Draft Final
January 2014

Decision Document for Reservoir No. 2 Burning Ground FUDS Project No. G05OH001812

Former Plum Brook Ordnance Works Sandusky, Ohio

US Army Corps
of Engineers

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Decision Document for Reservoir No. 2 Burning Ground
FUDS Project No. G05OH001812
Former Plum Brook Ordnance Works
Sandusky, Ohio

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Issued by: U.S. Army Corps of Engineers

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List of Acronyms

AR	Administrative Record
ARAR	applicable or relevant and appropriate requirement
ATS	Alternative Treatment Standard
BCF	bioconcentration factors
bgs	below ground surface
BHHRA	Baseline Human Health Risk Assessment
CDI	chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	chemical of concern
COPC	chemical of potential concern
COPEC	chemical of potential ecological concern
cy	cubic yards
DERP	Defense Environmental Restoration Program
DNT	dinitrotoluene
DoD	U.S. Department of Defense
DSMOA	Defense and State Memorandum of Agreement
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
FFS	focused feasibility study
FS	feasibility study
ft^2	square feet
FUDS	Formerly Used Defense Sites
GSA	General Services Administration
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
ICI	International Consultants, Inc.
ILCR	incremental lifetime cancer risk
IRIS	Integrated Risk Information System
IT	IT Corporation
Jacobs	Jacobs Engineering Group, Inc.

List of Acronyms *(Continued)*

LDR	land disposal restriction
LRD	Great Lakes and Ohio River Division
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
mg/kg-day	milligrams per kilogram of body weight per day
NACA	National Advisory Committee for Aeronautics
NASA	National Aeronautics and Space Administration
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
ng/kg	nanograms per kilogram
NOAEL	no-observed-adverse-effects level
Ohio EPA	Ohio Environmental Protection Agency
PAH	polycyclic aromatic hydrocarbons
PBOW	former Plum Brook Ordnance Works
PCB	polychlorinated biphenyl
PCDD/F	polychlorinated dibenzodioxin/furans
R2BG	Reservoir No. 2 Burning Ground
RAB	Restoration Advisory Board
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RG	remedial goal
RI	remedial investigation
RWP	red water pond areas
SACM	Superfund Accelerated Cleanup Model
SARA	Superfund Amendments and Reauthorization Act of 1986
SF	slope factor
Shaw	Shaw Environmental, Inc.
SLERA	screening-level ecological risk assessment
TAPP	Technical Assistance for Public Participation
TCDD TEQ	2,3,7,8-tetracholordibenzodioxin toxicity equivalents
TCLP	toxicity characteristic leaching procedure
TNT	2,4,6-trinitrotoluene

List of Acronyms *(Continued)*

TNTA	TNT Area A
TNTB	TNT Area B
TNTC	TNT Area C
TRV	toxicity reference values
TSCA	Toxic Substances Control Act
TSDF	transportation, storage, and disposal facility
USACE	U.S. Army Corps of Engineers
WAA	War Assets Administration

1.0 Declaration

1.1 Site Name and Location

Reservoir No. 2 Burning Ground
Former Plum Brook Ordnance Works
Sandusky, Ohio

1.2 Statement of Basis and Purpose

This Decision Document presents the selected final remedy for contamination in soil that is attributable to releases associated with historical operations at the Reservoir No. 2 Burning Ground (R2BG), located on the former Plum Brook Ordnance Works (PBOW), Sandusky, Ohio. No action is recommended for other R2BG environmental media. PBOW is an Army Defense Environmental Restoration Program (DERP) project under the U.S. Army Corps of Engineers (USACE) Great Lakes and Ohio River Division (LRD) Formerly Used Defense Site (FUDS) program. The R2BG site is identified as FUDS Project No. G05OH001812.

As the lead agency, the USACE is charged with planning and implementing environmental investigations and remedial actions at PBOW associated with past U.S. Department of Defense (DoD) activities. The USACE Louisville District is the project and program management office for all FUDS property in the USACE LRD. The USACE Huntington District provides overall project management of FUDS activities at PBOW for the Louisville District as well as acting as the contracting and oversight office for remedial actions. The USACE Nashville District provides design support services for environmental investigations at PBOW and provides technical review. The remedy selection has been made in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (U.S. Environmental Protection Agency [EPA], 1990). The investigation, reporting, and project decision process were conducted consistent with *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988) and subsequent guidance materials, including *Guidance on Implementation of the Superfund Accelerated Cleanup Model (SACM) under CERCLA and the NCP* (EPA, 1992). This decision is based on the Administrative Record (AR) file for R2BG.

This document has been prepared for the U.S. Department of the Army, the lead agency for response actions at PBOW. The remedy for this site has been selected by the USACE. The State of Ohio concurs with this remedy.

1.3 Assessment of Site

The response action selected in this Decision Document is necessary to protect public health, public welfare, or the environment from actual or threatened releases of hazardous substances into the environment or from actual or threatened releases of pollutants or contaminants from this site.

1.4 Description of the Selected Remedy

The remedy selected in this Decision Document addresses the contamination associated with R2BG soil. The components of this remedy are as follows:

- Excavation of contaminated soil
- Segregation and stabilization of the hazardous lead-contaminated soil
- Segregation and alkaline hydrolysis of hazardous 2,4-dinitrotoluene (DNT)-contaminated soil
- Segregation of soils containing polychlorinated biphenyls (PCB) or polychlorinated dibenzodioxin/furans (PCDD/F), measured as 2,3,7,8-tetracholordibenzodioxin toxicity equivalents (TCDD TEQ), at concentrations exceeding the remedial goals (RG)
- Off-site disposal of the treated material at a nonhazardous solid waste landfill and/or placement of the treated material on site.

Contaminated R2BG soil is characterized as being associated with one of two general areas: the area inside the Burn Area or the area outside the Burn Area. The Burn Area is the area within R2BG that evidently was the most used for burning and is identified by a contiguous layer of burned materials. Although its depth and thickness vary slightly, the burn layer is typically about 1 foot thick and approximately 1 foot below the surface. Contamination inside the Burn Area extends several feet below the surface, whereas contamination outside the Burn Area appears to be limited to surface and near-surface soil. Contaminated soil outside the Burn Area is mostly west of the Burn Area and appears to be limited to within approximately 1 foot of the surface.

Principal threat wastes are the subsurface soils within the Burn Area with the highest concentrations of nitroaromatics, as these represent the highest potential human health risk if direct exposure were to occur. PCBs have not been detected at concentrations constituting a PCB remediation waste (50 milligrams per kilogram [mg/kg]) that would require disposal at a Toxic Substances Control Act (TSCA)-approved transportation, storage, and disposal facility (TSDF). The volume of contaminated soil to be excavated from within the Burn Area (assuming a depth of 8 feet) is estimated as 5,056 cubic yards (cy). The estimated volume of contaminated soil to be excavated from outside the Burn Area (assuming a depth of 2 feet) is 2,339 cy. Thus, the total estimated volume is 7,395 cy, all of which is assumed to be hazardous with respect to 2,4-DNT and/or lead. The combined remediation area covers an estimated 48,600 square feet (ft^2).

Any soils found to be nonhazardous prior to treatment, based on toxicity characteristic leaching procedure (TCLP) and/or other analytical results of chemicals of concern (COC), will be disposed of off site at a nonhazardous waste landfill. Soils within the remediation area at a depth of 0 to 2 feet have elevated lead, nitroaromatics, PCB, and/or TCDD TEQ concentrations. The soil with elevated lead concentrations will require stabilization. The lead-stabilized soil is not suitable for on-site backfill. Therefore, it is assumed that soil excavated from the top 2 feet within the entire remedial area will require off-site disposal after alkaline hydrolysis treatment and/or lead stabilization. Soils excavated from within the Burn Area at a depth of 2 to 8 feet do not appear to have elevated lead, PCB, or TCDD TEQ concentrations and may be appropriate for on-site placement after alkaline hydrolysis treatment for nitroaromatics.

The Selected Remedy is estimated to cost $2.8M and to take approximately 31 months to implement. The expectation is that the Selected Remedy will reduce the concentrations of 2,4-DNT and the mobility of lead so that the soil may be disposed of as nonhazardous. For soil that does not exceed the RGs for any COCs except nitroaromatics, it is expected that the alkaline hydrolysis treatment will result in the soil attaining the RGs for on-site disposal.

1.5 Statutory Determinations

The Selected Remedy is protective of human health and the environment, complies with federal and State of Ohio requirements that are either applicable or relevant and appropriate to the remedial action, is cost effective, utilizes permanent solutions and treatment or resource recovery technologies to the maximum extent practicable, and satisfies the requirement for treatment as a principal element of the remedy. No soil contaminants will be left at levels to which direct exposure would be considered unacceptable by the Ohio Environmental Protection Agency (Ohio EPA) for unrestricted use. A 5-year review will not be required.

1.6 Decision Document Data Certification Checklist

The following information is included in the Decision Summary (Chapter 2.0) of this Decision Document.

- COCs and their respective concentrations
- Baseline risk represented by the COCs

- Cleanup levels established for COCs and the basis for these levels
- How source materials constituting principal threats are addressed
- Current and reasonable anticipated future land use assumptions used in the baseline risk assessment and Decision Document
- Potential land use that will be available at the site as a result of the Selected Remedy
- Estimated capital, annual operation and maintenance, and total present worth costs, discount rate, and the number of years over which the remedy cost estimates are projected
- Key factors that led to selecting the remedy.

Additional information can be found in the AR file for this site.

1.7 State Concurrence

The State of Ohio has been involved with the decision-making process in remedy selection for R2BG as part of the remedial investigation (RI)/feasibility study (FS) process. This involvement includes, but is not limited to, document review comments, quarterly Project Delivery Team meetings, quarterly Restoration Advisory Board (RAB) meetings, and teleconferences as needed. Representatives of the State of Ohio attended the August 14, 2012, Public Meeting at which the Preferred Alternative for R2BG was presented. The State of Ohio made no objection to the Selected Remedy during the meeting and provided no comments during the public comment period that extended from August 14, 2012 through September 18, 2012. The preferred remedy identified in the Proposed Plan has been identified as the Selected Remedy, without revision, in this Decision Document.

The State of Ohio is expected to formally indicate concurrence with the Selected Remedy for R2BG in a letter that will be issued after the Decision Document for R2BG is signed by the DoD. The concurrence letter will be appended to the Decision Document in the AR.

1.8 Authorizing Signature

This Decision Document presents the selected response action for contaminated soils at the Reservoir No. 2 Burning Ground, Plum Brook Ordnance Works, Sandusky, Ohio. The U.S. Army Corps of Engineers is the lead agency under the Defense Environmental Restoration Program at the Plum Brook Ordnance Works Formerly Used Defense Site and has developed this Decision Document consistent with the Comprehensive Environmental Response, Compensation, and Liability Act, as amended, and the National Oil and Hazardous Substances Pollution Contingency Plan. This Decision Document will be incorporated into the larger Administrative Record file for Plum Brook Ordnance Works, which is available for public view at Firelands Library, Bowling Green State University Firelands Campus, Huron, Ohio. This document, presenting a Selected Remedy with a present worth cost estimate of $2,800,000, is approved by the undersigned, pursuant to Memorandum, DAIM-ZA, September 9, 2003, subject: Policies for Staffing and Approving Decision Documents (DD), and to Engineer Regulation 200-3-1, Formerly Used Defense Sites (FUDS) Program Policy.

____________________________________ ______________

Luke T. Leonard Date
Colonel, Corps of Engineers
Commanding

2.0 Decision Summary

2.1 Site Name, Location, and Description

This Decision Document describes the determination that remedial action is required for R2BG soil at PBOW. The Decision Summary provides an overview of information presented in greater detail in the Site Characterization Report (Jacobs Engineering Group, Inc. [Jacobs], 2006), Baseline Human Health Risk Assessment (BHHRA) (Jacobs, 2010a), Screening Level Ecological Risk Assessment (SLERA) (Jacobs, 2010b), FS (Shaw Environmental, Inc. [Shaw], 2011), and other documents on file as part of the AR for R2BG. A summary of pertinent documents which are part of the AR for R2BG is provided in the text box on the following page.

R2BG comprises 1 of 18 DoD projects at PBOW; the other 17 DoD projects are identified in Section 2.4. The preferred remedial alternative, as described in the Proposed Plan (USACE, 2012), was presented to the public on August 14, 2012 during a public meeting at the Bowling Green State University Firelands Campus Library in Huron, Ohio. The remedial decision is recorded in this Decision Document in consultation with the Ohio EPA and the community. The goal for this remedial action is to enable the R2BG property to meet unrestricted land use criteria.

This Decision Document is being issued by the USACE in partnership with the State of Ohio and is consistent with EPA (1999a) guidance. As the lead agency for DoD environmental response actions at PBOW, the USACE is responsible for planning and implementing remedial action at the site. The partner support agencies include the Ohio EPA and the National Aeronautics and Space Administration (NASA). The Ohio EPA provides regulatory review, comment, and oversight. The environmental restoration of PBOW is being pursued by the USACE under the LRD DERP-FUDS program. The USACE Louisville District is the project and program management office for all FUDS property in the USACE Great Lakes and Ohio River Division. The USACE Huntington District provides overall project management of FUDS activities at PBOW for the Louisville District as well as acting as the contracting and oversight office for remedial actions. The USACE Nashville District provides design support services for environmental investigations at PBOW and provides technical review.

The FUDS program was established under DERP to clean up properties that were under the jurisdiction of the Secretary of Defense and owned by, leased to, or otherwise possessed by the United States at the time of actions leading to contamination or safety hazards caused by DoD. The Army is the executive agent for the FUDS program, and the USACE executes the program. The cleanup mission for the FUDS program is to perform appropriate, cost-effective cleanup of contamination caused by DoD and to protect human health, public safety, and the environment (U.S. Army Environmental Command, 2004).

Primary Background Documents for R2BG

IT Corporation, 1997, ***Site Investigations of the Reservoir No. 2 Burning Ground, Additional Burning Ground, Waste Disposal Plant No. 2, and Power House No. 2 Ash Pit***, Former Plum Brook Ordnance Works, Sandusky, Ohio, December.

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

Shaw Environmental and Infrastructure, Inc. (Shaw), 2011, ***Feasibility Study, Reservoir No. 2 Burning Ground***, Final, Former Plum Brook Ordnance Works, October.

U.S. Army Corps of Engineers, 2012, ***Proposed Plan for Reservoir No. 2 Burning Ground***, Former Plum Brook Ordnance Works, Sandusky, Ohio.

(These documents may be viewed on line at the USACE Huntington District website: http://www.lrh.usace.army.mil/projects/current/derp-fuds/pbow/documents.)

2.1.1 Site Location

PBOW is located approximately 4 miles south of Sandusky, Ohio, 7 miles southwest of Huron, Ohio, and 59 miles west of Cleveland (Figure 2-1). Although located primarily in Perkins and Oxford Townships, the eastern edge of the site extends into Huron and Milan Townships. PBOW is bounded on the north by Bogart Road, on the south by Mason Road, on the west by Patten Tract Road, and on the east by U.S. Highway 250. The area surrounding PBOW is mostly agricultural and residential (USACE, 2012). The former PBOW facility property is currently used by NASA as the Glenn Research Center, Plum Brook Station and is the home of the center's four world-class test facilities. None of these test facilities are located on R2BG, and NASA has not conducted any known activities in the vicinity of R2BG that have contributed to the environmental contamination resulting from the former DoD actions on the property. Further, there are no records or specific indications that NASA used the R2BG property for any beneficial purposes (USACE, 2008).

2.1.2 Site Description

R2BG is located in the northwestern portion of PBOW, approximately 400 feet south of Reservoir No. 2 between Ransom Road and Campbell Road (Figures 2-2 and 2-3). The site was used during demolition activities as a burning ground, and it may have been used during production for burning process wastes (Jacobs, 2006). No buildings or other man-made features are currently present or are known to have existed at R2BG. The site comprises approximately 4 acres. The former Burn Area portion of R2BG, identified by a layer of burned material, is approximately 17,000 square feet, or 0.4 acre. Although its depth and thickness vary slightly, the burn layer is typically about 1 foot thick and approximately 1 foot below the surface.

Vegetation at R2BG is currently composed of open old field and shrub thickets in the northeastern part of the site along the R2BG access road, with forested areas to the west and south. There is no aquatic habitat at R2BG, although drainage ditches that serve as wet-weather conveyances are present. The main R2BG drainage ditch runs east to west and forms the north edge of the site. A less pronounced south-to-north drainage ditch runs along the eastern side of the service road and discharges into the main ditch.

Nitroaromatic compounds (i.e., explosives), PCBs, PCDD/Fs, and lead are the COCs in impacted R2BG soil that are associated with past DoD activities. The presence of these contaminants in R2BG soil has resulted from production wastes and contaminated materials that were formerly brought to R2BG for burning as a former means of disposal. Groundwater at R2BG includes both shallow overburden/shale and the Delaware Limestone bedrock aquifers. Both of these units have very low water yields within R2BG. None of the organic COCs were detected in R2BG groundwater. Although lead marginally exceeded its screening level in one bedrock groundwater sample, it is likely that this exceedance resulted from the elevated concentrations of suspended solids, which are evidenced by the high turbidity of the samples, and is not resultant from site-related contamination (see Section 2.5.3.1).

2.2 Site History and Statutory Authority

2.2.1 Site History

The former Plum Brook Ordnance Works (PBOW) was established by the War Department as a government-owned, contractor-operated (GOCO) facility for the production of 2,4,6-trinitrotoluene (TNT), 2,4-DNT, and pentolite during World War II. The PBOW site originally consisted of approximately 9,100 acres, approximately 3,500 acres of which was used as a buffer area outside the facility fence line. The property was acquired in the name of the United States of America in 1941. The government contractor, Trojan Powder Company, operated the production facility from December 1941 until 1945. It is estimated that during this period more than 1 billion pounds of nitroaromatic explosives were manufactured.

At the end of production in September 1945, PBOW was placed in standby operation status and the Army conducted decontamination and decommissioning activities. On December 17, 1945 the U.S. Army Ordnance Department (Ordnance Department) obtained physical control of the site. The Ordnance Department continued decontamination efforts until August 1946. In 1946 over 6,200 acres, 3,231 being located within the fenced area, were transferred to the War Assets Administration (WAA), and approximately 2,800 acres were transferred to the Ravenna Arsenal. This 2,800-acre parcel, transferred to Ravenna Arsenal and referred to as the Magazine Area (and also the Plum Brook Depot), was transferred again in July 1947 to the Erie Ordnance Depot, LeCarne, Ohio (War Department, 1947). The Magazine Area included approximately 2,300 acres inside the fence line and 500 acres of the buffer area, outside of the fence line.

In 1949, the GSA took control of WAA's portion of the PBOW property, which included an indeterminate amount of acreage outside of the fence line due to conveyances by WAA to private landowners during the late 1940s and early 1950s. It is believed that farmers were given the opportunity to buy back land in the buffer area, outside the fence line.

In June 1954, the Army reacquired the 3,231 acres within the PBOW fence line that was previously transferred to the WAA and subsequently to GSA. From August 1954 to sometime in 1958, further decontamination was performed by the Army. The decontamination included removal of and disposal of contaminated surface and subsurface soil around the buildings and wooden and ceramic waste disposal lines containing TNT. This included thousands of pounds of TNT which were discovered in catch basins that were removed and incinerated at the burning grounds.

Two property use agreements were entered into by the Army and the National Advisory Committee of Aeronautics (NACA), the predecessor of NASA, in March 1956 and January 1958, respectively. The first agreement was for approximately 500 acres on which NACA built a nuclear reactor. The second agreement gave NACA (NASA as of October 1958) use of an additional 2,700 acres within the fenced area but outside the Magazine Area, for a total of 3,231 acres under the two use agreements. At this time, NASA had use of all property inside the PBOW fence except the 2,300 acres in the Magazine Area. The Army declared this 3,231-acre property as excess in October 1958.

In September 1961, the Army declared the Magazine Area as excess, and NASA formally requested custody of the property in October 1961 (NASA, 1961). On March 15, 1963, accountability and custody of the PBOW property (6,031 acres) were transferred from the Department of the Army to NASA.

However, prior to NASA's acceptance of the property in March 1963, Ravenna Arsenal performed additional decontamination and subsequently certified 500 acres of the former PBOW property was decontaminated and suitable for unrestricted future use. This decontamination certification was only for the 500 acres in the former pentolite manufacturing area (area where NASA built the nuclear reactor) under the first use agreement. NASA identified additional DoD-related contamination in 1963, after transfer of the property. NASA performed further decontamination efforts and the removal of structures in 1964.

NASA has operated and maintained the property inside the fence line since 1963, and the facility currently located there is the NASA Glenn Research Center, Plum Brook Station. NASA operates the property as a space research facility in support of its John Glenn Research Center at Lewis Field, Cleveland, Ohio. Most of the aerospace testing facilities built in the 1960s at the site have been demolished, or are currently on standby or inactive status. During 1967 through 1971, NASA purchased approximately 2,000 acres outside of the fence line from local farmers as "buffer." On April 18, 1978, NASA declared approximately 2,152 acres of PBOW as excess. This excess included approximately 1,500 acres of farmland outside the fence, including those acres purchased from farmers beginning in 1967, and was sold as farmland (NASA, 2013). Also, 46 acres outside of the fence in the northeast corner of the PBOW facility near the guard house was conveyed to the Perkins Township Board of Education and is used as a bus transportation area. In addition, the 2,152 acres of PBOW declared excess included a 604-acre parcel in the western part of the fenced area known as "Parcel 59." This area, although previously declared excess, was not transferred and remains under NASA control. According to a NASA newsletter, NASA presently controls approximately 6,432 acres (NASA, 2013); this includes approximately 5,500 acres within the fence line and 900 acres outside of the fence which have been leased for agriculture (NASA, 2012).

The former PBOW FUDS property includes the entire 9,100 acres, but the only project areas that have been approved (or proposed) for the property are located within the fenced area (currently controlled by NASA). The fence generally runs along the patrol road. The area outside the fence was used as a buffer zone during the PBOW manufacturing period, and there is no known or suspected DoD-related contamination outside the fence line.

The R2BG site is within the former PBOW and current NASA fence line. It is not known when the R2BG site was first used for burning; however, a 1950 aerial photograph clearly shows the site to be in existence, and there is documentation of burning related to PBOW demolition at the R2BG up to 1962 (Jacobs, 2006). Site restoration was performed in 1963, when the area was cleared of debris and the ground restored to proper grade. At some point after 1963, the R2BG site was used temporarily as a baseball field by NASA.

2.2.2 Statutory Authority

The PBOW property was acquired by DoD in 1941 for the U.S. Army Plum Brook Ordnance Works and operated under their direction until late 1945; therefore, the PBOW is administered as a FUDS site, and any contamination on the property that is a result of these activities is the responsibility of the Army under the DERP-FUDS program, as described in Section 2.1.

Under CERCLA, the President delegated authority to DoD (Secretary of Defense) for cleanup of active and formerly used defense sites. In addition, SARA (Section 211) required the Secretary of Defense to carry out the DERP, which in turn delegated these authorities to the USACE, thereby granting the USACE the authority to conduct removal/remediation projects such as R2BG.

The Defense and State Memorandum of Agreement (DSMOA) program was developed to involve states and territories in the cleanup of DoD installation through the DERP. The Ohio EPA is currently working under this agreement to provide the necessary technical services required for remediation of the PBOW R2BG. The Ohio EPA is funded via the DSMOA for its review and participation at PBOW and has entered into a 2-year cooperative agreement which can be revised or extended as needed, subject to changes in the DSMOA project.

2.3 Community Participation

Community relations activities are required under the NCP, CERCLA, and FUDS. The objective of this program is to provide a mechanism for the communication and exchange of information among Army agencies, government agencies, and residents of local communities and those adjacent to and downgradient from PBOW. In January 1997, a RAB, composed of approximately 20 local citizens with varying backgrounds, was established to promote a two-way dialog to not only keep local citizens informed about site progress but also facilitate the opportunity for them to provide input to site decisions. Since its inception, the RAB has been the basis for community involvement.

In compliance with CERCLA (Section 113), the USACE has developed the AR to provide documentation as to how and why decisions specific to the remediation of the site are made. To date, the investigations and assessments completed for R2BG are as follows: Site Characterization Report (Jacobs, 2006), BHHRA (Jacobs, 2010a), SLERA (Jacobs, 2010b), and FS (Shaw, 2011). The AR contains these final documents as well as all others for the PBOW site.

Currently, the final reports are located in the AR, maintained at the USACE Huntington District Office, 502 Eighth Street, Huntington, West Virginia, 25701. An electronic copy of the AR is also maintained locally in the public repository at the Firelands Library, Bowling Green State University Firelands Campus, Huron, Ohio. Free public computer access is available.

A community relations plan (ICI, 1999) was prepared that outlines the procedures through which the community is involved with the restoration of PBOW. In addition to providing access to the AR file, these procedures involve the following which are performed or initiated by the USACE Huntington District:

- AR file maintenance
- Quarterly fact sheets and policy letters
- Bulletin boards for the RAB to post pertinent information within the community
- Project-specific exhibits for community functions
- Direct two-way communication with RAB members
- News releases
- Annual PBOW newsletter
- Exhibits at public activities.

The PBOW RAB received a Technical Assistance for Public Participation (TAPP) grant from DoD on March 29, 2005. TAPP grants have a maximum of $25,000 per year and a lifetime ceiling of $100,000. The purpose of the TAPP grant is to provide a mechanism for the RAB to obtain professional technical assistance to help its members understand the restoration program. Also, the RAB holds quarterly meetings that are co-chaired by a representative of the community and the USACE point of contact. Through this communication process, the community has had active involvement in the selection of the remedy for R2BG.

A preferred remedial alternative was presented in the Proposed Plan (USACE, 2012). Notice of the Proposed Plan for R2BG appeared in the August 3, 2012 *Sandusky Register*, and the Proposed Plan was presented to the RAB and other interested members of the community at a public meeting at Firelands Library on August 14, 2012. RAB members and other members of the public who requested to be on the mailing list also received their choice of either email or standard mail notification of the public meeting. At this public meeting for the Proposed Plan, representatives of the USACE and the Ohio EPA were present to answer questions, address concerns, and receive additional community input. The public comment period for the Proposed Plan extended from August 14 through September 18, 2012. The remedial decision is recorded in this Decision Document in consultation with the Ohio EPA and the community. The R2BG documents were made available to the public in the AR file maintained at the Firelands Library, Bowling Green State University, Huron, Ohio, and at the following website address:

www.lrh.usace.army.mil/projects/current/derp-fuds/pbow/documents.

A record of community comments and concerns, as well as how the USACE addressed any comments and concerns, is provided in the Responsiveness Summary (Chapter 3.0).

2.4 Scope and Role of R2BG

One of DoD's specific goals from the Defense Planning Guidance for the DERP is to reduce risk to human health and the environment through implementation of effective, legally compliant, and cost-effective response actions. To that end, the environmental investigation of PBOW has been divided into 18 areas of concern, also referred to as DERP-FUDS projects, to address the potential concerns presented by each area associated with former DoD activities. Separate closeout documents are required for each of the 18 DERP-FUDS projects. This current Proposed Plan specifically addresses R2BG only.

Currently, soil cleanup actions that have led to site closeout, or that are expected to lead to site closeout once completed, have been or are being implemented by the USACE under three other PBOW DERP-FUDS projects. Soil actions at two additional DERP-FUDS projects have been proposed; once implemented and completed, these two are likewise expected to lead to site closure. Three other DERP-FUDS project sites have been closed out under no (further) action with State concurrence. Also, a decision for no further action concerning groundwater underlying the TNT and Red Water Pond Areas is currently being drafted; it is anticipated that this will lead to site closeout for that DERP-FUDS project. Other DERP-FUDS projects are at various stages of the CERCLA process. Once a DERP-FUDS site is closed out, NASA and the GSA may decide to make that site property available to public or private interests. This Proposed Plan addresses only on the Reservoir No. 2 Burning Grounds, as presented below.

Reservoir No. 2 Burning Grounds. The RI began in 2004, and the site characterization report was issued in January 2006. Human health and ecological risk assessments were completed in February 2010. Further delineation sampling was performed in October 2010, and a draft FS was submitted in July 2011. The final FS was completed in October 2011. A proposed plan was finalized in August 2012. This Decision Document is the next step in the site closure process.

2.5 Site Characteristics

2.5.1 Site Overview

R2BG is located in the northwestern portion of PBOW, approximately 400 feet south of Reservoir No. 2 between Ransom Road and Campbell Road (Figures 2-2 and 2-3). The site was used during demolition activities as a burning ground, and it may have been used during production for burning process wastes (Jacobs, 2006). No buildings or other man-made features are currently present or are known to have existed at R2BG. The site comprises approximately 4 acres. The former Burn Area portion of R2BG, identified by a layer of burned material, is approximately 17,000 square feet, or 0.4 acre. Although its depth and thickness vary slightly, the burn layer is typically about 1 foot thick and approximately 1 foot below the surface.

Vegetation at R2BG is currently composed of open old field and shrub thickets in the northeastern part of the site along the R2BG access road. The Burn Area is within this old field and shrub area. The remainder of R2BG to the west and south is forest. Soil at R2BG consists of clay or silty clay with a fairly continuous layer of silt and clayey silt near the surface. The clay content of this silt layer varies with location and with depth and is generally marked by gradational changes downward from silt to clay.

