reconnaissance. Further, based on the habitat present at R2BG and/or lack of sightings in the vicinity of PBOW, no T&E bird species are expected to be found at R2BG. Likewise, the only T&E mammal (Ohio endangered) historically documented at PBOW, the Indiana bat, has widespread sightings throughout Ohio, but R2BG does not provide the preferred habitat (caves or trees with exfoliated bark)

5.2 Identification of Chemicals of Potential Ecological Concern

A screening process was performed on the analytical data from the RI and SI to identify COPECs that may pose a threat to ecological receptors. These data include all soil samples collected to a depth of 5 feet and sediment samples. Groundwater was excluded because exposure to this R2BG medium is considered to be an incomplete pathway for ecological receptors. Sample locations are presented on Figure 3-1.

The COPEC selection process was performed to develop a subset of chemicals detected at the site that are not naturally occurring or are associated with non-site-related sources. These chemicals are also present at sufficient frequencies, concentrations, and spatial areas to possibly pose a potential risk to ecological receptors. Examples of screening criteria that were used

include the following: analytical detection limit, frequency of detection less than 5 percent, comparability with background, status as a nutrient, and comparison with risk-based screening ecotoxicity values. This selection process and the screening values used for COPEC selection are described in the SLERA (Appendix C).

The results of the COPEC screening as presented in the SLERA (Appendix C) are presented in Table 5-1. Results for soil inside and outside the Burn Area are presented separately. The table presents the following information:

- Chemical name
- Frequency of detection
- Range of detected concentrations
- Range of detection limits
- Arithmetic mean (average) of site concentrations
- Distribution type
- Upper confidence limit of the mean of the concentration (only for chemicals selected as COPECs)
- Appropriate ecological screening value
- BSC
- COPEC selection conclusion: NO (with rationale for exclusion) or YES (selected)
- 95th percent upper confidence limit on the arithmetic mean concentration.

Chemicals identified as COPECs were quantitatively evaluated in the predictive SLERA, summarized in Sections 5.3 through 5.6.

5.3 Selection of Ecological Receptors

Ecological assessment receptors were selected in the SLERA to focus the exposure characterization on species, groups of species, or functional groups that are directly related to the following assessment endpoints: the protection of long-term survival and reproductive capabilities for terrestrial invertebrates, herbivorous mammals, omnivorous mammals, insectivorous mammals and birds, and carnivorous birds.

As part of this receptor selection process, site biota were organized into major functional groups. For terrestrial communities, the major groups are plants and wildlife, including terrestrial invertebrates, mammals, and birds. Because the intermittent surface water drainage on the northern and eastern sides of the site is typically dry, the drainage is considered poor aquatic habitat. Thus, aquatic and/or wetland communities or functional groups are not present at R2BG and were not evaluated.

Seven representative terrestrial receptor species that are expected or possible in the area of R2BG (based on the ecological description of the site presented in Section 5.1) were selected as indicator species for the potential effects of COPECs. These indicator species represent two classes of vertebrate wildlife (mammals and birds) and a range of both body size and food habits and include herbivores, omnivores, and carnivores. The seven species selected include the deer mouse (small omnivorous mammal), short-tailed shrew (small insectivorous mammal), Eastern cottontail rabbit (medium-sized terrestrial herbivorous mammal), marsh wren (small insectivorous bird), raccoon (medium-sized omnivorous mammal), white-tailed deer (large herbivorous mammal), and red-tailed hawk (large carnivorous bird).

A terrestrial food web is presented on Figure 5-2. Many of the species evaluated, particularly the deer mouse, cottontail rabbit, short-tailed shrew, and marsh wren, have limited home ranges which make them particularly vulnerable to exposure from site contaminants. The species selected to represent the various foraging guilds present at R2BG have the following desirable characteristics:

- Potential high abundance and wide distribution at the site.
- Sufficient toxicological information (with the exception of some bird species) is available in the literature for comparative and interpretive purposes.
- Importance with respect to the stability of the local ecological food chain and biotic community.
- Readily available exposure data, as summarized in the *Wildlife Exposure Factors Handbook* (EPA, 1993b).

5.4 Exposure Characterization

A description of the nature, extent, and magnitude of potential exposure of assessment receptors to COPECs that are present at or migrating from the site is presented in this section, considering both current and reasonably plausible future use of the site. Exposure characterization is critical

in further evaluating the risk of chemicals identified as COPECs during the screening process. The exposure assessment links the magnitude (concentration) and distribution (locations) of the contaminants detected in the media sampled during the investigation, evaluating pathways by which chemicals may be transported through the environment, and determining the points at which organisms found in the study area may contact contaminants.

Ecological routes of exposure for biota may be direct (bioconcentration) or through the food web via the consumption of contaminated organisms (biomagnification). Direct exposure routes include dermal contact, absorption, inhalation, and ingestion. Examples of direct exposure include animals incidentally ingesting contaminated soil or sediment (e.g., during burrowing or dust-bathing activities), animals ingesting surface water, plants absorbing contaminants by uptake from contaminated sediment or soil, and dermal contact of aquatic organisms with contaminated surface water or sediment. Given the scarcity of available data for wildlife dermal and inhalation exposure pathways, potential risk from these pathways is not estimated in the SLERA. In addition, these pathways are generally considered to be incidental for most species, with the possible exceptions of burrowing animals and dust-bathing birds. Food web exposure can occur when terrestrial or aquatic fauna consume contaminated biota. Examples of food web exposure include animals at higher trophic levels consuming plants or animals that bioaccumulate contaminants.

Daily doses of COPECs for vertebrate receptors were calculated using standard exposure algorithms. These algorithms incorporate species-specific natural history parameters (i.e., feeding rates, water ingestion rates, dietary composition, etc.) as well as site-specific area use factors. These algorithms are presented and described in the SLERA (Appendix C).

Exposure to soil and sediment is discussed in the following paragraphs. Surface water was not present in the drainage adjacent to the site, and groundwater is not a medium of concern for ecological receptors at this site.

Soil Exposure Pathway. Soil exposure pathways are potentially important for terrestrial plants and animals at the site. A depth of 0 to 5 feet bgs was evaluated to account for potential effects on deep-rooted plants and burrowing animals such as the shrew. Although the shrew itself may not actually burrow to a depth of 5 feet, there may be other mammals that burrow this deep. Also, for herbivores that feed on deep-rooted plants the evaluation of exposure to soil from a depth of 0 to 5 feet bgs is appropriate because most feeder roots are located within this depth,

and contaminants may be translocated to parts of the plants eaten by animals (e.g., main roots and leaves).

Sediment Exposure Pathway. Potential contaminant sources for sediment include over-ground transport from the R2BG and contaminated surface water, groundwater, and soil. The release mechanisms include surface water runoff, groundwater discharge, and airborne deposition. Potential receptors of chemicals in contaminated sediment include aquatic flora and fauna. Direct exposure routes for contaminated sediment include contact by benthic-dwelling organisms such as amphipod invertebrates, uptake by aquatic flora, and ingestion by aquatic fauna. Indirect exposure pathways from sediment include consumption of bioaccumulated contaminants by consumers in the food chain. Only direct exposure to aquatic sediment-dwelling organisms was evaluated in the SLERA due to limited aquatic habitat.

5.5 Risk Characterization

The risk characterization phase integrates information on exposure, exposure-effects relationships, and defined or presumed target populations. The result is a determination of the likelihood, severity, and characteristics of adverse effects to environmental stressors present at a site. Qualitative and semiquantitative approaches were used to estimate the likelihood of adverse effects occurring as a result of exposure of the selected site receptors to COPECs.

Food chain modeling was used to estimate exposure rates for the representative assessment receptors. These exposure rates were compared with toxicity reference values (TRV) to calculate HQs (Wentsel, et al., 1996). Only conservative TRVs based on a no-observed-adverse-effects level (NOAEL) were used in the food chain model. HQs are calculated by summing intake doses across all exposure pathways for each chemical for a given receptor and dividing by the TRV. HQs less than or equal to 1 represent no probable hazard. Although OEPA considers all HQs above 1 to be potentially significant, the following uncertainties regarding HQ interpretation are noted:

- HQs are not measures of risk.
- HQs are not population based.
- HQs are not linearly scaled.
- HQs are often produced that are unrealistically high and toxicologically impossible (e.g., estimated HQs greater than 1,000; it is noted that several chemicals had calculated HQs greater than 1,000 at the R2BG).

- Trace soil concentrations of inorganic chemicals (including concentrations well below background levels) can lead to HQ threshold exceedances.

Therefore, it should be understood that HQs greater than 1 do not mean that adverse ecological effects are occurring at the site or may occur in the future.

Tables 5-2 and 5-3 summarize the NOAEL-based HQs for the seven evaluated assessment receptors inside the Burn Area and outside the Burn Area, respectively, as presented in Section 5.3 of the SLERA (Appendix C).

Inside the Burn Area (Table 5-2), terrestrial receptors are predicted to incur elevated hazards from exposure to 2,3,7,8-TCDD, explosives, and two PAHs (acenaphthene and naphthalene), based on the NOAEL-based HQ approach. Several metals had elevated HQs, but the metals concentrations are within the range of naturally occurring background. Estimated HQs are above 1,000 for some receptors using the NOAEL-approach. However, the estimated HQs that are above 1,000 using the NOAEL-based approach are considered unrealistic and toxicologically impossible. The white-tailed deer and red-tailed hawk had no HQ exceedances greater than 10 outside of the Burn Area and only an HQ greater than 10 for 2,4-DNT inside 2BG.

Outside the Burn Area (Table 5-3), terrestrial receptors are predicted to incur elevated hazards from exposure to explosives only, with 2,4,6-TNT the greatest risk driver for the raccoon only. The white-tailed deer and red-tailed hawk had no HQ exceedance greater than 10.

Sediment-dwelling aquatic receptors are predicted to have potentially elevated hazards from exposure to 2,3,7,8-TCDD and PAHs based on a comparison of sediment data to RBSLs. However, given the limited to poor quality aquatic habitat at the site, the potential for adverse impacts to aquatic biota is considered negligible.

5.6 SLERA Conclusions

The SLERA evaluated exposure to contaminants inside and outside the Burn Area separately. No federal threatened or endangered species have been observed on site. The results of the SLERA indicate that several contaminants associated with former site operations may have adverse effects on ecological receptors exposed to site soils. Within the Burn Area (Table 5-2), HQ values exceeding 10 were observed for 2,4-DNT (shrew, deer, wren, mouse, rabbit, hawk, and raccoon), 2,6-DNT (shrew, wren, mouse, rabbit, and raccoon), 2,3,7,8-TCDD TEQ (shrew,

mouse, and raccoon), acenaphthene (shrew, mouse, and raccoon), naphthalene (shrew, mouse, and raccoon), and 2,4,6-TNT (shrew, wren, mouse, rabbit, and raccoon). HQ values inside the Burn Area were as high as 19,000 (2,4-DNT for the mouse). HQs outside the Burn Area (Table 5-3) were substantially lower, with only 2,4-DNT (shrew, mouse, rabbit, and raccoon), 2,6-DNT (shrew, mouse, and rabbit), and TNT (shrew, wren, mouse, rabbit, and raccoon) having HQ values above 10. The highest HQ value for outside the Burn Area was 420.

6.0 DERP-FUDS Project No. G05OH001812 (R2BG) Recommendations

The purpose of the RI is to gather information concerning the site characteristics so that appropriate remedial alternatives may be developed in the FS. However, it is unnecessary to perform an FS if the BHHRA indicates that the human health risk goals are met under baseline conditions and the ecological risk assessment indicates a lack of adverse ecological effects (DoD, 2004; 2012).

Based on the RI results, including the BHHRA and SLERA, the U.S. Army Corps of Engineers recommends that an FS be performed for R2BG soils. This includes surface and subsurface soils inside the Burn Area and surface soil outside of the Burn Area. The results of the BHHRA indicate that exposure to each of these media would result in elevated cancer risks or elevated noncancer hazards that are associated with U.S. Department of Defense-related contaminants.

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TABLES

Table 4-1
Summary of Statistics and Identification of Human Health COPCs for Constituents Detected in Environmental Media
Reservoir 2 Burning Ground Inside the Burn Area
Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Background	Toxicity Screening Level	COPC
Inside the Burn Area												
Surface Soil												
DIO	2,3,7,8-TCDD TEQ	1	1	100	ng/Kg		127	127	127			YES
HE	1,3,5-Trinitrobenzene	7	2	29	ug/Kg	125 - 50000	686	5640	5,707		180,000	
HE	2,4,6-Trinitrotoluene	7	7	100	ug/Kg		4,750	3,120,000	603,477		16,000	YES
HE	2,4-Dinitrotoluene	7	5	71	ug/Kg	5000 - 50000	993	18,750	8,929		12,000	YES
HE	2,6-Dinitrotoluene	7	2	29	ug/Kg	125 - 50000	352	977	7,243		6,100	YES
HE	2-Amino-4,6-Dinitrotoluene	4	2	50	ug/Kg	125 - 125	2,960	28,900	7,996			YES
HE	4-Amino-2,6-Dinitrotoluene	7	3	43	ug/Kg	625 - 250000	2,180	4,170	26,275			YES
INO	Aluminum	7	7	100	mg/Kg		6,780	9,750	8,783	15,500	7,600	
INO	Antimony	7	1	14	mg/Kg	0.41 - 7.7	0.963	0.963	1.84	9.3	3.1	
INO	Arsenic	7	7	100	mg/Kg		4.91	9.10	6.48	36.5	0.39	
INO	Barium	7	7	100	mg/Kg		73.4	314	174	828	540	
INO	Beryllium	7	5	71	mg/Kg	0.63 - 0.64	0.548	0.665	0.519	1	15	
INO	Cadmium	7	4	57	mg/Kg	0.61 - 0.64	0.279	0.611	0.409		3.7	
INO	Calcium	7	7	100	mg/Kg		5,830	13,205	8,608	52,300		
INO	Chromium	7	7	100	mg/Kg		11.8	26.6	18.8	29		
INO	Cobalt	7	6	86	mg/Kg	6.3 - 6.3	6.23	10.6	7.52	116	90	
INO	Copper	7	7	100	mg/Kg		23.1	99.0	58.7	56.2	310	
INO	Iron	7	7	100	mg/Kg		15,000	23,170	17,761	234,000	2,300	
INO	Lead	7	7	100	mg/Kg		155	778	486	48.6	40	YES
INO	Magnesium	7	7	100	mg/Kg		2,300	6,600	4,706	10,400		
INO	Manganese	7	7	100	mg/Kg		183	319	266	3,506	180	
INO	Mercury	7	7	100	mg/Kg		0.0780	0.409	0.246	0.1	2.3	
INO	Moisture, Percent	7	7	100	PERCENT		18.4	30.0	21.9			
INO	Nickel	7	7	100	mg/Kg		16.4	56.3	32.0	55.1	160	
INO	Potassium	7	6	86	mg/Kg	626 - 626	985	1540	1,150	3,390		
INO	Selenium	7	7	100	mg/Kg		0.680	1.75	1.19	2	39	
INO	Silver	7	4	57	mg/Kg	0.108 - 1.3	0.132	1.20	0.460	11.1	39	
INO	Sodium	7	4	57	mg/Kg	610 - 639	64.7	250	228			
INO	Thallium	7	4	57	mg/Kg	1.19 - 1.26	1.30	1.95	1.20	1.3	0.52	YES
INO	Tin	3	1	33	mg/Kg	0.467 - 0.472	5.31	5.31	1.93		4,700	
INO	Vanadium	7	7	100	mg/Kg		18.4	25.9	23.0	40.9	7.8	
INO	Zinc	7	7	100	mg/Kg		75.0	489	249	322	2,300	
PAH	Acenaphthene	7	4	57	ug/Kg	400 - 420	772	11,000	2,021		370,000	
PAH	Acenaphthylene	7	4	57	ug/Kg	400 - 420	614	4,140	1,276			YES
PAH	Anthracene	7	4	57	ug/Kg	35.9 - 410	21.4	55.0	78.0		2,200,000	
PAH	Benzo(a)anthracene	7	3	43	ug/Kg	63.5 - 420	31.3	83.8	119		620	
PAH	Benzo(a)pyrene	7	3	43	ug/Kg	78.3 - 420	61.3	108	127		62	YES
PAH	Benzo(b)fluoranthene	7	4	57	ug/Kg	400 - 420	75.9	140	145		620	
PAH	Benzo(g,h,i)perylene	7	3	43	ug/Kg	113 - 420	47.4	103	131			YES
PAH	Benzo(k)fluoranthene	7	3	43	ug/Kg	29.4 - 420	75.5	209	150		6,200	
PAH	Chrysene	7	5	71	ug/Kg	400 - 410	38.9	193	117		62,000	
PAH	Fluoranthene	7	6	86	ug/Kg	400 - 400	56.0	192	138		230,000	

