Final

Screening-Level Ecological Risk Assessment Power House 2 Ash Pits

Plum Brook Ordnance Works,
Sandusky, Ohio

Prepared for:

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Submittal of the Final Site Characterization Report for Powerhouse 2 Ash Pits Former Plum Brook Ordnance Works, Sandusky, Ohio Contract No. W912QR-08-D-0013: Shaw Project Number 133422

Dear Ms. McClanahan:

In accordance with the requirements of Delivery Order No. DX05 of Contract No. W912QR-08-D-0013, Shaw is pleased to submit this Final Site Characterization Report for Powerhouse 2 Ash Pits at the Former Plum Brook Ordnance Works (PBOW) located in Sandusky, Ohio.

Enclosed are four copies of this final report. Copies have also been sent to those on the distribution list, as indicated, for their records. As requested, the document was sent to the Center of Expertise and Mark Boone (RAB) in electronic format only.

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

Sincerely,

Steven T. Downey, PE, PMP
Project Manager

Enclosures

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List of Acronyms

AP2	Power House 2 Ash Pits
ARP	assessment receptor profile
BAF	bioaccumulation factor
BERA	baseline ecological risk assessment
bgs	below ground surface
BSC	background screening concentration
COPEC	chemical of potential ecological concern
CT	central tendency
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ESCM	ecological site conceptual model
ESV	ecological screening value
HQ	hazard quotient
IAEA	International Atomic Energy Agency
ICP	inductively coupled plasma spectrometry
IT	IT Corporation
K_{ow}	octanol-water partition coefficient
LOAEL	lowest-observed-adverse-effect level
MDC	maximum detected concentration
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MS	mass spectrometry
NASA	National Aeronautics and Space Administration
NOAEL	no-observed-adverse-effect level
NWI	National Wetland Inventory
ODNR	Ohio Department of Natural Resources
OEPA	Ohio Environmental Protection Agency
PAH	polynuclear aromatic hydrocarbons
PBOW	Plum Brook Ordnance Works
RME	reasonable maximum exposure
Shaw	Shaw Environmental, Inc.
SLERA	screening-level ecological risk assessment
TNT	trinitrotoluene
TNTA	TNT Area A

List of Acronyms (continued)

TNTB	TNT Area B
TNTC	TNT Area C
TRV	toxicity reference value
UCL	upper confidence limit
USACE	U.S. Army Corps of Engineers
WRS	Wilcoxon Rank Sum

Executive Summary

A screening-level ecological risk assessment was performed to provide an estimate of current and future ecological risk associated with potential hazardous substance releases within the Power House 2 Ash Pits site at Plum Brook Ordnance Works in Sandusky, Ohio. The results of the screening-level ecological risk assessment contribute to the overall characterization of the site and serve as part of the baseline used to develop, evaluate, and select appropriate remedial alternatives, if necessary. The primary objective of the assessment was to determine the potential for unacceptable risks to ecological receptors as a result of exposure to chemicals detected at the site This objective was met by characterizing the ecological communities in the vicinity of the site, determining the particular hazardous substances being released from the site, identifying pathways for receptor exposure, and estimating the magnitude and likelihood of potential risk to identified receptors. The assessment addresses the potential for adverse effects to the vegetation, wildlife, aquatic life, and endangered and threatened species.

Vegetative communities at the site were classified during two site reconnaissance trips. The site consists almost entirely of successional and lowland forest. A small stream, Pipe Creek, flows from the southwest to northeast and is located adjacent to the site's western boundary. No wetlands were formally identified at the site, although ponding of water likely associated with rain events was observed in localized depressions. Vegetative stress attributable to chemicals was not observed at the site. No threatened or endangered species were documented at the site. Based on the site reconnaissance information, there was no indication that ecological threats exist at the site, as there was no definitive absence of biota or animal life in areas expected to support these ecological components.

The maximum detected concentrations of chemicals detected in sampled media were compared with risk-based screening ecotoxicity values during an initial screening step. Chemicals that exceeded the screening values, or for which no screening values were available, and that did not meet additional screening criteria (e.g., comparison with background data, nutrient status, frequency of detection, etc.) were retained as chemicals of potential ecological concern (COPEC) and assessed further. Four COPECs were selected for soil, four were selected for surface water, and one was chosen for sediment. Ninety-five percent upper confidence limits were calculated for these chemicals and used as their exposure point concentrations during the subsequent stages of the risk assessment.

Eight representative receptor species that are expected or possible at the site were selected as indicator species for the potential effects of the COPECs. The eight species selected included the deer mouse, short-tailed shrew, Eastern cottontail rabbit, marsh wren, white-tailed deer, raccoon, red-tailed hawk, and muskrat. The raccoon and muskrat were selected as aquatic receptors.

The assessment endpoints for the site were the protection of long-term survival and reproductive capabilities for terrestrial invertebrates, herbivorous mammals, omnivorous mammals, insectivorous mammals and birds, carnivorous birds, benthic invertebrates, omnivorous aquatic mammals, and omnivorous aquatic birds. Measurement assessment endpoints, or measurable responses to stressors, included lowest-observed-adverse-effect levels and no-observed-adverse-effect levels, collectively termed toxicity endpoint values.

Measurable responses to stressors, collectively termed toxicity reference values, were selected as measurement endpoints. The most appropriate measurement endpoints were chosen based on exposure pathways as well as ecotoxicity of the contaminant. An exposure analysis combining the spatial and temporal distribution of the assessment receptors and the COPECs was performed to evaluate potential exposure. The focus of the analysis was dependent on the assessment receptors evaluated and the assessment and measurement endpoints.

The intake estimates were combined with the toxicity reference values to derive estimates of potential adverse ecological effects. The uncertainties associated with the estimation of potential adverse ecological effects were identified, with the degree of uncertainty estimated qualitatively or quantitatively, and the impact of the uncertainty estimated qualitatively (overestimate or underestimate, as appropriate).

Risk characterization integrates information on exposure, exposure-effects relationships, and defined or presumed target populations. The result is an estimate of the likelihood, severity, and characteristics of adverse effects to ecological receptors resulting from exposure to environmental stressors present at the site. Qualitative and semiquantitative approaches were taken to estimate the likelihood of adverse effects occurring as a result of exposure of the selected site receptors to chemicals.

For the semiquantitative predictive assessment, toxicity reference values and exposure rates were calculated and used to generate hazard quotients by dividing the receptor exposure rate for each chemical by the calculated reference toxicity values. Hazard quotients are a means of estimating the potential for adverse effects to organisms at a contaminated site and for assessing the potential for toxicological effects to occur.