No aquatic habitat is present in the vicinity of R2BG, although drainage ditches are present. A main drainage ditch runs east to west and forms the north edge of the site. This drainage ditch is located 200 to 300 feet north of the Burn Area and drains to the west across the site, then northwest to Pipe Creek. 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. These ditches are wet-weather conveyances and contain water only during substantial precipitation events.

Groundwater at R2BG includes both shallow overburden/shale and the Delaware Limestone bedrock aquifers. The presence of overburden/shale groundwater is highly seasonally dependent. Groundwater flow direction in the overburden/shale is from the southwest to the north, northeast, and east. Bedrock groundwater flows from the site in a southeastern direction. The bedrock aquifer at R2BG has very low potential for contaminant transport, based on the low porosity observed from the rock cores and the extremely low permeability observed during monitoring well development and groundwater sampling. It is noted that because of an extremely low rate of groundwater recharge, full well development could not be performed at any of the Delaware Limestone wells (see Section 2.5.3).

As described in Section 2.2.1, nitroaromatic explosives were manufactured at PBOW from 1941 through 1945 as part of the World War II effort. R2BG soils were contaminated as a result of the disposal and burning of nitroaromatic compounds and other materials during demolition of PBOW. Figure 2-4 depicts a simplified conceptual site model for contamination at R2BG. Note that more detailed exposure models for human and ecological receptors are presented in Sections 2.7.1 and 2.7.2.

2.5.2 Investigation Overview

A preliminary site assessment in 1991 identified the existence of the Burn Area near Reservoir No. 2. A site investigation conducted in 1996 included a geophysical survey and sampling of surface and subsurface soil from borings and trench excavations (IT Corporation [IT], 1997). Based on the result of the 1996 site investigation, RI activities were conducted at R2BG in 2004 and 2005. These activities included additional trenching and sampling of soil, groundwater and sediment. The sediment samples were collected from adjacent drainage ditches in which no surface water was present. Subsequent delineation soil samples were collected in 2010 in support of the FS.

2.5.2.1 Soil Sampling

During the site investigation, 16 subsurface soil samples and 8 surface soil samples were collected from eight soil borings. During the RI, a total of 65 surface and subsurface soil samples were collected. The RI samples collected in 2004 and 2005 included 24 surface soil samples and 26 subsurface samples from borings. The RI also included trenching activities to locate the extent of the Burn Area through visual observation of a burn layer and laboratory analysis of samples. This area was found to be characterized by a layer that is, on average, approximately 1 foot below the surface and 1 foot thick. In addition to the soil boring samples, 15 RI subsurface soil samples were collected from the trenches; 10 were collected from within the burn layer, 3 were collected below the burn layer, and 2 subsurface soil trench samples were collected outside the Burn Area. These samples were analyzed for nitroaromatics, PCBs, semivolatiles, and volatile organic compounds (VOC), and some were analyzed for PCDD/Fs.

In the fall of 2010, additional surface soil sampling was performed in support of the FS to delineate contamination outside the Burn Area. The results of these delineation samples (Shaw, 2011) were used to fill in data gaps identified based on the results of the 2006 RI (Jacobs, 2006). These include a total of 26 samples (including duplicates) from 22 previously sampled site investigation and RI locations that were collected and analyzed again in 2010 for PCDD/Fs only, as well as 16 samples (including duplicates) from 12 new locations that were analyzed for a full suite of chemicals, including PCDD/Fs, nitroaromatics, PCBs, and semivolatiles.

All soil sampling locations are shown on Figure 2-5. The resulting COCs for R2BG soil are presented in Section 2.5.3.

2.5.2.2 Sediment Sampling

Sediment samples were collected in 2004 from three locations within the drainage ditches north of the site (Figure 2-5). Sediment samples were analyzed for PCDD/Fs, nitroaromatics, PCBs, semivolatiles, and VOCs. No surface water was present in these ditches, which serve as wet-weather conveyances, during the RI sampling event; therefore, no surface water samples could be collected.

2.5.2.3 Groundwater Sampling

Three bedrock wells were installed in 2004 (Figure 2-5), and groundwater samples were collected to evaluate any impacts from the burning ground activity. Groundwater samples were analyzed for nitroaromatics, semivolatiles, VOCs, and general chemistry parameters. Due to slow recharge and limited water volume, the wells could not be developed or purged, and groundwater had to be sampled via bailer. Only one round of groundwater samples was collected because of limited water yield. These samples were highly turbid (101 to 1,910 nepholometric units). No monitoring wells were installed in the overburden because of a lack of sufficient permeable material.

2.5.3 Contamination Characterization

The following seven COCs were identified for R2BG soil:

- Nitroaromatics: 2,4-DNT, 2,6-DNT, and TNT
- PCB mixtures: Aroclor 1254 and Aroclor 1260
- TCDD TEQ
- Metals: Lead.

Table 2-1 provides a data summary of the COCs in soil, including frequency of detection and concentration ranges. No COCs were identified for sediment or groundwater.

Note that PCBs were historically used as specific commercial mixtures of the 209 individual PCB congeners. Although there were numerous PCB manufacturers which produced various families of PCB mixtures (e.g., Aroclors, Kanechlors, Clophens), the vast majority of PCBs used in the United States are the Aroclor mixtures. For this reason, EPA laboratory methods require the reporting of PCB mixture concentrations as Aroclor concentrations, using Aroclor standards.

2.5.3.1 Spatial Distribution and Potential Sources

The soil at the R2BG was evaluated separately for soil inside and outside the Burn Area. The maximum detected concentrations of the COCs for soil samples collected within the Burn Area (surface and subsurface soil) and those collected from outside the Burn Area (surface soil only) are presented below. COCs are defined as any site-related chemical that contributes significantly to an exposure pathway with an unacceptable risk or hazard. Site-related chemicals are those which are resultant from former DoD-related activities at PBOW. Note that PCDD/Fs are quantitatively evaluated in terms of TCDD TEQ. The maximum detected concentration of each COC is presented in the list below, and the locations of these concentrations are provided in parentheses. The areas to be remediated are shown on Figure 2-6.

Inside the Burn Area (surface and subsurface soil; subsurface includes the burn layer):

- TCDD TEQ – 128 nanograms per kilogram (ng/kg) in surface soil (BH17); 1,186 ng/kg in subsurface soil (TR10-2)

- TNT – 3,120 mg/kg in surface soil (BH18); 35,400 mg/kg in subsurface soil (TR08-1)

- 2,4-DNT – 35 mg/kg in surface soil (2BGSO02); 9,700 mg/kg in subsurface soil (TR08-1)

- 2,6-DNT – 0.98 mg/kg in surface soil (BH17); 1,400 mg/kg in subsurface soil (TR09-1)

- Aroclor 1254 – not detected in surface soil; 3.67 mg/kg in subsurface soil (TR08-1)

- Aroclor 1260 – 11.6 mg/kg in surface soil (BH17); 4.01 mg/kg in subsurface soil (TR08-1)

- Lead – 778 mg/kg in surface soil (2BGSO02); 8,220 mg/kg in subsurface soil (TR05-1D).

Outside the Burn Area (surface soil only):

- TCDD TEQ – 956 ng/kg (BH51)
- TNT – 2,270 mg/kg (BH23)
- 2,4-DNT – 200 mg/kg (BH42)
- 2,6-DNT – 78 mg/kg (BH42)
- Aroclor 1254 – 0.149 mg/kg (BH55)
- Aroclor 1260 – 44.4 mg/kg (BH23)
- Lead – 603 mg/kg (2BGSO-08).

The highest concentrations of COCs are found in the Burn Area subsurface burn layer soils. Contamination outside the Burn Area appears to be limited to within approximately 1 foot of the surface.

TCDD TEQ was detected in sediment at a maximum concentration (6.9 ng/kg) that only marginally exceeded the screening level (4.5 ng/kg) and is less than the RG (18 ng/kg; see Section 2.8). Lead was detected in sediment at a maximum concentration less than the screening level and consistent with background soil concentrations. No other soil COCs were detected in the sediment samples.

None of the organic COCs identified for soil were detected in the bedrock groundwater samples. Although the inorganic soil COC lead was detected in groundwater at a maximum concentration (17.9 micrograms per liter [μg/L]) that is marginally above the screening level (15 μg/L), the groundwater analytical data were regarded to be of poor quality and thus unsuitable for risk assessment because the wells had very low yield, could not be properly developed or purged, had to be sampled via bailer, and as a result were extremely turbid (Jacobs, 2006). It is likely that this marginal exceedance of the lead screening level resulted from the elevated concentrations of suspended solids, which are evidenced by the high turbidity of the samples, and is not resultant from site-related contamination.

2.5.3.2 Toxicity and Mobility of the Chemicals of Concern

The toxic characteristics of the nine COCs are presented in Section 2.7.1.3. In summary, each of the COCs is regarded as a carcinogen, and each of these except Aroclor 1260 have known adverse noncancer effects and recognized noncancer toxicological values that are used in risk assessment, as presented in Section 2.7.1.3.

Because the concentrations of the COCs generally dissipate notably with depth, it does not appear that these chemicals have been very mobile in soil. Note that the R2BG soil contamination does not appear to have affected sediment or groundwater. Therefore, the organic COCs appear to be bound to soil particles, and the lead is either bound to soil particles or otherwise in a relatively insoluble form.

2.5.3.3 Quantity of Waste

The total volume of contaminated soil requiring remediation is estimated at 7,395 cy. The FS estimated that 100 percent of this soil will be classified as Resource Conservation and Recovery Act (RCRA) hazardous waste based on toxicity characteristic. This volume of hazardous waste is based on anticipated 2,4-DNT and lead TCLP testing results. It is anticipated that none of the soil will be TSCA-regulated material because the maximum detected concentration for combined PCBs (44.4 mg/kg) is less than the 50 mg/kg criterion for PCB remediation waste [40 Code of Federal Regulations (CFR) 761.61(a)(5)(i)(B)(2)(iii)].

2.5.3.4 Potential Human and Ecological Receptors at Risk

Human health and ecological risks are summarized in Sections 2.7.1 and 2.7.2, respectively. No current human receptors appear to be at risk. Estimated noncancer hazards in the BHHRA for the future resident and various workers, which would serve as appropriately conservative surrogates for future land use, exceeded the threshold goal. The recommendation for remediation is based on potential future human health risks.

Terrestrial ecological receptors were found to be potentially at risk in the SLERA (Jacobs, 2010b). However, the FS estimated that risks to ecological receptors would be substantially reduced by remediating soil to the human health RG levels (see Section 2.8.1). Therefore, given the uncertainties and other considerations expressed in the SLERA (see Section 2.7.3), the FS recommended no additional action specifically for the protection of ecological receptors.

2.6 Current and Potential Future Land Uses

The PBOW facility is currently surrounded by a chain-link fence, and the perimeter is patrolled regularly. Access by authorized personnel is limited to established checkpoints. Public access is restricted except during the controlled annual deer hunting season. R2BG may be hunted during these times. There are currently no regular uses of R2BG.

Two deep bedrock groundwater aquifer systems are utilized for drinking water in the region: a carbonate aquifer to the west and a shale aquifer to the east (IT, 1997). PBOW is located within the transition of the two systems. Groundwater underlying PBOW is not currently used for any purpose. A majority of residents in Erie County receive water from public utilities whose sources are surface water.

At some point in the future, it is possible that NASA may desire to either use or excess the R2BG property. If a decision were made to excess, the GSA would be contacted to facilitate transfer of the property through its process. R2BG could potentially be developed in the future, either for commercial/industrial or residential purposes, as there are no land use controls or restrictions on this property. The remedial alternatives in this Decision Document were developed assuming residential/unrestricted future land use. This assumption is appropriate because the area surrounding the former PBOW facility is rural and residential and if/when the property is excessed, the land will likely become residential. Property that was formerly owned by the Army during PBOW operations as part of a buffer area has been developed for residential purposes.

Other potential future uses for the site include training for National Guard, or the property may be used for wildlife management. It is noted that a portion of the property adjacent to PBOW that was previously excessed by NASA (see Section 2.2.1) is used by the National Guard for training. As discussed in Section 2.5.1, the groundwater underlying the TNT and RWP areas is of poor natural quality. This finding is borne out by the observation that none of the residents within 1 mile downgradient of PBOW use the water as a potable source. Given the low groundwater quality, including the hydrogen sulfide off-gassing (that produces offensive odors that may represent a health hazard and damage pump, well casing, and plumbing components) and the availability of municipal water within the vicinity, it is unlikely that any individual will use groundwater underlying the TNT and RWP Areas.

2.7 Summary of Site Risks

Potential risks to human health and the environment were evaluated for R2BG. The purposes of this section are as follows:

- Provide a brief summary of the relevant portions of the BHHRA (Section 2.7. 1).
- Provide a brief summary of the SLERA (Section 2.7.2).
- Provide a discussion of the human health and ecological risk results (Section 2.7.3).
- State the basis for taking action at the site (Section 2.7.4).

2.7.1 Summary of Human Health Risks

The BHHRA for R2BG soil, sediment, and groundwater was completed in 2010 (Jacobs, 2010a). The identification of COCs, exposure assessment, toxicity assessment, and risk characterization are described below. Only validated analytical data were used in the BHHRA.

2.7.1.1 Identification of Chemicals of Concern

COCs were identified for R2BG soil as those chemicals that contributed most to an additional cancer risk exceeding 1×10^{-5} or an additional noncancer hazard index (HI) exceeding 1. The following chemicals were identified as COCs for soil and are discussed in Section 2.5.3: TNT, 2,4-DNT, 2,6-DNT, TCDD TEQ, Aroclor 1254, Aroclor 1260, and lead.

2.7.1.2 Exposure Assessment

Exposure assessment presents the exposure pathways evaluated, the populations potentially exposed to the chemicals of potential concern (COPC), the data and assumptions used to characterize exposure point concentrations (EPC), and assumptions about exposure frequency and duration included in the exposure assessment. The mathematical output of the exposure assessment is the chronic daily intake (CDI), which represents the level of exposure to a chemical that an individual would receive under a given set of exposure assumptions. Exposure associated with the COPCs was evaluated using the following human receptors as surrogates to represent all plausibly exposed groups of people at R2BG under current land use and future land use. The exposure pathways for all environmental media and human receptors evaluated are depicted on Figure 2-7. Each of the receptors and the pathways evaluated are briefly described below. Please note that for soil pathways, separate evaluations were performed for exposure to soil outside the Burn Area and exposure to soil inside the Burn Area.

Groundskeeper. The groundskeeper represents a long-term, on-site outdoor worker exposed to surface soil. Potential soil exposure pathways evaluated were incidental ingestion and dermal contact with surface soil and inhalation of dust.

Indoor Worker. The indoor worker represents a long-term, on-site worker exposed to lower levels of surface soil than an outdoor worker, and also to groundwater. The only soil pathway quantified for this receptor is incidental ingestion. Groundwater exposure was quantified for the ingestion and dermal pathways. The soil gas-to-indoor air pathway was not quantified for this receptor because no volatile COPCs were identified for subsurface soil.

Construction Worker. The construction worker represents a shorter-term worker potentially exposed to surface soil, subsurface soil, and sediment. The following pathways were evaluated for the construction worker: incidental ingestion and dermal contact with soil, inhalation of dust, incidental ingestion of sediment, and dermal contact with sediment.

Hunter/Venison Consumer. A current hunter was assumed to be exposed to surface soil (via incidental ingestion and dermal contact) and ingestion of venison from deer that fed on plants growing on R2BG surface soil. Also, a young child (ages 1 through 6) venison consumer was assumed to be exposed via the ingestion of venison taken from R2BG. Cancer risk and noncancer hazard estimates were performed separately for the adult and child.

Future On-Site Resident. A future on-site resident was assumed to be exposed to surface soil, subsurface soil, sediment, and groundwater. The following pathways were evaluated for the on-site resident: incidental ingestion and dermal contact with soil, inhalation of dust, incidental ingestion and dermal contact with sediment, and ingestion and dermal contact with groundwater. The on-site residential scenario was evaluated using both an adult and a young child (ages 1 through 6 years). Cancer risk was estimated as the sum of the risks calculated for the adult and the child. The soil gas-to-indoor air pathway was not quantified for this receptor because no volatile COPCs were identified for subsurface soil.

Exposure Point Concentrations. The EPCs are based on reasonable maximum exposure assumptions (EPA, 1989); either the 95 percent upper confidence limit of the mean or the maximum detected concentration, whichever is less, was used (Jacobs, 2010a). The EPC values for the COCs are included in Table 2-1.

2.7.1.3 Toxicity Assessment

The toxicity assessment provides information regarding the type and severity of adverse health effects that could result from exposure to COPCs and a measure of the dose-response relationship for each chemical. The dose-response relationships for oral, inhalation, and dermal toxicity are expressed quantitatively as noncancer chronic reference doses (RfD) and cancer slope factors (SF). The exception is lead, known to have neurological effects, especially with respect to developing children. Lead exposure and risk are evaluated based on modeled blood-lead concentrations. A residential soil concentration of 400 mg/kg was developed based on the model and used in the BHHRA to identify areas which had unacceptably high soil lead concentrations.

RfDs are chemical-specific values that have been developed by EPA for indicating the potential for adverse noncancer health effects resulting from exposure. RfDs, which are expressed in units of milligrams per kilogram of body weight per day (mg/kg-day), are estimates of lifetime daily exposure levels for humans, including sensitive individuals. SFs are developed by EPA and were used to estimate excess lifetime cancer risks associated with exposure to potentially carcinogenic chemicals. SFs, expressed in cancer incidence per mg/kg-day ($[mg/kg\text{-}day]^{-1}$), were used in the BHHRA to provide an upper-bound estimate of the incremental lifetime cancer risk (ILCR) associated with exposure to contaminants in R2BG media. A weight-of-evidence classification is placed on each SF by the EPA's Carcinogenic Assessment Group, as shown in Table 2-2.

These chemical-specific RfD and SF values were obtained from the EPA Integrated Risk Information System (IRIS) database (EPA, 2012) or from other EPA sources if no values were available from IRIS. Target organ information for noncancer effects and additional toxicity information were likewise obtained from IRIS or other sources if not available on IRIS. Please note that the IRIS data base is continuously updated, and that IRIS information used in the BHHRA (which was finalized in 2010) was current at the time that the BHHRA was drafted. Toxicity values and associated information used in the HHRAs for the COCs are shown in Table 2-2.

2.7.1.4 Risk Characterization

Cancer risk and noncancer hazard values were calculated separately for each receptor and exposure scenario. Cancer risks are generally expressed as the incremental probability of an individual developing cancer over a lifetime as the result of exposure to the carcinogen. The ILCR represents the "excess" risk posed by exposure to the specific carcinogen source in question. The baseline cancer risk for the U.S. population has been estimated at approximately 40 percent. EPA's generally acceptable risk range, as described in the NCP (EPA, 1990) and EPA risk assessment guidance (e.g. 1991a; 1999a), is between 1×10^{-4} (1 in 10,000) and 1×10^{-6} (1 in 1,000,000). This range is hereinafter referred to as the "NCP risk management range." For the sake of illustration, if it were assumed that an individual had exactly a 40 percent chance (400,000 in 1,000,000) of developing cancer without a specific exposure, an additional exposure resulting in an ILCR of 1×10^{-5} (1 in 100,000) would result in an overall cancer risk of 400,010 in 1,000,000. The PBOW Project Delivery Team selected a target ILCR goal of 1×10^{-5}, which is the logarithmic midpoint of this range. This PBOW cancer risk goal has been used as a point of comparison in all PBOW site BHHRAs for more than a decade. The PBOW cancer risk goal is discussed further in Section 2.8.1.

The ILCR is calculated from the following equation:

$$\text{ILCR} = \text{CDI} \times \text{SF} \qquad \text{Eq. 1}$$

where:

ILCR = incremental lifetime cancer risk of an individual developing cancer over a lifetime (unitless)
CDI = chronic daily intake averaged over a 70-year lifetime (mg/kg-day)
SF = slope factor ($[\text{mg/kg-day}]^{-1}$).

The potential for noncancer effects is evaluated by comparing an exposure level over a specified time period (e.g., 30 years) with an RfD appropriate for that time period (i.e., chronic). An RfD is the threshold level at which one could be exposed and not suffer any deleterious effect. The ratio of exposure to the RfD is the hazard quotient (HQ). The HQ values were calculated for PBOW as follows:

$$\text{HQ} = \text{CDI}/\text{RfD} \qquad \text{Eq. 2}$$

where:

HQ = noncancer hazard quotient
CDI = chronic daily intake (mg/kg-day)

RfD = chronic reference dose.

Thus, a CDI less than the RfD results in an HQ of less than 1. The HI is calculated by adding the HQ values of the COCs that affect the same target organ in a given environmental medium (e.g., soil) or across all media to which an individual is assumed to be exposed. An HI of less than or equal to 1 indicates that adverse noncancer effects are unlikely to occur; an HI exceeding 1 indicates that adverse effects may potentially occur.

The following paragraphs summarize the risks associated with the COCs for the various receptors to surface soil and subsurface soil, which were the predominant contributors to the ILCR and HI for the respective receptors. As described below, no COCs were identified for sediment or groundwater. Risk characterization results for the COCs are presented in Tables 2-3 through 2-14 for all receptors with significant cancer risk ($>1 \times 10^{-5}$) or noncancer hazard (HI>1). Overall BHHRA risk characterization results for all the receptors are summarized in Table 2-15.

Inside the Burn Area Surface Soil. The COC-related total ILCR associated with Burn Area surface soil for the combined adult/child resident (3×10^{-4}) exceeded the 1×10^{-6} to 1×10^{-4} NCP risk management range and the PBOW ILCR goal of 1×10^{-5}. Of the other receptors, only the groundskeeper (8×10^{-5}) and indoor worker (4×10^{-5}) had ILCR values that exceed the PBOW ILCR goal. The ILCR values for the remaining receptors evaluated do not exceed the PBOW ILCR goal or the NCP risk management range. The COC-related total HI for the groundskeeper (12), indoor worker (6), construction worker (33), adult resident (15) and child resident (139) all exceed the HI goal of 1.

Inside the Burn Area Subsurface Soil. The COC-related total ILCR associated with Burn Area subsurface soil for the combined adult/child resident (4×10^{-3}) exceeded the 1×10^{-6} to 1×10^{-4} NCP risk management range and the PBOW ILCR goal of 1×10^{-5}. The ILCR of the construction worker (5×10^{-5}) exceeded the PBOW ILCR goal, but was within the NCP risk management range. The COC-related total HI for each receptor exceeds the HI goal of 1. These are the construction worker (154), adult resident (70), and child resident (650).

Outside the Burn Area Surface Soil. None of the COC-related total ILCR values associated with soil outside the Burn Area exceeded the NCP risk management range, but the ILCRs of the resident (1×10^{-4}) and the groundskeeper (3×10^{-5}) exceed the PBOW ILCR goal. The COC-related total HIs for the construction worker (3), adult resident (2) and child resident (14) all exceed the HI goal of 1.

Outside the Burn Area Subsurface Soil. No COCs were detected in subsurface soil above risk-based screening concentrations; therefore, risks are regarded as *de minimis*.

Sediment. No COCs were identified for R2BG sediment, based on low cancer risk and *de minimis* noncancer hazard.

Groundwater. No COCs were identified for R2BG groundwater, because no site-related COPCs were detected.

Uncertainty Analysis. Numerous uncertainties, many of which are difficult to quantify, exist throughout the risk assessment process and may affect the ILCR and HI estimates. Most of the uncertainties described in the R2BG are common to the risk assessment practice and are not specific to the R2BG BHHRA. However, uncertainties were associated with the inadequacy of the R2BG sample set outside of the Burn Area, especially toward the west. This uncertainty was addressed after the BHHRA under the post-delineation sampling effort described in Section 2.5.2.1.

2.7.2 Ecological Risk Summary

A SLERA was performed for R2BG (Jacobs, 2010b). The SLERA is composed of the following main steps: problem formulation, exposure characterization, ecological effects characterization, and risk characterization. The results of the SLERA are summarized below, following the EPA (1999a) Record of Decision guidance format.

2.7.2.1 Identification of COPECs

Chemicals of potential ecological concern (COPEC) were selected based on frequency of detection and a comparison to risk-based screening ecological toxicity values for soil and sediment. COPECs for soil and sediment are presented in Tables 2-16 and 2-17, respectively. COCs were not formally identified based on ecological risks, but COCs identified on the basis of human health risks were also found to be among the major risk drivers for ecological risks. The implications of potential benefit to ecological receptors if soil contaminated by these human health COCs were to be remediated are discussed in Section 2.7.3 and further presented in Section 2.8.1.

2.7.2.2 Ecological Exposure Assessment

The exposure assessment provides an estimate of the nature, extent, and magnitude of potential exposure of assessment receptors to COPECs that are present at or migrating from the site. The assessment receptors are based on the types of habitat and wildlife present at the site, as well as other site conditions that together are used to determine potential exposure pathways.

Ecological Exposure Setting. R2BG is composed of upland old fields, early shrub thicket, and successional woodlands. There are no surface water bodies on or adjacent to R2BG, but a drainage ditch runs east to west, just north of R2BG. No water is typically present in this ditch, and none was present at the time of sampling. Thus, no substantial aquatic habitat is present in the vicinity of R2BG, and sediment in this ditch was qualitatively determined as not representing significant ecological hazards.

Mammalian, avian, and herptilian wildlife species have been identified at PBOW, some of which would be expected and/or have been observed at R2BG. Although several threatened and endangered animal and plant species have been reported within a 2-mile radius of PBOW, none were observed at R2BG during the site ecological survey (Jacobs, 2010b).

Exposure Pathways. Exposure pathways consist of four primary components: source and mechanism of contaminant release, transport medium, potential receptors, and exposure route. A chemical may also be transferred between several intermediate media before reaching the potential receptor. If any of these components are not complete, then the exposure pathway is incomplete, and the contaminants in those media do not constitute an environmental risk at that specific site. R2BG soil and sediment exposure pathways are all regarded as complete. Exposure of terrestrial receptors to surface water may also be a complete pathway, but surface water is generally not present and was not present during the RI sampling event.

Ecological Receptors. Site biota are organized into major functional groups. For terrestrial communities, the major groups are plants and wildlife, including terrestrial invertebrates, mammals, and birds. Species presence at the sites was determined during a literature review and site reconnaissance prior to identification of target indicator receptor species.

The following seven indicator receptor species were selected to evaluate the potential terrestrial effects for R2BG soil COPECs:

- Deer mouse (*Peromyscus maniculatus*) (small omnivorous mammal)
- Short-tailed shrew (*Blarina brevicauda*) (small insectivorous mammal)

- Eastern cottontail rabbit (*Sylvilagus floridanus*) (medium-sized herbivorous mammal)
- Marsh wren (*Cistothorus palustris*) (small insectivorous bird)
- White-tailed deer (*Odocoileus virginianus*) (large herbivorous mammal)
- Raccoon (*Procyon lotor*) (medium-sized omnivorous mammal)
- Red-tailed hawk (*Buteo jamaicensis*) (large carnivorous bird).

Potential impacts to terrestrial plants and macroinvertebrates were considered qualitatively in the risk characterization. Ecological receptors were evaluated for exposure to soil from the surface to a depth of 5 feet below ground surface (bgs). For inside the Burn Area, this likely encompasses the entire burn layer, which varies in thickness and depth but was typically found at a depth of approximately 1 foot bgs and is about 1 foot thick. The terrestrial food web for the above receptors is depicted on Figure 2-8.

Exposure Routes. Ecological routes of exposure for biota may be direct or indirect. 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) and plants absorbing contaminants by uptake from contaminated sediment or soil. Indirect exposure occurs when one animal ingests (preys upon) another organism that has assimilated COPEC concentrations in its tissues. The exposure levels experienced by the receptor depend on the concentrations of the COPECs in the affected environmental media, concentrations in the prey items, and the ingestion/uptake rates of these items into the receptor.

For terrestrial faunal receptors, the calculation of exposure levels relies upon determination of an organism's direct and indirect exposure to COPECs found in surface water and soil. Direct exposure estimates for terrestrial wildlife receptors in the SLERA were based solely upon ingestion of contaminants from these media. Indirect exposure estimates for terrestrial receptors were based on consumption of other organisms. Indirect exposure was calculated using bioconcentration factors (BCF). BCFs are chemical-specific factors derived to estimate the relative concentration of a COPEC based on initial concentration in an environmental medium or prey item. Exposure concentrations to the target receptor can then be estimated based on the tissue concentrations of its prey items.

2.7.2.3 Ecological Effects Assessment

The ecological effects evaluation includes the identification of literature benchmark concentration values and dose rates that are referred to as toxicity reference values (TRV). The main source of benchmark values used in the SLERA is EPA (1999b). Other sources when benchmark values were not available from the main source include Sample et al. (1996), U.S. Navy (1998), and CH2MHill (2000).

The main source of TRVs used in the R2BG SLERA is EPA (1999b). TRVs were generally available for each of the COPECs; however, in a few cases, data for a surrogate chemical were used. R2BG TRVs were based on either a no-observed-adverse-effects level (NOAEL) or a value estimated to approximate a NOAEL.