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Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Background	Toxicity Screening Level	COPC
PAH	Fluorene	7	1	14	ug/Kg	44.9 - 420	66.3	66.3	118		270,000	
PAH	Indeno(1,2,3-cd)pyrene	7	3	43	ug/Kg	27.8 - 420	33.9	58.7	109		620	
PAH	Naphthalene	7	4	57	ug/Kg	400 - 420	835	9,930	2,399		5,600	YES
PAH	Phenanthrene	7	4	57	ug/Kg	400 - 420	68.8	404	177			YES
PAH	Pyrene	7	4	57	ug/Kg	58.7 - 400	44.0	203	104		230,000	
PCB	PCB-1260 (Aroclor 1260)	7	6	86	ug/Kg	1260 - 1260	1,950	11,600	5,909		220	YES
VOC	1,1,1-Trichloroethane	7	1	14	ug/Kg	0.52 - 6.4	1.70	1.70	1.71		200,000	
VOC	1,1-Dichloroethene	7	1	14	ug/Kg	0.508 - 6.4	0.660	0.660	1.56		12,000	
VOC	Acetone	7	2	29	ug/Kg	3.58 - 26	8.90	17.8	9.74		1,400,000	
VOC	Benzene	7	3	43	ug/Kg	0.457 - 6.4	1.70	20.6	5.88		640	
VOC	Chloroform	7	1	14	ug/Kg	0.528 - 6.4	2.00	2.00	1.76		220	
VOC	Methylcyclohexane	1	1	100	ug/Kg		1.90	1.90	1.90		260,000	
VOC	Toluene	7	2	29	ug/Kg	0.345 - 6.4	3.50	1,570	226		66,000	
Subsurface Soil												
DIO	2,3,7,8-TCDD TEQ	13	13	100	ng/Kg		0.699	1,187	132			YES
HE	1,3,5-Trinitrobenzene	19	3	16	ug/Kg	125 - 12500	46,100	85,400	10,599		180,000	
HE	1,3-Dinitrobenzene	19	1	5	ug/Kg	125 - 12500	3,545	3,545	1,323		610	YES
HE	2,4,6-Trinitrotoluene	19	13	68	ug/Kg	125 - 250	394	35,400,000	3,941,819		16,000	YES
HE	2,4-Dinitrotoluene	19	11	58	ug/Kg	125 - 250	370	9,700,000	917,202		12,000	YES
HE	2,6-Dinitrotoluene	19	5	26	ug/Kg	125 - 12500	10,800	1,400,000	102,611		6,100	YES
HE	2-Amino-4,6-Dinitrotoluene	13	5	38	ug/Kg	125 - 125	4,980	342,000	42,614			YES
HE	2-Nitrotoluene	19	3	16	ug/Kg	125 - 12500	782	7,040	1,760		880	YES
HE	3-Nitrotoluene	19	1	5	ug/Kg	125 - 12500	777	777	1,178		73,000	
HE	4-Amino-2,6-Dinitrotoluene	19	1	5	ug/Kg	125 - 58000	10,600	10,600	3,019			YES
HE	4-Nitrotoluene	13	3	23	ug/Kg	125 - 12500	444	6,670	1,849		12,000	
INO	Aluminum	19	19	100	mg/Kg		4,640	17,390	11,959	15500	7,600	YES
INO	Antimony	19	6	32	mg/Kg	0.404 - 7.6	0.724	5.55	1.96	9.3	3.1	
INO	Arsenic	19	19	100	mg/Kg		4.70	27.8	11.8	36.5	0.39	
INO	Barium	19	19	100	mg/Kg		55.1	3965	438	826	540	YES
INO	Beryllium	19	18	95	mg/Kg	0.59 - 0.59	0.569	1.27	0.724	1	15	
INO	Cadmium	19	14	74	mg/Kg	0.59 - 0.63	0.0657	2.04	0.505		3.7	
INO	Calcium	19	19	100	mg/Kg		2,945	55,790	16,729	52300		
INO	Chromium	19	19	100	mg/Kg		8.86	81.5	23.4	29		YES
INO	Cobalt	19	19	100	mg/Kg		7.26	25.2	12.5	116	90	
INO	Copper	19	19	100	mg/Kg		9.82	1580	146	56.2	310	YES
INO	Iron	19	19	100	mg/Kg		13,130	37,300	26,693	234000	2,300	
INO	Lead	19	19	100	mg/Kg		8.94	8,220	757	48.6	40	YES
INO	Magnesium	19	19	100	mg/Kg		2550	18,310	7,173	10400		
INO	Manganese	19	19	100	mg/Kg		152	1,360	467	3506	180	
INO	Mercury	19	14	74	mg/Kg	0.039 - 0.042	0.0143	0.207	0.0547	0.1	2.3	
INO	Moisture, Percent	19	19	100	PERCENT		15.6	28.4	19.7			
INO	Nickel	19	19	100	mg/Kg		17.1	103	41.7	55.1	160	
INO	Potassium	19	19	100	mg/Kg		928	3,440	2,235	3390		YES
INO	Selenium	19	16	84	mg/Kg	0.59 - 0.63	0.267	4.57	1.72	2	39	

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INO	Silver	19	11	58	mg/Kg	0.108 - 1.3	0.190	1.30	0.520	11.1	39	
INO	Sodium	19	13	68	mg/Kg	592 - 632	75.0	1,390	408			
INO	Thallium	19	13	68	mg/Kg	1.18 - 1.21	1.63	3.32	1.78	1.3	0.52	YES
INO	Vanadium	19	19	100	mg/Kg		10.5	40.8	27.9	40.9	7.8	
INO	Zinc	19	19	100	mg/Kg		48.6	1,540	241	322	2,300	
PAH	Acenaphthene	19	7	37	ug/Kg	68.8 - 420	90.9	67,400	7,194		370,000	
PAH	Acenaphthylene	19	10	53	ug/Kg	39.9 - 420	42.2	131,000	14,362			YES
PAH	Anthracene	19	5	26	ug/Kg	4.55 - 420	4.69	73.2	80.8		2,200,000	
PAH	Benzo(a)anthracene	19	6	32	ug/Kg	7.56 - 420	9.70	501	120		620	
PAH	Benzo(a)pyrene	19	5	26	ug/Kg	9.65 - 420	12.4	108	98.8		62	YES
PAH	Benzo(b)fluoranthene	19	10	53	ug/Kg	3.82 - 420	4.00	212	97.3		620	
PAH	Benzo(g,h,i)perylene	19	4	21	ug/Kg	13.9 - 601	35.7	70.9	112			YES
PAH	Benzo(k)fluoranthene	19	10	53	ug/Kg	13.8 - 420	41.7	469	136		6,200	
PAH	Chrysene	19	9	47	ug/Kg	5.68 - 420	13.9	928	154		62,000	
PAH	Dibenz(a,h)anthracene	19	3	16	ug/Kg	8.09 - 420	16.1	302	105		62	YES
PAH	Fluoranthene	19	6	32	ug/Kg	22.5 - 973	37.0	720	209		230,000	
PAH	Fluorene	19	4	21	ug/Kg	23.2 - 1040	25.6	317	160		270,000	
PAH	Indeno(1,2,3-cd)pyrene	19	5	26	ug/Kg	3.43 - 420	9.59	151	83.7		620	
PAH	Naphthalene	19	10	53	ug/Kg	26 - 420	37.9	51,300	5,070		5,600	YES
PAH	Phenanthrene	19	10	53	ug/Kg	19.2 - 420	24.2	1,550	328			YES
PAH	Pyrene	19	1	5	ug/Kg	25.7 - 1150	96.2	96.2	142		230,000	
PCB	PCB-1254 (Aroclor 1254)	19	2	11	ug/Kg	40 - 14200	1,660	3,670	845		220	YES
PCB	PCB-1260 (Aroclor 1260)	19	7	37	ug/Kg	39 - 8620	53.0	4,010	789		220	YES
SV	bis(2-Ethylhexyl)phthalate	6	1	17	ug/Kg	390 - 420	60.0	60.0	178		35,000	
VOC	1,1,1-Trichloroethane	19	2	11	ug/Kg	0.463 - 31	1.085	140	9.89		200,000	
VOC	1,1-Dichloroethane	19	2	11	ug/Kg	0.411 - 31	1.60	10.1	3.06		51,000	
VOC	1,1-Dichloroethene	19	9	47	ug/Kg	0.47 - 31	0.580	2.55	3.03		12,000	
VOC	2-Butanone (Methyl ethyl ketone)	19	3	16	ug/Kg	3.27 - 120	3.60	54.0	13.0		2,200,000	
VOC	Acetone	19	7	37	ug/Kg	3.07 - 120	8.70	300	40.0		1,400,000	
VOC	Benzene	19	4	21	ug/Kg	0.393 - 31	1.40	2.80	2.85		640	
VOC	Cyclohexane	13	7	54	ug/Kg	0.419 - 1.05	0.630	24.9	4.80		280,000	
VOC	Ethylbenzene	19	1	5	ug/Kg	0.332 - 31	2.30	2.30	2.55		190,000	
VOC	Isopropylbenzene (Cumene)	13	1	8	ug/Kg	0.393 - 1.11	1.30	1.30	0.366		57,000	
VOC	Methylcyclohexane	13	3	23	ug/Kg	0.445 - 1.12	1.10	23.9	2.25		260,000	
VOC	Methylene Chloride	19	1	5	ug/Kg	1.18 - 31	1.90	1.90	2.96		9100	
VOC	Tetrachloroethene (PCE)	19	1	5	ug/Kg	0.332 - 31	0.870	0.870	2.48		480	
VOC	Toluene	19	5	26	ug/Kg	0.297 - 31	0.990	79.5	6.75		66,000	
VOC	Xylenes, Total	19	2	11	ug/Kg	0.341 - 31	0.780	12.5	3.11		27,000	
Outside the Burn Area												
Surface Soil												
HE	1,3,5-Trinitrobenzene	42	13	31	ug/Kg	87 - 5000	210	15,000	728		180,000	
HE	1,3-Dinitrobenzene	42	3	7	ug/Kg	83 - 12000	120	220	272		610	
HE	2,4,6-Trinitrotoluene	42	31	74	ug/Kg	87 - 250	140	2,270,000	65,461		16,000	YES

Table 4-1
Summary of Statistics and Identification of Human Health COPCs for Constituents Detected in Environmental Media
Reservoir 2 Burning Ground Inside the Burn Area
Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Background	Toxicity Screening Level	COPC
HE	2,4-Dinitrotoluene	42	23	55	ug/Kg	110 - 250	240	200,000	6,892		12,000	YES
HE	2,6-Dinitrotoluene	42	14	33	ug/Kg	110 - 12000	152	78,000	2,458		6,100	YES
HE	2-Amino-4,6-Dinitrotoluene	37	16	43	ug/Kg	125 - 625	150	26,000	1,296			YES
HE	2-Nitrotoluene	42	6	14	ug/Kg	87 - 12000	110	2,000	324		880	YES
HE	4-Amino-2,6-Dinitrotoluene	42	16	38	ug/Kg	87 - 110000	130	27,000	2,759			YES
HE	4-Nitrotoluene	37	1	3	ug/Kg	87 - 625	260	260	70.5		12,000	
HE	HMX	42	4	10	ug/Kg	87 - 25000	150	820	514		310,000	
HE	Nitrobenzene	47	1	2	ug/Kg	92 - 12000	180	180	262		2,000	
HE	RDX	42	2	5	ug/Kg	87 - 25000	270	540	503		4,400	
INO	Aluminum	32	32	100	mg/Kg		8,840	14,900	10,749	15,500	7,600	
INO	Antimony	32	3	9	mg/Kg	0.421 - 7.8	0.534	0.782	1.32	9.3	3.1	
INO	Arsenic	32	32	100	mg/Kg		5.13	11.1	7.45	36.5	0.39	
INO	Barium	32	32	100	mg/Kg		47.1	212	104	826	540	
INO	Beryllium	32	29	91	mg/Kg	0.61 - 0.65	0.515	0.851	0.606	1	15	
INO	Cadmium	32	28	87	mg/Kg	0.26 - 0.65	0.0771	0.78	0.425		3.7	YES
INO	Calcium	32	32	100	mg/Kg		2,320	35,800	7,559	52,300		
INO	Chromium	32	32	100	mg/Kg		10.7	26.7	16.9	29		
INO	Cobalt	32	32	100	mg/Kg		4.02	16.4	6.95	116	90	
INO	Copper	32	32	100	mg/Kg		13.0	534	55.9	56.2	310	YES
INO	Iron	32	32	100	mg/Kg		11,550	29,960	18,522	234,000	2,300	
INO	Lead	42	42	100	mg/Kg		21.1	603	184	48.6	40	YES
INO	Magnesium	32	32	100	mg/Kg		993	6,370	2,993	10,400		
INO	Manganese	32	32	100	mg/Kg		147	600	282	3,506	180	
INO	Mercury	32	32	100	mg/Kg		0.0308	0.518	0.133	0.1	2.3	
INO	Moisture, Percent	17	17	100	PERCENT		17.7	35.7	23.7			YES
INO	Nickel	32	32	100	mg/Kg		11.6	35.7	20.7	55.1	160	
INO	Potassium	32	32	100	mg/Kg		598	2,520	1,421	3,390		
INO	Selenium	32	13	41	mg/Kg	0.202 - 0.83	0.546	2.06	0.641	2	39	
INO	Silver	32	5	16	mg/Kg	0.111 - 1.3	0.138	0.471	0.204	11.1	39	
INO	Sodium	32	13	41	mg/Kg	245 - 646	45.9	402	147			YES
INO	Thallium	32	4	12	mg/Kg	0.31 - 1.42	1.20	1.44	0.503	1.3	0.52	
INO	Tin	4	1	25	mg/Kg	0.474 - 0.486	3.78	3.78	1.12		4700	
INO	Vanadium	32	32	100	mg/Kg		20.3	31.3	25.1	40.9	7.8	
INO	Zinc	32	32	100	mg/Kg		35.7	498	144	322	2,300	
INX	Cyanide	20	12	60	mg/Kg	0.15 - 0.65	0.170	1.00	0.280		120	
PAH	Acenaphthene	42	11	26	ug/Kg	24 - 430	34.2	697	101		370,000	
PAH	Acenaphthylene	42	11	26	ug/Kg	16.7 - 430	26.8	1,960	190			YES
PAH	Anthracene	42	13	31	ug/Kg	4.93 - 430	2.74	55.0	34.1		2,200,000	
PAH	Benzo(a)anthracene	42	21	50	ug/Kg	8.72 - 430	4.08	186	58.7		620	
PAH	Benzo(a)pyrene	42	21	50	ug/Kg	24 - 430	12.5	360	77.7		62	YES
PAH	Benzo(b)fluoranthene	42	21	50	ug/Kg	24 - 430	12.1	820	107		620	YES
PAH	Benzo(g,h,i)perylene	42	18	43	ug/Kg	5.65 - 430	13.1	270	61.5			YES
PAH	Benzo(k)fluoranthene	42	20	48	ug/Kg	24 - 430	30.9	430	93.9		6,200	
PAH	Chrysene	42	25	60	ug/Kg	6.33 - 430	8.30	297	78.4		62,000	