For soil, terrestrial invertebrates and plants may have slightly elevated hazard based upon the exceedance of ecological benchmarks. However, only four chemicals exceeded benchmarks, and the concentrations were not highly elevated. Given the conservative nature of benchmark values, it is unlikely that these communities are adversely impacted at the site. Ecological risk from soil was primarily evaluated using food chain models for the selected terrestrial assessment receptors (i.e., deer mouse, short-tailed shrew, Eastern cottontail rabbit, marsh wren, white-tailed deer, raccoon, and red-tailed hawk). Thallium in soil was the only chemical that resulted in hazard quotients that exceeded the threshold value of 1. However, hazard quotient values using conservative inputs did not exceed 10 when rounded and did not exceed 1 when more realistic input values were used. Further, a review of the data indicated that all elevated thallium detections originated from historical data collected over 15 years ago. Samples collected in 2009 and analyzed using updated laboratory methods did not exceed background or ecological screening values. Therefore, the potential for adverse ecological impacts associated with chemicals in soil is considered to be negligible at this site.

For surface water and sediment, benthic invertebrates and plants may have slightly elevated hazard based upon the exceedance of ecological benchmarks. However, due to the limited aquatic habitat present near the site and the limited number of exceedances, it is unlikely that these communities are significantly impacted. Ecological risk from surface water and sediment was primarily evaluated using a food chain model for the selected aquatic assessment receptors (i.e., the raccoon and muskrat). Based on the food chain model results, the aquatic receptors were not predicted to have elevated hazards from exposure to chemicals in sediment or surface water at this site.

Based on the findings of the screening-level ecological risk assessment, the potential for adverse effects to populations of ecological receptors exposed to chemicals in soil, surface water, and sediment is expected to be very low. No chemicals at the Power House 2 Ash Pits are recommended for further evaluation for ecological purposes alone.

1.0 Introduction

This screening-level ecological risk assessment (SLERA) evaluates the potential for adverse effects posed to ecological receptors from potential releases at Power House 2 Ash Pits (AP2) at the former Plum Brook Ordnance Works (PBOW). This SLERA is consistent with the ecological risk assessment process described in U.S. Environmental Protection Agency (EPA) guidance (e.g., EPA, 1997), Ohio Environmental Protection Agency (OEPA) – Division of Emergency and Remedial Response (OEPA, 2008) guidance, and with the procedures previously established in previous ecological risk assessments performed at PBOW (e.g., IT Corporation [IT], 2001a; Jacobs Engineering Group, 2010), with some adjustments to accommodate current practices in the field of ecological risk assessment.

This work is being conducted by Shaw Environmental, Inc. (Shaw) for the U.S. Army Corps of Engineers (USACE) under the Defense Environmental Restoration Program - Formerly Used Defense Sites and managed by the USACE Huntington District, with technical oversight provided by the USACE Nashville District.

1.1 Facility Description and Location

PBOW is located approximately 4 miles south of Sandusky, Ohio, and 59 miles west of Cleveland (Figure 1-1). Although located primarily in Perkins and Oxford Townships, the eastern edge of the facility extends into Huron and Milan Townships. PBOW is bounded on the north by Bogart Road, on the south by Mason Road, on the west by Patten Tract Road, and on the east by U.S. Highway 250. The areas surrounding PBOW are mostly agricultural and residential. The facility is currently surrounded by a chain-link fence, and the perimeter is regularly patrolled. Access by authorized personnel is limited to established checkpoints. Public access is restricted. Hunting is allowed by permit on portions of PBOW during the annual deer hunting season.

1.2 Facility History and Background

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

After plant operations ceased, the manufacturing process lines were decontaminated by the War Department in late 1945. During decontamination, all structures, equipment, and manufacturing debris were either removed and salvaged or removed and burned. After decontamination, 3,280 acres of the property was initially transferred to the Ordnance Department, then to the War Assets Administration after it was certified by the U.S. Army to be decontaminated. In 1949, PBOW was transferred to the General Services Administration. This transfer did not include the Plum Brook depot areas, which consists of approximately 2,800 acres. The Department of the Army acquired the 3,280 acres in 1954 and performed remedial efforts from the mid-1950s until 1963. In 1955, the Army completed further decontamination of manufacturing process lines. This effort included removal of contaminated surface and subsurface soil around the building and wooden and ceramic waste disposal lines containing TNT. Thousands of pounds of TNT were discovered in catch basins; this TNT was removed and burned at the burning grounds.

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

NASA has operated and maintained the former PBOW property since 1963, and the facility is currently the NASA Glenn Research Center, Plum Brook Station. NASA operates the property as a space research facility in support of their John Glenn Research Center at Lewis Field, Cleveland, Ohio. Most of the aerospace testing facilities built in the 1960s at the facility are currently on standby or inactive status. On April 18, 1978, NASA declared approximately 2,152 acres of PBOW as excess. The Perkins Township Board of Education acquired 46 acres of the excess acreage and uses this area as a bus transportation area. The General Services

Administration retains ownership of the remaining excess acreage and currently has a use agreement with the Ohio National Guard for 604 acres of this land. NASA currently controls approximately 6,400 acres. The details of land transactions are listed in the site management plan (USACE, 1995).

1.3 Power House 2 Ash Pits Description and History

As noted previously, PBOW was built in early 1941 and manufactured TNT, dinitrotoluene, and pentolite until 1945. Three power stations, Power House 1, Power House 2, and Power House 3, were constructed and utilized to support the TNT manufacturing process. Each power station consisted of a main power house, a coal storage area, and an aboveground fuel storage tank. The power house buildings also contained two to four large coal-burning boilers, a turboelectric generator, a feed water treatment system, and several steam-driven or electric air compressors. The generated steam was used for space heating, driving compressors, and generating electrical power. Coal ash generated from each of the boilers in the power house was collected in pits. Water was added to the ash, producing a slurry that flowed through a sluice trench to an ash sump located at the end of each power house. From the ash sump, the ash slurry traveled through a pipeline to a nearby surface water/ash impoundment, referred to as an “ash pit” (USACE, 1995).

AP2 is located west of Campbell Road in an area that appears to be an old surface impoundment (Figure 1-2). Historical drawings indicated that the surface impoundment was rectangular in shape, measuring approximately 400 feet long by 200 feet wide, and was surrounded by an earthen embankment (USACE, 1995). Based on topographical quadrangles (dated 1959 and 1969), aerial photographs, and a visual site survey conducted in 1999, the ash pit areas are noted to have essentially remained unchanged. As mentioned in the previous paragraph, ash from the coal-fired boilers was reportedly disposed of in the ash pit through a pipeline. During this investigation, the bermed area was observed, and black to dark brown cinders were found within the bermed area at depths up to 4 feet. Environmental sampling was not conducted prior to the 1996 investigation.