2.7.2.4 Ecological Risk Characterization

The risk characterization integrates information on exposure and dose-effects relationships of the COPECs on the receptor populations. Qualitative and semiquantiative approaches were taken to estimate the potential for adverse effects that may result from exposure to COPECs by the assessment receptors. Potential adverse effects to terrestrial plants were qualitatively assessed by comparing COPEC concentrations to plant toxicity benchmarks. Potential adverse impacts to aquatic biota were qualitatively assessed by comparing sediment COPEC concentrations to sediment quality criteria for the protection of aquatic life. Ecological HQ values for terrestrial and aquatic wildlife were calculated by dividing the receptor exposure rate by the TRV for each contaminant.

Terrestrial Plant Impact Assessment. Screening benchmarks based on effects to terrestrial plants were exceeded by the COPECs identified for soil in Table 2-16. These COPECs are semiquantitatively evaluated for the mammalian and avian assessment receptors. No signs of vegetative stress were observed either inside or outside of the Burn Area during the ecological reconnaissance surveys; therefore, no further evaluation specific to terrestrial plants was performed.

Aquatic Biota Sediment Assessment. The only soil COC detected in the R2BG sediment samples is TCDD TEQ; it was present at a relatively low concentration (maximum concentration of 6.9 ng/kg). The only other COPECs, identified using the benthic invertebrate benchmark values, are polycyclic aromatic hydrocarbons (PAH), volatile organic compounds (acetone, methyl ethyl ketone, and 1,1-dichloroethane), and cadmium (Table 2-17). The highest PAH concentrations were detected in a ditch sample (SWSD-02) located approximately 300 feet north-northeast of the Burn Area, adjacent to and across the access road (Figure 2-5). PAHs associated with this sample likely originate from degraded asphalt road materials and/or vehicle emissions. Two of the three VOC COPECs are common laboratory contaminants, none are soil COPECs, and given the volatile nature of these compounds, VOCs would not be expected to be present in sediment as DoD-related contaminants several decades after DoD operations have concluded at R2BG. In summary, R2BG impact to the sediment is minor, and the aquatic habitat at R2BG is minimal or negligible. Therefore, former R2BG-related activities do not represent an ecological hazard to benthic or other organisms that may be exposed to sediment.

Predictive Risk Estimation for Terrestrial Wildlife. Quantitative hazard estimates for terrestrial wildlife were performed through a series of quantitative direct contact and food-chain calculations. These calculations resulted in the estimation of an ecological HQ, which is a comparison of estimated intake to TRVs. HQ values were calculated for each soil COPEC inside the Burn Area and each COPEC outside the Burn Area.

HQs less than or equal to 1 present no probable risk. Generally, HQs between 1 and 10 present a low potential for environmental effects; HQs from 10 to 100 present a significant potential that effects could result from exposure; and HQs of 100 or greater present the highest potential for expected effects (Wentsel et al., 1996). It is noted that the Ohio EPA considers HQs greater than 1.0 to be potentially significant.

Table 2-18 identifies and summarizes the ecological hazards for each COPEC that has an associated HQ value greater than 10 for at least one terrestrial wildlife receptor; these COPECs are referred to as the ecological "hazard drivers." Lead is shown in Table 2-18 even though it has no associated HQ values greater than 10 because it was identified as both a site-related COC and a COPEC. Inorganic chemicals that were identified as COPECs in the SLERA but that are clearly associated with background soil concentrations have been excluded from Table 2-18.

As can be observed from Table 2-18, the nitroaromatics have the highest HQ values among the ecological hazard drivers inside the Burn Area. (Please note that only nitroaromatics were identified as ecological hazard drivers outside the Burn Area.) Although nitroaromatic COCs have the highest HQ values, it is recognized that HQ values are not linearly scaled and are not necessarily comparable between chemicals. The ranges of ecological hazards for the COCs inside and outside the Burn Area are summarized below.

Inside the Burn Area. The following five soil COCs were identified as R2BG COPECs inside the Burn Area. The ranges of HQ values are shown for each:

- TCDD TEQ: HQs = 0.006 (deer) to 92 (shrew)
- 2,4-DNT: HQs = 35 (hawk) to 19,000 (mouse)
- 2,6-DNT: HQs = 1 (hawk) to 660 (mouse)
- TNT: HQs = 5 (deer) to 4,200 (wren)
- Lead: HQs = 0.01 (deer) to 5 (shrew).

Outside the Burn Area. The following four soil COCs were identified as R2BG COPECs outside the Burn Area. The ranges of HQ values are shown for each:

- 2,4-DNT: HQs = 0.1 (hawk) to 59 (mouse)
- 2,6-DNT: HQs = 0.02 (hawk) to 23 (mouse)
- TNT: HQs = 0.5 (deer) to 420 (wren)
- Lead: HQs = 0.001 (deer) to 0.6 (shrew).

Please note that the magnitudes of the HQ values are much greater for the COCs inside the Burn Area than outside of the Burn Area. This suggests a greater possibility of ecological hazard inside the Burn Area,

2.7.3 Discussion of Human Health and Ecological Risk Results

Site-related HI values exceeding the goal of 1 are associated with exposure to surface soil and/or subsurface soil inside the Burn Area for multiple human receptors. Similarly, exposure to surface soil and subsurface soil results in ILCR values exceeding the PBOW ILCR goal of 1×10^{-5} for multiple receptors and a residential ILCR that exceeds the NCP risk management range (1×10^{-6} to 1×10^{-4}) for residential exposure to both surface and subsurface soil.

Site-related HI values exceeding the goal of 1 are associated with exposure to surface soil outside the Burn Area for the construction worker and resident. With respect to cancer risks for surface soils outside of the Burn Area, only the ILCR of the resident exceeded the PBOW goal of 1×10^{-5}, but the ILCR for this receptor did not exceed the NCP risk management range.

Because the HI goal and the PBOW ILCR goal were exceeded in soils both inside and outside of the Burn Area, human health COCs were identified and human health-based RGs were developed for these COCs (see Section 2.8.1), specifically considering these scenarios for the following: surface soil inside the Burn Area, subsurface soil inside the Burn Area. Human health COCs were not identified for sediment or groundwater, because the site-related risks and hazards associated with these media did not exceed the ILCR and HI goals, nor did they contribute appreciably to overall risks and hazards.

A weight-of-evidence approach was used to interpret the findings of the SLERA. It was concluded in the SLERA that remedial action to meet ecological goals was unwarranted for the following reasons: numerous uncertainties associated with the SLERA; the relatively small size of the site; the lack of rare, threatened, and endangered species; the lack of stress to site vegetation; and the anticipation that a cleanup would be recommended based on human health concerns. The SLERA further stated that cleanup of the site to meet human health goals would also effectively protect the environment. As presented in Section 2.8.1, remedial action objectives (RAO) were developed for soil in the FS based on human health risks. Meeting the RAOs will consist of attaining human health-based RG concentrations throughout R2BG. The major hazard drivers (i.e., TNT and DNTs) for ecological receptors also are predominant with respect to human health risks; thus, the attainment of RG concentrations for human health COCs will substantially reduce the estimates of terrestrial ecological hazard. These reductions are further discussed in Section 2.8.1.

In conclusion, by implementing the soil response action to meet human health-based RGs, it is expected that residual COCs at R2BG will be at soil concentrations that are also protective of the environment. Based on human health and ecological considerations, no remediation is required for other site media (i.e., sediment or groundwater).

2.7.4 Basis for Action

The response action selected in the Decision Document is necessary to protect public health and the environment from actual or threatened releases of hazardous substances.

2.8 Remedial Action Objectives

The RAO identified in the R2BG FS is as follows: prevention of human exposure via any exposure route (ingestion, inhalation, or dermal contact) to site soil containing any of the seven COCs at concentrations that exceed RGs (Table 2-19).

The RGs were derived assuming future unrestricted land use. This assumption is appropriate because the area surrounding the former PBOW facility is rural and residential and if/when the property is excessed, the land will likely become residential. Please note that because no unacceptable site-related risks are associated with R2BG groundwater or sediment, no RAOs for these media were developed. The derivations of the RGs for soil are described in Section 2.8.1.

2.8.1 Soil Remedial Goals

In general, an RG may be based on an applicable or relevant and appropriate requirement (ARAR) or human health or ecological risks/hazards. Because no ARARs are pertinent to any of the COCs at the concentrations present, the RG for each R2BG COC is risk based. RGs for each of the seven COCs, except lead, are derived using the residential scenario and chemical-specific values from the BHHRA. The RG for lead (400 mg/kg) was based on the to be considered criterion EPA (1998) residential screening level, which accurately represents acceptable risk-based levels as indicated in the BHHRA. A chemical-specific, risk-based value of 1 mg/kg was selected as the RG for Aroclors 1254 and 1260, based on unrestricted use. It is noted that all concentrations of PCBs (as summed Aroclor concentrations) at R2BG are less than 50 mg/kg. RG values for soil are presented for the COCs in Table 2-19.

The risk-based RGs were designed based on site-specific concentrations such that the cumulative cancer risk (i.e., ILCR) associated with residential exposure to the soil would not result in a cumulative cancer risk that exceeds the target cancer goal of 1×10^{-5} or the target cumulative noncancer hazard of 1. The USACE is bound by the CERCLA/NCP cancer risk management range of 1×10^{-6} to 1×10^{-4}. The PBOW Project Delivery Team selected a target ILCR goal of 1×10^{-5}, which is the logarithmic midpoint of this range. This PBOW cancer risk goal has been used at all PBOW remediation sites for more than a decade. It can be used to initially set goals for remediation, subject to possible modification in accordance with appropriate risk considerations. It is also noted that Ohio EPA policy is to use a target cancer risk goal of 1×10^{-5} (Ohio EPA, 2009). The noncancer RGs were derived so that the sum of the noncancer effects of those chemicals that affect the same target organ does not exceed the target HI goal of 1.

As discussed in Section 2.7.3, no COCs were identified and no RGs were developed specifically for ecological receptors. The major risk drivers for human health risks include those that drive the potential for adverse ecological effects; therefore, remediation to human health-based RGs will also substantially reduce the potential ecological hazards to a level protective of all ecological receptors. Following remediation which attains human health-based RG concentrations, estimated potential ecological hazards will be greatly reduced. The most dramatic decrease is for the rabbit, where the ecological hazard estimates associated with TNT are expected to be reduced nearly 5,000-fold (Table 2-20).

2.8.2 Use of the Remedial Goals

The R2BG RGs are used for three purposes: 1) identify and estimate the extent of areas to be remediated prior to the commencement of remediation efforts, 2) determine the limits of excavation during confirmation sampling, and 3) determine whether a given batch of treated material may be placed on site.

The RGs were used as criteria for the purpose of identifying areas at R2BG requiring soil remediation. They will also be used statistically during excavation and confirmation sampling as part of a risk-based approach to aid in determining whether additional soil removal is required. The analytical results of the COCs will be averaged for an excavation. The average concentrations will be compared to the respective RGs. The exceedance of an individual RG for COCs will be acceptable for an area of an excavation as long as the overall PBOW 1×10^{-5}

cancer risk goal (ILCR$\leq$1 × 10^{-5}) and noncancer hazard goal (HI$\leq$1) are not exceeded by the summed ILCR and summed HI of all nitroaromatic COCs for the area represented by those samples. If both an RG and either the cancer risk goal or noncancer hazard goal are exceeded for the average samples from an excavation, the need for further soil removal is indicated. Also, for selected Remedial Alternatives 3 and 4 (Section 2.9), which include treatment technologies for nitroaromatic-contaminated materials, the nitroaromatic RGs will be used to make determinations as to when materials have been adequately treated for on-site placement. Even if an individual nitroaromatic RG is exceeded for a batch of treated material, the material may be placed on site as long as the average concentrations for the batch do not exceed the overall PBOW risk goals (i.e., ILCR$\leq$1 × 10^{-5} and HI$\leq$1).

The health effects of lead are evaluated separately from those of other chemicals. Therefore, the comparison of lead concentrations in confirmation samples to the lead RG (400 mg/kg) does not consider the summed cancer risks or noncancer hazards of other COCs, and the cleanup for lead is met when the average concentration of lead for an excavation does not exceed 400 mg/kg. Similarly, the cleanup goal for Aroclors 1254 and 1260 is met when the average combined Aroclor concentration for an excavation does not exceed its RG. Because Remedial Alternatives 3 and 4 are not intended to treat lead or PCBs for on-site placement, the RGs for lead and Aroclors 1254/1260 are not used to determine post-treatment suitability for on-site placement of treated materials.

As described in the previous paragraph, the remedial efforts will use the RGs as part of a risk-based approach which results in a remediation that achieves the PBOW risk goals (i.e., ILCR$\leq$1 × 10^{-5} and HI$\leq$1). This approach considers additive noncancer effects of nitroaromatics and additive carcinogenic effects, such that even if all COCs were hypothetically present at their respective RGs, the PBOW risk goals would not be exceeded.

2.9 Description of Alternatives

The following four remedial alternatives were developed and evaluated in the FS for contaminated soil at R2BG:

- ***Alternative 1:*** No action
- ***Alternative 2:*** Excavation and Off-Site Treatment/Disposal
- ***Alternative 3:*** Excavation, Windrow Composting, Chemical Stabilization, and On-Site and Off-Site Disposal

- ***Alternative 4:*** Excavation, Alkaline Hydrolysis, Chemical Stabilization, and On-Site and Off-Site Disposal.

Each of the three action-based alternatives (Alternatives 2 through 4) would require the excavation of an estimated 7,395 cubic yards of contaminated soil from the locations shown on Figure 2-6. This includes an estimated 5,056 cubic yards within the Burn Area (0 to 8 feet deep) and 2,339 cubic yards in areas outside of the Burn Area (0 to 2 feet deep). Based on existing soil data from R2BG, 100 percent of the soil volume may be classified as a characteristic hazardous waste due to anticipated 2,4-DNT and/or lead concentrations. Unless the excavated soil is first treated to render it nonhazardous, this material must be disposed of in a RCRA TSDF. It is estimated that a total of 7,395 cubic yards are hazardous with respect to either lead or 2,4-DNT. This includes 3,793 cubic yards that are hazardous only with respect to leachable 2,4-DNT, 1,300 cubic yards that are hazardous only with respect to leachable lead, and 2,303 cubic yards that are hazardous with respect to both 2,4-DNT and lead.

Alternatives 3 and 4 employ treatment technologies, whereas Alternative 2 includes only off-site disposal. The treatment technologies associated with Alternatives 3 and 4 address 2,4-DNT and lead but are not designed to treat PCBs or PCDD/Fs. PCBs and PCDD/Fs adsorb strongly to soil and are effectively treated only by thermal technologies such as incineration, which are not cost effective for on-site treatment. Therefore, soils with PCB and/or TCDD TEQ concentrations that exceed the respective RGs are disposed of off site in all three action-based alternatives. If the soil contaminated with PCBs or PCDD/Fs is also a hazardous waste because it fails the TCLP test for lead and/or 2,4-DNT, then prior to disposal, the soil would be treated for nitroaromatics and the lead in the soil would be stabilized under alternatives 3 and 4. Whether it is sent off site for disposal at a nonhazardous waste landfill or a hazardous waste landfill, the stabilized soil must comply with the land disposal restrictions (LDR) including treatment for any underlying hazardous constituents before placement into any land disposal unit. The lead-stabilized soil is not suitable for on-site backfill because the residual risk associated with the reduced bioavailability of lead in soil cannot be adequately quantified and cannot be regarded as acceptable for human health unless the total lead concentration of the stabilized soil is less than the lead RG.

If during remediation any of the soil is determined to be nonhazardous based on TCLP testing, the material may be disposed of at a nonhazardous waste landfill under Alternatives 2 through 4. Alternatively, this material may be placed on site under Alternatives 3 and 4 if the RGs are met. Any nonhazardous disposal facility must be approved in advance by the EPA as appropriate facilities to receive CERCLA waste (40 CFR 300.440); the Ohio EPA will also be consulted.

Based on the current data, contamination is estimated to extend to a total depth of 8 feet below the surface in the Burn Area and to a depth of 2 feet outside the Burn Area. The extent of soil excavation needed to attain the RAO will be confirmed in the field by sampling and analysis of the excavation sidewalls and comparing the sample results to the RGs. Additional soil excavation may be required laterally if indicated by a comparison of the confirmation samples to the RGs. Outside the Burn Area, it is possible that soil removal to a depth greater than the planned 2 feet may be required in some areas based on sampling and analysis of the excavation floor. Additional removal of soil to a greater depth is not anticipated within the Burn Area because the planned excavation to 8 feet is expected to extend to the water table. Characterization of the excavated soil as hazardous or nonhazardous waste will be confirmed by analysis using TCLP prior to disposal.

Alternative 1 – No Action

A no-action alternative is developed as required by the NCP. Under this alternative, no remedial action or monitoring would be conducted for contaminated soil at the site. This alternative fails to meet the RAO for soil at the site.

The following estimated costs and durations are associated with Alternative 1:

Capital Cost: $0 K
Total Operation and Maintenance Costs: $0 K
Present Worth Cost: $0 K
Time to Implement: 0 Months
Time to Achieve RAO: (would not be met in the foreseeable future).

Alternative 2 – Excavation and Off-Site Disposal

This alternative includes the following remedial components:

- Excavation of the contaminated soil from the areas exceeding RGs (Figure 2-6)
- Off-site treatment and disposal of hazardous soil at a RCRA TSDF
- Off-site disposal of nonhazardous soil without treatment at a nonhazardous solid waste landfill.

The following estimated costs and durations are associated with Alternative 2:

Capital Cost: $4.7M
Annual Operation and Maintenance Costs: $0
Present Worth Costs: $3.5M
Time to Implement: 25 Months
Time to Achieve RAO: 25 Months.

Alternative 3 – Excavation, Windrow Composting, Chemical Stabilization, and On-Site and Off-Site Disposal

This alternative includes the following remedial components:

- Excavation of the contaminated soil exceeding RGs
- Direct disposal of nonhazardous soil offsite without treatment at a nonhazardous waste landfill
- Windrow composting of soil hazardous for 2,4-DNT
- Chemical stabilization of soil hazardous for lead
- Placement of treated soil that meets RGs back on site
- Off-site disposal of treated soil that exceeds RGs at a nonhazardous waste landfill.

A simplified decision flow chart for this alternative is depicted on Figure 2-9.

Soil within the remediation area (Figure 2-6) at a depth of 0 to 2 feet has elevated concentrations of nitroaromatic compounds, lead, PCBs, and/or TCDD TEQ. Soil that is hazardous for 2,4-DNT will be composted to reduce 2,4-DNT below the TCLP limit. Soil that is hazardous for lead will require chemical stabilization (e.g., Maectite®) to immobilize the lead. The lead-stabilized soil is not suitable for on-site backfill because the residual risk associated with the reduced bioavailability of lead in soil cannot be adequately quantified. PCDD/Fs and PCBs cannot be treated effectively using composting, so soil excavated from the top 2 feet within the entire remedial area will require off-site disposal after treatment to meet the TCLP limit for 2,4-DNT and lead and to comply with the LDRs for all underlying hazardous constituents.

Soil within the Burn Area at a depth of 2 to 8 feet exceeds the RGs for nitroaromatic explosives and does not appear to have concentrations of lead, PCB, or TCDD TEQ above the RGs. Excavated soil within this depth interval that fails the TCLP test for 2,4-DNT would be composted. Composting biodegrades and transforms the nitroaromatic constituents into less toxic and less mobile compounds. The composted soil may be appropriate for placement back on site if the concentrations of all COCs are below the RGs and the concentrations of all underlying hazardous constituents meet LDR requirements after treatment. Composted soil is not suitable as a structural backfill, but it may be an adequate topsoil amendment for landscaping purposes.

The following estimated costs and durations are associated with Alternative 3:

Capital Cost: $3.8M
Annual Operation and Maintenance Costs: $0
Present Worth Costs: $3.8M
Time to Implement: 34 Months
Time to Achieve RAO: 34 Months.

Alternative 4 – Excavation, Alkaline Hydrolysis, Chemical Stabilization, and Off-Site and On-Site Disposal

This alternative includes the following remedial components:

- Excavation of the contaminated soil exceeding RGs
- Direct disposal of nonhazardous soil offsite without treatment at a nonhazardous waste landfill
- Alkaline hydrolysis of soil hazardous for 2,4-DNT
- Chemical stabilization of soil hazardous for lead
- Placement of treated soil that meets RGs back on site
- Off-site disposal of treated soil that exceeds RGs at a nonhazardous waste landfill.

A simplified decision flow chart for this alternative is depicted on Figure 2-9.

Soil within the remediation area (Figure 2-6) at a depth of 0 to 2 feet has elevated concentrations of nitroaromatic compounds, lead, PCB, and/or TCDD TEQ. Compliance testing for the alkaline hydrolysis technology will be performed at the end of the treatment cycle. A composite sample will be collected for each batch and analyzed for pH, total nitroaromatic compounds, nitrate/nitrite, and TCLP 2,4-DNT. The USACE has found that analytical results for nitroaromatic explosive compounds using EPA Method 8330 may be biased low if the pH levels of the soil samples are elevated (Larson et al., 2012). Therefore, the pH of soil samples submitted for Method 8330 analysis will be reduced to a pH of $\leq$10 or the background soil pH, whichever is greater. Soil that is hazardous for 2,4-DNT will be treated using alkaline hydrolysis to reduce 2,4-DNT below the TCLP limit. Soil that is hazardous for lead will require chemical stabilization (e.g., Maectite), unless the prior alkaline hydrolysis treatment has effectively immobilized the lead. The lead-stabilized soil is not suitable for on-site backfill because the residual risk associated with the reduced bioavailability of lead in soil cannot be adequately quantified. PCDD/Fs and PCBs cannot be treated effectively using alkaline hydrolysis, so soil excavated from the top 2 feet within the entire remedial area will require off-site disposal after treatment to meet the TCLP limit for 2,4-DNT and lead and comply with the LDRs for all underlying hazardous constituents.

Soil within the Burn Area at a depth of 2 to 8 feet exceeds the RGs for nitroaromatic explosives and does not appear to have concentrations of lead, PCBs, or TCDD TEQ above the RGs. Excavated soil within this depth interval that fails the TCLP test for 2,4-DNT would be treated using alkaline hydrolysis. Alkaline hydrolysis chemically transforms nitroaromatic constituents into less toxic compounds. The alkaline hydrolysis treated soil may be appropriate for placement back on site if the concentrations of all COCs are below the RGs and the concentrations of all underlying hazardous constituents meet LDR requirements after treatment. Addition of the alkaline chemicals to the contaminated soil will result in the pH of this material being raised, at least temporarily. Therefore, addition of a neutralization agent (e.g., ferrous sulfate) may be required to lower the pH for disposal on site or for acceptance by a landfill if disposed off site. Placement of soil back on site as subsurface soil will be acceptable after the soil pH has decreased to ≤10 or the background soil pH, whichever is lower.

The following estimated costs and durations are associated with Alternative 4:

Capital Cost: $2.8M
Annual Operation and Maintenance Costs: $0
Present Worth Costs: $2.8M
Time to Implement: 31 Months
Time to Achieve RAO: 31 *Months.*

2.10 Comparative Analysis of Alternatives

Each of the four remedial alternatives was evaluated with respect to the following nine criteria, as required by the NCP at 40 CFR 300.430 (e)(9)(iii). Criteria 1 and 2 are the threshold criteria, which must be met, criteria 3 through 7 are the primary balancing criteria, and criteria 8 and 9 are the modifying criteria.

Threshold Criteria

1. Overall Protectiveness of Human Health and the Environment
2. Compliance with Applicable or Relevant and Appropriate Requirements

Primary Balancing Criteria

3. Long-Term Effectiveness and Permanence
4. Reduction of Toxicity, Mobility, or Volume of Contaminants through Treatment
5. Short-Term Effectiveness
6. Implementability
7. Cost

Modifying Criteria

8. State Support/Agency Acceptance
9. Community Acceptance.

The threshold criteria are requirements that a remedial alternative must meet to be eligible for selection. The five primary balancing criteria are used to determine the trade-offs between alternatives. The modifying criteria are public and state acceptance. An analysis of each alternative against these criteria is presented in Table 2-21. A comparison among the remedial alternatives with respect to these criteria is provided in this section.

Threshold Criteria. Each of the three action-based alternatives (i.e., Alternatives 2 through 4) meets the threshold criteria for protection of human health and the environment and compliance with ARARs. These ARARs (Table 2-23) include the Federal Land Disposal Restrictions and the Special Federal Provision for Cleanup—Staging Piles. Alternative 1, no action, does not meet the threshold criterion for protection of human health and the environment. Thus, Alternative 1 is not regarded as viable for R2BG and is not further discussed in this evaluation of alternatives.

Primary Balancing Criteria. Alternatives 2 through 4 are equally effective in the long term because the contaminated soil would be treated and/or taken off site. Alternatives 3 and 4 would meet the preference for treatment technologies that result in a reduction in toxicity, mobility, or volume. Alternative 2 relies only on off-site disposal and assumes that based on existing data, all materials would be treated at a RCRA/TSCA TSDF to comply with the LDR requirements prior to disposal.

Each of the three action-based alternatives could be performed in 34 months or less upon commencement of field remediation activities. Alternative 2 is estimated to take the shortest duration (25 months). Alternatives 3 and 4 could be performed within similar time frames (34 and 31 months, respectively). Alternatives 2 through 4 can be carried out safely without appreciable risk to remediation workers, NASA employees, or nearby residents. Although Alternative 4 requires the handling of hazardous chemicals (e.g., caustic soda) whereas the other alternatives do not, proper adherence to the safety and health plan that would be developed specifically for this alternative would allow for safe implementation.

Alternatives 2 through 4 represent proven technological approaches and each is regarded as implementable. Windrow composting, the primary technology of Alternative 3, has been used successfully at the PBOW TNTB and Pentolite Road Red Water Pond Area sites. Chemical stabilization of lead, included in Alternatives 3 and 4, has also been used at various PBOW sites.

Alternative 2 is implementable, because it is simply off-site disposal. The effectiveness of alkaline hydrolysis, which is the primary technology for Alternative 4, has been demonstrated on even high concentrations of TNT (>99 percent destruction) and DNTs (~97 percent destruction for 2,4-DNT). Alkaline hydrolysis has been used for contaminated soil from TNTA and TNTC.

Once treatment of nitroaromatic-contaminated soil is complete using composting under Alternative 3, the composted material is not a suitable base for construction, but it may be used for landscaping purposes and as a soil amendment with respect to plant growth. Under Alternative 4, the alkaline-treated soil cannot be used as a growth medium for plants, but it is suitable as a construction base as subsurface soil.

Costs of the three action-based alternatives are as follows, from least to most expensive:

- Alternative 4 – $2.8M
- Alternative 2 – $3.5M
- Alternative 3 – $3.8M.

In addition, it is possible that Alternative 4 will not require neutralization for on-site placement of the remediated soil which is planned to be placed on site below the surface. This would result in greater cost savings. Also, a stabilizing agent may not be required for lead under Alternative 4 because the alkalizing agent should precipitate the lead out as stable lead hydroxide. These possibilities represent additional potential cost savings under this alternative that are not reflected in the above estimate for Alternative 4.

Modifying Criteria. Each of the technologies represented by the three action-based alternatives has been presented to the State and public during the August 14, 2012, public meeting. Neither the State nor the public expressed concern over any of these technologies during the public meeting or the public comment period. Notably, both composting (used in Alternative 3) and alkaline hydrolysis (used in Alternative 4) have been presented to the State and public in the past, and both of these technologies have been employed at different PBOW sites.

2.11 Principal Threat Waste

The NCP establishes a preference for methods that employ treatment that reduces toxicity, mobility, or volume [300.430(e)(9)(ii)(D)]. This especially includes the expectation that treatment will be used to address principal threats posed by a site when practicable [300.430(a)(1)(iii)(A)]. The term "principal threat wastes" refers to source materials, but does not include contaminants dissolved or suspended in groundwater (EPA, 1991b). At R2BG, the principal threat wastes are the soils with the highest soil concentrations of COCs inside the Burn

Area that may result in an ILCR greater than 1×10^{-3} if an individual may be directly exposed under a future residential land-use scenario (EPA, 1997). The toxicity and mobility of these principal threat wastes would be reduced through treatment, using windrow composting under Alternative 3 or alkaline hydrolysis under Alternative 4. Although Alternative 2 utilizes off-site disposal, it is possible that the hazardous waste materials taken to the RCRA Subtitle C TSDF will be treated there prior to disposal.

2.12 Selected Remedy

2.12.1 Rationale for Selection

The rationale for selecting Alternative 4, Excavation, Alkaline Hydrolysis Chemical Stabilization, and On-Site/Off-Site Disposal, for the soil response action is that this alternative meets both of the threshold evaluation criteria and provides the best overall set of tradeoffs in meeting the primary balancing criteria. Notably, Alternative 4 meets the NCP statutory preference for treatment technologies that permanently reduce the toxicity and mobility through treatment, and Alternative 4 is estimated to be the least expensive alternative for R2BG. Also, the community has expressed a preference for treatment technologies over those remedial approaches that rely primarily on landfill disposal, and NASA has previously expressed the desire to use treated materials on site if these materials meet the RGs.