Table 4-1
Summary of Statistics and Identification of Human Health COPCs for Constituents Detected in Environmental Media
Reservoir 2 Burning Ground Inside the Burn Area
Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Background	Toxicity Screening Level	COPC
PAH	Dibenz(a,h)anthracene	42	5	12	ug/Kg	3.33 - 430	10.4	124	38.9		62	YES
PAH	Fluoranthene	42	28	67	ug/Kg	24 - 430	21.3	350	98.2		230,000	
PAH	Fluorene	42	9	21	ug/Kg	9.79 - 430	10.7	91.3	41.4		270,000	
PAH	Indeno(1,2,3-cd)pyrene	42	17	40	ug/Kg	1.4 - 430	8.20	230	55.4		620	
PAH	Naphthalene	42	11	26	ug/Kg	24 - 430	23.4	1,738	111		5,600	
PAH	Phenanthrene	42	25	60	ug/Kg	8.03 - 430	12.8	190	67.0			YES
PAH	Pyrene	42	25	60	ug/Kg	11.5 - 430	13.0	295	83.8		230,000	
PCB	PCB-1260 (Aroclor 1260)	42	33	79	ug/Kg	40 - 13300	13.0	44,400	2,066		220	YES
SV	1,4-Dichlorobenzene	17	1	6	ug/Kg	0.349 - 430	0.420	0.420	60.7		3,400	
SV	2-Methylnaphthalene	30	4	13	ug/Kg	24 - 430	36.0	110	52.1			YES
SV	bis(2-Ethylhexyl)phthalate	5	1	20	ug/Kg	400 - 430	61.0	61.0	176.2		35,000	
VOC	1,1,1-Trichloroethane	17	1	6	ug/Kg	0.5 - 32	1.70	1.70	4.12		200,000	
VOC	1,1-Dichloroethene	17	4	24	ug/Kg	0.472 - 32	0.570	0.750	4.11		12,000	
VOC	Acetone	17	3	18	ug/Kg	3.32 - 130	4.60	15.5	17.8		1,400,000	
VOC	Cyclohexane	12	1	8	ug/Kg	0.453 - 0.586	0.720	0.720	0.296		280,000	
VOC	Tetrachloroethene (PCE)	17	4	24	ug/Kg	0.385 - 32	0.390	3.40	4.22		480	
Subsurface Soil												
HE	2,4,6-Trinitrotoluene	26	5	19	ug/Kg	125 - 250	229	817	167		16,000	YES
HE	2,4-Dinitrotoluene	26	4	15	ug/Kg	125 - 250	417	755	166		12,000	YES
HE	4-Amino-2,6-Dinitrotoluene	26	1	4	ug/Kg	125 - 610	1,500	1,500	146			YES
INO	Aluminum	26	26	100	mg/Kg		6,225	233,600	20,972	15,500	7,600	YES
INO	Antimony	26	2	8	mg/Kg	0.401 - 8.35	0.413	0.519	1.69271	9.3	3.1	
INO	Arsenic	26	26	100	mg/Kg		4.10	131	14.5	36.5	0.39	
INO	Barium	26	26	100	mg/Kg		40.7	798	110	826	540	
INO	Beryllium	26	20	77	mg/Kg	0.59 - 0.63	0.388	11.4	1.00	1	15	
INO	Cadmium	26	15	58	mg/Kg	0.0572 - 0.64	0.0779	8.64	0.650		3.7	YES
INO	Calcium	26	26	100	mg/Kg		3,030	1,173,000	74,271	52,300		
INO	Chromium	26	26	100	mg/Kg		10.8	367	32.2	29		YES
INO	Cobalt	26	26	100	mg/Kg		6.30	166	16.8	116	90	YES
INO	Copper	26	26	100	mg/Kg		17.6	504	46.0	56.2	310	YES
INO	Iron	26	26	100	mg/Kg		17,650	412,600	38,804	234,000	2300	
INO	Lead	26	26	100	mg/Kg		7.88	227	21.2	48.6	40	YES
INO	Magnesium	26	26	100	mg/Kg		3,340	363,100	24,747	10,400		
INO	Manganese	26	26	100	mg/Kg		205	8230	905	3,506	180	YES
INO	Mercury	26	17	65	mg/Kg	0.038 - 0.042	0.0137	0.0580	0.0225	0.1	2.3	
INO	Moisture, Percent	25	25	100	PERCENT		12.2	22.4	17.8			YES
INO	Nickel	26	26	100	mg/Kg		17.6	475	46.8	55.1	160	
INO	Potassium	26	26	100	mg/Kg		1,250	58,210	4,397	3,390		
INO	Selenium	26	16	62	mg/Kg	0.57 - 0.64	0.527	51.8	3.39	2	39	YES
INO	Silver	26	6	23	mg/Kg	0.104 - 1.3	0.160	3.21	0.451	11.1	39	
INO	Sodium	26	16	62	mg/Kg	569 - 637	68	3,690	334			
INO	Thallium	26	6	23	mg/Kg	1.15 - 24.3	1.30	2.10	1.71	1.3	0.52	YES
INO	Vanadium	26	26	100	mg/Kg		20.2	536	49.4	40.9	7.8	YES
INO	Zinc	26	26	100	mg/Kg		47.6	1,140	103	322	2,300	

Table 4-1
Summary of Statistics and Identification of Human Health COPCs for Constituents Detected in Environmental Media
Reservoir 2 Burning Ground Inside the Burn Area
Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Background	Toxicity Screening Level	COPC
PAH	Acenaphthene	25	1	4	ug/Kg	26.9 - 420	169	169	107		370,000	
PAH	Acenaphthylene	25	6	24	ug/Kg	14.7 - 420	59.3	408	122			YES
PAH	Anthracene	25	7	28	ug/Kg	1.67 - 420	4.93	22.8	83.9		2,200,000	
PAH	Benzo(a)pyrene	25	10	40	ug/Kg	3.65 - 420	10.6	28.6	87.3		62	YES
PAH	Benzo(b)fluoranthene	25	9	36	ug/Kg	1.44 - 420	5.13	27.3	86.0		620	YES
PAH	Benzo(g,h,i)perylene	25	1	4	ug/Kg	5.25 - 420	51.9	51.9	85.9			YES
PAH	Benzo(k)fluoranthene	25	13	52	ug/Kg	1.37 - 420	30.9	191	133		6,200	
PAH	Chrysene	25	7	28	ug/Kg	2.15 - 420	12.8	30.5	86.5		62,000	
PAH	Fluoranthene	25	8	32	ug/Kg	8.51 - 420	25.7	298	123		230,000	
PAH	Fluorene	25	1	4	ug/Kg	9.1 - 420	50.1	50.1	88.8		270,000	
PAH	Indeno(1,2,3-cd)pyrene	25	8	32	ug/Kg	1.3 - 420	9.89	23.1	85.3		620	
PAH	Naphthalene	25	6	24	ug/Kg	9.84 - 420	51.2	256	108		5,600	
PAH	Phenanthrene	25	7	28	ug/Kg	7.06 - 420	22.6	175	107			YES
VOC	1,1,1-Trichloroethane	26	6	23	ug/Kg	0.353 - 32	0.770	15.3	3.21		200,000	
VOC	1,1-Dichloroethane	26	4	15	ug/Kg	0.313 - 32	0.660	1.70	1.90		51,000	
VOC	1,1-Dichloroethene	26	9	35	ug/Kg	0.411 - 32	0.480	2.10	2.03		12,000	
VOC	Acetone	26	9	35	ug/Kg	2.89 - 25	6.40	290	24.6		1,400,000	
VOC	Cyclohexane	16	1	6	ug/Kg	0.319 - 0.477	3.90	3.90	0.443		280,000	
VOC	Styrene	26	1	4	ug/Kg	0.259 - 32	1.00	1	1.80		440,000	
VOC	Tetrachloroethene (PCE)	26	3	12	ug/Kg	0.253 - 32	1.20	2.95	1.99		480	
VOC	Toluene	26	4	15	ug/Kg	0.226 - 6.3	1.50	20.0	1.75		66,000	
VOC	Xylenes, Total	26	1	4	ug/Kg	0.259 - 6.3	11.0	11.0	1.57		27,000	
Sediment												
DIO	2,3,7,8-TCDD TEQ	3	3	100	ng/Kg		0.120	6.91	3.45			YES
INO	Aluminum	3	3	100	mg/Kg		7,790	9,980	9,077	15,500	7,600	
INO	Arsenic	3	3	100	mg/Kg		4.30	6.09	5.105	36.5	0.39	
INO	Barium	3	3	100	mg/Kg		51.2	70.3	57.8	826	540	
INO	Beryllium	3	3	100	mg/Kg		0.427	0.566	0.481	1	15	
INO	Cadmium	3	3	100	mg/Kg		0.586	1.91	1.07		3.7	
INO	Calcium	3	3	100	mg/Kg		9,170	82,280	40,363	52,300		
INO	Chromium	3	3	100	mg/Kg		12.0	15.4	13.9	29		
INO	Cobalt	3	3	100	mg/Kg		4.56	6.17	5.52	116	90	
INO	Copper	3	3	100	mg/Kg		19.7	26.7	23.8	56.2	310	
INO	Iron	3	3	100	mg/Kg		12,100	16,430	14,690	234,000	2,300	
INO	Lead	3	3	100	mg/Kg		14.0	24.9	19.4	48.6	40	
INO	Magnesium	3	3	100	mg/Kg		3,385	11,900	7,682	10,400		
INO	Manganese	3	3	100	mg/Kg		107	181	145	3,506	180	
INO	Mercury	3	3	100	mg/Kg		0.0402	0.0725	0.0531	0.1	2.3	
INO	Moisture, Percent	3	3	100	PERCENT		37.3	52.7	43.3			
INO	Nickel	3	3	100	mg/Kg		16.1	19.0	18.0	55.1	160	
INO	Potassium	3	3	100	mg/Kg		1,510	2,295	1,952	3,390		
INO	Selenium	3	3	100	mg/Kg		2.71	3.69	3.34	2	39	
INO	Sodium	3	3	100	mg/Kg		90.3	107	98.6			
INO	Vanadium	3	3	100	mg/Kg		21.5	25.0	23.3	40.9	7.8	

Table 4-1
Summary of Statistics and Identification of Human Health COPCs for Constituents Detected in Environmental Media
Reservoir 2 Burning Ground Inside the Burn Area
Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Background	Toxicity Screening Level	COPC
INO	Zinc	3	3	100	mg/Kg		60.2	92.0	72.4	322	2,300	
PAH	Acenaphthene	3	1	33	ug/Kg	34.3 - 46.9	5,750	5,750	1,930		370,000	
PAH	Acenaphthylene	3	2	67	ug/Kg	18.7 - 18.7	53.0	853	305			YES
PAH	Anthracene	3	3	100	ug/Kg		6.41	288	101		2,200,000	
PAH	Benzo(a)anthracene	3	3	100	ug/Kg		22.5	1,130	393		620	YES
PAH	Benzo(a)pyrene	3	3	100	ug/Kg		126	1,590	641		62	YES
PAH	Benzo(b)fluoranthene	3	3	100	ug/Kg		31.9	1,230	438		620	YES
PAH	Benzo(g,h,i)perylene	3	3	100	ug/Kg		22.3	728	269			YES
PAH	Benzo(k)fluoranthene	3	3	100	ug/Kg		41.5	881	324		6,200	
PAH	Chrysene	3	3	100	ug/Kg		33.4	1,330	468		62,000	
PAH	Dibenz(a,h)anthracene	3	3	100	ug/Kg		16.5	31.6	24.0		62	
PAH	Fluoranthene	3	3	100	ug/Kg		75.5	3,680	1,294		230,000	
PAH	Indeno(1,2,3-cd)pyrene	3	3	100	ug/Kg		13.6	751	266		620	YES
PAH	Naphthalene	3	2	67	ug/Kg	12.5 - 12.5	216	2,660	961		5,600	
PAH	Phenanthrene	3	3	100	ug/Kg		66.8	1,460	583			YES
PAH	Pyrene	3	3	100	ug/Kg		30.9	2,440	845		230,000	
VOC	1,1-Dichloroethane	3	1	33	ug/Kg	0.644 - 1.2	4.50	4.50	1.81		51,000	
VOC	1,1-Dichloroethene	3	2	67	ug/Kg	0.794 - 0.794	1.00	1.55	0.982		12,000	
VOC	2-Butanone (Methyl ethyl ketone)	3	2	67	ug/Kg	5.13 - 5.13	36.5	51.2	30.1		2,200,000	
VOC	Acetone	3	3	100	ug/Kg		13.8	234	145		1,400,000	
VOC	Cyclohexane	3	2	67	ug/Kg	0.762 - 0.762	2.30	11.0	4.56		280,000	
VOC	Toluene	3	2	67	ug/Kg	0.865 - 0.865	0.520	0.860	0.604		66,000	
Groundwater												
INO	Aluminum (total)	3	3	100	ug/L		1,290	11,600	6,503	309	3,600	YES
INO	Antimony (total)	3	3	100	ug/L		2.00	3.00	2.53		1.5	YES
INO	Arsenic (total)	3	3	100	ug/L		45.3	221	113	7.4	0.045	YES
INO	Barium (total)	3	3	100	ug/L		286	842	489	11,800	260	
INO	Beryllium (total)	3	3	100	ug/L		0.0850	0.760	0.428		7.3	
INO	Cadmium (total)	3	2	67	ug/L	0.04 - 0.04	0.240	1.40	0.547		1.8	
INO	Calcium (total)	3	3	100	ug/L		237,000	743,000	559,667	316,000		
INO	Chromium (total)	3	2	67	ug/L	0.38 - 0.38	20.0	31.7	17.23333			
INO	Cobalt (total)	3	3	100	ug/L		2.60	9.90	6.40	12.1	73	
INO	Copper (total)	3	3	100	ug/L		4.00	17.7	11.8	19.8	150	
INO	Hardness (as CACO3)	2	2	100	mg/L		936	1,440	1,188			
INO	Iron (total)	3	3	100	ug/L		3,590	27,300	15,263	1,550	1,100	YES
INO	Lead (total)	3	3	100	ug/L		2.90	17.9	11.1			
INO	Magnesium (total)	3	3	100	ug/L		118,000	263,000	181,333	217,000		
INO	Manganese (total)	3	3	100	ug/L		409	1,020	702	636	88	YES
INO	Nickel (total)	3	3	100	ug/L		11.1	36.5	25.2	8.6	73	
INO	Nitrate	2	1	50	mg/L	0.0341 - 0.0341	0.137	0.137	0.0685			
INO	Potassium (total)	3	3	100	ug/L		40,500	56,400	49,000	116,000		
INO	Selenium (total)	3	0	0	ug/L	3.2 - 3.2					18	
INO	Silver (total)	3	2	67	ug/L	0.04 - 0.04	0.0820	0.130	0.0707		18	
INO	Sodium (total)	3	3	100	ug/L		380,000	785,000	623,667	1,390,000		