During a site walk conducted in October 2008, the AP2 area was observed to be overgrown with trees and nearly indistinguishable from surrounding forest. Several moss-covered concrete slabs approximately 7 feet long and 3 feet wide were observed partially buried in the underbrush northwest of the power house. A small hole constructed of mortared shale/limestone blocks and approximately 2 feet in diameter was located near the concrete slabs. Based on the construction, this appears to be a hand-dug well. The depth of the hand-dug well was not determined. A strong sulfur odor was noted in the vicinity of the well and was thought to be emanating from it. The structure was nearly filled with water during a site visit in December 2008. The origin of these concrete structures is not known with certainty; however, they appear to be remnants associated with a historical farmstead. A review of historical drawings and other documents indicates that a farmstead was present south of the slabs and the hand-dug well. Remnants of other concrete and stone foundations are present in the former farmstead area indicated on the historic drawings. It is likely that all of the concrete and stone foundations, concrete slabs, and hand-dug well are remnants associated with agricultural activities predating the PBOW facility.

1.4 Scope and Objectives

The objective of this SLERA is to provide an estimate of the potential for adverse ecological effects associated with contamination resulting from former PBOW activities at AP2. The results of the SLERA will contribute to the overall characterization of the site and may be used to determine the need for additional investigations or to develop, evaluate, and select appropriate remedial alternatives. Guidance documents used to perform the SLERA include the general guidelines of the *Tri-Service Procedural Guidelines for Ecological Risk Assessments* (Wentsel, et al., 1996), as well as the *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (EPA, 1997), *Region 5 Biological Technical Assistance Group (BTAG) Ecological Risk Assessment Guidance Bulletin No. 1* (EPA, 1996), and *Guidance for Conducting Ecological Risk Assessments* (OEPA, 2008). The SLERA fits into Steps 1 and 2 of the ecological risk assessment guidance for Superfund process (EPA, 1997), and Level I through a maximum of Level III evaluation using the OEPA (2008) process.

The goal of the SLERA is to evaluate the potential for adverse ecological effects to ecological receptors from site-related contaminants at AP2. This objective is met by characterizing the ecological communities in the vicinity of the site, determining the particular contaminants present, identifying pathways for receptor exposure, and estimating the magnitude of the likelihood of potential adverse effects to identified receptors. The SLERA addresses the potential for adverse effects to the vegetation, wildlife, aquatic life (e.g., sediment-dwelling organisms), threatened and endangered species, and wetlands or other sensitive habitats associated with the site.

Concentrations of chemicals measured in relevant environmental media were used to perform a SLERA, which includes a problem formulation (Chapter 2.0); exposure characterization (Chapter 3.0); ecological effects characterization (Chapter 4.0); risk characterization (Chapter 5.0); and summary and conclusions (Chapter 6.0). These subtasks are described in greater detail in the following sections.

The chemicals of potential ecological concern (COPEC), the ecosystems and receptors at risk, the ecotoxicity of the contaminants known or suspected to be present, and observed or anticipated ecological effects are evaluated in this SLERA. This evaluation is conducted in two steps: (1) a screening assessment step and (2) a predictive assessment step. Ecological endpoints to be addressed in both steps are identified. The results and conclusions of the screening assessment determine whether a predictive assessment is needed. The criteria by which the need for a predictive assessment is measured are formalized as null hypotheses to be accepted (in which case a predictive assessment is not needed) or rejected (in which case a predictive assessment is needed).

2.0 Problem Formulation

The screening assessment null hypotheses are stated as follows:

- Potential for adverse ecological effects to ecological entities at the site is minimal or nonexistent due to the lack of viable habitat for potential ecological receptors.
- Potential for adverse ecological effects to ecological entities at the site is minimal or nonexistent due to the lack of potential ecological receptors.
- Potential for adverse ecological effects to ecological entities at the site is minimal or nonexistent due to the lack of potential exposure pathways.
- Potential for adverse ecological effects to ecological entities at the site is minimal or nonexistent due to the lack of potential chemical stressors.

If one or more of these null hypotheses are accepted, a predictive assessment is not triggered. All four null hypotheses must be rejected for a predictive assessment to be triggered. The first three null hypotheses are tested with the results of the ecological site description, the pre-assessment reconnaissance, the documentation of potential receptors of special concern and critical habitats, and the determination of significant ecological threats (Section 2.1). The fourth null hypothesis is tested with the results of COPEC selection (Section 2.2).

If a predictive assessment is triggered, terrestrial and aquatic ecological conceptual site models are developed, as appropriate, and additional problem formulation tasks are performed as described in Sections 2.3 through 2.5.

2.1 Ecological Site Description

This ecological site description section includes a general discussion of site background and the area of concern, surface water resources, wetlands, and vegetative communities; a species inventory; and a discussion on threatened and endangered species. Ecological characterization of the study area was based on a compilation of existing ecological information and site reconnaissance activities. A photographic record was made during the site reconnaissance (see Figure 2-1). Information was obtained on the presence of state- and federally listed, threatened, and endangered species; species of special concern; and wildlife and fisheries resources. A botanist searched for threatened and endangered plant species. A checklist of biological species present at the site was developed using existing site investigation reports, environmental data sources mentioned previously, and information gathered during the site reconnaissance.

Information on unique and special-concern habitats, preserves, wildlife refuge parks, and natural areas within the general vicinity was also obtained.

2.1.1 General Site Background

PBOW, approximately 6,400 acres in size, is located within the Eastern Lake Plains physiographic region of the Eastern Huron/Erie Lake Plain Ecoregion (Lafferty, 1979; Omernik, 1986). This region is generally characterized as containing flat plains as the predominant land-surface form and as having a dominant natural vegetation of elm and ash in undisturbed areas. Approximately two-thirds of Erie County was once covered by a glacial lake that produced features such as beach ridges and wave-cut cliffs. Much of the region is poorly drained due to the flat topography and low stream gradients. Many of the wetlands adjacent to Lake Erie in this region have been preserved by various federal, state, and private organizations (Peterjohn and Rice, 1991), thereby providing important wetland habitat for wildlife.

Across PBOW, the land slopes gently to the north-northeast towards Lake Erie. Elevations range from 675 feet above mean sea level at the southwest edge of the site to 625 feet above mean sea level in the northern portion of the property at Bogart Road, resulting in an average slope of approximately 0.3 percent. The Lake Plains region itself is over 69 percent cropland, 2.7 percent pasture land, and 10.5 percent forest (Ohio Department of Natural Resources [ODNR], 1985). However, since the U.S. Army acquired the site in 1941 and removed the land from agricultural production, undeveloped portions of the former PBOW have become second generation forest and open fields. This has resulted in PBOW becoming an island of forest and open fields within a sea of agricultural land in north-central Ohio.