2.12.2 Description of Selected Remedy

The Selected Remedy includes excavation of the contaminated soil (Figure 2-6), TCLP testing, segregation and stabilization of the hazardous lead-contaminated soil, segregation and alkaline hydrolysis of hazardous 2,4-DNT-contaminated soil, segregation of soils containing PCBs or TCDD TEQ at concentrations exceeding the RGs, and off-site disposal of the treated material at a nonhazardous solid waste landfill and/or placement of the treated material on site. Any excavated soils found to be nonhazardous prior to treatment based on TCLP and/or other analytical results, and that are not a PCB remediation waste, will be disposed of off site at a nonhazardous waste landfill. Based on analytical data collected to date, PCBs and PCDD/Fs in R2BG soil meet the LDRs. Alkaline hydrolysis-treated soils that exceed RGs will be disposed of off site at a nonhazardous waste landfill; alkaline hydrolysis-treated soils that do not exceed RGs will be disposed of on site as subsurface soil. A simplified decision flow chart for this alternative is depicted on Figure 2-9.

Soils within the remediation area at a depth of 0 to 2 feet shown on Figure 2-6 have lead, PCB, and/or TCDD TEQ concentrations that exceed RGs. The soil with elevated lead concentrations will require stabilization. The lead-stabilized soil is not suitable for on-site backfill because the residual risk associated with the reduced bioavailability of lead in soil cannot be adequately quantified. Additionally, alkaline hydrolysis treatment technology does not effectively remediate PCDD/Fs and PCBs. Therefore, it is assumed that soil excavated from the top 2 feet within the entire remedial area will require off-site disposal after alkaline hydrolysis treatment and/or lead stabilization as described in the following paragraphs. Soils excavated from within the Burn Area at a depth of 2 to 8 feet do not appear to have elevated lead, PCB, or TCDD TEQ concentrations and may be appropriate for on-site placement after alkaline hydrolysis.

The excavated soil will be hauled to an outdoor staging area and characterized as hazardous or nonhazardous using the results of the TCLP test and analyses for the COCs. Soils that pass the TCLP test as nonhazardous and have PCB concentrations less than 50 mg/kg will be hauled to the Erie County Landfill or other nonhazardous solid waste landfill that can accept the soil. Note that if any soil contains PCBs at 50 mg/kg or greater, it will be hauled to a TSCA-approved, RCRA Subtitle C hazardous waste landfill, regardless of whether the soil fails for a RCRA hazardous waste characteristic or analytical results for the other COCs.

Soils that initially fail the TCLP testing for 2,4-DNT will be treated with an alkaline chemical mixture (e.g., caustic soda) at the existing area designed for treatment, until the TCLP criterion for 2,4-DNT is met. Chemicals will be mixed into the soil using an excavator or compost turner. The nitroaromatics are chemically reacted to less toxic compounds. Alkaline hydrolysis treatment of this soil will continue until the 2,4-DNT TCLP criterion is met. If RGs are also met for all COCs, the alkaline-treated material will be placed on site; if RGs are not met, then this material will be disposed of off site. Addition of the alkaline chemicals to the contaminated soil will result in the pH of this material being raised, at least temporarily. Therefore, addition of a neutralization agent (e.g., acetic acid) may be required to lower the pH for disposal on site or for acceptance by a landfill if disposed of off site. Placement of soil back on site as subsurface soil will be acceptable at a pH value ≤10 or the background soil pH, whichever is greater. It is anticipated that only the soil currently at a depth of 2 to 8 feet, all within the Burn Area, may be placed back on site.

Soil that fails the TCLP for lead will be treated with a reagent (e.g., Maectite) to immobilize the lead within the soil matrix. This stabilization treatment will be performed in the same area as the alkaline hydrolysis treatment. TCLP testing will be used to confirm that the stabilized soil is nonhazardous for lead. Soils that have been stabilized with respect to lead will be disposed of at a nonhazardous solid waste landfill. Likewise, soils that have PCBs or TCDD TEQ at concentrations that exceed the respective RGs will be disposed of at a nonhazardous solid waste landfill. All excavated soil that was hazardous at the time it was excavated will be treated to comply with the LDRs for all underlying hazardous constituents before land disposal.

It is possible that treatment with the alkaline agent (caustic soda) will irreversibly bind the lead to soil, even after neutralization. If this is the case, a separate stabilization reagent such as Maectite would not be required.

Materials treated with alkaline hydrolysis may be disposed of on site under the following criteria: 1) the TCLP criterion for 2,4-DNT is met; 2) the material did not require stabilization for lead; 3) concentrations of all COCs meet the RGs; and 4) the LDR Alternative Treatment Standard (ATS) for contaminated soil are met.

2.12.3 Estimated Costs of Selected Remedy

The overall estimated capital cost and present worth cost for the implementation of the Selected Remedy is $2.8M. A detailed breakdown of the estimated costs for implementing the Selected Remedy is provided in Table 2-22. The cost information in Table 2-22 is based on the best available information regarding the scope of the remedial alternative. Changes in the cost elements are likely to occur as the result of new information and data collected during the engineering design of the remedial alternative. Post-Decision Document changes in the remedy that may affect the overall costs may be documented in the form of a memorandum in the AR, an Explanation of Significant Difference, or a Decision Document Amendment, depending on the nature of the changes.

2.12.4 Expected Outcome of Selected Remedy

The expected outcome of the Selected Remedy is that the R2BG property will have unrestricted use. Also, the Selected Remedy will result in soil concentrations that are protective of environmental receptors.

2.13 Statutory Determinations

Exposure to soil associated with R2BG may result in adverse human health effects as indicated by the BHHRA. Therefore, remedial actions are necessary at R2BG.

The Selected Remedy satisfies the following CERCLA 121 statutory requirements found at 40 CFR 300.430(f)(5)(ii) and the USACE Engineering Regulation ER-200-3-1 Formerly Used Defense Sites (FUDS) Program Policy, which must comply with DERP statute 10USC2701, CERCLA 42USCSS9601, and the NCP 40 CFR 300.

Documentation of the Selected Remedy meeting these requirements is found in the paragraphs that follow:

- Protection of human health and the environment
- Compliance with ARARs and/or justification of an ARAR waiver
- Cost effectiveness
- Utilization of permanent solutions and treatment or resource recovery technologies to the maximum extent practicable
- Preference for treatment as a principal element that reduces toxicity, mobility, or volume.

Protection of Human Health and the Environment. The Selected Remedy is protective of human health via the excavation of soil that had not met the RGs. The excavations will be backfilled with treated and/or other clean materials. Treated materials that may be placed on site meet stringent criteria for unrestricted land use. The Selected Remedy does not pose unacceptable short-term risks or ecological risks.

Compliance with ARARs. The Selected Remedy complies with all action-specific ARARs (Table 2-23). No location-specific or chemical-specific ARARs were identified for R2BG.

Cost Effectiveness. The Selected Remedy is regarded as cost effective, as it meets the RAOs and the nine NCP criteria at a feasible cost that is less than the other remedial alternatives.

Utilization of Permanent Solutions and Treatment. The Selected Remedy meets the permanence and treatment criteria. The toxicities of the previously hazardous nitroaromatic-impacted materials will be permanently reduced through alkaline hydrolysis. Lead-contaminated materials will be stabilized and disposed of at a nonhazardous waste landfill. PCB-contaminated materials (<50 mg/kg) and TCDD TEQ that exceed RGs will be permanently removed off site at a nonhazardous waste landfill without treatment.

Treatment as a Principal Element. The Selected Remedy satisfies the requirement for treatment by using alkaline hydrolysis and stabilization of materials identified as characteristic hazardous wastes.

Institutional Controls. Because the Selected Remedy will meet cleanup criteria that are based on unrestricted land use, institutional controls will not be required.

Five-Year Reviews. No 5-year reviews will be required.

2.14 Documentation of Significant Changes

The Proposed Plan for R2BG was released on August 14, 2012. This Proposed Plan (USACE, 2012) identified Alternative 4 (excavation, alkaline hydrolysis, chemical stabilization, and on-site/off-site disposal) as the Preferred Alternative for soil remediation. No comments were submitted verbally during the Public Meeting, and no written comments were submitted during the August 14, 2012 through September 18, 2012 comment period. Therefore, it was determined that no significant changes to the Preferred Alternative identified in the Proposed Plan are necessary or appropriate.

3.0 Responsiveness Summary

The purposes of the Responsiveness Summary are to a) summarize information concerning the views of the public and support agencies regarding the remedial alternatives and any general concerns about the site that were submitted during the public comment period, and b) provide documentation in AR as to how these public comments were integrated into the decision-making process for remedy selection.

A presentation of the R2BG Proposed Plan was provided by the USACE to the community during an August 14, 2012, public meeting jointly chaired by representatives of the RAB and the USACE. As discussed in Section 2.3, this meeting was announced in the *Sandusky Register* on August 3, 2012. Several members of the local community attended. The State of Ohio was also represented at the public meeting, as was NASA. No comments or concerns were expressed during the public meeting, and no comments were submitted during the August 14, 2012, through September 18, 2012 public comment period. Therefore, as stated in Section 2.14, the Preferred Remedy identified in the Proposed Plan is appropriately identified, without change, as the Selected Remedy in this Decision Document.

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TABLES

Table 2-1

Summary Statistics of COCs in Reservoir No. 2 Burning Ground Soil, Former Plum Brook Ordnance Works, Sandusky, Ohio

Chemical of Concern	Number of Detects	Number of Samples	Percent Detect	Units	Minimum Detected Concentration	Maximum Detected Concentration	Toxicity Screening Level	95% Upper Confidence Limit of Mean	Exposure Point Concentration	Basis of EPC
Inside the Burn Area										
Surface Soil										
TCDD TEQ	1	1	100	ng/kg		127	4.5		127	Max
2,4,6-Trinitrotoluene	7	7	100	mg/kg	4.75	3,120	16	6,048	6,048	UCL
2,4-Dinitrotoluene	5	7	71	mg/kg	0.99	18.8	12	11.9	11.9	UCL
2,6-Dinitrotoluene	2	7	29	mg/kg	0.35	0.98	6.1	0.88	0.88	UCL
Aroclor 1260	6	7	86	mg/kg	1.95	11.6	0.22	8.91	8.91	UCL
Lead	7	7	100	mg/kg	155	778	40	673	673	UCL
Subsurface Soil										
TCDD TEQ	13	13	100	ng/kg		1,187	4.5		1,187	Max
2,4,6-Trinitrotoluene	13	19	68	mg/kg	0.39	35,400	16	27,540	27,540	UCL
2,4-Dinitrotoluene	11	19	58	mg/kg	0.37	9,700	12	1,974	1,974	UCL
2,6-Dinitrotoluene	5	19	26	mg/kg	11	1,400	6.1	251	251	UCL
Aroclor 1254	2	19	11	mg/kg	1.66	3.67	0.22	2.04	2.04	UCL
Aroclor 1260	7	19	37	mg/kg	0.053	4.01	0.22	1.26	1.26	UCL
Lead	19	19	100	mg/kg	8.94	8,220	40	5304	5304	UCL
Outside the Burn Area										
Surface Soil										
2,4,6-Trinitrotoluene	31	42	74	mg/kg	0.14	2,270	16	606	606	UCL
2,4-Dinitrotoluene	23	42	55	mg/kg	0.24	200	12	37.4	37.4	UCL
2,6-Dinitrotoluene	14	42	33	mg/kg	0.15	78.0	6.1	10.7	10.7	UCL
Aroclor 1260	33	42	79	mg/kg	0.013	44.4	0.22	8.50	8.50	UCL
Lead	42	42	100	mg/kg	21.1	603	40	238	238	UCL

EPC - exposure point concentration; TCDD TEQ - 2,3,7,8-tetrachlorodibenzodioxin toxicity equivalents; ng/kg - nanogram(s) per kilogram; mg/kg - milligram(s) per kilogram; Max - maximum detected concentration; UCL - 95th percent upper confidence limit of the arithmetic mean concentration

Note: The TCDD TEQ values are calculated from the polychlorodibenzodioxin/furan chemical-specific analytical results. The "Maximum Detected Concentration" shown was calculated from the sample yielding the highest TCDD TEQ. For surface soil inside the Burn Area, this is sample BH17; for subsurface soil this is burn layer sample TR10-2.

Source: Jacobs, 2010a

Table 2-2

Toxicity Values Used in the Baseline Human Health Risk Assessment for Chemicals of Concern
Former Plum Brook Ordnance Works, Sandusky, Ohio

Chemical of Concern	Reference Doses[a]			Cancer Slope Factors[b]		
	Oral	Dermal	Inhalation	Oral	Dermal	Inhalation
TCDD TEQ[c]	--	--	--	1.50E+05	1.50E+05	1.50E+05
2,4,6-Trinitrotoluene	5.00E-04	5.00E-04	5.00E-04	3.00E-02	3.00E-02	3.00E-02
2,4-Dinitrotoluene	2.00E-03	2.00E-03	2.00E-03	--	--	--
2,6-Dinitrotoluene	1.00E-03	1.00E-03	1.00E-03	--	--	--
Aroclor 1254	2.00E-05	2.00E-05	2.00E-05	2.00E+00	2.00E+00	2.00E+00
Aroclor 1260	--	--	--	2.00E+00	2.00E+00	2.00E+00

-- = Toxicity value not available

[a] Reference doses are in dose rate units of milligrams per kilogram(s) per day.

[b] Cancer slope factors are in units of cancer risk at the dose rate of 1 milligram per kilogram per day

[c] TCDD TEQ - 2,3,7,8-tetrachlorodibenzodioxin toxicity equivalents

Source: Jacobs, 2010a

Table 2-3

COC Cancer Risk and Noncancer Hazard Index: Groundskeeper Exposure to Surface Soil Inside the Burn Area
Reservoir No. 2 Burning Ground
Former Plum Brook Ordnance Works, Sandusky, Ohio

Chemical		Exposure-Point Concentration (mg/kg)	Oral HQ	Oral ILCR	Dermal HQ	Dermal ILCR	Inhalation HQ	Inhalation ILCR	**HI All Pathways**	**ILCR All Pathways**
Surface Soil										
2,4-Dinitrotoluene		1.19E+01	5.84E-03	NA	NA	NA	2.73E-07	NA	**5.84E-03**	**NA**
2,6-Dinitrotoluene		8.80E-01	8.61E-04	NA	NA	NA	4.02E-08	NA	**8.61E-04**	**NA**
Dinitrotoluene mixture		8.60E+00	NA	2.04E-06	NA	NA	NA	9.55E-11	**NA**	**2.04E-06**
2,4,6-Trinitrotoluene		6.05E+03	1.18E+01	6.34E-05	NA	NA	5.53E-04	2.96E-09	**1.18E+01**	**6.34E-05**
TCDD TEQ		1.27E-04	NA	6.66E-06	NA	2.03E-07	NA	3.11E-10	**NA**	**6.87E-06**
Lead		6.73E+02	NA	NA	NA	NA	NA	NA	**NA**	**NA**
Aroclor 1260		8.91E+00	NA	6.22E-06	NA	8.86E-07	NA	2.91E-10	**NA**	**7.11E-06**
	Total HI		**11.8**		**NA**		**0.0006**		**12**	
Surface Soil Sums	**Total ILCR**			**7.83E-05**		**1.09E-06**		**3.66E-09**		**8.E-05**

COC - Chemical of concern.
HQ - Hazard quotient; HI - Hazard index; sum of the HQ values.
ILCR - Incremental lifetime cancer risk.
mg/kg - Milligrams per kilogram.
NA - Not applicable.
1) HI values equal to or less than 1 are unlikely to result in adverse noncancer human health effects for any member of the exposed population and are regarded as acceptable.
2) ILCR values equal to or less than $1x10^{-5}$ (1 in 100,000) are generally regarded by the Ohio Environmental Protection Agency (OEPA) as acceptable. Risks less than $1x10^{-6}$ are regarded as very minimal, and risks greater than $1x10^{-5}$ are regarded by OEPA as requiring cleanup or further study if appropriate. It is noted that the average lifetime cancer risk of the general American population is estimated as about 400,000 in 1,000,000.

Source: Jacobs, 2010a

Table 2-4

COC Cancer Risk and Noncancer Hazard Index: Indoor Worker Exposure to Surface Soil Inside the Burn Area
Reservoir No. 2 Burning Ground
Former Plum Brook Ordnance Works, Sandusky, Ohio

Chemical		Exposure-Point Concentration (mg/kg)	Oral HQ	Oral ILCR
Surface Soil				
2,4-Dinitrotoluene		1.19E+01	2.92E-03	NA
2,6-Dinitrotoluene		8.80E-01	4.31E-04	NA
Dinitrotoluene mixture		8.60E+00	NA	1.02E-06
2,4,6-Trinitrotoluene		6.05E+03	5.92E+00	3.17E-05
TCDD TEQ		1.27E-04	NA	3.33E-06
Lead		6.73E+02	NA	NA
Aroclor 1260		8.91E+00	NA	3.11E-06
	Total HI		**6**	
Surface Soil Sums	**Total ILCR**			**4.E-05**

COC - Chemical of concern.
HQ - Hazard quotient; HI - Hazard index; sum of the HQ values.
ILCR - Incremental lifetime cancer risk.
mg/kg - Milligrams per kilogram.
NA - Not applicable.

1) HI values equal to or less than 1 are unlikely to result in adverse noncancer human health effects for any member of the exposed population and are regarded as acceptable.
2) ILCR values equal to or less than $1x10^{-5}$ (1 in 100,000) are generally regarded by the Ohio Environmental Protection Agency (OEPA) as acceptable. Risks less than $1x10^{-6}$ are regarded as very minimal, and risks greater than $1x10^{-5}$ are regarded by OEPA as requiring cleanup or further study if appropriate. It is noted that the average lifetime cancer risk of the general American population is estimated as about 400,000 in 1,000,000.

Source: Jacobs, 2010a

Table 2-5

COC Cancer Risk and Noncancer Hazard Index: Construction Worker Exposure to Surface Soil Inside the Burn Area
Reservoir No. 2 Burning Ground
Former Plum Brook Ordnance Works, Sandusky, Ohio

Chemical		Exposure-Point Concentration (mg/kg)	Oral HQ	Oral ILCR	Dermal HQ	Dermal ILCR	Inhalation HQ	Inhalation ILCR	**HI All Pathways**	**ILCR All Pathways**
Surface Soil										
2,4-Dinitrotoluene		1.19E+01	1.63E-02	NA	NA	NA	2.62E-07	NA	**1.63E-02**	**NA**
2,6-Dinitrotoluene		8.80E-01	2.40E-03	NA	NA	NA	3.86E-08	NA	**2.40E-03**	**NA**
Dinitrotoluene mixture		8.60E+00	NA	1.14E-07	NA	NA	NA	1.83E-12	**NA**	**1.14E-07**
2,4,6-Trinitrotoluene		6.05E+03	3.29E+01	3.53E-06	NA	NA	5.31E-04	5.69E-11	**3.30E+01**	**NA**
TCDD TEQ		1.27E-04	NA	3.71E-07	NA	3.47E-08	NA	5.98E-12	**NA**	**3.71E-07**
Lead		6.73E+02	NA	NA	NA	NA	NA	NA	**NA**	**NA**
Aroclor 1260		8.91E+00	NA	3.47E-07	NA	1.51E-07	NA	5.58E-12	**NA**	**4.98E-07**
	Total HI		**33.0**		**NA**		**0.0005**		**33**	
Surface Soil Sums	**Total ILCR**			**4.36E-06**		**1.86E-07**		**7.03E-11**		**5.E-06**

COC - Chemical of concern.
HQ - Hazard quotient; HI - Hazard index; sum of the HQ values.
ILCR - Incremental lifetime cancer risk.
mg/kg - Milligrams per kilogram.
NA - Not applicable.
1) HI values equal to or less than 1 are unlikely to result in adverse noncancer human health effects for any member of the exposed population and are regarded as acceptable.
2) ILCR values equal to or less than $1x10^{-5}$ (1 in 100,000) are generally regarded by the Ohio Environmental Protection Agency (OEPA) as acceptable.
Risks less than $1x10^{-6}$ are regarded as very minimal, and risks greater than $1x10^{-5}$ are regarded by OEPA as requiring cleanup or further study if appropriate.
It is noted that the average lifetime cancer risk of the general American population is estimated as about 400,000 in 1,000,000.

Source: Jacobs, 2010a

Table 2-6

COC Cancer Risk : On-Site Residential Exposure to Surface Soil Inside the Burn Area
Reservoir No. 2 Burning Ground
Former Plum Brook Ordnance Works, Sandusky, Ohio

Chemical		Exposure-Point Concentration (mg/kg)	Oral ILCR	Dermal ILCR	Inhalation ILCR	**ILCR All Pathways**
Surface Soil						
2,4-Dinitrotoluene		1.19E+01	NA	NA	NA	**NA**
2,6-Dinitrotoluene		8.80E-01	NA	NA	NA	**NA**
Dinitrotoluene mixture		8.60E+00	8.24E-06	NA	1.83E-10	**8.24E-06**
2,4,6-Trinitrotoluene		6.05E+03	2.56E-04	NA	5.67E-09	**2.56E-04**
TCDD TEQ		1.27E-04	2.69E-05	3.19E-06	5.96E-10	**3.01E-05**
Lead		6.73E+02	NA	NA	NA	**NA**
Aroclor 1260		8.91E+00	2.51E-05	1.39E-05	5.57E-10	**3.90E-05**
	Total HI					
Surface Soil Sums	**Total ILCR**		**3.16E-04**	**1.71E-05**	**7.01E-09**	**3.E-04**

COC - Chemical of concern.
HQ - Hazard quotient; HI - Hazard index; sum of the HQ values.
ILCR - Incremental lifetime cancer risk; values reflect the sum of adult and child exposure.
mg/kg - Milligrams per kilogram.
NA - Not applicable.
1) HI values equal to or less than 1 are unlikely to result in adverse noncancer human health effects for any member of the exposed population and are regarded as acceptable.
2) ILCR values equal to or less than $1x10^{-5}$ (1 in 100,000) are generally regarded by the Ohio Environmental Protection Agency (OEPA) as acceptable.
Risks less than $1x10^{-6}$ are regarded as very minimal, and risks greater than $1x10^{-5}$ are regarded by OEPA as requiring cleanup or further study if appropriate. It is noted that the average lifetime cancer risk of the general American population is estimated as about 400,000 in 1,000,000.

Source: Jacobs, 2010a

Table 2-7

COC Noncancer Hazard Index: On-Site Residential Exposure to Surface Soil Inside the Burn Area
Reservoir No. 2 Burning Ground
Former Plum Brook Ordnance Works, Sandusky, Ohio

Chemical		Exposure-Point Concentration (mg/kg)	Ingestion Child HQ	Ingestion Adult HQ	Dermal Child HQ	Dermal Adult HQ	Inhalation Child HQ	Inhalation Adult HQ	**HI All Pathways Child**	**HI All Pathways Adult**
Surface Soil										
2,4-Dinitrotoluene		1.19E+01	6.87E-02	7.36E-03	NA	NA	8.02E-07	3.44E-07	**6.87E-02**	**7.36E-03**
2,6-Dinitrotoluene		8.80E-01	1.01E-02	1.08E-03	NA	NA	1.18E-07	5.07E-08	**1.02E-02**	**1.08E-03**
Dinitrotoluene mixture		8.60E+00	NA	NA	NA	NA	NA	NA	**NA**	**NA**
2,4,6-Trinitrotoluene		6.05E+03	1.39E+02	1.49E+01	NA	NA	1.63E-03	6.97E-04	**1.39E+02**	**1.49E+01**
TCDD TEQ		1.27E-04	NA	NA	NA	NA	NA	NA	**NA**	**NA**
Lead		6.73E+02	NA	NA	NA	NA	NA	NA	**NA**	**NA**
Aroclor 1260		8.91E+00	NA	NA	NA	NA	NA	NA	**NA**	**NA**
Surface Soil Sums	**Total HI**		**139.3**	**14.9**	**NA**	**NA**	**0.002**	**0.0007**	**139**	**15**

COC - Chemical of concern.
HQ - Hazard quotient; HI - Hazard index; sum of the HQ values.
ILCR - Incremental lifetime cancer risk.
mg/kg - Milligrams per kilogram.
NA - Not applicable.
1) HI values equal to or less than 1 are unlikely to result in adverse noncancer human health effects for any member of the exposed population and are regarded as acceptable.
2) ILCR values equal to or less than $1x10^{-5}$ (1 in 100,000) are generally regarded by the Ohio Environmental Protection Agency (OEPA) as acceptable. Risks less than $1x10^{-6}$ are regarded as very minimal, and risks greater than $1x10^{-5}$ are regarded by OEPA as requiring cleanup or further study if appropriate. It is noted that the average lifetime cancer risk of the general American population is estimated as about 400,000 in 1,000,000.

Source: Jacobs, 2010a

Table 2-8

COC Cancer Risk and Noncancer Hazard Index: Construction Worker Exposure to Subsurface Soil Inside the Burn Area
Reservoir No. 2 Burning Ground
Former Plum Brook Ordnance Works, Sandusky, Ohio

Chemical		Exposure-Point Concentration (mg/kg)	Oral HQ	Oral ILCR	Dermal HQ	Dermal ILCR	**HI All Pathways**	**ILCR All Pathways**
Subsurface Soil								
2,4-Dinitrotoluene		1.97E+03	2.69E+00	NA	NA	NA	**2.69E+00**	**NA**
2,6-Dinitrotoluene		2.51E+02	6.83E-01	NA	NA	NA	**6.83E-01**	**NA**
Dinitrotoluene mixture		2.23E+03	NA	2.95E-05	NA	NA	**NA**	**2.95E-05**
2,4,6-Trinitrotoluene		2.75E+04	1.50E+02	1.61E-05	NA	NA	**1.50E+02**	**1.61E-05**
TCDD TEQ		1.19E-03	NA	3.47E-06	NA	3.24E-07	**NA**	**3.79E-06**
Lead		5.30E+03	NA	NA	NA	NA	**NA**	**NA**
Aroclor 1254		2.04E+00	2.78E-01	7.93E-08	1.21E-01	3.46E-08	**3.99E-01**	**1.14E-07**
Aroclor 1260		1.26E+00	NA	4.89E-08	NA	2.13E-08	**NA**	**7.02E-08**
	Total HI		**153.7**		**0.12**		**154**	
Subsurface Soil Sums	**Total ILCR**			**4.92E-05**		**3.80E-07**		**5.E-05**

COC - Chemical of concern.
HQ - Hazard quotient; HI - Hazard index; sum of the HQ values.
ILCR - Incremental lifetime cancer risk.
mg/kg - Milligrams per kilogram.
NA - Not applicable.
1) HI values equal to or less than 1 are unlikely to result in adverse noncancer human health effects for any member of the exposed population and are regarded as acceptable.
2) ILCR values equal to or less than $1x10^{-5}$ (1 in 100,000) are generally regarded by the Ohio Environmental Protection Agency (OEPA) as acceptable. Risks less than $1x10^{-6}$ are regarded as very minimal, and risks greater than $1x10^{-5}$ are regarded by OEPA as requiring cleanup or further study if appropriate. It is noted that the average lifetime cancer risk of the general American population is estimated as about 400,000 in 1,000,000.

Source: Jacobs, 2010a

Table 2-9

COC Cancer Risk: On-Site Residential Exposure to Subsurface Soil Inside the Burn Area
Reservoir No. 2 Burning Ground
Former Plum Brook Ordnance Works, Sandusky, Ohio

Chemical		Exposure-Point Concentration (mg/kg)	Oral ILCR	Dermal ILCR	**ILCR All Pathways**
Surface Soil					
2,4-Dinitrotoluene		1.97E+03	NA	NA	**NA**
2,6-Dinitrotoluene		2.51E+02	NA	NA	**7.99E-06**
Dinitrotoluene mixture		2.23E+03	2.13E-03	NA	**2.13E-03**
2,4,6-Trinitrotoluene		2.75E+04	1.16E-03	NA	**1.17E-03**
TCDD TEQ		1.19E-03	2.51E-04	2.98E-05	**2.81E-04**
Lead		5.30E+03	NA	NA	**NA**
Aroclor 1254		2.04E+00	5.74E-06	3.18E-06	**8.92E-06**
Aroclor 1260		1.26E+00	3.54E-06	1.96E-06	**5.50E-06**
	Total HI				
Surface Soil Sums	**Total ILCR**		**3.56E-03**	**3.49E-05**	**4.E-03**

COC - Chemical of concern.
HQ - Hazard quotient; HI - Hazard index; sum of the HQ values.
ILCR - Incremental lifetime cancer risk; values reflect the sum of adult and child exposure.
mg/kg - Milligrams per kilogram.
NA - Not applicable.
1) HI values equal to or less than 1 are unlikely to result in adverse noncancer human health effects for any member of the exposed population and are regarded as acceptable.
2) ILCR values equal to or less than $1x10^{-5}$ (1 in 100,000) are generally regarded by the Ohio EPA as acceptable. ILCR values less than $1x10^{-6}$ are regarded as very minimal, and risks greater than $1x10^{-5}$ are regarded by OEPA as requiring cleanup or further study if appropriate. It is noted that the average lifetime cancer risk of the general American population is estimated as about 400,000 in 1,000.000.