Table 4-1
Summary of Statistics and Identification of Human Health COPCs for Constituents Detected in Environmental Media
Reservoir 2 Burning Ground Inside the Burn Area
Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Background	Toxicity Screening Level	COPC
INO	Suspended Solids (residue, Non-filterable)	2	2	100	mg/L		298	109,000	54,649			
INO	Thallium (total)	3	2	67	ug/L	0.1 - 0.1	0.36	2.30	0.88667		0.24	YES
INO	Total Dissolved Solids	2	2	100	mg/L		2,870	3,310	3,090			
INO	Turbidity	2	2	100	NTU		101	1,910	1,006			
INO	Vanadium (total)	3	2	67	ug/L	5.44 - 5.44	8.90	22.4	10.4		3.6	YES
INO	Zinc (total)	3	3	100	ug/L		11.3	47.2	29.6	507	1,100	
INX	Alkalinity, Total (as CaCO3)	2	2	100	mg/L		72.7	457	265			
INX	Chloride (as Cl)	2	2	100	mg/L		1,420	1,810	1,615			
INX	Cyanide	2	1	50	ug/L	1.72 - 1.72	290	290	145		73	YES
INX	Sulfate (as SO4)	2	2	100	mg/L		45.3	78.0	61.7			
PAH	Acenaphthene	1	1	100	ug/L		535	535	535		37	YES
PAH	Acenaphthylene	1	1	100	ug/L		26.2	26.2	26.2			
PAH	Anthracene	1	1	100	ug/L		3.24	3.24	3.24		180	
PAH	Benzo(a)anthracene	1	1	100	ug/L		0.293	0.293	0.293		0.092	YES
PAH	Fluoranthene	1	1	100	ug/L		1.65	1.65	1.65		150	
PAH	Naphthalene	1	1	100	ug/L		8.87	8.87	8.87		0.62	YES
PAH	Phenanthrene	1	1	100	ug/L		1.86	1.86	1.86			
PAH	Pyrene	1	1	100	ug/L		2.34	2.34	2.34		18	
VOC	Acetone	3	3	100	ug/L		27.4	518	339		550	
VOC	Benzene	3	2	67	ug/L	1.65 - 1.65	1,510	2,460	1,323	2.4	0.35	YES
VOC	Carbon Disulfide	3	3	100	ug/L		146	234	184		100	YES
VOC	Chloromethane	3	1	33	ug/L	25 - 25	54.0	54.0	18.0		16	YES
VOC	Cyclohexane	3	3	100	ug/L		295	683	535		1,000	
VOC	Ethylbenzene	3	3	100	ug/L		9.60	137	85.5	0.87	130	
VOC	Isopropylbenzene (Cumene)	3	3	100	ug/L		5.10	37.1	25.4		66	
VOC	Methylcyclohexane	3	3	100	ug/L		132	337	243		520	
VOC	Toluene	3	3	100	ug/L		17.6	403	248	1.7	72	
VOC	Xylenes, Total	3	3	100	ug/L		145	1,610	1,048	5.5	21	YES
VOC	m,p-Xylene (sum of isomers)	3	3	100	ug/L		115	1,160	748			
VOC	o-Xylene (1,2-Dimethylbenzene)	3	3	100	ug/L		29.9	454	303			

COPC - chemical of potential concern
DIO - dioxan/furan
HE
HMX - 1,3,5,7-tetranitro-1,3,5,7-tetrazocane (octogen or High-Molecular-weight rdX)
INO
INX
mg/kg - milligrams per kilogram
ng/kg - nanograms per kilogram
PAH - polycyclic aromatic hydrocarbon
PCB - polychlorinated biphenyl
PCE - tetrachloroethene
RDX - 1,3,5-Trinitroperhydro-1,3,5-triazine (cyclotrimethylenetrinitramine or cyclonite or hexogen or T4)
SV - semivolatile organic compound
TCDD - tetrachlorodibenzo-p-dioxan
TEQ - toxicity equivalent
ug/kg - micrograms per kilogram
VOC - volatile organic compound

Source: Revised Final Baseline Human Health Risk Assessment (Jacobs, 2010a).

Table 4-2

Summary of Noncancer Hazards and Cancer Risk Estimates From Potential Exposures at Reservoir 2 Burning Ground Inside the Burn Area Plum Brook Ordnance Works, Sandusky, Ohio

Groundskeeper Risks From Exposure to Surface Soil		
Exposure Route	Hazard Quotient	Excess Cancer Risk
Ingestion	1.E+01	8.E-05
Dermal Contact	3.E-05	1.E-06
Inhalation	6.E-04	4.E-09
Total	12	8.E-05

Construction Worker Risks From Exposure to Surface Soil		
Exposure Route	Hazard Quotient	Excess Cancer Risk
Ingestion	3.E+01	4.E-06
Dermal Contact	2.E-04	2.E-07
Inhalation	5.E-04	7.E-11
Total	33	4.E-06

Adult Hunter Risks From Exposure to Surface Soil		
Exposure Route	Hazard Quotient	Excess Cancer Risk
Ingestion	7.E-01	5.E-06
Dermal Contact	1.E-05	7.E-07
Inhalation	NA	NA
Total	0.7	6.E-06

Construction Worker Risks From Exposure to Subsurface Soil		
Exposure Route	Hazard Quotient	Excess Cancer Risk
Ingestion	2.E+02	2.E-05
Dermal Contact	1.E-01	4.E-07
Inhalation	NA	NA
Total	154	2.E-05

Adult Hunter Risks From Ingestion of Venison		
Exposure Route	Hazard Quotient	Excess Cancer Risk
Ingestion	9.E-05	1.E-09
Dermal Contact	NA	NA
Inhalation	NA	NA
Total	9.E-05	1.E-09

Indoor Worker Risks From Exposure to Grounndwater		
Exposure Route	Hazard Quotient	Excess Cancer Risk
Ingestion	1.E+01	2.E-03
Dermal Contact	6.E-01	4.E-05
Inhalation	NA	NA
Total	15	2.E-03

Child Risks From Ingestion of Venison		
Exposure Route	Hazard Quotient	Excess Cancer Risk
Ingestion	2.E-04	5.E-10
Dermal Contact	NA	NA
Inhalation	NA	NA
Total	2.E-04	5.E-10

Indoor Worker Risks From Exposure to Surface Soil		
Exposure Route	Hazard Quotient	Excess Cancer Risk
Ingestion	6.E+00	4.E-05
Dermal Contact	NA	NA
Inhalation	NA	NA
Total	6	4.E-05

Table 4-2

Summary of Noncancer Hazards and Cancer Risk Estimates From Potential Exposures at Reservoir 2 Burning Ground Inside the Burn Area Plum Brook Ordnance Works, Sandusky, Ohio

Adult Residential Risks From Exposure to Groundwater

Exposure Route	Hazard Quotient	Excess Cancer Risk
Ingestion	4.E+01	4.E-03
Dermal Contact	2.E+00	1.E-04
Inhalation	NA	NA
Total	44	5.E-03

Child Residential Risks From Exposure to Groundwater

Exposure Route	Hazard Quotient	Excess Cancer Risk
Ingestion	1.E+02	3.E-03
Dermal Contact	4.E+00	8.E-05
Inhalation	NA	NA
Total	101	3.E-03

Adult Residential Risks From Exposure to Surface Soil

Exposure Route	Hazard Quotient	Excess Cancer Risk
Ingestion	1.E+01	1.E-04
Dermal Contact	3.E-04	1.E-05
Inhalation	7.E-04	4.E-09
Total	15	1.E-04

Child Residential Risks From Exposure to Surface Soil

Exposure Route	Hazard Quotient	Excess Cancer Risk
Ingestion	1.E+02	2.E-04
Dermal Contact	5.E-04	5.E-06
Inhalation	2.E-03	3.E-09
Total	140	2.E-04

Adult Residential Risks From Exposure to Subsurface Soil

Exposure Route	Hazard Quotient	Excess Cancer Risk
Ingestion	7.E+01	1.E-03
Dermal Contact	2.E-01	3.E-05
Inhalation	NA	NA
Total	70	1.E-03

Child Residential Risks From Exposure to Subsurface Soil

Exposure Route	Hazard Quotient	Excess Cancer Risk
Ingestion	7.E+02	2.E-03
Dermal Contact	3.E-01	1.E-05
Inhalation	NA	NA
Total	651	3.E-03

Source: Revised Final Baseline Human health Risk Assessment (Jacobs, 2010a).

Table 4-3

Summary of Noncancer Hazards and Cancer Risk Estimates From Potential Exposures at Reservoir 2 Burning Ground Outside the Burn Area Plum Brook Ordnance works, Sandusky, Ohio

Groundskeeper Risks From Exposure to Surface Soil

Exposure Route	Hazard Quotient	Excess Cancer Risk
Ingestion	1.E+00	2.E-05
Dermal Contact	NA	9.E-07
Inhalation	6.E-05	1.E-09
Total	1	3.E-05

Construction Worker Risks From Exposure to Surface Soil

Exposure Route	Hazard Quotient	Excess Cancer Risk
Ingestion	3.E+00	1.E-06
Dermal Contact	NA	2.E-07
Inhalation	5.E-05	2.E-11
Total	3	2.E-06

Adult Hunter Risks From Exposure to Surface Soil

Exposure Route	Hazard Quotient	Excess Cancer Risk
Ingestion	7.E-02	2.E-06
Dermal Contact	NA	5.E-07
Inhalation	NA	NA
Total	0.1	2.E-06

Construction Worker Risks From Exposure to Subsurface Soil

Exposure Route	Hazard Quotient	Excess Cancer Risk
Ingestion	1.E+00	1.E-06
Dermal Contact	3.E-02	1.E-07
Inhalation	NA	NA
Total	1.3	1.E-06

Adult Hunter Risks From Ingestion of Venison

Exposure Route	Hazard Quotient	Excess Cancer Risk
Ingestion	9.E-05	1.E-09
Dermal Contact	NA	NA
Inhalation	NA	NA
Total	9.E-05	1.E-09

Construction Worker Risks From Exposure to Sediment

Exposure Route	Hazard Quotient	Excess Cancer Risk
Ingestion	NA	1.E-07
Dermal Contact	NA	5.E-08
Inhalation	NA	NA
Total	NA	2.E-07

Child Risks From Ingestion of Venison

Exposure Route	Hazard Quotient	Excess Cancer Risk
Ingestion	2.E-04	4.E-10
Dermal Contact	NA	NA
Inhalation	NA	NA
Total	2.E-04	4.E-10

Indoor Worker Risks From Exposure to Groundwater

Exposure Route	Hazard Quotient	Excess Cancer Risk
Ingestion	1.E+01	2.E-03
Dermal Contact	6.E-01	4.E-05
Inhalation	NA	NA
Total	15	2.E-03

Indoor Worker Risks From Exposure to Surface Soil

Exposure Route	Hazard Quotient	Excess Cancer Risk
Ingestion	6.E-01	1.E-05
Dermal Contact	NA	NA
Inhalation	NA	NA
Total	0.6	1.E-05

Table 4-3

Summary of Noncancer Hazards and Cancer Risk Estimates From Potential Exposures at Reservoir 2 Burning Ground Outside the Burn Area Plum Brook Ordnance works, Sandusky, Ohio

Adult Residential Risks From Exposure to Groundwater

Exposure Route	Hazard Quotient	Excess Cancer Risk
Ingestion	4.E+01	4.E-03
Dermal Contact	2.E+00	1.E-04
Inhalation	NA	NA
Total	44	5.E-03

Child Residential Risks From Exposure to Groundwater

Exposure Route	Hazard Quotient	Excess Cancer Risk
Ingestion	1.E+02	3.E-03
Dermal Contact	4.E+00	8.E-05
Inhalation	NA	NA
Total	101	3.E-03

Adult Residential Risks From Exposure to Surface Soil

Exposure Route	Hazard Quotient	Excess Cancer Risk
Ingestion	2.E+00	3.E-05
Dermal Contact	NA	1.E-05
Inhalation	7.E-05	1.E-09
Total	1.6	4.E-05

Child Residential Risks From Exposure to Surface Soil

Exposure Route	Hazard Quotient	Excess Cancer Risk
Ingestion	1.E+01	7.E-05
Dermal Contact	NA	4.E-06
Inhalation	2.E-04	8.E-10
Total	15	7.E-05

Adult Residential Risks From Exposure to Subsurface Soil

Exposure Route	Hazard Quotient	Excess Cancer Risk
Ingestion	6.E-01	2.E-05
Dermal Contact	4.E-02	6.E-06
Inhalation	NA	NA
Total	0.6	3.E-05

Child Residential Risks From Exposure to Subsurface Soil

Exposure Route	Hazard Quotient	Excess Cancer Risk
Ingestion	5.E+00	5.E-05
Dermal Contact	7.E-02	3.E-06
Inhalation	NA	NA
Total	5	5.E-05

Adult Residential Risks From Exposure to Sediment

Exposure Route	Hazard Quotient	Excess Cancer Risk
Ingestion	NA	7.E-07
Dermal Contact	NA	8.E-07
Inhalation	NA	NA
Total	NA	1.E-06

Child Residential Risks From Exposure to Sediment

Exposure Route	Hazard Quotient	Excess Cancer Risk
Ingestion	NA	2.E-06
Dermal Contact	NA	4.E-07
Inhalation	NA	NA
Total	NA	2.E-06

Source: Revised Final Baseline Human health Risk Assessment (Jacobs, 2010a).