AP2, approximately 5 acres in size, is relatively flat with a few low hummocks. The former ash pit area is located in a flat depression that is lower in elevation than Campbell Road to the east. Surface water drainage is generally to the west, to Pipe Creek. Based on site reconnaissance performed by Shaw ecologists on April 29, June 2, and September 9, 2009, a photographic record of the site was prepared and is presented on Figure 2-1. Prior to arrival at the site, Shaw personnel obtained relevant information on the site, including topographic maps; and township, county, or other appropriate maps, and determined the location of potential ecological units such as streams, creeks, ponds, grasslands, forest, and wetlands on or near the site. Additionally, the 1994 biological inventory of PBOW (NASA, 1995), which identifies and shows the locations of threatened and endangered species at PBOW, was reviewed. Shaw personnel completed a checklist similar to EPA's checklist for ecological assessment/sampling (EPA, 1997); also, information from this checklist was used to complete this chapter. The location of known or potential contaminant sources affecting the site and the probable gradient of the pathway by which contaminants may be released from the site to the surrounding environment were identified. Shaw personnel also used the reconnaissance to search for any indication of potential effects from contaminant release.

2.1.2 Surface Water

Due to the lack of topography at this site, surface water tends to pool in localized shallow depressions. The area as a whole drains to Pipe Creek, located approximately 800 feet west of Campbell Road.

2.1.3 Wetlands

According to the National Wetland Inventory (NWI) Maps for the area (U.S. Fish and Wildlife Services, 2010), there are no designated wetlands at the AP2 site. It should be noted that the accuracy of NWI maps is limited, especially in relatively flat landscapes (such as PBOW) because minor depressions often contain isolated wetlands not easily identified through air photo interpretation (the process used by the U.S. Fish and Wildlife Service in preparing NWI maps).

2.1.4 Vegetative Communities

Vegetative communities at the site were classified during the site reconnaissance trips. Figure 2-2 presents a map of the vegetation communities at the site. AP2 is entirely forested. This area contains a mosaic of wetland and upland forested areas that are dominated by young to moderate aged trees, primarily *Populus deltoides* (eastern cottonwood), *Fraxinus pennsylvanica* (green ash), *Acer saccharinum* (silver maple) and *A. negundo* (box elder). During the April, 2009 site visit, small areas of understory disturbance were observed in this area that were caused during the installation of monitoring wells and other investigative activities earlier in the year. The vegetational community adjacent to Campbell Road consists of disturbed edge habitat composed of ruderal species. The majority of area within the AP2 is successional and lowland forest (see photographs on Figure 2-1). A list of the plant species identified at the site is presented in Table 2-1.

During the site reconnaissance, the study area was examined for vegetative stress, including looking for plants displaying stunted growth, poor foliage growth, tissue discoloration, and a loss of leaf coverage. Vegetative stress attributable to chemicals was not observed at AP2. As noted previously, a few locations were devoid of understory vegetation at areas where wells had been installed and sampled earlier in the year (see bare areas in Photos 3 and 4 on Figure 2-1). These bare areas were most obvious during the April and June, 2009 site visit, but had mostly re-vegetated by the time the site was visited again in September, 2009 (see Photo 5 on Figure 2-1). Based on site reconnaissance information, abundant and robust ecological resources appeared to be present on site, and there was no evidence that significant ecological threats exist at the site.

2.1.5 Species Inventory

Based on information from ODNR (1995) and collected during the site reconnaissance, species lists were prepared for plants, mammals, birds, reptiles, amphibians, and fish (Tables 2-1 through 2-6). Unless noted on the tables, the species listed in Tables 2-1 through 2-6 apply to the former PBOW as a whole and are not necessarily specific to AP2.

A total of 92 plant species were documented at AP2 during the spring and fall vegetation survey (Table 2-1). This comprises approximately 22 percent of the total number of species documented at the site either during the 1994 biological inventory (ODNR, 1995) or during vegetation surveys at other sites at the former PBOW (Appendix A).

Signs of 5 of the 43 species of mammals that may be found in the region based on species range maps were observed at AP2 during site visits (Table 2-2), including opossum, cottontail rabbit, raccoon, red squirrel, and white-tailed deer. It is likely that other species are present but were not observed due to the short duration of the field visits.

A total of 130 species of birds are likely to be found in the region based on species range maps and field observations, and 105 species have been recorded at the former PBOW by the ODNR during their multi-year studies (Table 2-3). PBOW lies within a major migratory corridor that is used by birds travelling between their southern wintering grounds and their breeding grounds in Canada. Of the species recorded by the ODNR, 49 are neotropical migrants and would not be expected to nest at the former PBOW. Twenty-one bird species were documented at AP2 during the site visits performed by Shaw, and 15 of these were identified as being present during the breeding season.

Of the 14 species of reptiles that may be found in the region based on species range maps, 10 species (71 percent) have been observed at the former PBOW, including turtles and snakes (ODNR, 1995; Table 2-4). No reptiles were observed during the AP2 site reconnaissance.

Of the 10 species of amphibians that may be found in the region based on species range maps, 9 species (90 percent) have been observed at the former PBOW (ODNR, 1995; Table 2-5), including salamanders, toads, and frogs. No amphibians were observed during the AP2 site reconnaissance.

According to ODNR (1995), a combination of electro shocking and seining was conducted during the field investigation that identified 14 species of fish at PBOW. Species observed included suckers, sunfish, minnows, sticklebacks, and bullheads (Table 2-6). Although no fish were visually observed in the section of Pipe Creek that is adjacent to AP2 during the site reconnaissance, some of the smaller fish species are expected to be present in Pipe Creek.

2.1.6 Threatened and Endangered Species Information

According to an Ohio Division of Natural Areas and Preserves review of their natural heritage maps and files (ODNR, 2010), there are records of State of Ohio threatened or endangered species within a 2-mile radius of the site (no species on the federal list were identified). These species include the following:

- Bushy aster (*Symphyotrichum dumosum*) - endangered
- Canada St. John’s wort (*Hypericum canadense*) – endangered
- Flat-leaved rush (*Juncus platyphyllus*) – endangered
- Rough rattlesnake-root (*Prenanthes aspera*) – endangered
- Ashy sunflower (*Helianthus mollis*) – threatened
- Dwarf bulrush (*Lipocarpha micrantha*) – threatened
- Field sedge (*Carex conoidea*) – threatened
- Greene’s rush (*Juncus greenei*) – threatened
- Slender spike-rush (*Eleocharis tenuis*) – threatened
- Southern hairy panic grass (*Panicum meridionale*) – threatened
- Thin-leaved sedge (*Carex cephaloidea*) – threatened
- Tufted fescue sedge (*Carex brevior*) – threatened
- Twisted yellow-eye-grass (*Xyris torta*) – threatened
- Upland sandpiper (*Bartramia longicauda*) – threatened.