Source: Jacobs, 2010a

Table 2-10

COC Noncancer Hazard Index: On-Site Residential Exposure to Subsurface Soil Inside the Burn Area
Reservoir No. 2 Burning Ground
Former Plum Brook Ordnance Works, Sandusky, Ohio

Chemical		Exposure-Point Concentration (mg/kg)	Ingestion Child HQ	Ingestion Adult HQ	Dermal Child HQ	Dermal Adult HQ	Inhalation Child HQ	Inhalation Adult HQ	**HI All Pathways Child**	**HI All Pathways Adult**
Subsurface Soil										
2,4-Dinitrotoluene		1.97E+03	1.14E+01	1.22E+00	NA	NA	2.51E-06	1.08E-06	**1.14E+01**	**1.22E+00**
2,6-Dinitrotoluene		2.51E+02	2.88E+00	3.09E-01	NA	NA	1.44E-06	6.16E-07	**2.88E+00**	**3.09E-01**
Dinitrotoluene mixture		2.23E+03	NA	NA	NA	NA	NA	NA	**NA**	**NA**
2,4,6-Trinitrotoluene		2.75E+04	6.34E+02	6.79E+01	NA	NA	1.63E-04	6.98E-05	**6.34E+02**	**6.79E+01**
TCDD TEQ		1.19E-03	NA	NA	NA	NA			**NA**	**NA**
Lead		5.30E+03	NA	NA	NA	NA	NA	NA	**NA**	**NA**
Aroclor 1254		2.04E+00	1.17E+00	1.26E-01	2.87E-01	1.60E-01			**1.46E+00**	**2.86E-01**
Aroclor 1260		1.26E+00	NA	NA	NA	NA	NA	NA	**NA**	**NA**
Surface Soil Sums	**Total HI**		**649.2**	**69.56**	**2.87E-01**	**1.60E-01**	**0.0002**	**0.00007**	**650**	**70**

COC - Chemical of concern.
HQ - Hazard quotient; HI - Hazard index; sum of the HQ values.
ILCR - Incremental lifetime cancer risk.
mg/kg - Milligrams per kilogram.
NA - Not applicable.
1) HI values equal to or less than 1 are unlikely to result in adverse noncancer human health effects for any member of the exposed population and are regarded as acceptable.
2) ILCR values equal to or less than $1x10^{-5}$ (1 in 100,000) are generally regarded by the Ohio Environmental Protection Agency (OEPA) as acceptable. Risks less than $1x10^{-6}$ are regarded as very minimal, and risks greater than $1x10^{-5}$ are regarded by OEPA as requiring cleanup or further study if appropriate. It is noted that the average lifetime cancer risk of the general American population is estimated as about 400,000 in 1,000,000.

Source: Jacobs, 2010a

Table 2-11

COC Cancer Risk and Noncancer Hazard Index: Groundskeeper Exposure to Surface Soil Outside the Burn Area
Reservoir No. 2 Burning Ground
Former Plum Brook Ordnance Works, Sandusky, Ohio

Chemical		Exposure-Point Concentration (mg/kg)	Oral HQ	Oral ILCR	Dermal HQ	Dermal ILCR	Inhalation HQ	Inhalation ILCR	**HI All Pathways**	**ILCR All Pathways**
Surface Soil										
2,4-Dinitrotoluene		3.74E+01	1.83E-02	NA	NA	NA	8.55E-07	NA	**1.83E-02**	**NA**
2,6-Dinitrotoluene		1.07E+01	1.05E-02	NA	NA	NA	4.89E-07	NA	**1.05E-02**	**NA**
Dinitrotoluene mixture		5.13E+01	NA	1.22E-05	NA	NA	NA	5.69E-10	**NA**	**1.22E-05**
2,4,6-Trinitrotoluene		6.06E+02	1.19E+00	6.35E-06	NA	NA	5.54E-05	2.97E-10	**1.19E+00**	**NA**
Lead		2.38E+02	NA	NA	NA	NA	NA	NA	**NA**	**NA**
Aroclor 1260		8.50E+00	NA	5.94E-06	NA	8.46E-07	NA	2.78E-10	**NA**	**6.79E-06**
	Total HI		**1.21**		**NA**		**0.00006**		**1**	
Surface Soil Sums	**Total ILCR**			**2.45E-05**		**8.46E-07**		**1.14E-09**		**3.E-05**

COC - Chemical of concern.
HQ - Hazard quotient; HI - Hazard index; sum of the HQ values.
ILCR - Incremental lifetime cancer risk.
mg/kg - Milligrams per kilogram.
NA - Not applicable.
1) HI values equal to or less than 1 are unlikely to result in adverse noncancer human health effects for any member of the exposed population and are regarded as acceptable.
2) ILCR values equal to or less than $1x10^{-5}$ (1 in 100,000) are generally regarded by the Ohio Environmental Protection Agency (OEPA) as acceptable. Risks less than $1x10^{-6}$ are regarded as very minimal, and risks greater than $1x10^{-5}$ are regarded by OEPA as requiring cleanup or further study if appropriate. It is noted that the average lifetime cancer risk of the general American population is estimated as about 400,000 in 1,000,000.

Source: Jacobs, 2010a

Table 2-12

COC Cancer Risk and Noncancer Hazard Index: Construction Worker Exposure to Surface Soil Outside the Burn Area
Reservoir No. 2 Burning Ground
Former Plum Brook Ordnance Works, Sandusky, Ohio

Chemical		Exposure-Point Concentration (mg/kg)	Oral HQ	Oral ILCR	Dermal HQ	Dermal ILCR	Inhalation HQ	Inhalation ILCR	**HI All Pathways**	**ILCR All Pathways**
Surface Soil										
2,4-Dinitrotoluene		3.74E+01	5.09E-02	NA	NA	NA	8.21E-07	NA	**5.09E-02**	**NA**
2,6-Dinitrotoluene		1.07E+01	2.91E-02	NA	NA	NA	4.69E-07	NA	**2.91E-02**	**NA**
Dinitrotoluene mixture		5.13E+01	NA	6.78E-07	NA	NA	NA	1.09E-11	**NA**	**6.78E-07**
2,4,6-Trinitrotoluene		6.06E+02	3.30E+00	3.54E-07	NA	NA	5.32E-05	5.70E-12	**3.30E+00**	**NA**
Lead		2.38E+02	NA	NA	NA	NA	NA	NA	**NA**	**NA**
Aroclor 1260		8.50E+00	NA	3.31E-07	NA	1.44E-07	NA	5.33E-12	**NA**	**4.75E-07**
	Total HI		**3.38**		**NA**		**0.00005**		**3**	
Surface Soil Sums	**Total ILCR**			**1.36E-06**		**1.44E-07**		**2.20E-11**		**2.E-06**

COC - Chemical of concern.
HQ - Hazard quotient; HI - Hazard index; sum of the HQ values.
ILCR - Incremental lifetime cancer risk.
mg/kg - Milligrams per kilogram.
NA - Not applicable.
1) HI values equal to or less than 1 are unlikely to result in adverse noncancer human health effects for any member of the exposed population and are regarded as acceptable.
2) ILCR values equal to or less than $1x10^{-5}$ (1 in 100,000) are generally regarded by the Ohio Environmental Protection Agency (OEPA) as acceptable. Risks less than $1x10^{-6}$ are regarded as very minimal, and risks greater than $1x10^{-5}$ are regarded by OEPA as requiring cleanup or further study if appropriate. It is noted that the average lifetime cancer risk of the general American population is estimated as about 400,000 in 1,000,000.

Source: Jacobs, 2010a

Table 2-13

COC Cancer Risk: On-Site Residential Exposure to Surface Soil Outside the Burn Area
Reservoir No. 2 Burning Ground
Former Plum Brook Ordnance Works, Sandusky, Ohio

Chemical		Exposure-Point Concentration (mg/kg)	Oral ILCR	Dermal ILCR	Inhalation ILCR	**ILCR All Pathways**
Surface Soil						
2,4-Dinitrotoluene		3.74E+01	NA	NA	NA	**NA**
2,6-Dinitrotoluene		1.07E+01	NA	NA	NA	**NA**
Dinitrotoluene mixture		5.13E+01	4.91E-05	NA	1.09E-09	**4.91E-05**
2,4,6-Trinitrotoluene		6.06E+02	2.56E-05	NA	5.68E-10	**NA**
Lead		2.38E+02	NA	NA	NA	**NA**
Aroclor 1260		8.50E+00	2.40E-05	1.33E-05	5.32E-10	**3.72E-05**
	Total HI					
Surface Soil Sums	**Total ILCR**		**9.87E-05**	**1.33E-05**	**2.19E-09**	**1.E-04**

COC - Chemical of concern.
HQ - Hazard quotient; HI - Hazard index; sum of the HQ values.
ILCR - Incremental lifetime cancer risk; values reflect the sum of adult and child exposure.
mg/kg - Milligrams per kilogram.
NA - Not applicable.
1) HI values equal to or less than 1 are unlikely to result in adverse noncancer human health effects for any member of the exposed population and are regarded as acceptable.
2) ILCR values equal to or less than $1x10^{-5}$ (1 in 100,000) are generally regarded by the Ohio Environmental Protection Agency (OEPA) as acceptable.
Risks less than $1x10^{-6}$ are regarded as very minimal, and risks greater than $1x10^{-5}$ are regarded by OEPA as requiring cleanup or further study if appropriate. It is noted that the average lifetime cancer risk of the general American population is estimated as about 400,000 in 1,000,000.

Source: Jacobs, 2010a

Table 2-14

COC Noncancer Hazard Index: On-Site Residential Exposure to Surface Soil Outside the Burn Area
Reservoir No. 2 Burning Ground
Former Plum Brook Ordnance Works, Sandusky, Ohio

Chemical		Exposure-Point Concentration (mg/kg)	Ingestion Child HQ	Ingestion Adult HQ	Dermal Child HQ	Dermal Adult HQ	Inhalation Child HQ	Inhalation Adult HQ	**HI All Pathways Child**	**HI All Pathways Adult**
Surface Soil										
2,4-Dinitrotoluene		3.74E+01	2.15E-01	2.31E-02	NA	NA	2.51E-06	1.08E-06	**2.15E-01**	**2.31E-02**
2,6-Dinitrotoluene		1.07E+01	1.23E-01	1.32E-02	NA	NA	1.44E-06	6.16E-07	**1.23E-01**	**1.32E-02**
Dinitrotoluene mixture		5.13E+01	NA	NA	NA	NA	NA	NA	**NA**	**NA**
2,4,6-Trinitrotoluene		6.06E+02	1.39E+01	1.49E+00	NA	NA	1.63E-04	6.98E-05	**1.39E+01**	**1.49E+00**
Lead		2.38E+02	NA	NA	NA	NA	NA	NA	**NA**	**NA**
Aroclor 1260		8.50E+00	NA	NA	NA	NA	NA	NA	**NA**	**0.00E+00**
Surface Soil Sums	**Total HI**		**14.3**	**1.53**	**NA**	**NA**	**0.0002**	**0.00007**	**14**	**2**

COC - Chemical of concern.
HQ - Hazard quotient; HI - Hazard index; sum of the HQ values.
ILCR - Incremental lifetime cancer risk.
mg/kg - Milligrams per kilogram.
NA - Not applicable.
1) HI values equal to or less than 1 are unlikely to result in adverse noncancer human health effects for any member of the exposed population and are regarded as acceptable.
2) ILCR values equal to or less than $1x10^{-5}$ (1 in 100,000) are generally regarded by the Ohio Environmental Protection Agency (OEPA) as acceptable. Risks less than $1x10^{-6}$ are regarded as very minimal, and risks greater than $1x10^{-5}$ are regarded by OEPA as requiring cleanup or further study if appropriate. It is noted that the average lifetime cancer risk of the general American population is estimated as about 400,000 in 1,000,000.

Source: Jacobs, 2010a

Table 2-15

Summary of Total Hazard Index and Total Cancer Risk for Chemicals of Concern[a]
Reservoir No. 2 Burning Ground
Former Plum Brook Ordnance Works, Sandusky, Ohio

	Groundskeeper		Indoor Worker		Adult Hunter		Construction Worker		On-Site Resident		
									Adult	Child	
Contaminant Source	HI[b]	ILCR[c]	HI	ILCR	HI	ILCR	HI	ILCR	HI	HI	ILCR
Inside the Burn Area											
Surface Soil	***12***	*8.E-05*	***6.0***	*4.E-05*	0.67	6.E-06	***33***	5.E-06	***15***	***139***	***3.4E-04***
Subsurface Soil	Nad	NA	NA	NA	NA	NA	***154***	*5.E-05*	***70***	***650***	***3.6E-03***
Outside the Burn Area											
Surface Soil	1.2	*3.E-05*	0.6	1.E-05	0.07	2.E-06	***3.4***	2.E-06	***2***	***14***	*1.0E-04*

[a]The values shown are based on information contained in the text, tables, and appendices of the BHHRA (Jacobs, 2010a).

[b]The hazard index (HI) is a measure of noncancer hazard for an exposed individual.

[c]The incremental lifetime cancer risk (ILCR) is the estimated extra cancer risk which an individual encounters based on exposure to a site.

[d]NA = Not applicable.

Notes:

1. HI values equal to or less than 1 are unlikely to result in adverse noncancer human health effects for any member of the exposed population and are regarded as acceptable.
2. ILCR values equal to or less than 1E-5 (1 in 100,000) are generally regarded by the Ohio Environmental Protection Agency (OEPA) as acceptable.
3. The NCP identifies ILCR values less than 1E-6 (1 in 1,000,000) as negligible, and ILCR values of 1E-6 (1 in 1,000,000) through 1E-4 (1 in 10,000) are within the NCP risk management range. It is noted that the average lifetime cancer risk of the general U.S. population is approximately 40,000 in 100,000.
4. *Italics* (non-bolded) apply only to cancer risks and indicate that the value exceeds the the 1E-5 value that is regarded as acceptable by the OEPA.
5. ***Bold intalics*** indicates that the noncancer hazard is unacceptable, or that the cancer risk value exceeds the NCP risk management range (1E-6 to 1E-4).
6. A child venison consumer was also evaluated for the R2BG. Cancer risks (less than 1E-6) and potential noncancer hazards (less than 0.1) for this receptor were found to be negligible.

Table 2-16

Statistical Summary of Chemicals of Potential Ecological Concern in Soil
Reservoir No. 2 Burning Ground
Former Plum Brook Ordnance Works

Chemical of Potential Ecological Concern	Number of Detects	Number of Samples	Percent Detect	Units	Minimum Detected Concentration	Maximum Detected Concentration	Average	Background	Toxicity Screening Level
Inside the Burn Area									
TCDD TEQ	14	14	100	ng/Kg	0.699	1187	131		0.199
1,3,5-Trinitrobenzene	5	19	26	mg/kg	0.686	85.4	12.6		0.376
1,3-Dinitrobenzene	1	19	5	mg/kg	3.55	3.55	3.00		0.655
2,4,6-Trinitrotoluene	16	19	84	mg/kg	0.394	35,400	4,163		
2,4-Dinitrotoluene	14	19	74	mg/kg	0.370	9,700	920		1.28
2,6-Dinitrotoluene	7	19	37	mg/kg	0.352	1,400	105		0.0328
2-Amino-4,6-Dinitrotoluene	7	13	54	mg/kg	2.96	342	45.1		
2-Nitrotoluene	3	19	16	mg/kg	0.782	7.04	3.43		
3-Nitrotoluene	1	19	5	mg/kg	0.777	0.777	3		
4-Amino-2,6-Dinitrotoluene	4	19	21	mg/kg	2.18	10.6	12.6		
4-Nitrotoluene	3	13	23	mg/kg	0.444	6.67	1.87		
Aluminum	19	19	100	mg/kg	4,640	17,390	10,141	15500	50
Antimony	6	19	32	mg/Kg	0.963	5.55	1.98	9.3	0.142
Arsenic	19	19	100	mg/Kg	4.70	27.8	10.0	36.5	5.7
Barium	19	19	100	mg/Kg	57.8	3,965	469	826	1.04
Beryllium	16	19	84	mg/Kg	0.548	1.27	0.666	1	1.06
Cadmium	14	19	74	mg/Kg	0.0657	2.04	0.534		0.00222
Calcium	19	19	100	mg/Kg	2,945	21,120	7,977	52300	
Chromium	19	19	100	mg/Kg	8.86	81.5	22.6	29	0.4
Cobalt	18	19	95	mg/Kg	6.23	25.2	10.8	116	0.14
Copper	19	19	100	mg/Kg	9.815	1,580	157	56.2	5.4
Iron	19	19	100	mg/Kg	13,130	36,260	23,037	234000	200
Lead	19	19	100	mg/Kg	8.94	8,220	930	48.6	0.0537
Magnesium	19	19	100	mg/Kg	2,300	7,830	4,433	10400	
Manganese	19	19	100	mg/Kg	152	1,000	335	3506	100
Mercury	17	19	89	mg/Kg	0.0218	0.409	0.139	0.1	0.1
Nickel	19	19	100	mg/Kg	16.4	103	41.5	55.1	13.6
Potassium	18	19	95	mg/Kg	928	2,870	1,615	3390	
Selenium	18	19	95	mg/Kg	0.267	4.47	1.41	2	0.0276
Sodium	13	19	68	mg/Kg	64.7	1,390	400		
Thallium	14	19	74	mg/Kg	1.30	3.32	1.69	1.3	0.0569
Vanadium	19	19	100	mg/Kg	10.5	40.8	25.0	40.9	1.59
Zinc	19	19	100	mg/Kg	48.6	1,540	308	322	6.62
Acenaphthene	11	19	58	mg/kg	0.0909	67.4	7.90		20
Naphthalene	10	19	53	mg/kg	0.234	51.3	5.91		0.0994
Aroclor 1260	11	19	58	mg/kg	0.632	11.6	2.93		
Cyclohexane	5	13	38	mg/kg	0.00083	0.0249	0.00458		
Isopropylbenzene (Cumene)	1	12	8	mg/kg	0.00130	0.00130	0.00039		
Methylcyclohexane	4	10	40	mg/kg	0.00110	0.0239	0.00302		

Table 2-16

Statistical Summary of Chemicals of Potential Ecological Concern in Soil
Reservoir No. 2 Burning Ground
Former Plum Brook Ordnance Works

(Page 2 of 2)

Chemical of Potential Ecological Concern	Number of Detects	Number of Samples	Percent Detect	Units	Minimum Detected Concentration	Maximum Detected Concentration	Average	Background	Toxicity Screening Level
Outside the Burn Area									
1,3,5-Trinitrobenzene	13	55	24	mg/kg	0.210	15.0	0.58		0.376
2,4,6-Trinitrotoluene	33	55	60	mg/kg	0.140	2,270	50.0		
2,4-Dinitrotoluene	25	55	45	mg/kg	0.240	200	5.30		1.28
2,6-Dinitrotoluene	14	55	25	mg/kg	0.152	78.0	1.90		0.0328
2-Amino-4,6-Dinitrotoluene	16	45	36	mg/kg	0.150	26.0	1.08		
2-Nitrotoluene	6	55	11	mg/kg	0.110	2.00	0.268		
4-Amino-2,6-Dinitrotoluene	16	55	29	mg/kg	0.130	27.0	2.13		
4-Nitrotoluene	1	45	2	mg/kg	0.260	0.260	0.0691		
HMX	4	55	7	mg/kg	0.150	0.820	0.424		
RDX	2	55	4	mg/kg	0.270	0.540	0.416		
Aluminum	45	45	100	mg/Kg	8,840	16,450	11,571	15500	50
Antimony	3	45	7	mg/Kg	0.534	0.782	1.37	9.3	0.142
Arsenic	45	45	100	mg/Kg	5.13	21.7	8.63	36.5	5.7
Barium	45	45	100	mg/Kg	47.1	263	103	826	1.04
Cadmium	35	45	78	mg/Kg	0.0771	1.74	0.400		0.00222
Calcium	45	45	100	mg/Kg	2,320	61,200	8,863	52300	
Chromium	45	45	100	mg/Kg	10.7	26.7	17.8	29	0.4
Cobalt	45	45	100	mg/Kg	4.02	30.1	8.52	116	0.14
Copper	45	45	100	mg/Kg	13.0	534	48.1	56.2	5.4
Iron	45	45	100	mg/Kg	11,550	33,300	20,665	234000	200
Lead	55	55	100	mg/Kg	7.88	603	144	48.6	0.0537
Magnesium	45	45	100	mg/Kg	993	20,100	3,963	10400	
Manganese	45	45	100	mg/Kg	147	3,870	423	3506	100
Mercury	40	45	89	mg/Kg	0.0152	0.518	0.102	0.10	0.10
Nickel	45	45	100	mg/Kg	11.6	96.5	24.5	55.1	13.6
Potassium	45	45	100	mg/Kg	598	2,620	1,562	3390	
Selenium	21	45	47	mg/Kg	0.527	2.13	0.727	2.0	0.0276
Sodium	21	45	47	mg/Kg	45.9	402	154		
Thallium	10	45	22	mg/Kg	1.20	2.10	0.914	1.3	0.0569
Vanadium	45	45	100	mg/Kg	20.3	41.4	27.4	40.9	1.59
Zinc	45	45	100	mg/Kg	35.7	498	120	322	6.62
Naphthalene	11	55	20	mg/kg	0.0234	1.74	0.104		0.0994
Aroclor 1260	33	55	60	mg/kg	0.0130	44.4	1.60		
Cyclohexane	2	20	10	mg/kg	0.000720	0.00390	0.000448		

COPEC - chemical of potential ecological concern; TCDD TEQ - 2,3,7,8-tetrachlorodibenzodioxin eqivalents; mg/kg - milligrams per kilogram; ng/kg - nanograms per kilogram
HMX - 1,3,5,7-tetranitro-1,3,5,7-tetrazocane (octogen or High-Molecular-weight rdX); or cyclonite or hexogen or T4)
RDX - 1,3,5-Trinitroperhydro-1,3,5-triazine (cyclotrimethylenetrinitramine)

Note: COPECs were selected as chemicals with a maximum detected concentration that exceeded the toxicity screening level or for which no screening level was available.

Source: Jacobs, 2010b

Table 2-17

Statistical Summary of Chemicals of Potential Ecological Concern in Sediment
Reservoir No. 2 Burning Ground
Former Plum Brook Ordnance Works

Chemical of Potential Ecological Concern	Number of Detects	Number of Samples	Percent Detect	Units	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration	Toxicity Screening Level
TCDD TEQ	3	3	100	ng/Kg	0.120	6.91	3.45	0.12
Cadmium	3	3	100	mg/Kg	0.240	1.40	0.547	0.99
Acenaphthene	1	3	33	mg/kg	5.75	5.75	1.93	0.00671
Acenaphthalene	3	3	100	mg/kg	0.0530	0.853	0.305	0.00587
Anthracene	3	3	100	mg/kg	0.00641	0.288	0.101	0.0572
Benzo(a)anthracene	3	3	100	mg/kg	0.00225	1.13	0.393	0.108
Benzo(a)pyrene	3	3	100	mg/kg	0.126	1.59	0.641	0.15
Benzo(g,h,i)perylene	3	3	100	mg/kg	0.0223	0.728	0.269	0.17
Benzo(k)fluoranthene	3	3	100	mg/kg	0.0415	0.881	0.324	0.24
Chrysene	3	3	100	mg/kg	0.0334	1.33	0.468	0.166
Fluoranthene	3	3	100	mg/kg	0.0755	3.68	1.29	0.423
Indeno(1,2,3-c,d)pyrene	3	3	100	mg/kg	0.0136	0.751	0.266	0.20
Naphthalene	2	3	67	mg/kg	0.216	2.66	0.961	0.176
Phenanthrene	3	3	100	mg/kg	0.0668	1.46	0.583	0.204
Pyrene	3	3	100	mg/kg	0.0309	2.44	0.845	0.195
Acetone	3	3	100	mg/kg	0.0138	0.234	0.145	0.0099
2-Butanone	2	3	67	mg/kg	0.0365	0.0512	0.0301	0.0424
1,1-Dichloroethane	1	3	33	mg/Kg	0.00450	0.00450	0.00181	0.000575

TCDD TEQ - 2,3,7,8-tetrachlorodibenzodioxin eqivalents; mg/kg - milligrams per kilogram; ng/kg - nanograms per kilogram

Note: COPECs were selected as chemicals with a maximum detected concentration that exceeded the toxicity screening level or for which no screening level was available.

Source: Jacobs, 2010b

Table 2-18

Terrestrial Receptors Ecological Hazard Summary
Reservoir No. 2 Burning Ground
Former Plum Brook Ordnance Works, Sandusky, Ohio

COCs and Risk-Driving COPECs[a]	Exposure Point Concentration[b] (mg/kg)	Hazard Quotient						
		Short-tailed Shrew	White-tailed Deer	Marsh Wren	Deer Mouse	Eastern Cottontail Rabbit	Red-Tailed Hawk	Raccoon
Inside the Burn Area								
TCDD TEQ[c]	3.71E-04	***92***	0.006	NV	***45***	2	NV	***11***
2,4-Dinitrotoluene[c]	6.98E+03	***16,000***	**63**	***3,000***	***19,000***	***8,200***	***35***	***540***
2,6-Dinitrotoluene[c]	2.40E+02	***460***	2	***83***	***660***	***330***	1	***14***
2,4,6-Trinitrotoluene[c]	6.05E+03	***2,800***	5	***4,200***	***2,200***	***640***	***36***	***120***
Lead[c]	2.04E+03	5	0.02	3	3	2	0.03	0.07
Barium	2.76E+03	***26***	0.06	3	**20**	10	0.03	0.3
Acenaphthene	1.61E+01	***270***	0.002	NV	**140**	0.4	NV	***230***
Naphthalene	1.21E+01	***64***	0.004	NV	**33**	0.6	NV	***17***
Outside the Burn Area								
2,4-Dinitrotoluene[c]	2.17E+01	***51***	0.2	9	***59***	***26***	0.1	***14***
2,6-Dinitrotoluene[c]	8.22E+00	***16***	0.09	3	***23***	***11***	0.04	2
2,4,6-Trinitrotoluene[c]	6.06E+02	***280***	0.5	***420***	***230***	***64***	4	***12***
Lead[c]	2.43E+02	0.6	0.001	0.3	0.3	0.3	0.004	0.4

COC - Chemical of concern; COPEC - chemical of potential ecological concern; mg/kg - milligram(s) per kilogram;
TCDD TEQ - 2,3,7,8-tetrachlorinated dibenzodioxin toxicity equivalency; NV - no toxicity value available.

Note: Values in bold italics indicate that hazard quotient for the chemical-receptor combination exceeds a value of 10.

[a] Includes chemicals identified as COPECs in the screening-level ecological risk assessment (SLERA) (Jacobs, 2010b) that have a hazard quotient which exceeds a value of 10 for one or more receptors. The exception is lead, which is shown on this table because it is a COC that was identified as a COPEC, both inside and outside the Burn Area.

[b] The exposure point concentration is the upper 95th percent confidence limit of the arithmetic mean concentration for each chemcial shown, at a soil depth of 0 to 5 feet below ground surface.

[c] Chemical is a COC.

Source: Jacobs, 2010b

Table 2-19

Remedial Goals for Soil
Reservoir No. 2 Burning Grounds
Former Plum Brook Ordnance Works
Sandusky, Ohio

COC	Units	RG[a] (mg/kg)	Basis of RG	HQ of RG	ILCR of RG
TCDD TEQ	ng/kg	18	cancer risk[b]	0.2	4E-6
2,4,6-Trinitrotoluene	mg/kg	38	noncancer hazard	1	2E-6
2,4-Dinitrotoluene	mg/kg	1.4[c]	cancer risk[b]	0.01[d]	2E-6
2,6-Dinitrotoluene	mg/kg	1.4[c]	cancer risk[b]	0.02[d]	2E-6
Aroclor 1254[e]	mg/kg	1.0	cancer risk/noncancer hazard[f]	0.9	4.5E-6[g]
Aroclor 1260[e]	mg/kg	1.0	cancer risk[f]	NA	4.5E-6[g]
Lead	mg/kg	400	guidance/IEUBK Model[h]	NA	NA
Total HI/ILCR				**1**[i]	**1E-5** (1.45E-5)[j]

[a] The RGs were derived assuming unrestricted land use and are based on residential exposure, including all exposure pathways for the resident. Cancer-based RGs include combined childhood (6 years) and adult (24 years) exposure. Noncancer-based RGs are based on childhood exposure only, which is the most conservative assumption for noncancer effects.

[b] Considers cumulative cancer effects among the COCs.

[c] RG values of 2,4- and 2,6-dinitrotoluene may alternatively be added (2.8 mg/kg combined).

[d] RG derived on the basis of carcinogenicity of dinitrotoluene mixture; noncancer effects are negligible (HQ<0.1).

[e] RG based on combined Aroclor 1254 and 1260 concentrations.

[f] In additional to cancer risk and (for Aroclor 1254) noncancer hazard, this value of 1 mg/kg was selected because it was used for other Plum Brook Ordnance Works sites.

[g] ILCR for combined Aroclor 1254 and 1260 concentration of 1 mg/kg.

[h] RG is based on the EPA soil screening value for average lead concentration (USEPA, 1998). This screening level is consistent with the U.S. Environmental Protection Agency (EPA), 2010b, *Integrated Exposure Uptake Biokinetic Model for Lead in Children, Windows® version (IEUBKwin v1.1 build 11)*, February.

[i] Total HI reflects the HQ of the RG representing the highest noncancer hazard (TNT). The noncancer effects of TNT are not additive with those of the other COCs, because the other COCs have different target organs with respect to their critical effects.