Table 5-1
Summary of Statistics and Identification of Ecological COPCs for Constituents Detected in Environmental Media
Reservoir 2 Burning Ground
Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	95% UCL on Arithmetic Mean	Background	Toxicity Screening Level	COPEC
Inside the Burn Area												
Surface Soil												
DIO	2,3,7,8-TCDD TEQ	14	14	100	ng/Kg		0.69882	1187.33234	131.34547		0.199	YES
HE	1,3,5-Trinitrobenzene	19	5	26	ug/Kg	125 - 50000	686	85400	12584.92105		376	YES
HE	1,3-Dinitrobenzene	19	1	5	ug/Kg	125 - 50000	3545	3545	2995.78947		655	YES
HE	2,4,6-Trinitrotoluene	19	16	84	ug/Kg	125 - 250	394	35400000	4163046.526			YES
HE	2,4-Dinitrotoluene	19	14	74	ug/Kg	125 - 50000	370	9700000	919530.1579		1280	YES
HE	2,6-Dinitrotoluene	19	7	37	ug/Kg	125 - 50000	352	1400000	105162.7105		32.8	YES
HE	2-Amino-4,6-Dinitrotoluene	13	7	54	ug/Kg	125 - 125	2960	342000	45055			YES
HE	2-Nitrotoluene	19	3	16	ug/Kg	125 - 50000	782	7040	3432.21053			YES
HE	3-Nitrotoluene	19	1	5	ug/Kg	125 - 50000	777	777	2850.10526			YES
HE	4-Amino-2,6-Dinitrotoluene	19	4	21	ug/Kg	125 - 250000	2180	10600	12564.34211			YES
HE	4-Nitrotoluene	13	3	23	ug/Kg	125 - 12500	444	6670	1868			YES
INO	Aluminum	19	19	100	mg/Kg		4640	17390	10141.31579	15500	50	YES
INO	Antimony	19	6	32	mg/Kg	0.404 - 7.7	0.963	5.55	1.98047	9.3	0.142	YES
INO	Arsenic	19	19	100	mg/Kg		4.7	27.8	10.03474	36.5	5.7	YES
INO	Barium	19	19	100	mg/Kg		57.8	3965	468.8	826	1.04	YES
INO	Beryllium	19	16	84	mg/Kg	0.59 - 0.64	0.548	1.27	0.66584	1	1.06	YES
INO	Cadmium	19	14	74	mg/Kg	0.59 - 0.64	0.0657	2.04	0.53402		0.00222	YES
INO	Calcium	19	19	100	mg/Kg		2945	21120	7977.10526	52300		YES
INO	Chromium	19	19	100	mg/Kg		8.86	81.45	22.60579	29	0.4	YES
INO	Cobalt	19	18	95	mg/Kg	6.3 - 6.3	6.23	25.2	10.78632	116	0.14	YES
INO	Copper	19	19	100	mg/Kg		9.815	1580	157.07974	56.2	5.4	YES
INO	Iron	19	19	100	mg/Kg		13130	36260	23037.10526	234000	200	YES
INO	Lead	19	19	100	mg/Kg		8.94	8220	929.54053	48.6	0.0537	YES
INO	Magnesium	19	19	100	mg/Kg		2300	7830	4433.42105	10400		YES
INO	Manganese	19	19	100	mg/Kg		152	1000	334.81579	3506	100	YES
INO	Mercury	19	17	89	mg/Kg	0.039 - 0.04	0.0218	0.409	0.13854	0.1	0.1	YES
INO	Moisture, Percent	19	19	100	PERCENT		15.6	29.98	20.6			YES
INO	Nickel	19	19	100	mg/Kg		16.4	103	41.47368	55.1	13.6	YES
INO	Potassium	19	18	95	mg/Kg	626 - 626	928	2870	1614.78947	3390		YES
INO	Selenium	19	18	95	mg/Kg	0.59 - 0.59	0.267	4.47	1.4145	2	0.0276	YES
INO	Silver	19	13	68	mg/Kg	0.108 - 1.3	0.132	1.285	0.53195	11.1	2	
INO	Sodium	19	13	68	mg/Kg	592 - 639	64.7	1390	400.21842			YES
INO	Thallium	19	14	74	mg/Kg	1.18 - 1.26	1.3	3.32	1.69	1.3	0.0569	YES
INO	Tin	3	1	33	mg/Kg	0.467 - 0.472	5.31	5.31	1.9265		7.62	
INO	Vanadium	19	19	100	mg/Kg		10.5	40.8	24.95789	40.9	1.59	YES
INO	Zinc	19	19	100	mg/Kg		48.55	1540	308.02368	322	6.62	YES

Table 5-1
Summary of Statistics and Identification of Ecological COPCs for Constituents Detected in Environmental Media
Reservoir 2 Burning Ground
Plum Brook Ordnance Works, Sandusky, Ohio

type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Average	Background	Toxicity Screening Level	COPEC
PAH	Acenaphthene	19	11	58	ug/Kg	73.1 - 420	90.9	67400	7898.44737		20000	YES
PAH	Acenaphthylene	19	12	63	ug/Kg	39.9 - 420	42.2	131000	14785.69737		682000	
PAH	Anthracene	19	6	32	ug/Kg	4.55 - 410	4.69	73.2	75.39974		1480000	
PAH	Benzo(a)anthracene	19	8	42	ug/Kg	8.04 - 420	9.7	501	128.85342		5210	
PAH	Benzo(a)pyrene	19	5	26	ug/Kg	9.65 - 420	18.9	108	109.18342		1520	
PAH	Benzo(b)fluoranthene	19	10	53	ug/Kg	3.82 - 420	4	212	113.83158		59800	
PAH	Benzo(g,h,i)perylene	19	3	16	ug/Kg	13.9 - 601	47.4	103	116.70526		119000	
PAH	Benzo(k)fluoranthene	19	9	47	ug/Kg	13.8 - 420	42.3	469	143.34737		148000	
PAH	Chrysene	19	10	53	ug/Kg	5.68 - 410	38.9	928	157.82421		4730	
PAH	Dibenz(a,h)anthracene	19	3	16	ug/Kg	3.18 - 420	16.1	302	106.30921		18400	
PAH	Fluoranthene	19	9	47	ug/Kg	22.5 - 973	56	720	215.92632		122000	
PAH	Fluorene	19	4	21	ug/Kg	24.7 - 1040	25.6	317	160.42895		30000	
PAH	Indeno(1,2,3-cd)pyrene	19	4	21	ug/Kg	3.43 - 420	33.9	151	88.44289		109000	
PAH	Naphthalene	19	10	53	ug/Kg	26 - 420	234	51300	5908.93421		99.4	YES
PAH	Phenanthrene	19	10	53	ug/Kg	19.2 - 420	68.8	1550	349.79737		45700	
PAH	Pyrene	19	4	21	ug/Kg	26.6 - 1150	44	203	140.9		78500	
PCB	PCB-1254 (Aroclor 1254)	19	2	11	ug/Kg	40 - 14200	1660	3670	2003.78947		40000	
PCB	PCB-1260 (Aroclor 1260)	19	11	58	ug/Kg	39 - 8620	632	11600	2932.86842			YES
VOC	1,1,1-Trichloroethane	19	3	16	ug/Kg	0.463 - 31	1.085	140	9.32663		29800	
VOC	1,1-Dichloroethane	19	1	5	ug/Kg	0.411 - 31	10.1	10.1	2.34782		20100	
VOC	1,1-Dichloroethene	19	7	37	ug/Kg	0.508 - 31	0.62	2.55	2.28505		8280	
VOC	2-Butanone (Methyl ethyl ketone)	19	3	16	ug/Kg	3.27 - 120	3.6	54	10.61658		89600	
VOC	Acetone	19	8	42	ug/Kg	3.07 - 26	8.7	300	38.35447		2500	
VOC	Benzene	19	7	37	ug/Kg	0.393 - 31	1.4	20.6	3.83095		255	
VOC	Chloroform	19	1	5	ug/Kg	0.454 - 31	2	2	1.96245		1190	
VOC	Cyclohexane	13	5	38	ug/Kg	0.419 - 1.05	0.83	24.9	4.58158			YES
VOC	Ethylbenzene	19	1	5	ug/Kg	0.332 - 31	2.3	2.3	1.90529		5160	
VOC	Isopropylbenzene (Cumene)	12	1	8	ug/Kg	0.393 - 1.11	1.3	1.3	0.39075			YES
VOC	Methylcyclohexane	10	4	40	ug/Kg	0.445 - 1.12	1.1	23.9	3.01935			YES
VOC	Methylene Chloride	19	1	5	ug/Kg	1.18 - 31	1.9	1.9	2.33263		4050	
VOC	Tetrachloroethene (PCE)	19	1	5	ug/Kg	0.332 - 31	0.87	0.87	1.84076		9920	
VOC	Toluene	19	7	37	ug/Kg	0.297 - 31	0.99	1570	88.90084		5450	
VOC	Xylenes, Total	19	2	11	ug/Kg	0.341 - 31	0.78	12.5	2.46963		10000	

Table 5-1
Summary of Statistics and Identification of Ecological COPCs for Constituents Detected in Environmental Media
Reservoir 2 Burning Ground
Plum Brook Ordnance Works, Sandusky, Ohio

type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Average	Background	Toxicity Screening Level	COPEC
Outside the Burn Area												
Surface Soil												
HE	1,3,5-Trinitrobenzene	55	13	24	ug/Kg	87 - 5000	210	15000	576.32727		376	YES
HE	1,3-Dinitrobenzene	55	3	5	ug/Kg	83 - 12000	120	220	228.22727		655	
HE	2,4,6-Trinitrotoluene	55	33	60	ug/Kg	87 - 250	140	2270000	50035.18182			YES
HE	2,4-Dinitrotoluene	55	25	45	ug/Kg	110 - 250	240	200000	5302.47273		1280	YES
HE	2,6-Dinitrotoluene	55	14	25	ug/Kg	110 - 12000	152	78000	1897.71818		32.8	YES
HE	2-Amino-4,6-Dinitrotoluene	45	16	36	ug/Kg	125 - 625	150	26000	1076.54444			YES
HE	2-Nitrotoluene	55	6	11	ug/Kg	87 - 12000	110	2000	268.23636			YES
HE	4-Amino-2,6-Dinitrotoluene	55	16	29	ug/Kg	87 - 110000	130	27000	2130.89091			YES
HE	4-Nitrotoluene	45	1	2	ug/Kg	87 - 625	260	260	69.08889			YES
HE	HMX	55	4	7	ug/Kg	87 - 25000	150	820	424.15455			YES
HE	Nitrobenzene	65	1	2	ug/Kg	92 - 12000	180	180	221.70769		1310	
HE	RDX	55	2	4	ug/Kg	87 - 25000	270	540	416.21818			YES
INO	Aluminum	45	45	100	mg/Kg		8840	16450	11571.33333	15500	50	YES
INO	Antimony	45	3	7	mg/Kg	0.401 - 7.8	0.534	0.782	1.37022	9.3	0.142	YES
INO	Arsenic	45	45	100	mg/Kg		5.13	21.7	8.62778	36.5	5.7	YES
INO	Barium	45	45	100	mg/Kg		47.1	263	102.50889	826	1.04	YES
INO	Beryllium	45	40	89	mg/Kg	0.6 - 0.65	0.515	0.946	0.62764	1	1.06	
INO	Cadmium	45	35	78	mg/Kg	0.0572 - 0.65	0.0771	1.74	0.40024		0.00222	YES
INO	Calcium	45	45	100	mg/Kg		2320	61200	8862.55556	52300		YES
INO	Chromium	45	45	100	mg/Kg		10.7	26.7	17.78667	29	0.4	YES
INO	Cobalt	45	45	100	mg/Kg		4.02	30.1	8.51567	116	0.14	YES
INO	Copper	45	45	100	mg/Kg		13	534	48.11222	56.2	5.4	YES
INO	Iron	45	45	100	mg/Kg		11550	33300	20664.66667	234000	200	YES
INO	Lead	55	55	100	mg/Kg		7.88	603	143.99918	48.6	0.0537	YES
INO	Magnesium	45	45	100	mg/Kg		993	20100	3962.84444	10400		YES
INO	Manganese	45	45	100	mg/Kg		147	3870	423.45556	3506	100	YES
INO	Mercury	45	40	89	mg/Kg	0.038 - 0.041	0.0152	0.518	0.10182	0.1	0.1	YES
INO	Moisture, Percent	30	30	100	PERCENT		12.2	35.66	20.85033			YES
INO	Nickel	45	45	100	mg/Kg		11.6	96.5	24.46111	55.1	13.6	YES
INO	Potassium	45	45	100	mg/Kg		598	2620	1562.43333	3390		YES
INO	Selenium	45	21	47	mg/Kg	0.202 - 0.83	0.527	2.13	0.72742	2	0.0276	YES
INO	Silver	45	8	18	mg/Kg	0.105 - 1.3	0.138	0.973	0.25151	11.1	2	
INO	Sodium	45	21	47	mg/Kg	245 - 646	45.9	402	154.13222			YES
INO	Thallium	45	10	22	mg/Kg	0.31 - 23.6	1.2	2.1	0.91422	1.3	0.0569	YES
INO	Tin	4	1	25	mg/Kg	0.474 - 0.486	3.78	3.78	1.12425		7.62	
INO	Vanadium	45	45	100	mg/Kg		20.3	41.4	27.39444	40.9	1.59	YES
INO	Zinc	45	45	100	mg/Kg		35.7	498	120.45556	322	6.62	YES
INX	Cyanide	25	12	48	mg/Kg	0.15 - 0.65	0.17	1	0.2838		1.33	

Table 5-1
Summary of Statistics and Identification of Ecological COPCs for Constituents Detected in Environmental Media
Reservoir 2 Burning Ground
Plum Brook Ordnance Works, Sandusky, Ohio

type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Average	Background	Toxicity Screening Level	COPEC
PAH	Acenaphthene	55	11	20	ug/Kg	24 - 430	34.2	697	100.57455		20000	
PAH	Acenaphthylene	55	12	22	ug/Kg	14.7 - 430	26.8	1960	166.22091		682000	
PAH	Anthracene	55	13	24	ug/Kg	1.67 - 430	2.74	55	44.26191		1480000	
PAH	Benzo(a)anthracene	55	21	38	ug/Kg	2.96 - 430	4.08	186	63.28927		5210	
PAH	Benzo(a)pyrene	55	26	47	ug/Kg	3.65 - 430	10.6	360	78.66227		1520	
PAH	Benzo(b)fluoranthene	55	24	44	ug/Kg	1.44 - 430	5.125	820	100.51936		59800	
PAH	Benzo(g,h,i)perylene	55	18	33	ug/Kg	5.25 - 430	13.05	270	65.90064		119000	
PAH	Benzo(k)fluoranthene	55	27	49	ug/Kg	1.37 - 430	30.9	430	101.49973		148000	
PAH	Chrysene	55	25	45	ug/Kg	2.15 - 430	8.3	297	78.23682		4730	
PAH	Dibenz(a,h)anthracene	55	5	9	ug/Kg	3.17 - 430	10.4	124	48.26945		18400	
PAH	Fluoranthene	55	29	53	ug/Kg	8.51 - 430	21.3	350	94.78282		122000	
PAH	Fluorene	55	9	16	ug/Kg	9.1 - 430	10.7	91.3	51.34627		30000	
PAH	Indeno(1,2,3-cd)pyrene	55	18	33	ug/Kg	1.3 - 430	8.2	230	60.74418		109000	
PAH	Naphthalene	55	11	20	ug/Kg	9.84 - 430	23.4	1737.5	104.26945		99.4	YES
PAH	Phenanthrene	55	25	45	ug/Kg	7.06 - 430	12.8	190	70.46264		45700	
PAH	Pyrene	55	25	45	ug/Kg	10.1 - 430	13	295	83.91182		78500	
PCB	PCB-1260 (Aroclor 1260)	55	33	60	ug/Kg	38 - 13300	13	44400	1596.83636			YES
SV	1,4-Dichlorobenzene	30	1	3	ug/Kg	0.304 - 430	0.42	0.42	67.29775		546	
SV	2-Methylnaphthalene	35	4	11	ug/Kg	24 - 430	36	110	72.75714		3240	
SV	bis(2-Ethylhexyl)phthalate	10	1	10	ug/Kg	380 - 430	61	61	186.6		925	
VOC	1,1,1-Trichloroethane	30	5	17	ug/Kg	0.435 - 32	0.8	11.9	3.5978		29800	
VOC	1,1-Dichloroethane	30	2	7	ug/Kg	0.386 - 32	0.66	0.67	2.85762		20100	
VOC	1,1-Dichloroethene	30	8	27	ug/Kg	0.446 - 32	0.48	1	2.95477		8280	
VOC	Acetone	30	6	20	ug/Kg	2.89 - 130	4.6	18	13.05567		2500	
VOC	Cyclohexane	20	2	10	ug/Kg	0.394 - 0.586	0.72	3.9	0.44798			YES
VOC	Styrene	30	1	3	ug/Kg	0.32 - 32	1	1	2.82807		4690	
VOC	Tetrachloroethene (PCE)	30	7	23	ug/Kg	0.312 - 32	0.39	3.4	3.13308		9920	
VOC	Toluene	30	2	7	ug/Kg	0.279 - 32	1.5	1.9	2.69532		5450	

Source: Revised Final Baseline Human Health Risk Assessment (Jacobs, 2010a).