In addition, based on information contained in ODNR (1995), several species of threatened or endangered plants, potentially threatened plants, and threatened or endangered birds have been recorded at PBOW, as follows (note that the status of some of these species may have changed since the report was published):

- Grove sandwort (*Arenaria lateriflora*) - threatened
- Prairie false indigo (*Baptisia lactea*) - potentially threatened
- Broad-winged sedge (*C. alata*) - potentially threatened
- Round-fruited hedge-hyssop (*Gratiola virginiana*) - potentially threatened
- Tall St. John’s wort (*H. majus*) - potentially threatened
- Virginia meadow beauty (*Rhexia virginica*) - potentially threatened
- Tall nut rush (*Scleria triglomerata*) - potentially threatened
- Lance-leaved violet (*Viola lanceolata*) - potentially threatened
- Cattle egret (*Bublucus ibis*) - endangered
- Black-crowned night heron (*Nycticorax nycticorax*) - threatened
- Trumpeter swan (*Cygnus buccinator*) - endangered
- Indiana bat (*Mytolis sodalis*) - endangered.

The site reconnaissance included detailed searches performed by a qualified botanist subcontractor during the June and September 2009 site visits. Based on the results of the site reconnaissance, no threatened or endangered plant species were found at AP2.

None of the threatened or endangered bird species would typically be expected to be found at the site. The cattle egret, trumpeter swan, and upland sandpiper are all considered rare visitors or migrants at the former PBOW (ODNR, 1995), and have not been documented nesting within 1 mile of the site (ODNR, 2010).

The black-crowned night heron, an Ohio threatened species, is a regular visitor at ponds, streams, and ditches within the former PBOW; however, it does not nest at the former PBOW (ODNR, 1995; 2010). The species is typically found near water and wetlands, and since the early 1980s there has been a nesting colony of approximately 100 pairs located on an island in Sandusky Bay, approximately 10 miles north northwest of the study area (Peterjohn and Rice, 1991).

The Indiana bat has not been documented at the site and is generally not expected at PBOW because its preferred habitat (e.g., caves along streams or trees with exfoliated bark) is not present at AP2. Trees with exfoliated bark, such as shagbark or shellbark hickory, are rare or not present at the site, respectively, thereby providing little bat roosting habitat (Appendix A).

With the exception of the Erie Sand Barrens State Nature Preserve, there are no existing or proposed state nature preserves or scenic rivers near the site, and ODNR is unaware of any unique ecological sites, geological features, breeding or nonbreeding animal concentrations, champion trees, or state parks, forests, or wildlife areas within a 2-mile radius of the site (ODNR, 2010). The Erie Sand Barrens State Nature Preserve is located southwest of PBOW. The 32-acre preserve is a remnant sand beach of Lake Warren, the fifth ancestral Lake Erie, that supports many threatened and endangered plant species such as field sedge, Least St. John’s wort, dwarf bullrush, twisted yellow-eyed-grass, flat-leaved rush, bushy aster, and Virginia meadow beauty. Many of the preserve’s rare plant species thrive in open windswept conditions such as those found on the sand barrens. The ODNR Division of Natural Areas and Preserves actively manages the preserve to ensure that the open wind-swept areas remain and do not become overgrown with woody vegetation.

2.1.7 Pre-Assessment Reconnaissance

Shaw ecological scientists performed site visits to AP2 on April 29, June 2, and September 9, 2009. The primary purpose of the April trip was to perform a habitat assessment and fauna inventory at the site, and the visit was intentionally performed during the period when birds are migrating north to their breeding areas to capture transient species. The primary purposes of the June and September site visits were to perform a summer and fall walkover to identify plant species (including threatened and endangered species). The June visit was also used as a follow-up to the April fauna visit; during early June, breeding birds are vocalizing as they establish and defend territories, while migrants that breed further to the north have moved on. Therefore, bird species identified during the June site visit were assumed be using the site for breeding. The list of plant species observed during the two site walks is presented in Table 2-1. The bird species observed at AP2 are listed in Table 2-3.

Information obtained during the reconnaissance trips was used to select representative receptors, refine exposure scenarios for the risk assessment, and identify protected species or habitats of special concern in the study area. Reconnaissance personnel completed a checklist similar to that on EPA's checklist for ecological assessment/sampling (EPA, 1997) and OEPA's ecological risk assessment guidance (OEPA, 2008). The locations of known or potential contaminant sources affecting the site and the probable gradient of the pathway by which contaminants may be released from the site to the surrounding environment were identified. Reconnaissance personnel used the site visit to evaluate the site for more subtle clues of potential effects from contaminant release.

The methods used to characterize natural resources focused on aquatic and terrestrial resources at the site and within the immediate vicinity. General habitat maps showing the types and extent of vegetation communities present within the immediate vicinity of the site were prepared based on information collected during the site reconnaissance discussed previously.

2.2 Selection of Chemicals of Potential Ecological Concern

A list of AP2 media samples used for the SLERA is presented in Table 2-7. Sample locations are presented on Figure 2-3. From the chemical results of samples on this list, a COPEC selection process was performed to develop a subset of chemicals detected at the site that are not naturally occurring or are associated with non-site-related sources. These chemicals are also present at sufficient frequency, concentration, and location to pose a potential risk to ecological receptors. Examples of screening criteria that were used include the following: analytical detection limit, frequency of detection less than 5 percent, comparability with background, status as a nutrient, and comparison with risk-based screening ecotoxicity values. This selection process is described in more detail in Section 2.2.3.

2.2.1 Data Organization

Chemical analytical data, as well as all previous and ongoing investigations, were reviewed and evaluated for quality, usefulness, and uncertainty. Data identified as being of acceptable quality for use in the SLERA were summarized in a manner that presents the pertinent information to be applied in the SLERA. Any data rejected during the data evaluation as a result of the data evaluation ("R"-qualified data) were identified along with the rejection rationale. Only validated data were used in the SLERA.

The data for each chemical were sorted by medium. For ecological impacts, soil from 0 to 6 feet below ground surface (bgs) were considered. The 0 to 6 feet depth interval was selected for three primary reasons: (1) to maintain consistency with other PBOW ecological risk assessments (e.g., IT, 2001a); (2) to include potential exposure to ecological receptors that may be exposed to deeper soil; and (3) to increase the size of the total soil database by including samples collected from samples up to 6 feet bgs. Therefore, COPEC selection was performed for the 0 to 6 feet interval. Chemicals that are not detected at least once in a medium were not included in the risk assessment. Available background data were determined for each medium. Potential sources of background information include data from previous and current investigations, as well as monitoring wells in areas unaffected by site activities.

The analytical data included qualifiers from the analytical laboratory quality control or from the data validation process that reflect the level of confidence in the data. Some of the more common qualifiers and their meanings are as follows (EPA, 1989a):

- U - Chemical was analyzed for but not detected; the associated value is the sample quantitation limit.
- J - Value is estimated, probably below the contract-required quantitation limit.
- R - Quality control indicates that the data are unusable (chemical may or may not be present).
- B - Concentration of chemical in sample is not sufficiently higher than concentration in the blank (using the "5-times, 10-times" rule).