[j] Value outside of parentheses is for nitroaromatics at the RG levels; value shown in parentheses is the total ILCR assuming the combined Aroclor 1254/1260 concentration is equal to the RG. This combined ILCR rounds to an ILCR of 1E-5.

COC - Chemical of concern.
HI - Hazard index; sum of HQ values.
HQ - Hazard quotient.
IEUBK - Integrated Exposure Uptake Biokinetic.
ILCR - Incremental lifetime cancer risk.
mg/kg - Milligrams per kilogram.
NA - Not applicable.
ng/kg - Nanograms per kilogram.
RG - Remedial goal.
TBC - To be considered criterion.
TCDD TEQ - 2,3,7,8-Tetrachlorodibenzo-p-dioxin toxicity equivalency.

Source: Shaw, 2011

Table 2-20

Implications of Human Health Soil RGs on Ecological Receptors
Reservoir No. 2 Burning Ground, Former Plum Brook Ordnance Works
Sandusky, Ohio

Inside the Burn Area							
Chemical[a]	**Human Health RG (mg/kg)**	**Expected Residual Conc. (mg/kg)[b]**	**Maximum EHQ (and receptor)[c]**		**EPC[d] for Ecological Receptor (mg/kg)**	**Scaled[e] EHQ Using Expected Residual Conc.**	**Estimated Ecological Hazard Reduction Factor[f]**
2,3,7,8-TCDD TEQ[g]	18	18	92	shrew	371	4	21
2,4-Dinitrotoluene	1.4	1.4	19,000	mouse	6978	4	4984
2,6-Dinitrotoluene	1.4	1.4	660	mouse	240	4	171
2,4,6-Trinitrotoluene	38	38	4,200	wren	6048	26	159
Acenaphthene	NA	0.241	280	shrew	16.1	4	67
Naphthalene	NA	0.234	64	shrew	12.1	1	52

Outside the Burn Area							
Chemical[a]	**Human Health RG (mg/kg)**	**Expected Residual Conc. (mg/kg)[b]**	**Maximum EHQ (and receptor)[c]**		**EPC[d] for Ecological Receptor (mg/kg)**	**Scaled[e] EHQ Using Expected Residual Conc.**	**Estimated Ecological Hazard Reduction Factor[f]**
2,4-Dinitrotoluene	1.4	1.4	59	mouse	21.7	4	16
2,6-Dinitrotoluene	1.4	1.4	23	mouse	8.2	4	6
2,4,6-Trinitrotoluene	38	38	420	wren	606	26	16

RG=Remedial goal; EHQ=ecological hazard quotient; 2,3,7,8-TCDD TEQ=2,3,7,8-tetrachlorinated dibenzo-p-dioxin Toxicity Equivalents
mg/kg=milligram per kilogram; NA = not applicable

[a] Chemicals shown are those which are site-related and have an ecological hazard quotient greater than 10 in at least one receptor as reported in the screening level ecological risk assessment (SLERA) (Jacobs, 2010), as updated by October 2011 replacement pages.

[b] Residual concentration is assumed to be the RG for all chemicals of concern (COC). For non-COCs, residual concentration is assumed to be the highest

[c] Value and corresponding receptor shown are for the highest EHQ value among receptors evaluated in the SLERA.

[d] Value shown is from the SLERA.

[e] Estimated using the following scaling relationship:

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

Note that the resultant scaled quotients are rounded to one significant figure.

[f] Estimated by dividing pre-remediation EPC by expected residual concentration (note that EHQs are linear with concentration).

Ecological hazard reduction factors are rounded to the nearest whole number.

[g] Units for 2,3,7,8-TCDD TEQ are in nanograms per kilogram (ng/kg).

Source: Shaw, 2011

Table 2-21

Comparative Analysis of Remedial Alternatives
Reservoir No. 2 Burning Grounds
Former Plum Brook Ordnance Works
Sandusky, Ohio

Criteria	**Alternative 1:** No Action	**Alternative 2:** Excavation and Off-Site Disposal	**Alternative 3:** Excavation, Windrow Composting, Chemical Stabilization, On-Site and Off-Site Disposal	**Alternative 4:** Excavation, Alkaline Hydrolysis, Chemical Stabilization, On-Site and Off-Site Disposal
Overall Protectiveness				
Human Health Protection	No reduction in risk.	Reduces the concentration of COCs to levels below RGs.	Reduces the concentration of COC to levels below RGs.	Reduces the concentration of COC to levels below RGs.
Environmental Protection	No reduction in risk.	Significantly reduces the hazard quotients calculated for ecological receptors, and lowers the likelihood of contaminant spread to other media.	Significantly reduces the hazard quotients calculated for ecological receptors, and lowers the likelihood of contaminant spread to other media.	Significantly reduces the hazard quotients calculated for ecological receptors, and lowers the likelihood of contaminant spread to other media.
Compliance with ARARs				
Chemical-Specific ARARs	No chemical-specific ARARs.	No chemical-specific ARARs.	No chemical-specific ARARs.	No chemical-specific ARARs.
Location-Specific ARARs	No location-specific ARARs.	No location-specific ARARs.	No location-specific ARARs.	No location-specific ARARs.
Action-Specific ARARs	No action-specific ARARs.	Complies with all action-specific ARARs.	Complies with all action-specific ARARs.	Complies with all action-specific ARARs.

Table 2-21

Comparative Analysis of Remedial Alternatives
Reservoir No. 2 Burning Grounds
Former Plum Brook Ordnance Works
Sandusky, Ohio

Criteria	**Alternative 1:** No Action	**Alternative 2:** Excavation and Off-Site Disposal	**Alternative 3:** Excavation, Windrow Composting, Chemical Stabilization, On-Site and Off-Site Disposal	**Alternative 4:** Excavation, Alkaline Hydrolysis, Chemical Stabilization, On-Site and Off-Site Disposal
Other Criteria and Guidance	Permits exposures to concentrations of COCs above risk-based RGs that are derived from EPA toxicity data and from the EPA child lead model and associated guidance as described in the human health risk assessment.	Prevents exposures to concentrations of COCs above risk-based RGs that are derived from EPA toxicity data and from the EPA child lead model and associated guidance as described in the human health risk assessment.	Prevents exposures to concentrations of COCs above risk-based RGs that are derived from EPA toxicity data and from the EPA child lead model and associated guidance as described in the human health risk assessment.	Prevents exposures to concentrations of COCs above risk-based RGs that are derived from EPA toxicity data and from the EPA child lead model and associated guidance as described in the human health risk assessment.
Long-Term Effectiveness and Permanence				
Magnitude of Residual Risk	Existing unacceptable risk will remain.	Residual risk will be within the risk management range.	Residual risk will be within the risk management range.	Residual risk will be within the risk management range.
Adequacy and Reliability of Controls	No controls over remaining contamination. No reliability.	No long-term controls required at site.	No long-term controls required at site.	No long-term controls required at site.
Reduction of Toxicity, Mobility, or Volume through Treatment				
Treatment Process Used	None.	None.	Biological treatment of nitroaromatic compounds and using windrow composting. Ex situ chemical stabilization of lead.	Chemical treatment of nitroaromatic compounds using alkaline hydrolysis. Ex situ chemical stabilization of lead.
Amount Destroyed or Treated	None.	Soil characterized as a hazardous waste will be treated at an off-site facility.	Soil characterized as a hazardous waste will be treated.	Soil characterized as a hazardous waste will be treated.

Table 2-21

Comparative Analysis of Remedial Alternatives
Reservoir No. 2 Burning Grounds
Former Plum Brook Ordnance Works
Sandusky, Ohio

Criteria	**Alternative 1:** No Action	**Alternative 2:** Excavation and Off-Site Disposal	**Alternative 3:** Excavation, Windrow Composting, Chemical Stabilization, On-Site and Off-Site Disposal	**Alternative 4:** Excavation, Alkaline Hydrolysis, Chemical Stabilization, On-Site and Off-Site Disposal
Irreversible Treatment	None.	No on-site treatment.	Composting research has demonstrated that a high percentage (>80%) of TNT-carbon is irreversibly bound to the soil through covalent binding with humic substances. Stabilization may not be an irreversible process, but placement of stabilized waste in an engineered disposal cell minimizes the possibility that conditions conducive to leaching will be created.	Alkaline hydrolysis irreversibly transforms NACs in soil to less toxic end products. Stabilization may not be an irreversible process, but placement of stabilized waste in an engineered disposal cell minimizes the possibility that conditions conducive to leaching will be created.
Type and Quantity of Residuals Remaining after Treatment (all volumes are based on in-place, consolidated soil)	An estimated 7,395 cy (in place volume) of contaminated soil remains on-site. No treatment residuals.	Estimated 9,614 cy (excavated volume) of contaminated soil for off-site disposal as a hazardous waste.	An estimated 11,415 cy of treated soil for off-site disposal as a nonhazardous waste. An estimated 15,818 cy of compost placed back on site.	An estimated 4,931 cy of alkaline hydrolysis treated and neutralized soil that complies with RGs for placement back on site as subsurface backfill. An estimated 5,041 cy of alkaline hydrolysis treated and/or lead stabilized soil for off-site disposal as a nonhazardous waste.

Table 2-21

Comparative Analysis of Remedial Alternatives
Reservoir No. 2 Burning Grounds
Former Plum Brook Ordnance Works
Sandusky, Ohio

Criteria	**Alternative 1:** No Action	**Alternative 2:** Excavation and Off-Site Disposal	**Alternative 3:** Excavation, Windrow Composting, Chemical Stabilization, On-Site and Off-Site Disposal	**Alternative 4:** Excavation, Alkaline Hydrolysis, Chemical Stabilization, On-Site and Off-Site Disposal
Short-Term Effectiveness				
Community Protection	May present future risk to community.	Normal safeguards would be required during transportation of waste materials off site.	Normal safeguards would be required during transportation of waste materials off site.	Normal safeguards would be required during transportation of waste materials off site.
Worker Protection	No risk to workers	Dust released during excavation and screening may require controls.	Safeguards would be required to protect workers from chemical exposures during windrow turning operations. Dust released during excavation, screening, amendment mixing, windrow turning, and stabilization may require controls.	Chemicals used in the treatment process are very corrosive. Material handling processes must be carefully designed to protect workers from chemical exposures. Safeguards would be required to protect workers from chemical exposures during windrow turning operations. Dust released during excavation, screening, amendment mixing, windrow turning, and stabilization may require controls.

Table 2-21

Comparative Analysis of Remedial Alternatives
Reservoir No. 2 Burning Grounds
Former Plum Brook Ordnance Works
Sandusky, Ohio

Criteria	**Alternative 1:** No Action	**Alternative 2:** Excavation and Off-Site Disposal	**Alternative 3:** Excavation, Windrow Composting, Chemical Stabilization, On-Site and Off-Site Disposal	**Alternative 4:** Excavation, Alkaline Hydrolysis, Chemical Stabilization, On-Site and Off-Site Disposal
Environmental Impacts	Continued impact from existing conditions.	Design of staging piles would require safeguards to prevent migration of contaminants.	Design of staging piles would require safeguards to prevent migration of contaminants. Treatment area would be bermed and a contact water retention system provided to control storm water run-on and run-off.	Design of staging piles would require safeguards to prevent migration of contaminants. Treatment area would be bermed and a contact water retention system provided to control storm water run-on and runoff. Hazardous chemicals would be managed to segregate incompatible chemicals and prevent uncontrolled releases to the environment.
Time Until Action is Complete	Not applicable	25 months	34 months	31 months

Table 2-21

Comparative Analysis of Remedial Alternatives
Reservoir No. 2 Burning Grounds
Former Plum Brook Ordnance Works
Sandusky, Ohio

Criteria	**Alternative 1:** No Action	**Alternative 2:** Excavation and Off-Site Disposal	**Alternative 3:** Excavation, Windrow Composting, Chemical Stabilization, On-Site and Off-Site Disposal	**Alternative 4:** Excavation, Alkaline Hydrolysis, Chemical Stabilization, On-Site and Off-Site Disposal
Implementability				
Ability to Construct and Operate	No construction or operation.	No significant issues.	Technologies well developed and implemented on a full-scale basis at numerous sites. Composting previously implemented at TNT Area B and Pentolite Road Red Water Ponds. Chemical stabilization of lead has been used at many sites.	Alkaline hydrolysis using caustic soda to treat NACs in soil is a relatively new process, but has been successfully implemented at full scale at TNT Area A and TNT Area C. Chemical stabilization of lead has been used at many sites.
Ease of Doing More Action if Needed	Does not preclude additional remedial action for soil.	Does not preclude additional remedial action for soil.	Does not preclude additional remedial action for soil.	Does not preclude additional remedial action for soil.
Ability to Monitor Effectiveness	No monitoring performed.	Effectiveness of excavation is evaluated by confirmatory soil sampling and analysis.	Effectiveness of excavation is evaluated by confirmatory soil sampling and analysis. Effectiveness of composting is evaluated by post-treatment sampling and analysis of treated soil. Effectiveness of stabilization evaluated through leaching tests.	Effectiveness of excavation is evaluated by confirmatory soil sampling and analysis. Effectiveness of alkaline hydrolysis is evaluated by post-treatment sampling and analysis of treated soil. Effectiveness of stabilization evaluated through leaching tests.

Table 2-21

Comparative Analysis of Remedial Alternatives
Reservoir No. 2 Burning Grounds
Former Plum Brook Ordnance Works
Sandusky, Ohio

Criteria	**Alternative 1:** No Action	**Alternative 2:** Excavation and Off-Site Disposal	**Alternative 3:** Excavation, Windrow Composting, Chemical Stabilization, On-Site and Off-Site Disposal	**Alternative 4:** Excavation, Alkaline Hydrolysis, Chemical Stabilization, On-Site and Off-Site Disposal
Ability to Obtain Approvals and Coordinate with Other Agencies	None required	Off-site disposal of RCRA waste at a hazardous waste landfill. Off-site disposal of nonhazardous solid waste at landfill approved to accept CERCLA waste.	Off-site disposal of nonhazardous solid waste at landfill approved to accept CERCLA waste.	Off-site disposal of nonhazardous solid waste at landfill approved to accept CERCLA waste.
Availability of Equipment, Specialists, and Materials	None required	Equipment, technical specialists, and materials readily available.	Equipment, technical specialists, and materials readily available.	Equipment, technical specialists, and materials readily available.
Availability of Technologies	None required	Available	Available	Available
Cost				
Capital Cost	None	$3.5 million	$3.8 million	$2.8 million
Annual O&M Cost	None	None	None	None
Present Worth Cost	None	$3.5 million	$3.8 million	$2.8 million
State Acceptance	Not acceptable	To be determined	To be determined	To be determined
Community Acceptance	Not acceptable	To be determined	To be determined	To be determined

ARAR - Applicable or relevant and appropriate requirement.
COC - Chemical of concern.
cy - Cubic yard.
mg/kg - Milligrams per kilogram.
O&M - Operation and maintenance.
OEPA - Ohio Environmental Protection Agency.
RCRA - Resource Conservation and Recovery Act.
RG - Remedial goal.
TNT - Trinitrotoluene.
TSDF - Treatment, storage, and disposal facility.
EPA - U.S. Environmental Protection Agency.

Source: Shaw, 2011

Table 2-22

Cost Estimate for Selected Remedy
Reservoir No. 2 Burning Grounds
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Alternative 4	**Site:** TNT Area A
Excavation/Alkaline Hydrolysis/Stabilization/	Plum Brook Ordnance Works
On- & Off-Site Disposal	**Date: 3/23/2011**
Cost Estimate	

Scope:
1. Prepare work plans and closeout report, and complete procurement.
2. Mobilize/demobilize equipment and personnel.
3. Prepare site for remedial activity.
4. Excavate contaminated soil, perform confirmation sampling & characterize waste.
5. Alkaline hydrolysis and neutralization of soil that is hazardous due to 2,4-DNT TCLP.
7. Chemical stabilization of soil that is hazardous due to lead TCLP.
8. On site disposal of soil treated via alkaline hydrolysis and windrow composting.
9. Off-site disposal of non-hazardous waste.
10. Site restoration.

1.0 Treatability Study, Work Plans, Reports and Procurement

Includes:
1. Labor to generate work plans, including engineering specifications and Health and Safety Plan, along with the Final Report.
2. Procure equipment and materials.
3. Treatability study to optimize AH neutralization and lead stabilzation.

Service	Unit	Unit Cost		Subtotal	
Work Plans and Final Report	1	$75,000.00	/ls	$75,000.00	
Lab Treatability Study	1	$25,000.00	/ls	$25,000.00	
Procurement	1	$15,000.00	/ls	$15,000.00	
				Subtotal	**$115,000.00**

2.0 Mobilization/Demobilization of Equipment and Personnel

Includes:
1. Mobilization and demobilization of local equipment and personnel.
2. Set-up/tear down office trailer.

Assumptions:
1. Labor and equipment are available locally.
2. Pressure washer to be purchased for use during project.

Service/Materials	Unit	Unit Cost		Subtotal	
Labor/Equipment:					
Mobe/Demobe	1	$5,000.00	/ls	$5,000.00	
Office Trailer (set up/tear down)	1	$500.00	/ls	$500.00	
Pressure Washer	1	$500.00	/ls	$500.00	
				Subtotal	**$6,000.00**

3.0 Site Preparation

Includes:
1. Existing site can be used and no additional site preparation costs are required.

Table 2-22

Cost Estimate for Selected Remedy
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Former Plum Brook Ordnance Works
Sandusky, Ohio

4.0 Excavation of Contaminated Soil

Includes:
1. Excavation of soil with contaminants exceeding RGOs.
2. Screen oversize material.
3. Collect confirmatory samples to verify extent of excavation.
4. Staging and characterizing waste stream.

Assumptions and Calculations:

1. Cubic yards of consolidated soil excavated =	7395
2. Swell factor for soil upon excavation =	1.3
3. Cubic yards of unconsolidated soil =	9614
4. Density of unconsolidated soil (tons/cy) =	1.1
5. Mass of unconsolidated soil (tons) =	10575
6. Capacity of screening plant (tons/hr) =	100
7. Excavator: hydraulic backhoe, 1 cy bucket.	
8. Excavator output (cy/day) =	600
9. Days to excavate soil =	19
10. Dump truck capacity (cy) =	12
11. Dump truck haul distance (mi.) =	0.5
12. Dump truck output (cy/day) =	250
13. No. of required dump trucks per day =	2
14. Soil sample collected for waste characterization / cy =	300
15. No. of soil samples collected for waste characterization =	32
16. Number of excavation crew =	2
17. Number of screening crew =	3
18. Lineal foot of excavation per confirmation sample =	20
19. Resampling factor for confirmation sampling =	1.1
20. No. of confirmatory samples from excavated area =	225
21. Excavation area (ft^2) =	48612
22. Cost multiplier for 1-week turnaround on analytical data =	1.25
23. Fraction of excavation work performed in Level C PPE =	0.10
24. Labor productivity factor for Level C work =	0.67
25. Days excavation crew in Level C =	2
26. Days screening crew in Level C =	2
27. Perimeter of excavation area (ft) =	1656
28. Excavation area (sf) =	48612
29. Volume of pit water requiring offsite disposal (gal) =	20000

30. Standard work week is 5 days per week at 8 hours per day. Thus, assuming 22 working days per 31 day month.

Service/Materials	Unit	Unit Cost		Subtotal
Labor:				
Site Superintendent	152	$49.00	/hr	$7,448.00
QA (Sampling) Coordinator	152	$36.00	/hr	$5,472.00
H&S Coordinator	152	$49.00	/hr	$7,448.00
Chemist (home office)	38	$51.00	/hr	$1,938.00
Equipment Operator	19	$406.00	/day	$7,714.00
Equipment Operator	15	$406.00	/day	$6,090.00
Equipment Operator	15	$406.00	/day	$6,090.00
Laborers	34	$341.60	/day	$11,614.40
Truck Drivers	38	$341.60	/day	$12,980.80

Table 2-22

Cost Estimate for Selected Remedy
Reservoir No. 2 Burning Grounds
Former Plum Brook Ordnance Works
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4.0 Excavation of Contaminated Soil (continued)					
Equipment:					
Excavator	1	$4,000.00	/mo	$4,000.00	
100-ton/hr Screening Plant	3	$1,800.00	/wk	$5,400.00	
Radial Stacking Conveyor	3	$1,222.00	/wk	$3,666.00	
Dozer	1	$3,500.00	/mo	$2,625.00	
Dump Truck	1	$3,890.00	/mo	$3,890.00	
Dump Truck	1	$3,890.00	/mo	$3,890.00	
3000 gal. Water Truck	19	$402.00	/day	$7,638.00	
21,000 gal Frac Tank	6	$1,400.00	/mo	$8,400.00	
150 gpm Pump	1	$2,439.00	/ea.	$2,439.00	
300 gpm Pump	1	$3,749.00	/ea.	$3,749.00	
Office Trailer	1	$800.00	/mo	$800.00	
Porta Jon	1	$175.22	/mo	$175.22	
Generator	1	$170.35	/mo	$170.35	
P/U Truck	1	$1,800.00	/mo	$1,800.00	
Analytical:					
TCLP Extraction	32	$12.88	/ea	$412.00	
SVOCs (8270C)	257	$300.00	/ea	$77,100.00	
NACs (8330)	257	$197.50	/ea	$50,757.50	
Lead	257	$30.00	/ea	$7,710.00	
PCBs	257	$103.75	/ea	$26,663.75	
NAC field analyses	225	$40.00	/ea	$9,000.00	
Lead field analyses	1	$4,200.00	/mo.	$4,200.00	
Shipping	69	$40.00	/ea	$2,741.33	
Materials & Services:					
Level D PPE	73	$10.00	/day	$730.00	
Level C PPE	10	$35.00	/day	$350.00	
PID rental	1	$974.00	/mo.	$974.00	
CGI rental	1	$380.00	/mo.	$380.00	
Pit Water Disposal	20	$1.62	/kgal	$32.40	
				Subtotal	**$296,489.00**

Table 2-22

Cost Estimate for Selected Remedy
Reservoir No. 2 Burning Grounds
Former Plum Brook Ordnance Works
Sandusky, Ohio

5.0 Alkaline Hydrolysis with Neutralization

Includes:
1. Treat the 2,4-DNT contaminated soil with caustic soda pellets and 30% ferric chloride solution.
2. Neutralize alkaline hydrolysis treated soil with ferrous sulfate.
3. Temporary storage for the caustic soda pellets, 30% ferric chloride, and ferrous sulfate.

Assumptions and Calculations:

1. Volume of consolidated 2,4 DNT soil to be treated (cy) =		6095	
2. Swell factor for soil upon excavation =		1.3	
3. Cubic yards of unconsolidated soil =		7924	
4. Soil shall be treated via alkaline hydrolysis using caustic acid in 300 cy batches within the treatment area.			
5. Each 300 cy area =	52 ft Wide	52 ft Long	
6. Batch size (cy) =		300	
7. Soil to be spread out to a depth of (ft) =		3	
8. Treatment chemical requirements based on treatability study conducted by Shaw E&I Technology Dev. Lab			
9. Caustic soda, NaOH pellets =		61	lb/cy soil
10. Water, used to saturate soil with water =		37	gal/cy soil
11. Ferric chloride 30% solution =		1	gal/cy soil
12. NaOH mol wt =		40	lb/lb mol
13. Ferrous sulfate needed to neutralize NaOH =		108	lb/cy soil
14. Number of days for completed treatment with neutralization =		21	
15. Number of batches =		27	
16. Number of batches during one treatment cycle =		5	
17. Number of treatment cycles =		6	
18. Standard work week is 5 days per week at 8 hours per day. Thus, assuming 22 working days per 31 day month.			
19. Number of field days =		126	
20. Number of field crew =		8	
21. Mass of caustic soda (lb) =		483364	
22. Volume of ferric chloride, 30% solution (gal) =		7924	
23. Density of 30% ferric chloride solution (lb/gal) =		10.77	
24. Volume of water (gal) =		293188	

25. Confirmation sampling for alkaline hydrolysis prior to neutralization shall consist of nitroaromatics, nitrate and nitrite, and pH, one sequence per batch.
26. Upon neutralization with the citric acid confirmation sampling shall be performed for nitrate and nitrite, and pH, one sequence per batch.
27. Temporary storage is required for the caustic soda pellets, 30% ferric chloride, ~~and ferrous sulfate~~ preventing exposure to inclement weather and release into the environment. The duration for the alkaline hydrolysis is 20 days. Therefore assume equipment rental for 1.5 months.
28. The caustic soda pellets come in 2000 pound super sacks at approximately 4-feet by 4-feet by 3-feet high.

29. Number of caustic soda super sacks (ea) =	242	
30. Required storage capacity for caustic soda pellets (cf) =	11616	

31. The 30% ferric chloride solution comes in 330 gallon totes at approximately 46.5-inches by 46.5-inches by 48-inches high.

32. Number of 30% ferric chloride solution totes (ea) =	25	
33. Required storage capacity for 30% ferric acid solution (cf) =	1502	

34. The ferrous sulfate comes in 2,000 pound super sacks at 4-feet by 4-feet by 3-feet high or a 48 cubic feet pallet.

35. Number of ferrous sulfate super sacks or pallets (ea) =	430	
36. Required storage capacity for ferrous sulfate (cf) =	20640	

37. Temporary storage shall be provided utilizing a 48-foot swing open-door land-sea cargo trailer. The trailer is 45.42-feet long by 8.25 -feet wide by 9-feet high. 40 super sacks per trailer. The monthly rental is $100/mo.

38. Available capacity in the Land-Sea Cargo Trailer (cf) =	1920	
39. Number of Land-Sea Cargo Trailers for caustic soda pellets (ea)		7
40. Number of Land-Sea Cargo Trailers for 30% ferric chloride solution (ea) =		1
41. Number of Land-Sea Cargo Trailers for ferrous sulfate (ea) =		11

42. Phosphoric acid is used in place of ferrous sulfate will be used to partially neutralize the AH treated soil because it also facilitates lead stabilization (See section 6.0).

Table 2-22

Cost Estimate for Selected Remedy
Reservoir No. 2 Burning Grounds
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Service/Materials	Unit	Unit Cost		Subtotal	
5.0 Alkaline Hydrolysis with Neutralization (continued)					
Labor:					
Site Superintendent	1008	$49.00	/hr	$49,392.00	
QA (Sampling) Coordinator	1008	$36.00	/hr	$36,288.00	
H&S Coordinator	1008	$49.00	/hr	$49,392.00	
Sampling Technician	1008	$28.00	/hr	$28,224.00	
Equipment Operator	126	$406.00	/day	$51,156.00	
Equipment Operator	126	$406.00	/day	$51,156.00	
Equipment Operator	126	$406.00	/day	$51,156.00	
Equipment Operator	126	$406.00	/day	$51,156.00	
Equipment Operator	126	$406.00	/day	$51,156.00	
Equipment Operator	126	$406.00	/day	$51,156.00	
Laborer	126	$341.60	/day	$43,041.60	
Laborer	126	$341.60	/day	$43,041.60	
Equipment:					
Dozer	6	$3,500.00	/mo	$20,650.00	
Excavator	6	$4,000.00	/mo	$23,600.00	
Excavator	6	$4,000.00	/mo	$23,600.00	
Front End Loader	6	$5,000.00	/mo	$29,500.00	
Fork Lift	6	$6,480.00	/mo	$38,232.00	
Fork Lift	6	$6,480.00	/mo	$38,232.00	
4000 gal. Water Truck	6	$402.00	/day	$2,371.80	
21,000 gal Frac Tank	12	$1,400.00	/mo	$16,520.00	
Air Monitoring	6	$750.00	/ls	$4,425.00	
Office Trailer	6	$800.00	/mo	$4,720.00	
Porta Jon	6	$175.22	/mo	$1,033.79	
Generator	6	$170.35	/mo	$1,005.08	
P/U Truck	6	$1,800.00	/mo	$10,620.00	
Materials:					
Caustic Soda	483364	$0.45	/lb	$217,513.80	Brenntag - Pgh
Ferric Chloride 30% Solution	85342	$0.15	/lb	$12,801.30	Brenntag - Pgh
Water	293	$9.40	/1000 gal	$2,754.20	
Ferrous Sulfate	858962	$0.11	/lb	$93,626.86	Crown Technology
Level C PPE	1008	$35.00	/day	$35,280.00	
PID rental	5.9	$974.00	/mo.	$5,746.60	
CGI rental	5.9	$380.00	/mo.	$2,242.00	
Chem Storage - NaOH pellets	42	$100.00	/mo.	$4,200.00	
Chem Storage - 30% $FeCl_3$	6	$100.00	/mo.	$600.00	
Chem. Storage - $FeSO_4$*7H_2O	66	$100.00	/mo.	$6,600.00	
Analytical:					
Pre-Compliance Sampling:					
pH meter	1	$1,800.00	/ea	$1,800.00	
Compliance Sampling for Alkaline Hydrolysis:					
NACs (8330)	27	$145.00	/ea	$3,915.00	
TCLP 2,4-DNT	27	$173.00	/ea	$4,671.00	
E300 - Nitrite and Nitrate	27	$15.00	/ea	$405.00	
Compliance Sampling Following Neutralization with Ferrous Sulfate:					
E300 - Nitrite and Nitrate	27	$15.00	/ea	$405.00	
				Subtotal	**$1,163,386.00**

Table 2-22

Cost Estimate for Selected Remedy
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Former Plum Brook Ordnance Works
Sandusky, Ohio

6.0 Chemical Stabilization of Lead-Contaminated Soil

Includes:
1. Chemical stabilzation of lead using phosphate chemicals.
2. Compliance testing for TCLP lead.