Table 5-2

Hazard Quotients for All Wildlife Assessment Receptors Inside the Burn Area
Reservoir No. 2 Burning Ground
Former Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Short-Tailed Shrew	White-Tailed Deer	Marsh Wren	Deer Mouse	Eastern Cottontail Rabbit	Red-Tailed Hawk	Raccoon
2,3,7,8-TCDD TEQ[a]	**9.2E+01**	6.2E-03	**NA[b]**	**4.5E+01**	**2.2E+00**	NA	**1.1E+01**
2,4-Dinitrotoluene	**1.6E+04**	**6.3E+01**	**3.0E+03**	**1.9E+04**	**8.2E+03**	**3.5E+01**	**5.4E+02**
2,6-Dinitrotoluene	**4.6E+02**	**2.5E+00**	**8.3E+01**	**6.6E+02**	**3.3E+02**	**1.2E+00**	**1.4E+01**
2,4,6-Trinitrotoluene	**2.8E+03**	**4.9E+00**	**4.2E+03**	**2.2E+03**	**6.4E+02**	**3.6E+01**	**1.2E+02**
1,3,5-Trinitrobenzene	NA	NA	NA	NA	NA	NA	NA
Aluminum	**2.8E+02**	9.3E-02	**2.4E+00**	**1.2E+02**	**3.4E+01**	1.5E-02	**2.8E+00**
Antimony	9.5E-02	2.9E-04	NA	8.6E-02	4.5E-02	NA	1.3E-03
Arsenic	3.1E-01	3.6E-04	6.3E-02	1.6E-01	8.3E-02	5.0E-04	3.5E-03
Barium	**2.6E+01**	6.0E-02	**3.1E+00**	**2.0E+01**	**9.8E+00**	3.1E-02	3.2E-01
Beryllium	5.7E-01	2.3E-04	NA	2.5E-01	7.4E-02	NA	5.8E-03
Cadmium	1.7E-01	2.8E-04	7.2E-02	1.3E-01	4.0E-02	6.1E-04	3.1E-03
Chromium	1.8E-01	1.9E-04	8.4E-02	5.7E-02	6.4E-02	6.5E-04	2.2E-03
Cobalt	5.1E-01	2.6E-03	NA	6.5E-01	3.8E-01	NA	8.4E-03
Copper	5.1E-01	6.7E-03	3.5E-02	**1.3E+00**	9.5E-01	1.7E-03	1.4E-02
Iron	**4.7E+01**	1.4E-02	**1.2E+01**	**2.0E+01**	**5.4E+00**	7.4E-02	4.7E-01
Lead	**5.0E+00**	1.1E-02	**2.6E+00**	**2.9E+00**	**2.3E+00**	3.0E-02	6.7E-02
Manganese	4.0E-01	2.9E-04	1.9E-02	2.1E-01	6.1E-02	1.3E-04	4.3E-03
Mercury	3.9E-03	7.1E-06	2.4E-03	2.1E-03	1.6E-03	2.4E-05	5.2E-05
Nickel	2.4E-02	4.5E-05	2.6E-03	1.2E-02	1.1E-02	2.9E-05	3.2E-04
Selenium	4.4E-01	2.2E-04	8.6E-02	2.0E-01	6.2E-02	5.7E-04	4.5E-03
Thallium	**1.4E+00**	4.6E-04	1.4E-01	5.9E-01	1.6E-01	8.9E-04	1.4E-02
Vanadium	**6.3E+00**	2.0E-03	5.7E-02	**2.7E+00**	7.4E-01	3.5E-04	6.3E-02
Zinc	2.9E-01	3.9E-05	**1.8E+00**	1.3E-01	1.6E-02	1.1E-02	3.2E-03
Acenaphthene	**2.7E+02**	2.4E-03	NA	**1.4E+02**	3.7E-01	NA	**2.3E+02**
Naphthalene	**6.4E+01**	4.0E-03	NA	**3.3E+01**	5.6E-01	NA	**1.7E+01**

Source of hazard quotient values: Jacobs Engineering Inc., 2010, Revised Final Screening Level Ecological Risk Assessment, Reservoir No. 2 Burning Ground, Former Plum Brook Ordnance Works, Sandusky, Ohio, February.

Note: Bolded hazard quotients exceed a value of 1. Bolded, shaded hazard quotient values indicate an elevated potential for adverse ecological effects (i.e., >10).

[a]2,3,7,8-TCDD TEQ refers to 2,3,7,8-tetrachloro-dibenzodioxin toxicity equivalents.
[b]"NA" indicates that no toxicological effective dose was available.

Table 5-3

Hazard Quotient for All Wildlife Assessment Receptors Outside the Burn Area
Reservoir No. 2 Burning Ground
Former Plum Brook Ordnancne Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Short-Tailed Shrew	White-Tailed Deer	Marsh Wren	Deer Mouse	Eastern Cottontail Rabbit	Red-Tailed Hawk	Raccoon
2,4-Dinitrotoluene	**5.1E+01**	1.9E-01	**9.3E+00**	**5.9E+01**	**2.6E+01**	1.1E-01	**1.4E+01**
2,6-Dinitrotoluene	**1.6E+01**	8.5E-02	**2.9E+00**	**2.3E+01**	**1.1E+01**	4.0E-02	**2.1E+00**
2,4,6-Trinitrotoluene	**2.8E+02**	4.9E-01	**4.2E+02**	**2.3E+02**	**6.4E+01**	**3.6E+00**	**2.0E+03**
1,3,5-Trinitrobenzene	**NA**[a]	NA	NA	NA	NA	NA	NA
Aluminum	**3.0E+02**	9.8E-02	**2.5E+00**	**1.3E+02**	**3.6E+01**	1.6E-02	**2.9E+04**
Arsenic	2.4E-01	2.8E-04	4.8E-02	1.2E-01	6.3E-02	3.8E-04	1.8E-02
Antimony	3.0E-02	9.0E-05	NA	2.7E-02	1.4E-02	NA	1.0E-03
Barium	**1.1E+00**	2.5E-03	1.3E-01	8.3E-01	4.0E-01	1.3E-03	9.9E-01
Cadmium	7.4E-02	1.2E-04	3.1E-02	5.6E-02	1.7E-02	2.6E-04	1.9E-03
Chromium	1.1E-01	1.2E-04	5.4E-02	3.7E-02	4.1E-02	4.2E-04	4.7E-03
Cobalt	3.9E-01	2.0E-03	NA	4.9E-01	2.8E-01	NA	4.5E-02
Copper	1.8E-01	2.4E-03	1.2E-02	4.5E-01	3.4E-01	5.8E-04	7.3E-02
Iron	**4.0E+01**	1.2E-02	**1.0E+01**	**1.7E+01**	**4.6E+00**	6.3E-02	**7.1E+03**
Lead	6.0E-01	1.3E-03	3.1E-01	3.4E-01	2.8E-01	3.6E-03	4.0E-01
Manganese	5.5E-01	4.1E-04	2.6E-02	3.0E-01	8.6E-02	1.9E-04	**3.9E+00**
Mercury	2.8E-03	5.0E-06	1.7E-03	1.5E-03	1.1E-03	1.7E-05	6.9E-05
Nickel	1.3E-02	2.4E-05	1.4E-03	6.2E-03	5.6E-03	1.5E-05	9.9E-04
Selenium	2.3E-01	1.1E-04	4.5E-02	1.1E-01	3.2E-02	2.9E-04	5.4E-03
Thallium	9.0E-01	3.0E-04	9.3E-02	3.9E-01	1.1E-01	5.8E-04	2.4E-02
Vanadium	**6.5E+00**	2.1E-03	5.8E-02	**2.8E+00**	7.6E-01	3.6E-04	**1.6E+00**
Zinc	1.2E-01	1.6E-05	7.3E-01	5.3E-02	6.3E-03	4.5E-03	2.2E-01
Naphthalene	7.3E-01	4.5E-05	NA	3.7E-01	6.3E-03	NA	1.0E-02

Source of hazard quotient values: Jacobs Engineering Inc., 2010, Revised Final Screening Level Ecological Risk Assessment, Reservoir No. 2 Burning Ground, Former Plum Brook Ordnance Works, Sandusky, Ohio, February.

Note: Bolded hazard quotients exceed a value of 1. Bolded, shaded hazard quotient values indicate an elevated potential for adverse ecological effects (i.e., >10).

[a]"NA" indicates that no toxicological effective dose was available.