"J"-qualified data are used in the risk assessment; "R"- and "B"-qualified data are not. The handling of "U"-qualified data (nondetects) is described in the following sections.

2.2.2 Descriptive Statistical Calculations

Because of the uncertainty associated with characterizing contamination in environmental media, both the mean and the 95 percent upper confidence limit (UCL) of the mean are usually estimated for chemicals of interest. The EPA ProUCL software (Version 4.00.04 [EPA, 2009]) was used to estimate UCLs for the data sets of all environmental media represented by at least five samples. If the data set consisted of fewer than five data points, the maximum detected concentration (MDC) was selected as the exposure point concentration (EPC). One-half the reporting limit was used as the ProUCL input concentration for nondetects.

ProUCL generates a variety of UCL estimates for each data set. Generally, the results of one or two (sometimes more) of the UCL estimates are recommended. This recommendation is based on a variety of factors, including the distribution (i.e., normal, lognormal, gamma, or not discernable) that provides the best fit, number of nondetects, size of the data set, and skewness. In general, the UCL recommended by ProUCL will be selected as the EPC. Occasionally, ProUCL will recommend the 97.5 or 99 percent UCL on the arithmetic mean estimated by the Chebyshev method. In these cases, the 95 percent UCL estimated by the Chebyshev method was selected as the EPC because this is more consistent with the intent of the reasonable maximum exposure paradigm as defined by EPA (1989a; 2002).

Analytical data from field duplicates were joined with parent sample results to yield one result for use in the generation of mean and UCL concentrations, as follows:

- The average of field duplicate and parent sample was used if both were positive detections, or if both were nondetects.
- The detected value was used if one sample was a positive detection and the other was nondetect.

The UCL generated by ProUCL or the MDC, whichever is smaller, was selected as the EPC, and this value is understood to represent a conservative estimate of average for use in the risk assessment. Unusually high detected values were retained in the calculation of the UCL concentration. Inclusion of these high values increases the statistical variability and the overall conservativeness of the risk estimate.

2.2.3 COPEC Selection Criteria

The criteria used to identify COPECs in the SLERA are described in the following sections.

2.2.3.1 Comparison to Ecological Screening Values

MDCs of chemicals detected in various media were compared with ecological screening values (ESV) for ecological endpoints following recommendations received from OEPA and as discussed in *Region 5 Biological Technical Assistance Group (BTAG) Ecological Risk Assessment Bulletin No. 1* (EPA, 1996). Chemicals that exceed the ESVs, or for which no ESVs are available, were retained as COPECs if other COPEC selection criteria were also met. The following ESVs, or ESV hierarchy (as noted), were used for the ecological evaluation:

- ***Soil.*** Soil screening values were selected using the following hierarchy: (1) EPA ecological soil screening levels (EPA, 2008), (2) *Preliminary Remediation Goals for Ecological Endpoints* (Efroymson, et. al., 1997a), (3) EPA Region 5 ecological screening levels (note: these values were previously known as ecological data quality levels) (EPA, 2003), (4) *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process* (Efroymson, et al., 1997b), and (5) *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants* (Efroymson, et al., 1997c). It should be noted that effects on heterotrophic processes may not be relevant to ecological receptors of concern at the site.

- ***Surface Water.*** The lowest surface water screening value was selected from the following three sources: (1) OEPA Water Quality Criteria (OAC Chapter 3745-1) for the protection of aquatic life, (2) *Preliminary Remediation Goals for Ecological Endpoints* (Efroymson, et al., 1997a), and (3) EPA Region 5 ecological screening levels (EPA, 2003). Because OEPA water quality criteria do not consider food-chain effects, a hierarchy could potentially eliminate important surface water COPECs.

- ***Sediment.*** Sediment screening values were selected using the following hierarchy: (1) Consensus-based threshold effect concentration values (MacDonald, et al., 2000), (2) EPA Region 5 ecological screening levels (EPA, 2003), (4) *Preliminary Remediation Goals for Ecological Endpoints* (Efroymson, et al., 1997a), and (5) *Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario* (Ontario Ministry of the Environment and Energy; 1993).

The development of the ESVs used for the former PBOW SLERAs is presented in Appendix B.

2.2.3.2 Frequency of Detection

Chemicals that are detected infrequently may be artifacts in the data that may not reflect site-related activity or disposal practices. These chemicals are not evaluated further in the risk evaluation. Generally, chemicals that are detected only at low concentrations in less than 5 percent of the samples from a given medium are dropped from further consideration, unless their presence is expected based on historical information about the site. Chemicals detected infrequently at elevated concentrations as compared with applicable risk-based thresholds may identify the existence of “hot spots” and have been retained in the evaluation, unless other information exists to suggest that their presence is unlikely to be related to site activities.

2.2.3.3 Background Evaluation

Chemical concentrations were compared to site-specific background concentrations (see next paragraph for details) as an indication of whether a chemical is present from site-related activity or as natural background. This comparison is generally valid for inorganic chemicals but not for organic chemicals, because inorganic chemicals are naturally occurring and most organic chemicals are not. Statistical techniques are used as tools to aid the exercise of professional judgment in resolving site-related issues for metals, because metals are naturally present in most environmental media. The statistical techniques generally involve comparing the site data with background data. Background data are only available for soil at PBOW. Background soil values were also used to compare to concentrations in sediment from samples collected from Pipe Creek, as the shallow creek bed in Pipe Creek at AP2 most likely accumulates sediment as a result of overland runoff from site soils. Background data do not exist for surface water; therefore, a statistical background evaluation for this medium cannot be performed.

The first statistical technique used for the background screen is the comparison of the MDC of the site data set to the PBOW background screening concentration (BSC). The background data set and derivation of soil BSCs for all PBOW soil investigations are described in IT (1998). The background soil samples were collected from near the property boundary, away from any potential source areas. BSCs were calculated for use at PBOW based on concentrations found in these background soil samples. Each BSC is either the MDC of the concentrations found in these background soil samples or the calculated 95th percent upper tolerance limit of the background data set, whichever value is lower (Shaw, 2005). The upper tolerance limit is the concentration, with a probability of 0.95 (or a confidence of 95 percent), that would capture (or cover) 95 percent of background samples if a larger number of samples were collected. Chemicals with MDCs less than their respective BSCs are eliminated from further consideration. If the MDC exceeds the BSC, the chemical may be retained as a COPEC, or a different statistical analysis may be performed to determine if the background data and the site data are drawn from the same population. The Wilcoxon Rank Sum (WRS) test is used for this purpose.