Assumptions and Calculations:

1. Vol. consolidated Pb contaminated soil inside Burn Area (cf) =	1263		
2. Vol. consolidated Pb contaminated soil outside Burn Area (cf) =	2339		
3. Volume of in-place lead contaminated soil to be stabilized (cy)=	3602		
4. Vol. of in-place soil AH treated + Pb stabilized (cy) =	2302		
5. Swell factor for soil upon excavation =	1.3		
6. Vol of unconsolidated soil for Pb stabilization (cy) =	4683		
7. Density of soil (ton/cy) =	1.1		
8. Mass of lead-contaminated soil (tons) =	5151		
9a. Average Pb conc. inside Burn Area soil (mg/kg) =	924	207.2	Pb mol. wt.
9b. Average Pb conc. outside Burn Area soil (mg/kg) =	116		
10. Vol.-wt. average lead conc. (mg/kg) =	399		
11. Mass of Pb to stabilize (lb) =	4114		
12. P/Pb molar stabilization ratio =	4.0	31	P mol. wt.
13. Mass of P required to stabilize Pb in soil (lb) =	2462		
14. Weight fraction H_3PO_4 in food grade acid =	0.75	0.316	lb P/lb H_3PO_4
15. Mass of 75% H_3PO_4 needed to stabilize Pb in soil (lb) =	10388	13.1	lb H_3PO_4/gal soln
16. Volume of H_3PO_4 needed to stabilize Pb in soil (gal) =	793		
17. Volume of H_3PO_4 container (gal) =	330		
18. Number of H_3PO_4 containers purchased =	3		
19. Total volume of H_3PO_4 purchased (gal) =	990		
20. Application rate of Apatite II (ton/cy) =	0.0267	ESTCP, 2006	
		Based on unconsolidate soil volume	
21. Mass of Apatite II required for Pb Stabilization (ton) =	124.9	before composting	
22. Mass of Apatite II per shipping container (ton) =	20		
23. Number of shipping containers of Apatite II =	6.245		
24. Mass of Apatite II per supersack (lb) =	1650		
25. Number of supersacks of Apatite II =	6.0		
26. Each 300 cy treatment cell =	52 ft Wide		52 ft Long
27. Size of stabilization batch (cy) =	300		
28. Soil to be spread out to a depth of (ft) =	3		
29. Number of days for batch treatment =	3	Includes expidited analytical turnaround	
30. Number of batches =	16		
31. Number of batches during one treatment cycle =	5		
32. Number of treatment cycles =	4		
33. Time required to stabilize soil (days) =	12		
34. Number of field crew =	2		

35. Standard work week is 5 days per week at 8 hours per day. Thus, assuming 22 working days per month.

36. The 75% H_3PO_4 solution comes in 330 gallon totes at approximately 46.5-inches by 46.5-inches by 48-inches high.

37. Required storage capacity for 30% ferric acid solution (cf) =	181		

38. Temporary storage shall be provided utilizing a 48-foot swing open-door land-sea cargo trailer. The trailer is 45.42-feet long by 8.25 -feet wide by 9-feet high. The monthly rental is $100/mo.

39. Available capacity in the Land-Sea Cargo Trailer (cf) =	1920	
40. Number of Land-Sea Cargo Trailers for 75% H3PO4 =	1	
41. Loader output (cy/day) =	1735	
42. Stage and remove chemical storage (days) =	2	
43. Time to move composted soil into stabilization cells (days)=	0	Same cells as AH
44. Total time on site (days) =	14	

Table 2-22

Cost Estimate for Selected Remedy
Reservoir No. 2 Burning Grounds
Former Plum Brook Ordnance Works
Sandusky, Ohio

6.0 Chemical Stabilization of Lead-Contaminated Soil (continued)						
Service/Materials	**Unit**	**Unit Cost**		**Subtotal**		
Labor:						
Site Superintendent	112	$49.00	/hr	$5,488.00		
QA (Sampling) Coordinator	112	$36.00	/hr	$4,032.00		
H&S Coordinator	112	$49.00	/hr	$5,488.00		
Sampling Technician	112	$28.00	/hr	$3,136.00		
Equipment Operator	14	$406.00	/day	$5,684.00		
Equipment:						
Excavator	0.7	$4,000.00	/mo	$2,800.00		
Office Trailer	0.7	$800.00	/mo	$560.00		
Porta Jon	0.7	$175.22	/mo	$122.65		
Generator	0.7	$170.35	/mo	$119.25		
P/U Truck	0.7	$1,800.00	/mo	$1,260.00		
Materials:						
Apatite II	125	$675.00	/ton	$84,307.50	http://www.pimsnw.com	
Apatite II	0	$2.50	/lb	$0.00	/pricing.php	
MgO	0	$200.00	/ton	$0.00	Stine, 2011	
Level D PPE	28	$10.00	/day	$280.00		
PID rental	0.7	$974.00	/mo.	$681.80		
CGI rental	0.7	$380.00	/mo.	$266.00		
Chem Storage - H_3PO_4	1	$100.00	/mo.	$100.00		
Analytical:						
TCLP Extraction	16	$19.25	/ea	$308.00		
Lead	16	$57.75	/ea	$924.00		
Shipping	16	$40.00	/ea	$640.00		
					Subtotal	**$116,197.00**

Table 2-22

Cost Estimate for Selected Remedy
Reservoir No. 2 Burning Grounds
Former Plum Brook Ordnance Works
Sandusky, Ohio

7.0 On-Site Disposal

Includes:

1. Load alkaline hydrolysis treated soil and stockpile for use as backfill material. The cost to backfill treated soil is accounted for in Section 9.0.
2. Confirmation testing under contaminated soil stockpiles.

Assumptions and Calculations:

1. Consol. vol. of inside burn area AH treated soil (cy) =	5,056
2. Consol. vol. of soil inside burn area with COC > RG or PB stabilized (cy) =	1,263
3. Vol. of consolidated AH treated soil for onsite disposal (cy) =	3,793
4. Swell factor for soil upon excavation =	1.3
5. Volume of unconsolidated soil used as backfill material (cy) =	4931
6. Loader output (cy/day) =	1735
7. Days to load alkaline hydrolysis treated soil =	4
8. Dump truck capacity (cy) =	12
9. Dump truck haul distance (mi.) =	0.5
10. Dump truck output (cy/day) =	300
11. No. of dump trucks per day =	6
12. The treated soil via alkaline hydrolysis only shall be stockpiled prior to use as backfill material as part of site restoration.	
13. The loading and hauling activities shall be performed consecutively.	
14. The duration to load & haul treated soil (days) =	4

Service/Materials	Unit	Unit Cost		Subtotal
Labor:				
Site Superintendent	32	$49.00	/hr	$1,568.00
QA Coordinator	32	$36.00	/hr	$1,152.00
Equipment Operator	4	$406.00	/day	$1,624.00
Equipment Operator	4	$406.00	/day	$1,624.00
Laborer/Oiler	4	$293.00	/day	$1,172.00
Truck Drivers	24	$341.60	/day	$8,198.40
Equipment:				
Wheel Loader	0.2	$5,000.00	/mo	$1,000.00
Dump Truck (6 ea)	1.2	$3,890.00	/mo	$4,668.00
Dozer	0.2	$3,500.00	/mo	$700.00
Office Trailer	1.0	$800.00	/mo	$800.00
Porta Jon	1	$175.22	/mo	$175.22
Generator	1	$170.35	/mo	$170.35
P/U Truck	1	$1,800.00	/mo	$1,800.00
Material:				
PID rental	0.2	$974.00	/mo.	$194.80
CGI rental	0.2	$380.00	/mo.	$76.00
Level D PPE	12	$10.00	/day	$120.00
			Subtotal	**$25,043.00**

Table 2-22

Cost Estimate for Selected Remedy
Reservoir No. 2 Burning Grounds
Former Plum Brook Ordnance Works
Sandusky, Ohio

8.0 Off-Site Disposal

Includes:
1. Dispose non-treated soil at a non-hazardous facility.

Assumptions and Calculations:

1. Consolidated volume of D008 soil for haz disposal (cy) =	0	
2. Consolidated volume of D030 soil for haz disposal (cy) =	0	
3. Consolidated volume of PCB soil for haz disposal (cy) =	0	
4. Total volume of consolidated hazardous soil (cy) =	0	
5. Total volume of unconsolidated hazardous soil (cy) =	0	
6. Consol. volume of treated soil for nonhaz disposal (cy) =	3602	
7. Unconsol. volume of treated soil for nonhaz disposal (cy) =	4683	
8. Weight of soil for nonhaz disposal (tons) =	5151	w/o mass of treatment chemicals
9. Consolidated volume of untreated soil (cy) =	0	
10. Unconsol vol untreated soil for non-hazardous disposal (cy) =	0	
11. Weight of soil for nonhaz disposal (ton) =	1.1	
12. Weight of AH treatment chemicals added to soil (tons) =	714	
13. Fraction of AH treated soil for offsite nonhaz disposal =	0.3777	
14. Wt. of AH treatment chem. in soil for nonhaz disposal (tons) =	270	
15. Weight of Pb stabilization chemicals added to soil (tons) =	125	
16. Weight of treated soil for nonhaz disposal (tons) =	5545	
17. Total volume of treated soil for non-haz disposal (cy) =	5041	Assume %wt↑ = %vol↑
18. Total weight of non-haz waste for offsite disposal (tons) =	5546	
19. Non-haz waste transportation cost ($/hr) =	72	
20. Non-haz waste disposal costs ($/ton) =	24.5	Erie County Landfill
21. Non-haz waste regulatory fees ($/ton) =	0	included in disposal
22. Haz waste transportation cost ($/ton) =	35	
23. D008 Haz waste disposal cost ($/ton) =	75	EO Environmental
24. D030 Haz waste disposal cost ($/ton) =	150	EO Environmental
25. PCB Haz waste disposal cost ($/ton) =	75	EO Environmental
26. Haz waste regulatory fees ($/ton) =	10	
27. No. of field crew =	4	
28. Load capacity of a 20 ton truck (tons) =	15	
29. Round trip travel time to non-haz waste landfill (hr) =	1	
30. Loads of non-haz waste or trips (hrs)=	370	
31. Output of wheel loader (cy/day) =	550	
32. No. of wheel loaders on site =	2	
33. No. of field days =	5	
34. No. of truckloads of stormwater for off-site disposal =	4	
35. Volume of water truck (gal) =	4000	
36. Volume of stormwater requiring off-site disposal (gal) =	16000	
37. Stormwater shall be analyzed for TCLP semivolatiles prior to transport.		
38. At one sample/truckload, no. of stormwater samples (ea) =	4	
39. Standard work week is 5 days per week at 8 hours per day.		

Table 2-22

Cost Estimate for Selected Remedy
Reservoir No. 2 Burning Grounds
Former Plum Brook Ordnance Works
Sandusky, Ohio

8.0 Off-Site Disposal (continued)					
Service/Materials	**Unit**	**Unit Cost**		**Subtotal**	
Labor:					
Site Superintendent	40	$49.00	/hr	$1,960.00	
QA Coordinator	40	$36.00	/hr	$1,440.00	
H&S Coordinator	40	$49.00	/hr	$1,960.00	
Equipment Operator	5	$406.00	/day	$2,030.00	
Equipment Operator	5	$406.00	/day	$2,030.00	
Laborer/Oiler	5	$293.00	/day	$1,465.00	
Laborer/Oiler	5	$293.00	/day	$1,465.00	
Materials:					
Level D PPE	20	$10.00	/day	$200.00	
Equipment:					
Wheel Loader	0.3	$5,000.00	/mo	$1,500.00	
Wheel Loader	0.3	$5,000.00	/mo	$1,500.00	
Office Trailer	0.3	$800.00	/mo	$240.00	
Porta Jon	0.3	$175.22	/mo	$52.57	
Generator	0.3	$170.35	/mo	$51.11	
P/U Truck	0.3	$1,800.00	/mo	$540.00	
Disposal Costs:					
Transportation (Non-Haz Waste)	370	$72.00	/hr	$26,640.00	truck & driver
Disposal Cost (Non-Haz waste)	5546	$24.50	/ton	$135,888.41	
Transportation (Haz Waste)	0	$35.00	/ton	$0.00	
Disposal Cost (D008 haz waste)	0	$85.00	/ton	$0.00	
Disposal Cost (D030 haz waste)	0	$160.00	/ton	$0.00	
Disposal Cost (PCB haz waste)	0	$85.00	/ton	$0.00	
Stormwater Disposal	16000	$0.25	/gal	$4,000.00	Enviro-Tank Clean
Analytical:					
Stormwater Sampling:					
TCLP 2,4-DNT	4	$175.00	/ea	$700.00	
				Subtotal	**$183,662.00**

Table 2-22

Cost Estimate for Selected Remedy
Reservoir No. 2 Burning Grounds
Former Plum Brook Ordnance Works
Sandusky, Ohio

9.0 Site Restoration

Includes:
1. Backfill excavated areas with alkaline hydrolysis treated soil and clean backfill.
2. Re-seed site.

Assumptions and Calculations:

1. Required volume of consolidated soil for excavated area (cy) =	7395	
2. Compaction factor =	1.15	
3. Volume of soil required for backfill (cy) =	8504	
4. Volume of alkaline hydrolysis treated soil (cy) =	4931	(less the lead contaminated soil)
5. Volume of required clean backfill (cy) =	3573	
6. Cost of clean backfill soil delivered to site ($/cy) =	12	
7. Output of front-end loader (cy/day) =	550	
8. Field days required to backfill soil =	7	
9. No. of field crew =	3	

10. Upon completion of remedial action, soil samples shall be taken within the laydown area to determine if any soil removal is required.
11. The laydown area shall be divided into 4 quarters and a 5-point composite collected (4 samples total).
12. No. of soil samples (ea) = 4
13. Allow 1 week for reseeding site and road repair.
14. Task duration (days) = 12
15. Standard work week is 5 days per week at 8 hours per day. Thus, assuming 22 working days per month.

Service/Materials	Unit	Unit Cost		Subtotal	
Labor:					
Site Superintendent	96	$49.00	/hr	$4,704.00	
QA Coordinator	96	$36.00	/hr	$3,456.00	
H&S Coordinator	96	$49.00	/hr	$4,704.00	
Equipment Operator	7	$406.00	/day	$2,842.00	
Equipment Operator	7	$406.00	/day	$2,842.00	
Laborer	7	$341.60	/day	$2,391.20	
Reseeding	1	$5,000.00	/area	$5,000.00	
Road Repair	1	$175,000.00	/ls	$175,000.00	Erie Blacktop
Equipment:					
Dozer	0.4	$3,500.00	/mo	$1,400.00	
Wheel Loader	0.4	$5,000.00	/mo	$2,000.00	
Office Trailer	0.4	$800.00	/mo	$320.00	
Porta Jon	0.4	$175.22	/mo	$70.09	
Generator	0.4	$170.35	/mo	$68.14	
P/U Truck	0.4	$1,800.00	/mo	$720.00	
Material:					
Backfill	3573	$12.00	/cy	$42,880.20	delivered to site
PID rental	0.4	$974.00	/mo.	$389.60	
CGI rental	0.4	$380.00	/mo.	$152.00	
Level D PPE	36	$10.00	/day	$360.00	
Analytical:					
SVOCs	4	$175.00	/ea	$700.00	
NACs (8330)	4	$145.00	/ea	$580.00	
Shipping	4	$40.00	/ea	$160.00	
				Subtotal	**$250,739.00**

Table 2-22

Cost Estimate for Selected Remedy
Reservoir No. 2 Burning Grounds
Former Plum Brook Ordnance Works
Sandusky, Ohio

10.0 Overall Cost	
Total Capital Cost	**$2,156,516.00**
Contingency (25%)	**$539,129.00**
Contractor Oversight (5%)	**$107,826.00**
Total Cost	**$2,803,000.00**

*This is an order-of-magnitude engineering cost estimate that is expected to be within +50 to -30 percent of the actual project cost.

Source: Shaw, 2011

Table 2-23

Applicable and Relevant or Appropriate Requirements for the Selected Remedy
Excavation, Alkaline Hydrolysis, Chemical Stabilization, and Off-Site and On-Site Disposal
Reservoir No. 2 Burning Grounds Proposed Plan
Former Plum Brook Ordnance Works
Sandusky, Ohio

Authority	Medium	Requirement	Status	Synopsis of Requirement	Action to be Taken to Attain Requirement
U.S. Environmental Protection Agency	Soil	Federal Applicability of Treatment Standards (40 CFR 268.40)	Applicable	Prohibits land disposal of hazardous waste unless treatment standards are attained.	Remedial alternatives will comply with the treatment standards for contaminated soil that is placed back on site if the soil is managed outside the contiguous area of contamination.
U.S. Environmental Protection Agency	Soil	Federal Universal Treatment Standards (40 CFR 268.48)	Applicable	Specifies universal treatment standards for hazardous constituents in hazardous waste.	Remedial alternatives will comply with the treatment standards for contaminated soil that is placed back on site if the soil is managed outside the contiguous area of contamination.
U.S. Environmental Protection Agency	Soil	Federal Land Disposal Restriction Alternative Treatment Standards for Contaminated Soil (40 CFR 268.49)	Applicable	Rules specify how the universal treatment standards for hazardous waste are applied for contaminated soil that contains a hazardous waste.	Remedial alternatives will comply with the treatment standards for contaminated soil that is placed back on site if the soil is managed outside the contiguous area of contamination.
U.S. Environmental Protection Agency	Soil	Federal Special Provisions for Cleanup – Staging Piles (40 CFR 264.554)	Applicable	Rule identifies requirements for temporary storage of solid, non-flowing hazardous remediation waste that is not in a containment building.	Remedial alternatives will comply with these requirements by observing the standards and design criteria for staging piles.

CFR – Code of Federal Regulations.

FIGURES

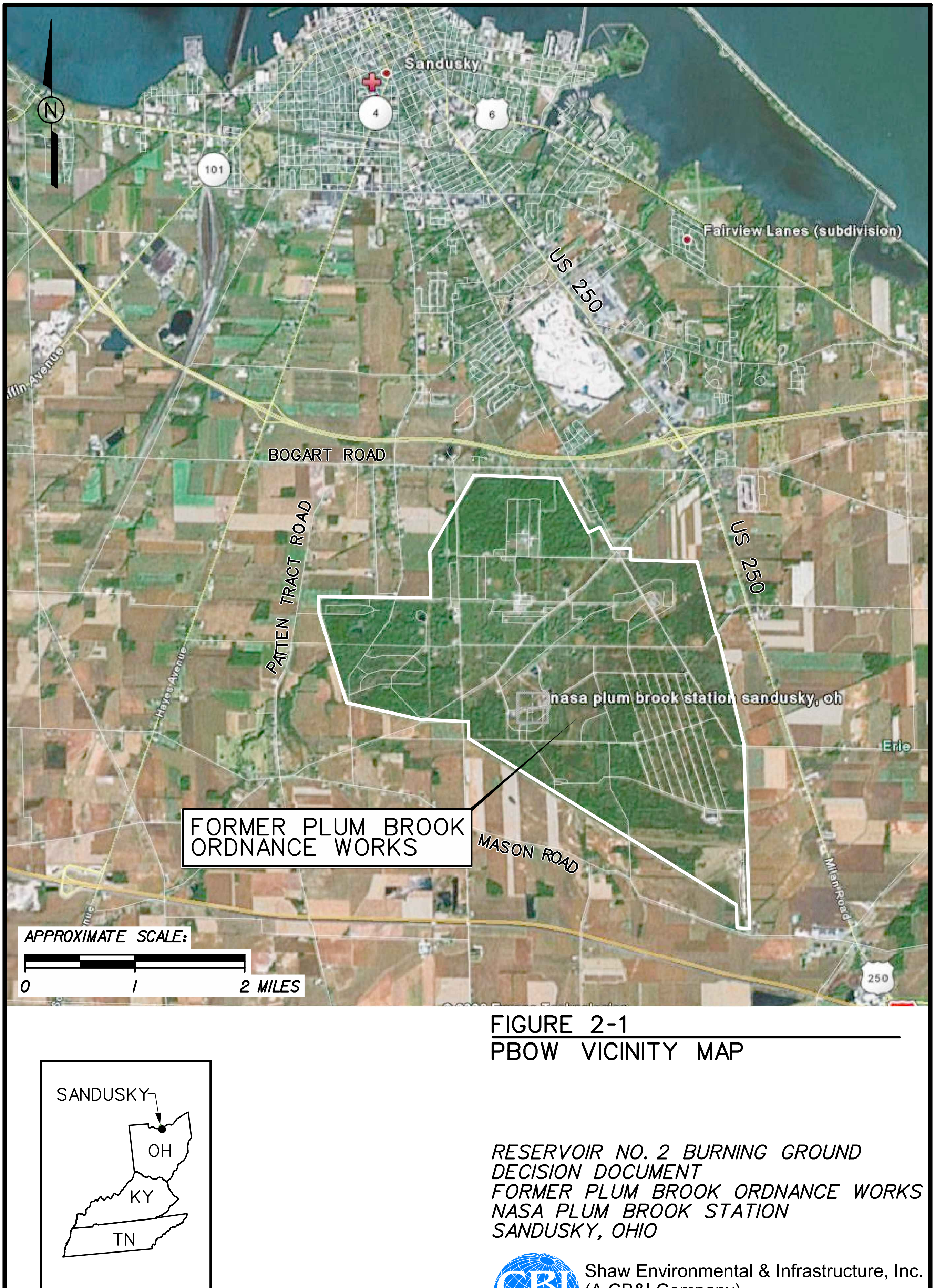

FIGURE 2-1
PBOW VICINITY MAP

RESERVOIR NO. 2 BURNING GROUND
DECISION DOCUMENT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw Environmental & Infrastructure, Inc.
(A CB&I Company)

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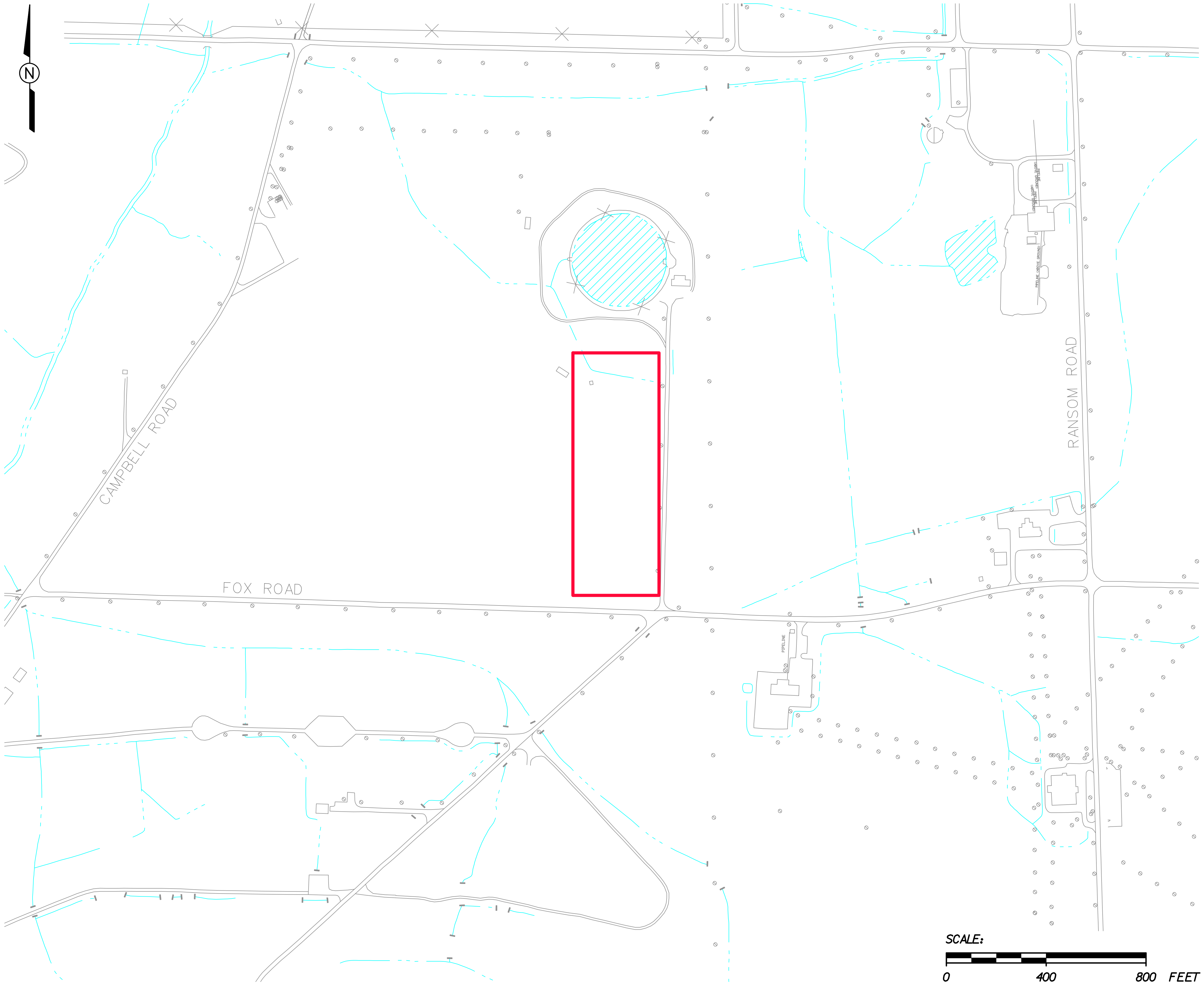


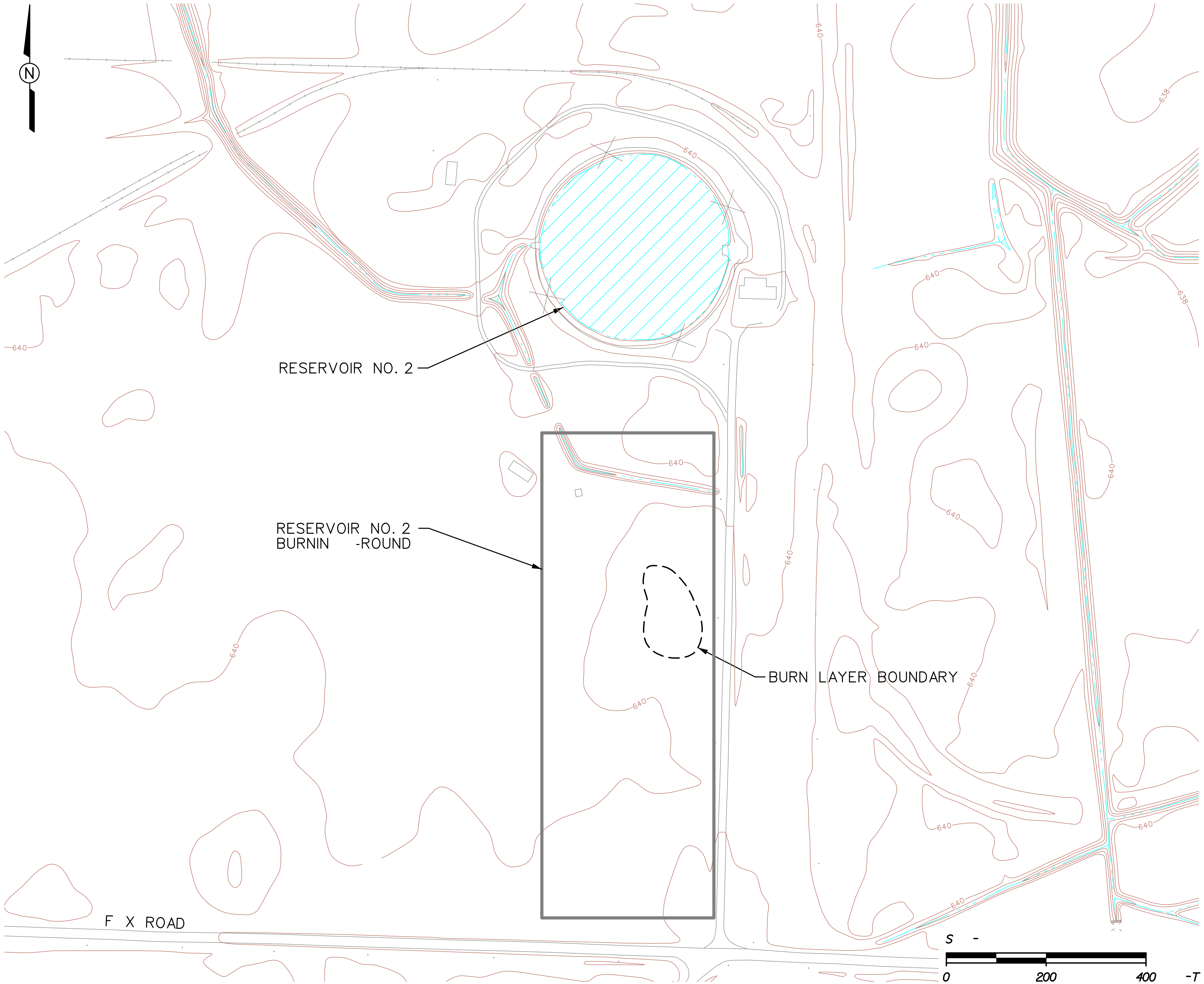
LEGEND:

- AREA OF CONCERN
- POND
- CREEK, DITCH, CONVEYANCE
- ROAD
- FENCE
- FACILITY BOUNDARY

FIGURE 2-2
LOCATION OF RESERVOIR NO.2 BURNING GROUND AT PBOW

RESERVOIR NO.2 BURNING GROUND DECISION DOCUMENT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw Environmental & Infrastructure, Inc.
(A CB&I Company)



LE -END:

- -RE- F ERN
- TOPO -R-PHIC CONTOUR (2 FT. INTERV-
- POND
- CREEK, DITCH, CONVEY- E
- R-ILRO-D
- RO-D
- BURN L-´ER BOUND-RY

FI- RE -

-ENER- ITE FE-TURES WITH SITE TOPO -R-PHY

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

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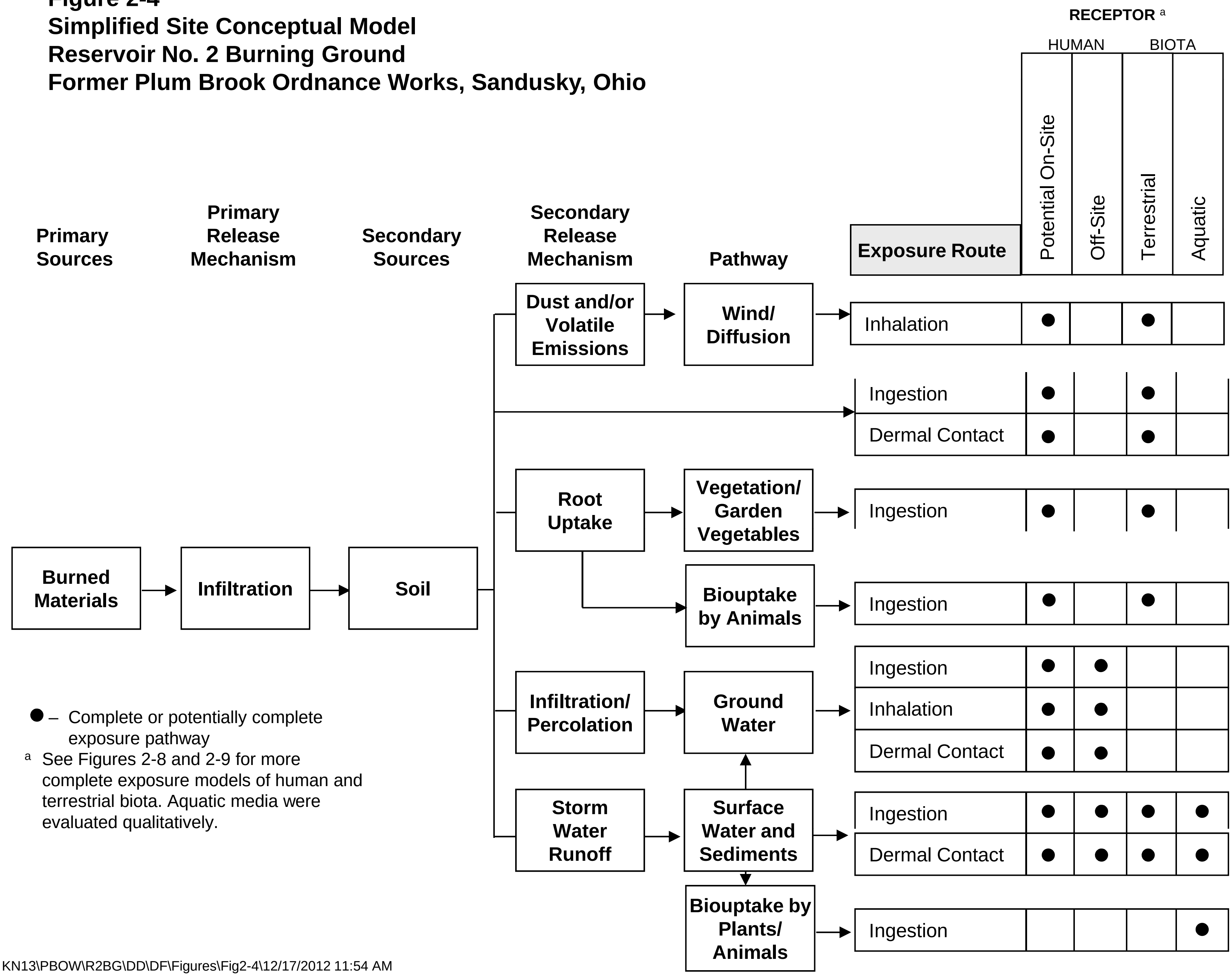
Figure 2-4
Simplified Site Conceptual Model
Reservoir No. 2 Burning Ground
Former Plum Brook Ordnance Works, Sandusky, Ohio



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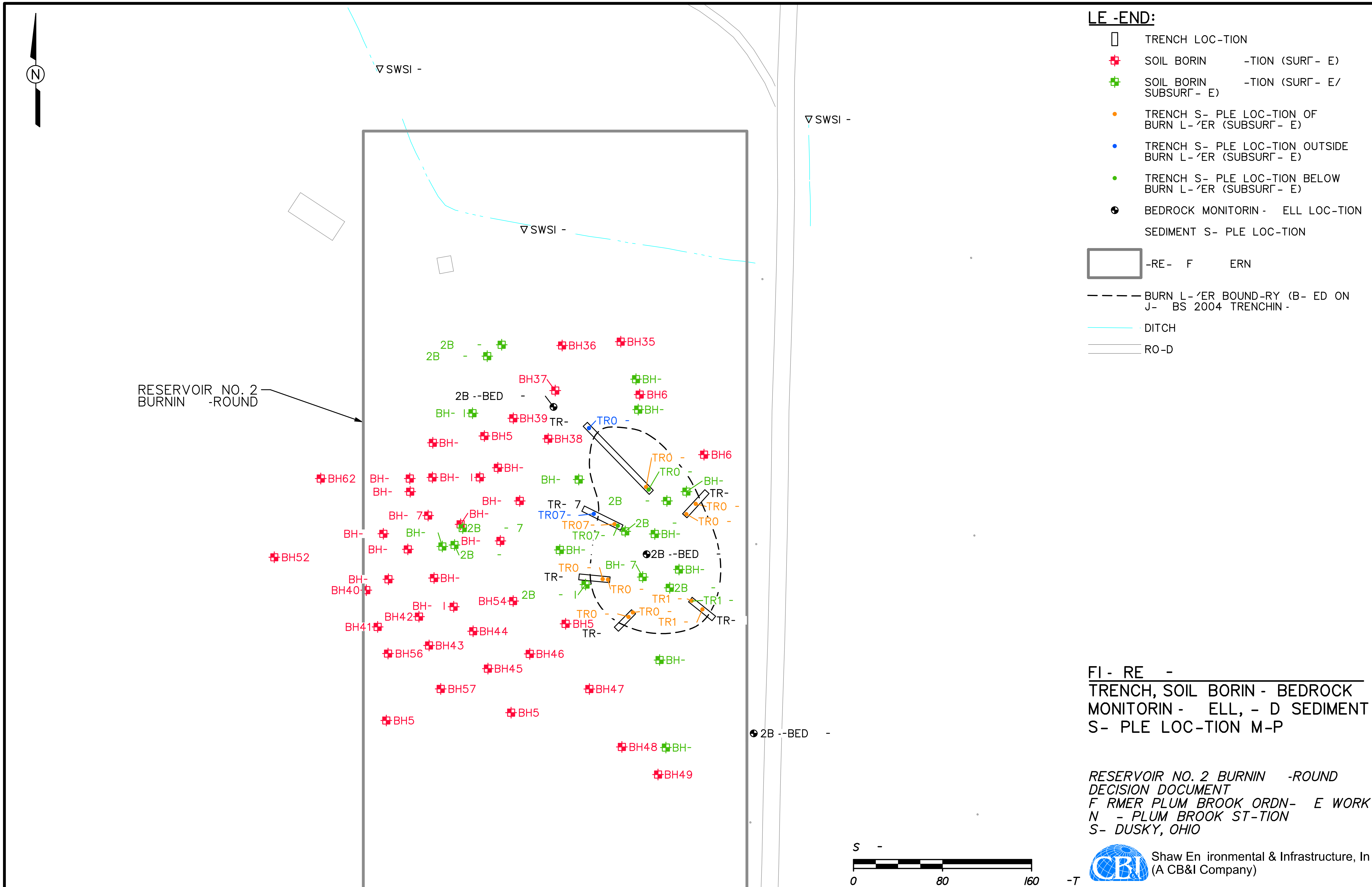

FI - RE -
TRENCH, SOIL BORIN - BEDROCK MONITORIN - ELL, - D SEDIMENT S- PLE LOC-TION M-P

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

Shaw En ironmental & Infrastructure, In .
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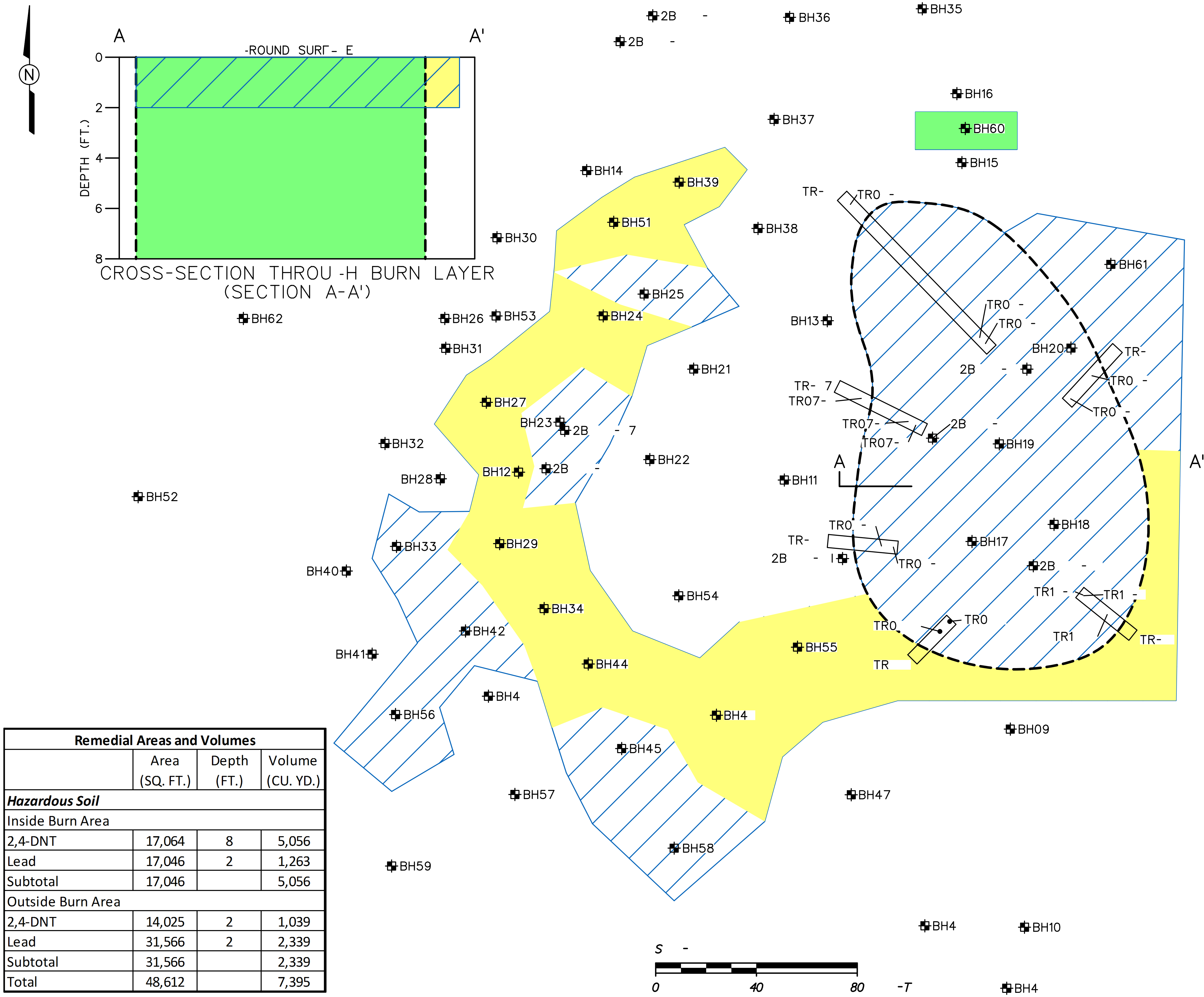

Remedial Areas and Volumes	Area (SQ. FT.)	Depth (FT.)	Volume (CU. YD.)
Hazardous Soil			
Inside Burn Area			
2,4-DNT	17,064	8	5,056
Lead	17,046	2	1,263
Subtotal	17,046		5,056
Outside Burn Area			
2,4-DNT	14,025	2	1,039
Lead	31,566	2	2,339
Subtotal	31,566		2,339
Total	48,612		7,395

LE -END:

- TRENCH LOC-TION
- BURN L-ΥER BOUND-RY (B- ED ON J- BS 2004 TRENCHIN -
- REMEDI -RE- - H -RDOUS F R 2,4-DNT (≤2.6 mg/kg)
- REMEDI -RE- - H -RDOUS F R 2,4-DNT (>2.6 mg/kg)
- REMEDI -RE- - H -RDOUS F R LE-D (>100 mg/kg) (SEE NOTES 1 - D 2)
- SURΓ- E SOIL S- PLE LOC-TION
- TRENCH S- PLE LOC-TION (SUBSURΓ- E)

NOTES:

1. - IL FROM 0 TO 2 FEET IS - ED H -RDOUS WITH RESPECT TO LE-D.
2. - BURN -RE- IL -T DEPTHS OF TO 8 FEET IS - ED H -RDOUS DUE TO 2,4-DNT ONLY.
3. REMEDI -RE- IRCUMSCRIBE S- PLE LOC-TIONS WITH - TOT - ER RISK >1E-
4. DEPTH OF REMEDI- VOLUME INSIDE LIMITS OF BURN -RE- ▪ FEET.
5. DEPTH OF REMEDI- VOLUME OUTSIDE LIMITS OF BURN -RE- ▪ FEET.
6. CONCENTR-TIONS OF PCBs - D POLYCHLORIN-TED DIBENZODIOXINS/F R- -RE LESS TH- THE L- D DISPOS- RESTRICTIONS - TERN-TIVE TRE-TMENT ST- D-RDS.

FI - RE -
REMEDI -RE - D VOLUMES
OF IL

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

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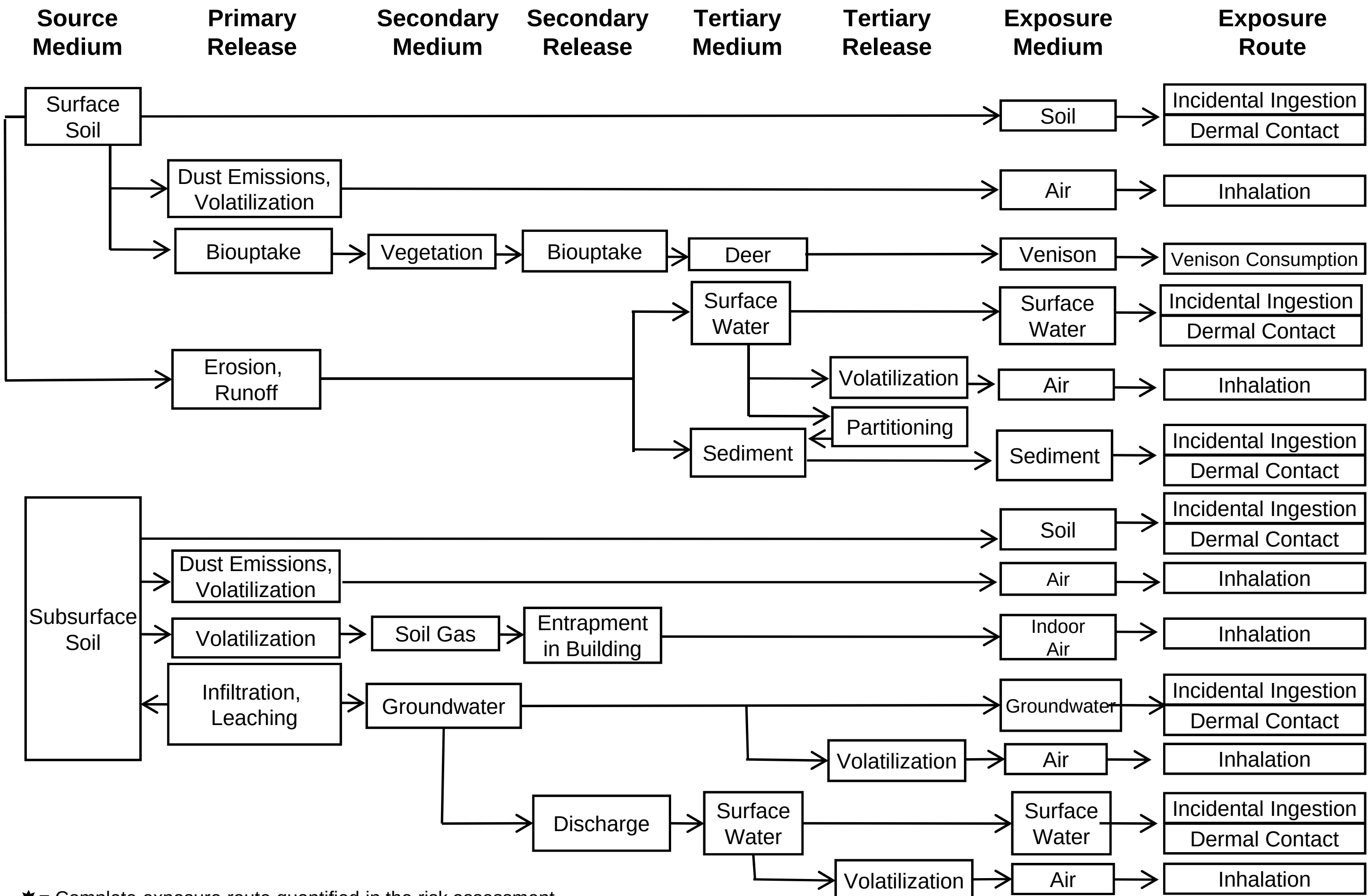
Figure 2-7
Human Health Conceptual Site Exposure Model
Reservoir No. 2 Burning Ground
Plum Brook Ordnance Works, Sandusky, Ohio



Source Medium	Exposure Medium	Exposure Route	Groundskeeper (Current/Future)	Construction Worker (Current/Future)	On-Site Resident (Future)	Indoor Worker (Future)	Hunter (Current/Future)	Hunter's Child (Current/Future)
Surface Soil	Soil	Incidental Ingestion	✸	✸	✸	✸	✸	1
Surface Soil	Soil	Dermal Contact	✸	✸	✸	2	✸	1
Surface Soil	Air	Inhalation	✸	✸	✸	2	2	1
Surface Soil	Venison	Venison Consumption	1	1	1	1	✸	✸
Surface Soil	Surface Water	Incidental Ingestion	3	3	3	3	3	3
Surface Soil	Surface Water	Dermal Contact	3	3	3	3	3	3
Surface Soil	Air	Inhalation	3	3	3	3	3	3
Surface Soil	Sediment	Incidental Ingestion	2	✸	✸	1	2	1
Surface Soil	Sediment	Dermal Contact	2	✸	✸	1	2	1
Subsurface Soil	Soil	Incidental Ingestion	1	✸	✸	1	4	1
Subsurface Soil	Soil	Dermal Contact	1	✸	✸	1	4	1
Subsurface Soil	Air	Inhalation	1	✸	✸	1	4	1
Subsurface Soil	Indoor Air	Inhalation	1	1	✸	✸	1	1
Subsurface Soil	Groundwater	Incidental Ingestion	1	2	✸	✸	1	1
Subsurface Soil	Groundwater	Dermal Contact	1	2	✸	✸	1	1
Subsurface Soil	Air	Inhalation	2	2	2	2	1	1
Subsurface Soil	Surface Water	Incidental Ingestion	3	3	3	3	3	3
Subsurface Soil	Surface Water	Dermal Contact	3	3	3	3	3	3
Subsurface Soil	Air	Inhalation	3	3	3	3	3	3

✸ = Complete exposure route quantified in the risk assessment.
1 = There is no plausible pathway for exposure to this medium.
2 = Although theoretically complete, this pathway is not quantified as explained in text.
3 = Incomplete pathway because no surface water was present in the drainage ditch during sampling event.
4 = Contact with this medium, although plausible, is not part of this receptor's normal or expected activities; therefore contact would be sporadic and is not quantified.

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Figure 2-8

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

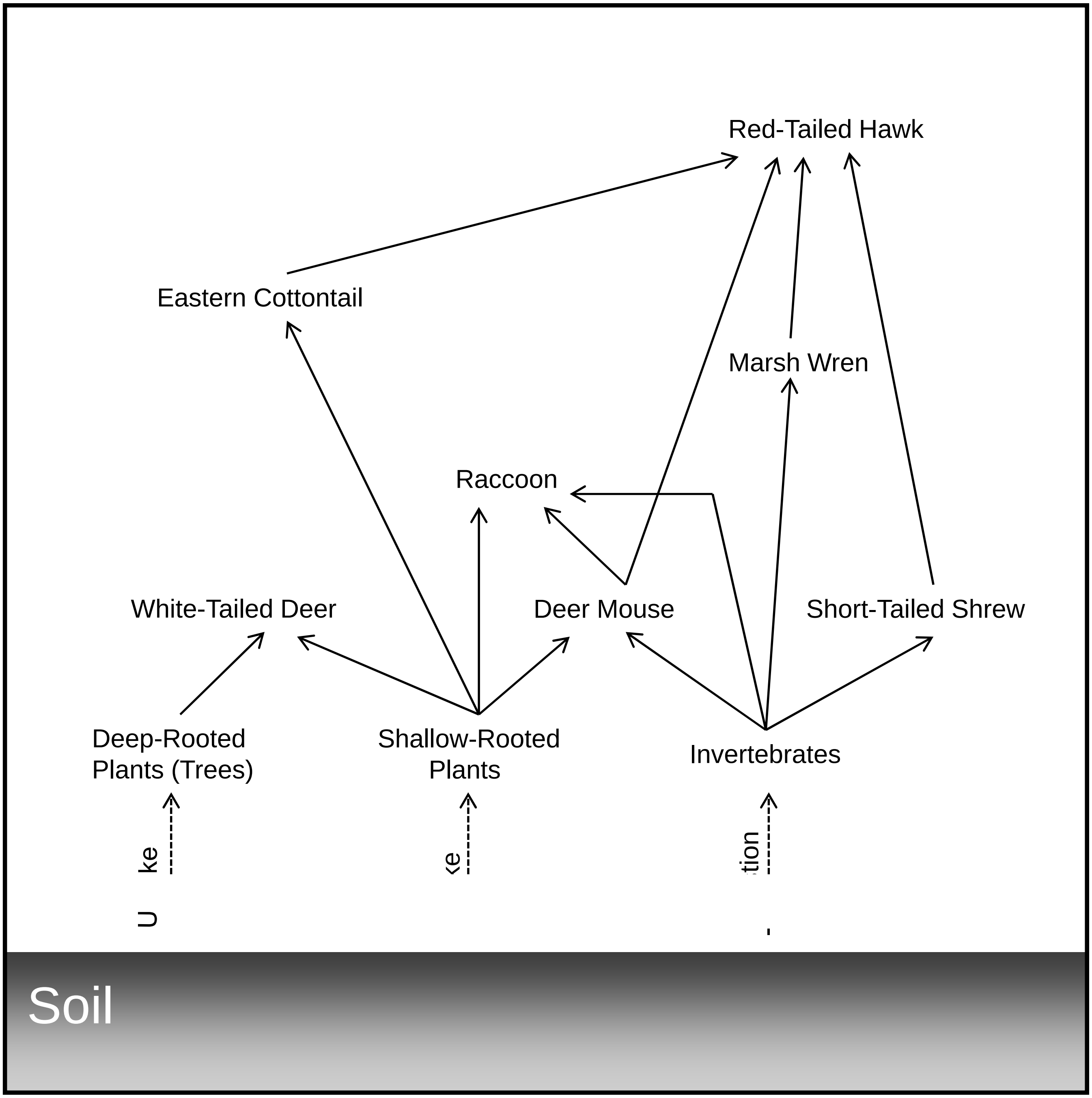
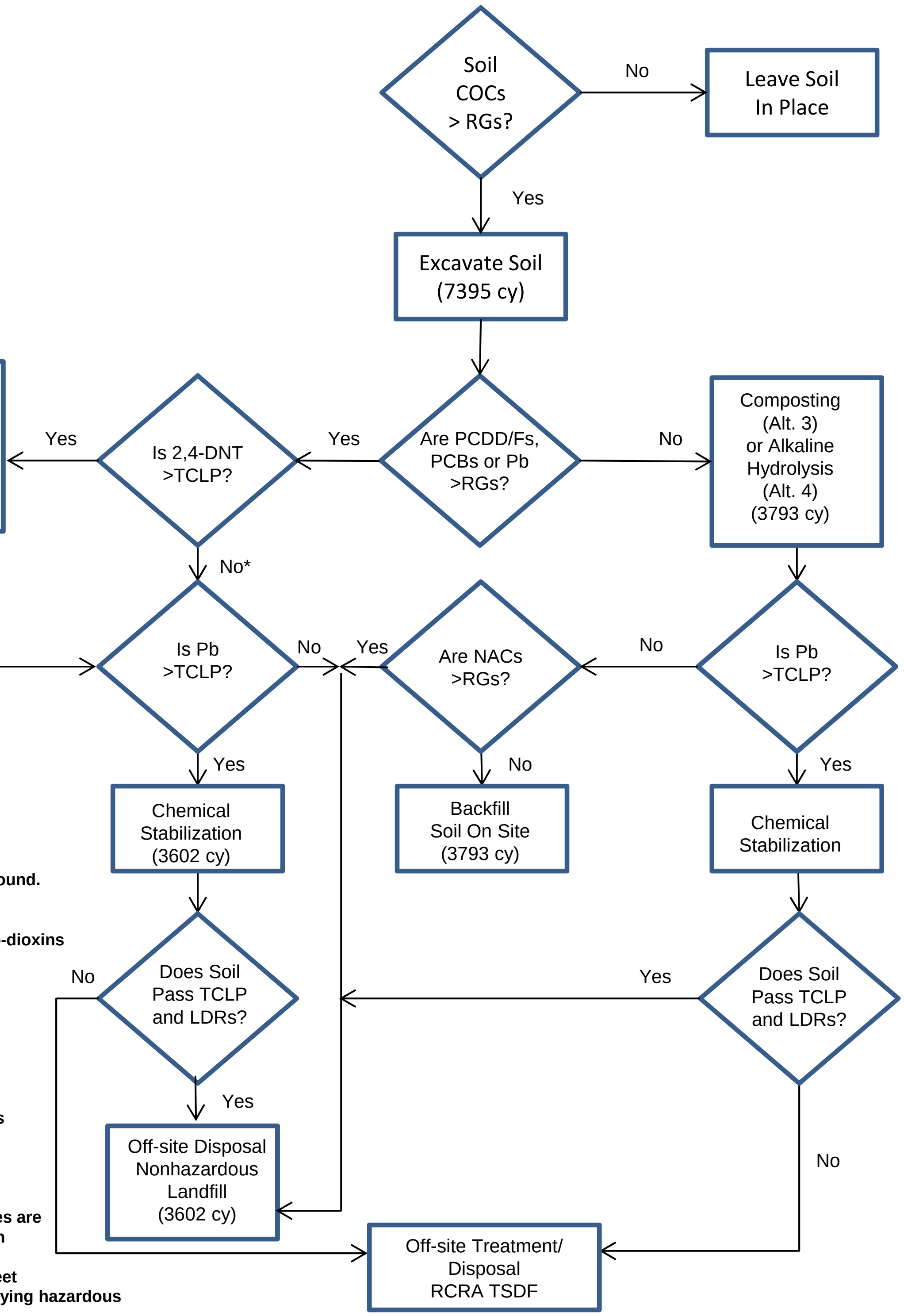


Figure 2-9

Simplified Decision Flow Chart for Treatment and Disposal of Soil, Alternative Nos. 3 and 4
Reservoir No. 2 Burning Ground
Former Plum Brook Ordnance Works, Sandusky, Ohio



Legend:

COC = Chemical of concern.
cy = Cubic yards.
DNT = Dinitrotoluene.
LDR = Land disposal restriction.
NAC = Nitroaromatic explosive compound.
Pb = Lead.
PCB = Polychlorinated biphenyls.
PCDD/Fs = Polychlorinated dipenzo-p-dioxins and dibenzofurans.
RG = Remedial goal.
TCLP = Toxicity characteristic leaching procedure.
TSDF = Treatment, storage, and disposal facility.

***Volume of 1300 cy is assumed to be hazardous for lead but nonhazardous for 2,4-DDT.**

Notes:

1. **Estimated consolidated volumes are shown in parentheses. Volumes are based on assumptions explained in the text.**
2. **Soil that meets LDRs must also meet treatment standards for any underlying hazardous constituents.**