FIGURES

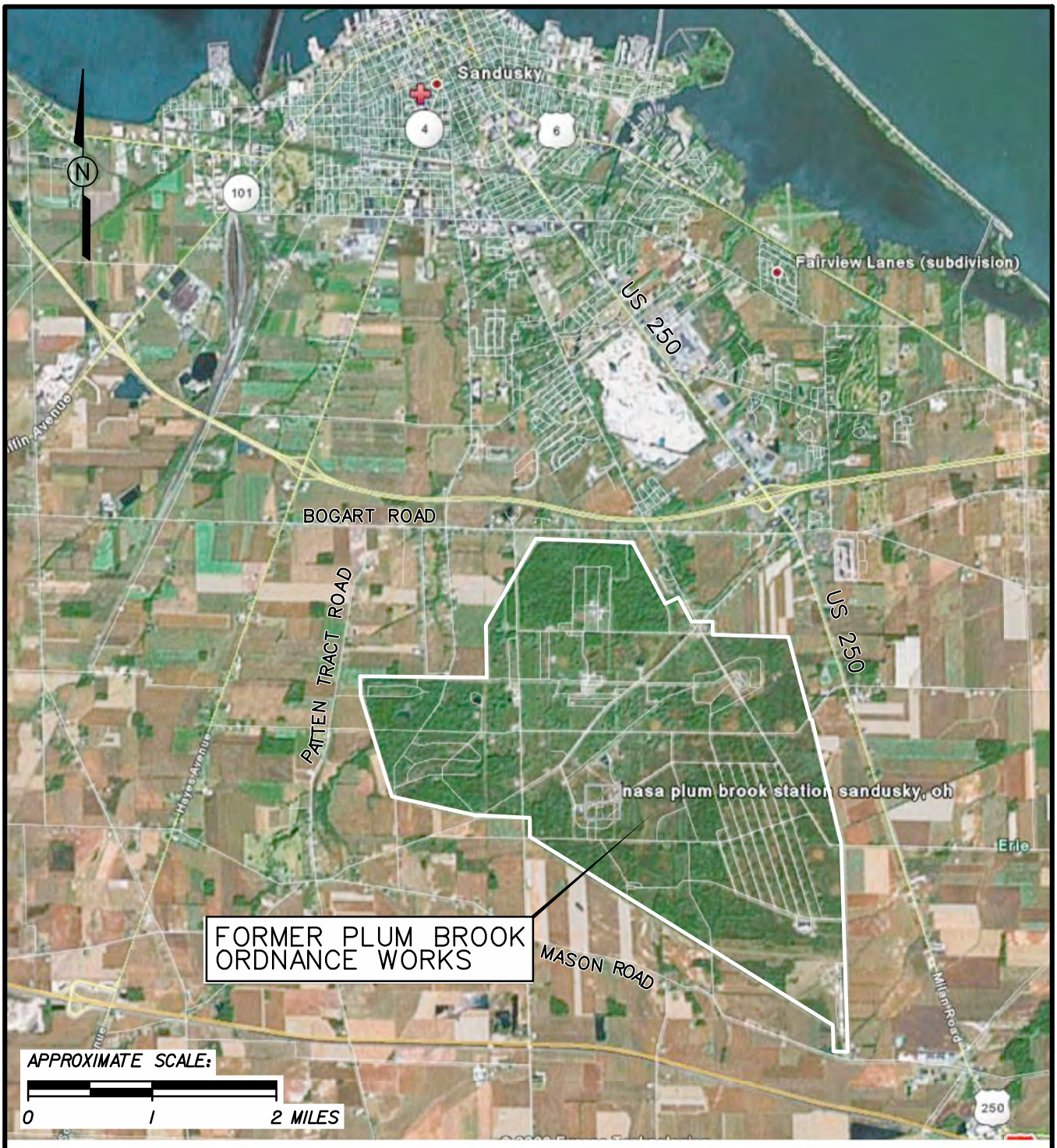

FIGURE 1-1
PBOW VICINITY MAP

RESERVOIR NO. 2 BURNING GROUND
REMEDIAL INVESTIGATION REPORT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

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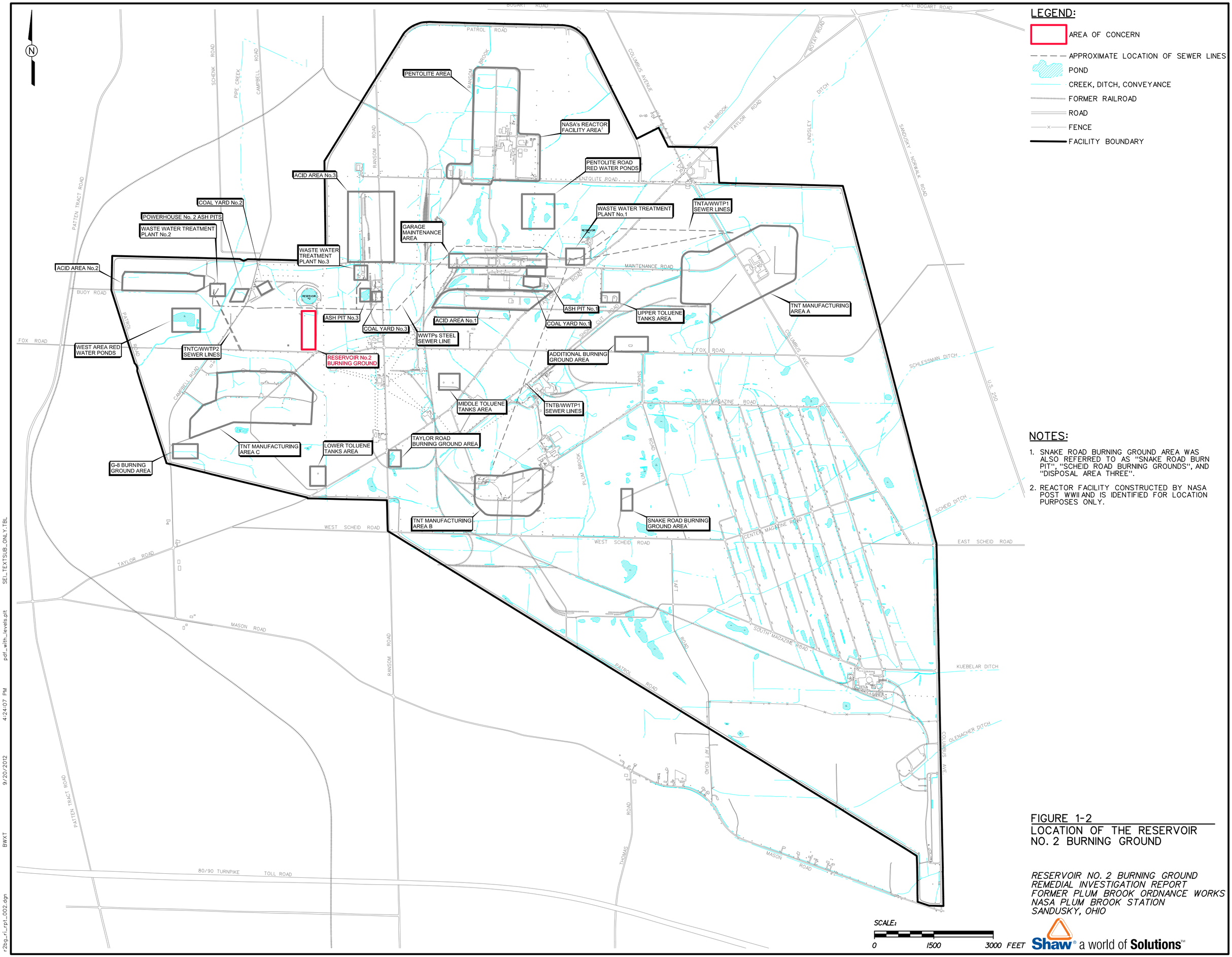

LEGEND:

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

NOTES:

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

SCALE: 0 1500 3000 FEET

FIGURE 1-2
LOCATION OF THE RESERVOIR NO. 2 BURNING GROUND

RESERVOIR NO. 2 BURNING GROUND
REMEDIAL INVESTIGATION REPORT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

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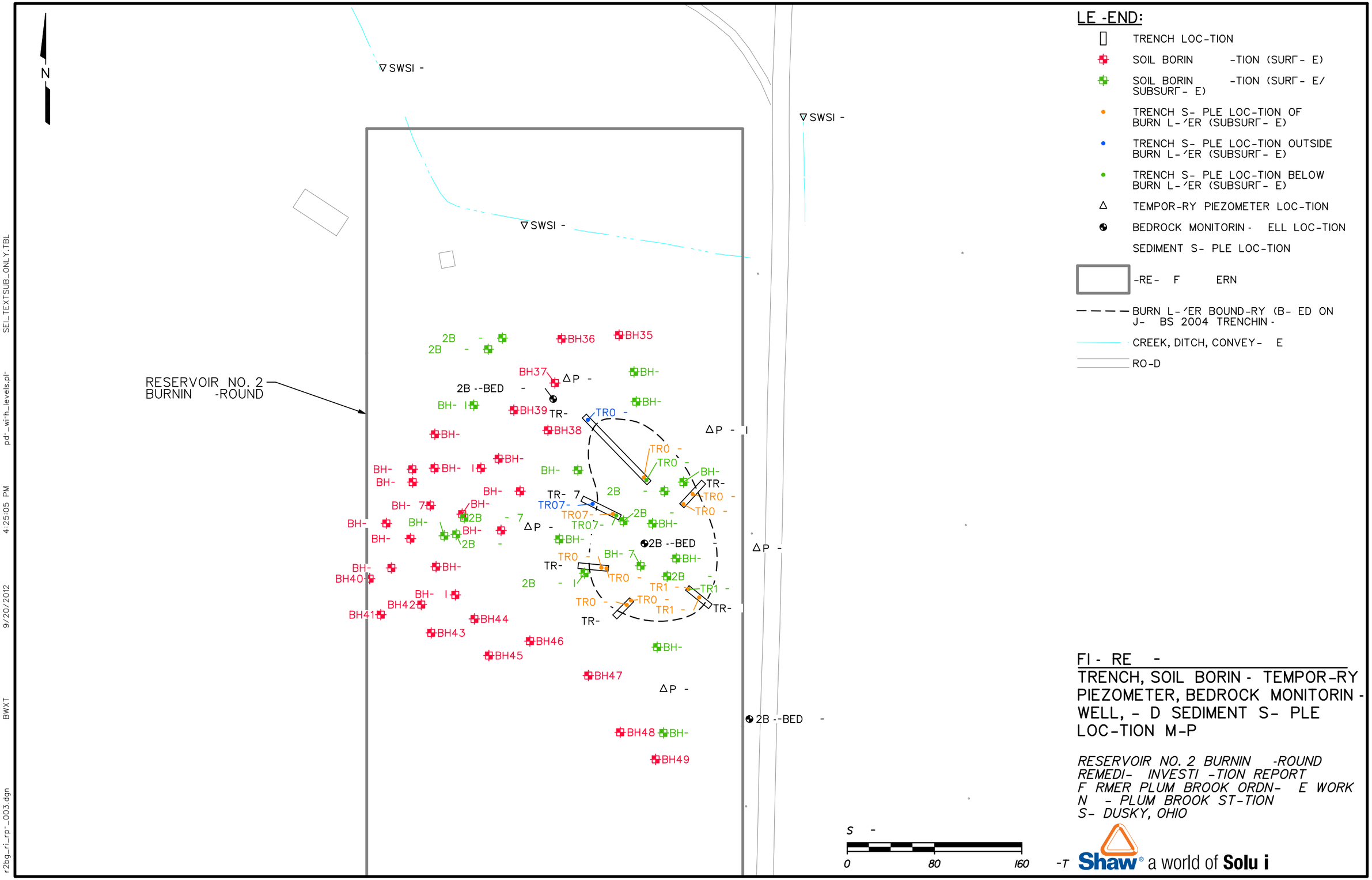

LE -END:

- TRENCH LOC-TION
- SOIL BORIN -TION (SURΓ- E)
- SOIL BORIN -TION (SURΓ- E/ SUBSURΓ- E)
- TRENCH S- PLE LOC-TION OF BURN L-΄ER (SUBSURΓ- E)
- TRENCH S- PLE LOC-TION OUTSIDE BURN L-΄ER (SUBSURΓ- E)
- TRENCH S- PLE LOC-TION BELOW BURN L-΄ER (SUBSURΓ- E)
- TEMPOR-RY PIEZOMETER LOC-TION
- BEDROCK MONITORIN - ELL LOC-TION
- SEDIMENT S- PLE LOC-TION
- -RE- F ERN
- BURN L-΄ER BOUND-RY (B- ED ON J- BS 2004 TRENCHIN -
- CREEK, DITCH, CONVEY- E
- RO-D

S -

0 80 160 -T

FI - RE -

TRENCH, SOIL BORIN - TEMPOR-RY PIEZOMETER, BEDROCK MONITORIN - WELL, - D SEDIMENT S- PLE LOC-TION M-P

RESERVOIR NO. 2 BURNIN -ROUND
REMEDI- INVESTI -TION REPORT
F RMER PLUM BROOK ORDN- E WORK
N - PLUM BROOK ST-TION
S- DUSKY, OHIO

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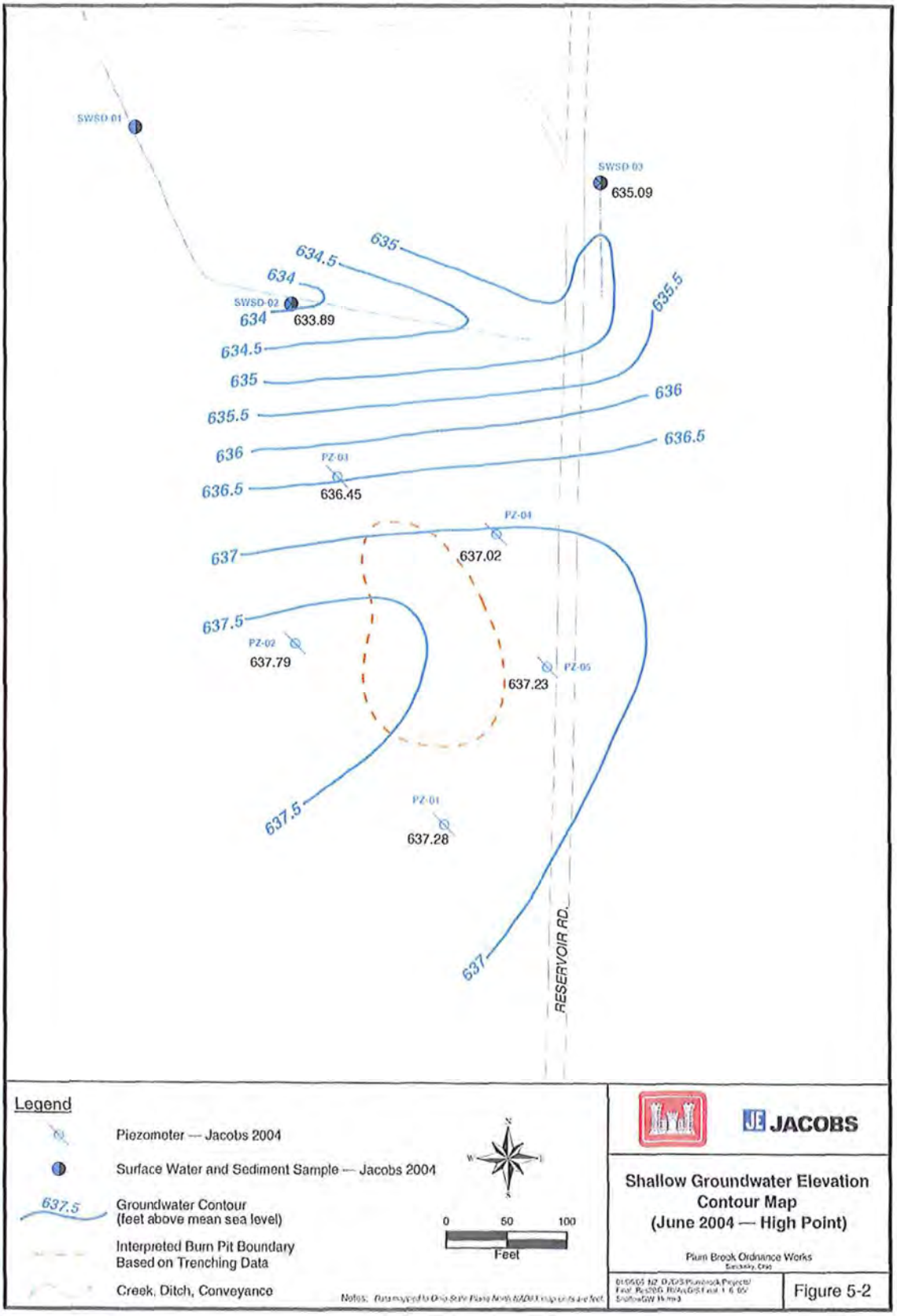

SOURCE: FIN- ITE CH-R- TERIZ-TION REPORT (J- BS, 2006).

FI- RE -
OVERBURDEN/SH- E -ROUNDW-TER
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RESERVOIR NO. 2 BURNIN -ROUNI
REMEDI- INVESTI -TION REPORT

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SOURCE: FIN- ITE CH-R- TERIZ-TION REPORT (J- BS, 2006)

FI- RE - DISTIBUTION OF T- IN- TS EXCEEDIN- PR- IN SURΓ- E SOIL

RESERVOIR NO. 2 BURNIN -ROUND REMEDI- INVESTI -TION REPORT

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cben-ley

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SOURCE: FIN- ITE CH-R- TERIZ-TION REPORT (J- BS, 2006).

FI- RE -I DISTRIBUTION OF T- IN- TS EXCEEDIN- PR- IN THE BURN L-ʻER SOI

RESERVOIR NO. 2 BURNIN -ROUND REMEDI- INVESTI -TION REPORT

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cben-ley

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SOURCE: FIN- ITE CH-R- TERIZ-TION REPORT (J- BS, 2006).

NOTE: EXCLUDES BURN L-ˊER SOIL (SEE FI -1).