The WRS test (also known as the Mann-Whitney U test) is described in Appendix M of Shaw (2005). WRS testing is performed for inorganic chemicals in soil whose MDCs exceed their respective BSCs, and when the site and background data sets each contain less than 50 percent nondetects. The WRS test is not performed on data sets containing 50 percent or more nondetects, because the medians of such data sets are unknown and the test lacks sufficient power to yield reliable results. Likewise, the WRS test is not performed on data sets of size $n < 5$; in such cases, the test lacks sufficient power to identify differences between the two samples. Site data sets are interpreted as being significantly different from PBOW background if the associated p-level is less than 0.05. WRS statistical output and box and whisker plots of the various inorganic COPEC data sets are appended to the SLERA for each inorganic data set evaluated against the site background data set. Analytes shown by the WRS results to exceed background (or for which the WRS testing was not run) are assumed to be site related and retained as COPECs, unless a qualitative chemical-specific explanation is presented in the uncertainties analysis as to why the analyte should not be regarded as site related. Analytes shown by the WRS results to be drawn from the same population as the background samples are assumed to be naturally occurring and are not retained as COPECs. WRS results were only used to evaluate lead in soil. Supporting information for the WRS test, including box-and-whisker plots, are presented in Appendix C.

Chemicals that fail the background evaluation are assumed to be site related and are not eliminated at this point of the screening process.

2.2.3.4 Essential Nutrients

Evaluating essential nutrients is a special form of risk-based screening applied to certain ubiquitous elements that are generally considered to be required nutrients. Essential nutrients such as calcium, iron, magnesium, potassium, and sodium are usually eliminated as COPECs because they are generally considered to be innocuous in environmental media. Other essential nutrients, including chloride, iodine, and phosphorus, may be eliminated as COPECs, provided that their presence in a particular medium is shown to be unlikely to cause adverse effects to biological health.

2.2.4 Summary of COPEC Selection

The results of the COPEC screening are presented in Tables 2-8 through 2-10 for soil, surface water, and sediment. The tables present the following information for each medium:

- Chemical name
- Frequency of detection
- Range of detected concentrations
- Range of detection limits
- Arithmetic mean (average) of site concentrations

- Distribution type
- UCL of the mean of the concentration (only for chemicals selected as COPECs)
- Appropriate ESV
- BSC
- COPEC selection conclusion: NO (with rationale for exclusion), or YES (selected).

The selected EPC is also presented for each chemical identified as a COPEC. For soil, two EPC results are presented, including a total soil EPC that represents concentrations in the 0-6 feet bgs depth range, and a surface soil that represents concentrations in the 0-1 foot bgs depth range. These two sets of EPCs are used to evaluate various ecological receptors that may be exposed to different soil depths associated with their various life-history characteristics (see Section 3.1). Footnotes in the tables provide the rationale for selecting or rejecting a chemical as a COPEC. In some situations, it is appropriate to reinstate as COPECs chemicals that have been eliminated using one or more of the screening criteria. Examples of these exceptions include potential breakdown products, chemicals known to have been used on site historically, chemicals with detection limits greater than the ESV, and chemicals with high bioconcentration and/or bioaccumulation factors. A qualitative evaluation of the COPEC tables for soil, surface water, and sediment was performed; based on this evaluation, no additional COPECs are recommended.

Four COPECs were selected for total soil (Table 2-8), four were selected for surface water (Table 2-9), and one was selected for sediment (Table 2-10). As discussed at the beginning of Chapter 2.0, the SLERA null hypotheses are that potential for adverse ecological effects are minimal or nonexistent due to the lack of viable habitat, potential ecological receptors, potential exposure pathways, and/or potential chemical stressors. Given the selection of COPECs in multiple media, and the finding that viable habitat, potential receptors, and potential exposure pathways exist at the site, a predictive assessment is triggered. Chemicals not eliminated using the screening procedures previously presented are considered COPECs and are quantitatively evaluated in the predictive SLERA.

2.3 Ecological Endpoint (Assessment and Measurement) Identification

The first step in the predictive SLERA is the identification of assessment and measurement endpoints. The protection of ecological resources, such as habitats and species of plants and animals, is a principal motivation for conducting the SLERA. Key aspects of ecological protection are presented as policy goals. These are general goals established by legislation or agency policy that are based on societal concern for the protection of certain environmental resources. For example, environmental protection is mandated by a variety of legislation and government agency policies (e.g., the Comprehensive Environmental Response, Compensation, and Liability Act, National Environmental Policy Act). Other legislation includes the

Endangered Species Act (16 U.S.Code 1531-1544) (1993, as amended) and the Migratory Bird Treaty Act 16 (U.S. Code 703-711) (1993, as amended). To determine whether these protection goals are met at the site, assessment and measurement endpoints have been formulated to define the specific ecological values to be protected and to define the degree to which each may be protected.

Unlike the human health risk assessment process, which focuses on individual receptors, the SLERA focuses on populations or groups of interbreeding nonhuman, nondomesticated receptors. This is accomplished by selecting measurement endpoints (discussed below) that are related to parameters most likely to result in population level effects (e.g., survival, growth, or reproduction) and consideration of lowest-observed-adverse-effect levels (LOAEL) in addition to no-observed-adverse-effect level (NOAEL) endpoints (see Chapter 4.0). In the SLERA process, risks to individual receptors are assessed only if they are protected under the Endangered Species Act, are species that are candidates for protection, or are species of special concern.

Given the diversity of the biological world and the multiple values placed on it by society, there is no universally applicable list of assessment endpoints. Suggested criteria that may be considered in selecting assessment endpoints suitable for a specific ecological risk assessment are (1) ecological relevance, (2) susceptibility to the contaminant(s), (3) accessibility to prediction and/or measurement, and (4) definability in clear, operational terms (Suter, 1993). Selected assessment endpoints reflect environmental values that are protected by law, are critical resources, or have relevance to ecological functions that may be impaired. Both the entity and attribute are identified for each assessment endpoint.

Assessment endpoints are inferred from effects to one or more measurement endpoints. The measurement endpoint is a measurable response to a stressor that is related to the valued attribute of the chosen assessment endpoint. It serves as a surrogate attribute of the ecological entity of interest (or of a closely related ecological entity) that can be used to draw a predictive conclusion about the potential for effects to the assessment endpoint.

Measurement endpoints for this SLERA are based on toxicity values from the available literature and not statistical or arithmetic summaries of actual field or laboratory observations or measurements. When possible, receptors and endpoints have been concurrently selected by identifying those that are known to be adversely affected by chemicals at the site based on published literature. COPECs for those receptors and endpoints have been identified by drawing on the scientific literature to obtain information regarding potential toxic effects of site chemicals to site species. This process ensures that a conservative approach is taken in selecting endpoints and evaluating receptors that are likely to be adversely affected by the potentially most toxic chemicals at the site.