FI- RE - DISTRIBUTION OF T- IN- TS EXCEEDIN- PR- IN SUBSURΓ- E SOI

RESERVOIR NO. 2 BURNIN -ROUND REMEDI- INVESTI -TION REPORT

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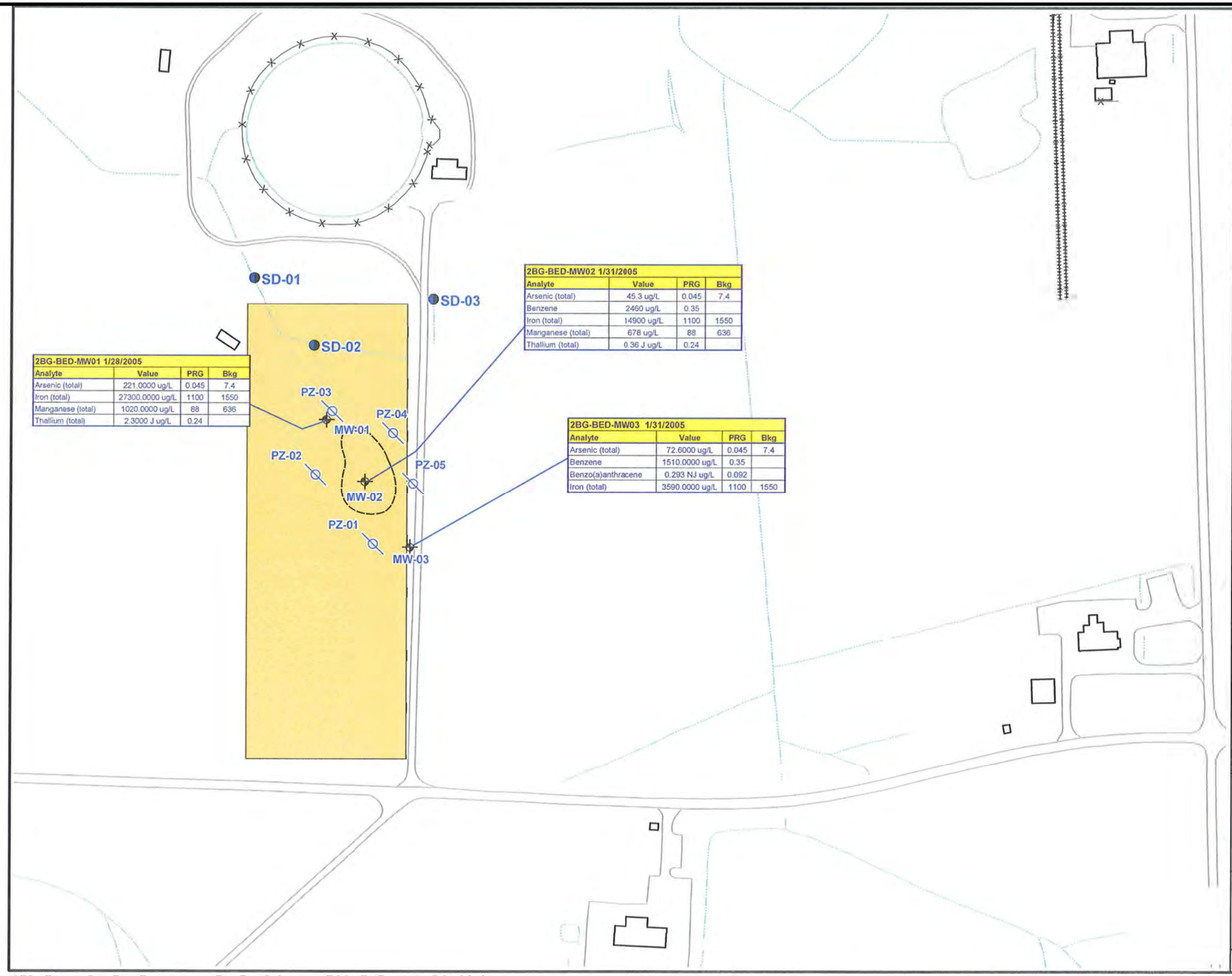

SOURCE: REVISED FIN- B- ELINE HUM- HE- TH RISK - ESSMENT (J- BS, 2010).

FI - RE - DISTRIBUTION OF T- IN- TS EXCEEDIN - PR - IN -ROUNDW-TER

RESERVOIR NO. 2 BURNIN -ROUND REMEDI- INVESTI -TION REPORT

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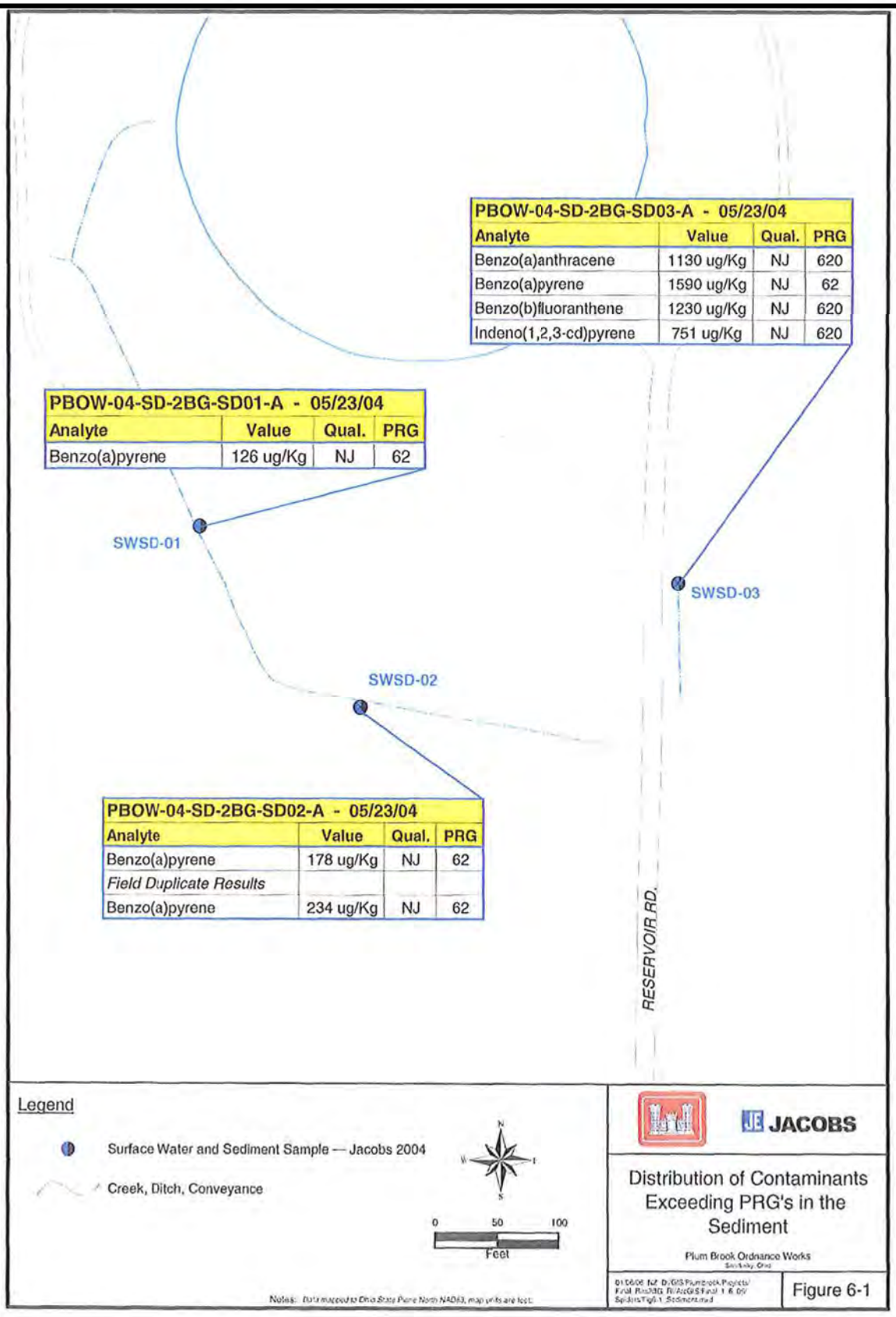

SOURCE: FIN- ITE CH-R- TERIZ-TION REPORT (J- BS, 2006).

FI- RE -7
DISTRIBUTION OF T- IN- TS EXCEEDIN- PR- IN SEDIMENT
RESERVOIR NO. 2 BURNIN -ROUND REMEDI- INVESTI -TION REPORT

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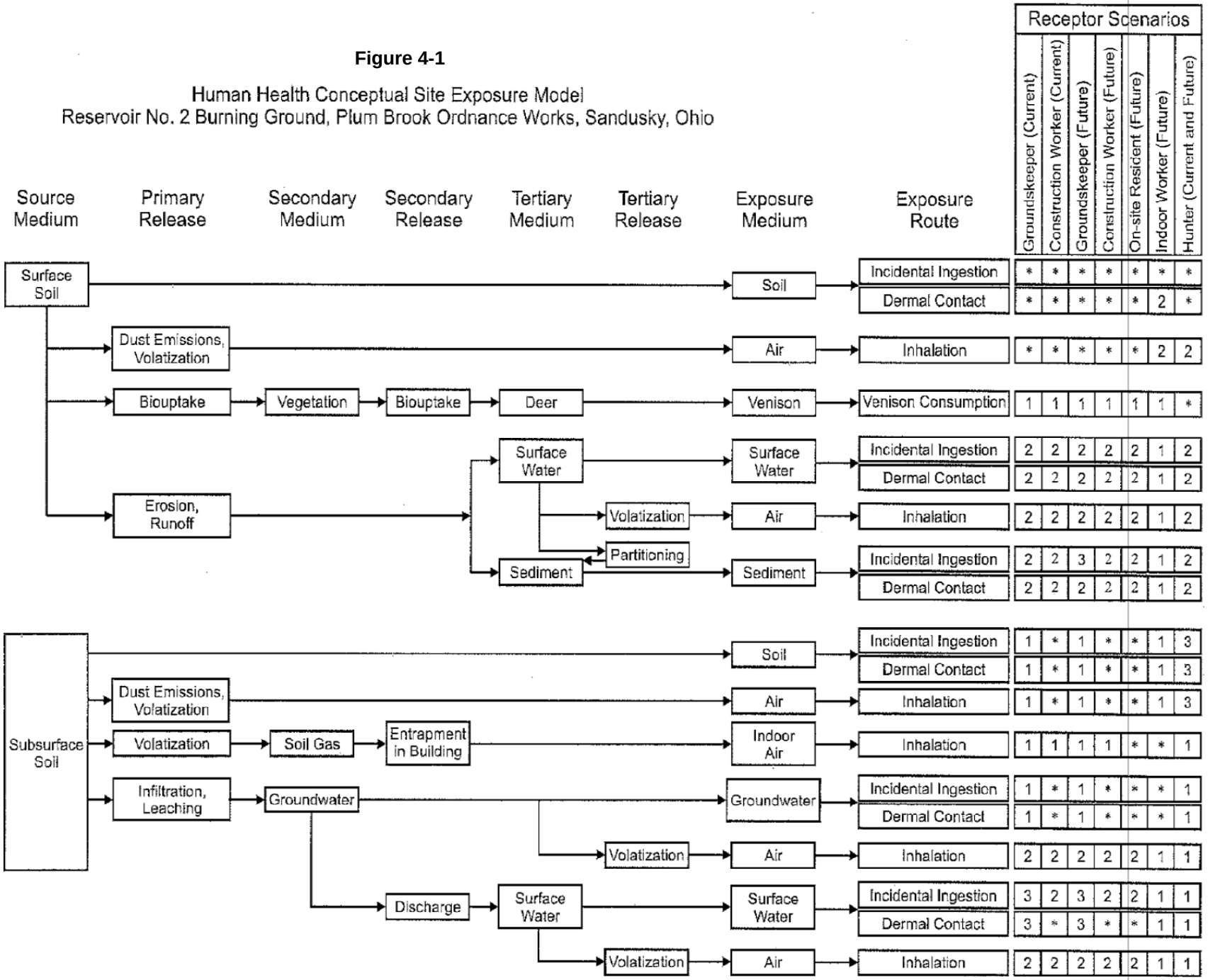
Figure 4-1

Human Health Conceptual Site Exposure Model
Reservoir No. 2 Burning Ground, Plum Brook Ordnance Works, Sandusky, Ohio



* = Complete exposure route quantified in the risk assessment.
1 = There is no plausible pathway for exposure in this medium.
2 = Although theoretically complete, this pathway in not quantified as explained in text.
3 = Contact with this medium, although plausible, is not part of this receptor's normal or expected activities; therefore, contact would be sporadic and is not quantified.

Source: Revised Final Baseline Human Health Risk Assessment (Jacobs, 2010a)

SOURCE: REVISED FIN- REENIN - EVEL ECOLO -IC- RISK - ESSMENT (J- BS, 2010).

FI - RE - H-BIT-T M-I

RESERVOIR NO. 2 BURNIN -ROUND REMEDI- INVESTI -TION REPORT

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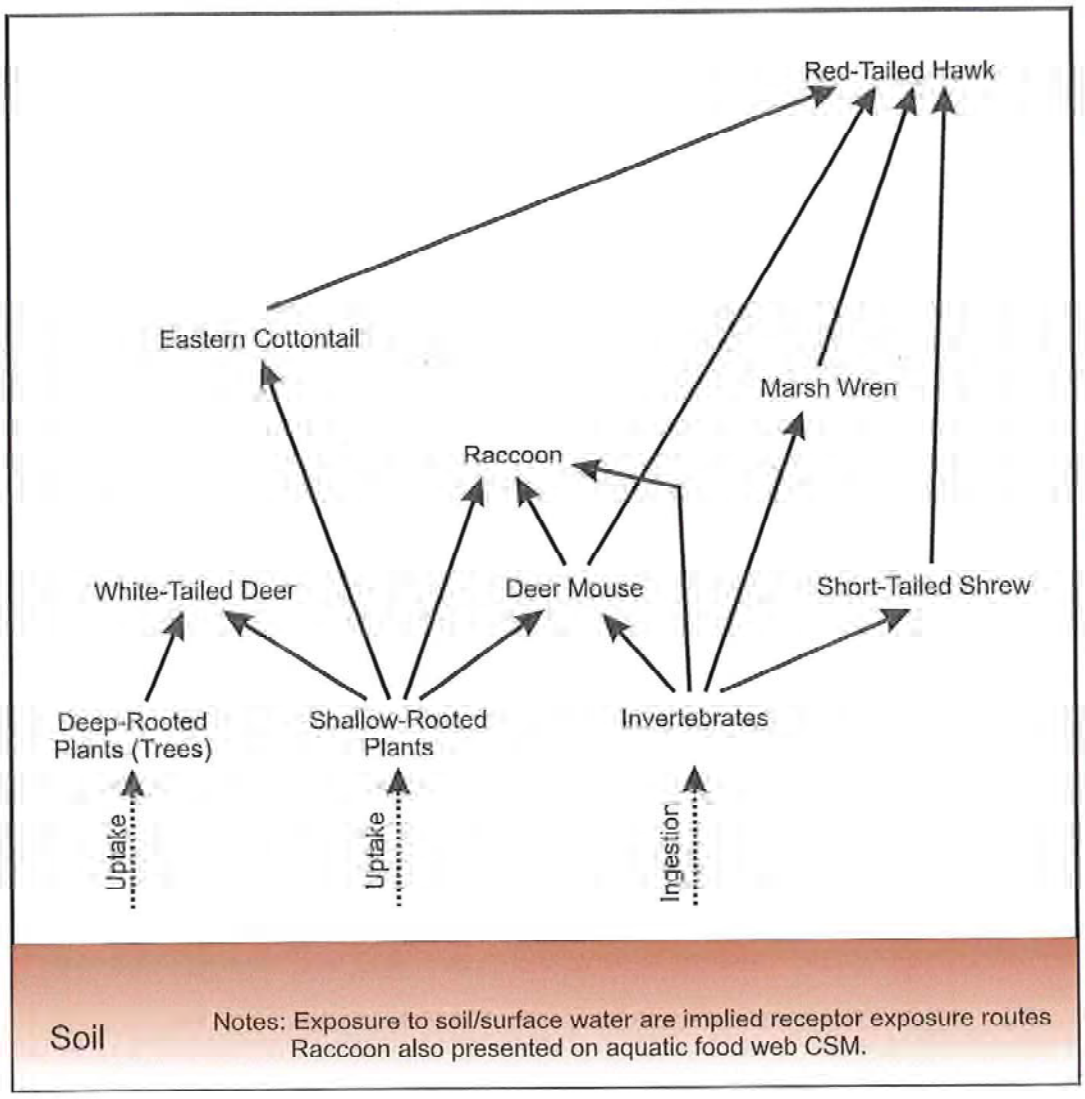
Figure 5-2

Simplified Terrestrial Food Web Conceptual Site Model (CSM)
Reservoir No. 2 Burning Ground
Former Plum Brook Ordnance Works, Sandusky, Ohio



Source: Revised Final Screening Level Ecological Risk Assessment (Jacobs, 2010b).