2.3.1 Assessment Endpoints

The assessment endpoints for AP2 are stated as “the protection of long-term survival and reproductive capabilities for terrestrial invertebrates, herbivorous mammals, omnivorous mammals, insectivorous mammals and birds, carnivorous birds, benthic invertebrates, omnivorous aquatic mammals, and omnivorous aquatic birds.” The corresponding null hypothesis for each of the assessment endpoints is stated as “the presence of site contaminants within soil, surface water, sediment, vegetation, and prey will have no effect on the survival or reproductive capabilities of terrestrial invertebrates, herbivorous mammals, omnivorous mammals, insectivorous mammals and birds, carnivorous birds, benthic invertebrates, omnivorous aquatic mammals, and omnivorous aquatic birds.”

Assessment receptor species were selected based on the likelihood of finding the species at the AP2. Historical information, the site reconnaissance (performed April 29, June 2, and September 9, 2009), and the availability of toxicological data were used to select terrestrial and aquatic assessment receptor species. These receptors species are depicted in food web models (Figures 2-4 and 2-5). Food web models are simplified versions of the possible movement of contaminants through the food chain present or potentially present at the site. Due to lack of data for all possible species, key species have been selected to represent broad classes, or guilds.

The food web conceptual site models were developed to illustrate how the selected terrestrial and aquatic species are ecologically linked within food webs. One species was used to represent each of the major trophic levels and habitats at the site. The decision was made not to complicate the food web models with species names for organisms at the base of the food web (e.g., species names of terrestrial invertebrates). Thus, generic terrestrial invertebrates, benthic invertebrates, and aquatic invertebrates were used to represent the bottom of the food chain. For terrestrial invertebrates and plants, partitioning coefficients and simple empirical uptake models were employed to estimate COPEC concentrations within tissues (Chapter 3.0). Brief life history descriptions for the selected receptor species are provided in Appendix D.

All trophic levels may be exposed to COPECs, either by direct exposure to contaminated abiotic media or through ingestion of lower trophic level food items. Primary producers (plants) absorb COPECs (as well as nutrients) from soil and/or water. Through abiotic processes, COPECs can adsorb to the sediment and detritus particles. When these particles settle and become part of the benthic substrate, they may also become a source of COPECs to benthic communities. Various species of aquatic biota fulfill the role of aquatic herbivores (feeding on aquatic plants and suspended detritus) and predatory invertebrates (feeding on benthic invertebrate species). The combination of COPEC bioconcentration from water, ingestion of contaminated prey, and restricted ranges for aquatic organisms provides good conditions for significant bioaccumulation of COPECs. In terrestrial species, bioconcentration occurs in plants and invertebrates, and higher food chain receptors bioaccumulate COPECs through the ingestion of food items.

2.3.2 Measurement Endpoints

Measurement endpoints are frequently numerical expressions of observations (e.g., toxicity test results or community diversity indices) that can be compared statistically to detect adverse responses to a site contaminant. Examples of typical measurement endpoints include mortality, growth, or reproduction parameters in toxicity tests; individual abundance; and species diversity (EPA, 1997).

For assessments, measurable responses to stressors may include LOAELs, NOAELs, lethal concentration to 50 percent of the test population, lethal dose to 50 percent of the test population, or effective concentration for 20 percent of the test population, collectively termed toxicity reference values (TRV) (see Section 4.1 for further explanation).

2.4 Selection of Assessment Receptors

In order to focus the exposure characterization portion of the SLERA on species or components that are the most likely to be affected and on those that, if affected, are most likely to result in significant impacts to the on-site ecosystem, the selection of assessment receptors focuses on species, groups of species, or functional groups that are directly related to the assessment endpoints previously identified (Section 2.3.1).

Site biota were organized into major functional groups. For terrestrial communities, the major groups are plants and wildlife, including terrestrial invertebrates, mammals, and birds. For aquatic and/or wetland communities, the major groups are flora and fauna, including vertebrates (water fowl and fish), aquatic invertebrates, and wetland/terrestrial mammals. Species presence and relative abundance were partly determined during the site reconnaissance.

Primary criteria for selecting appropriate assessment receptors include, but are not limited to, the following:

- The assessment receptor has a relatively high likelihood of contacting chemicals via direct or indirect exposure.

- The assessment receptor exhibits marked sensitivity to chemicals.

- The assessment receptor is a key component of ecosystem structure or function (e.g., importance in the food web, ecological relevance).

- The assessment receptor may be listed as rare, threatened, or endangered by a governmental organization, or the receptor consists of critical habitat for rare, threatened, or endangered species.

Additional criteria for selection of assessment receptors were used to identify species that offer the most favorable combination of characteristics for determining the implications of on-site contaminants. These criteria included (1) limited home range, (2) role in local nonhuman food chains, (3) potential high abundance and wide distribution at the site, (4) sufficient toxicological information available in the literature for comparative and interpretive purposes, (5) sensitivity to COPECs, (6) relatively high likelihood of occurrence on site following remediation (if required); (7) suitability for long-term monitoring, (8) importance to the stability of the ecological food-chain or biotic community of concern, and (9) relatively high likelihood that species will be present at the site or that habitats present at the site could support the species. Assessment receptors are representative species that are modeled for exposure to contaminants via multiple exposure routes. Organisms at the base of the food chain (i.e., plants, invertebrates, etc.) are not evaluated for food chain effects because direct exposure is the primary exposure route of concern for these organisms, which is evaluated by the ecological benchmark comparison during the initial COPEC screening process. Therefore, these types of organisms are not selected as assessment receptors.

2.4.1 Terrestrial Receptors

Seven representative terrestrial receptor species that are expected or possible in the area of AP2 (based on the ecological description of the site presented in Section 2.1) were selected as indicator species for the potential effects of COPECs. These indicator species represent two classes of vertebrate wildlife (mammals and birds) and a range of both body size and food habits, and include herbivores, omnivores, and carnivores. Vegetation is not considered an assessment receptor. The seven terrestrial species selected include the 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), and red-tailed hawk (*Buteo jamaicensis*) (large, carnivorous bird).

A terrestrial food web is presented on Figure 2-4. Many of the species evaluated have limited home ranges, particularly the deer mouse, cottontail rabbit, short-tailed shrew, and marsh wren, which make them particularly vulnerable to exposure from site contaminants. All of the selected terrestrial receptor species have a potential high abundance and wide distribution at the site; also, sufficient toxicological information (with the exception of some bird species) is available in the literature for comparative and interpretive purposes. All species are considered important to the stability of the local ecological food chain and biotic community. Finally, all the selected species have readily available exposure data, as summarized in the *Wildlife Exposure Factors Handbook* (EPA, 1993).

Larger mammal species were generally not selected as sensitive receptors due to their large home ranges; however, the red-tailed hawk was retained due to its unique role as a top predator in the food chain and the white-tailed deer was retained due to its high abundance at the site. Smaller birds were generally not included because most are migratory. The potential risk to species with larger home ranges and migratory avian species will be included within the predicted risks to the selected terrestrial indicator receptors. Area use factors were set to 100 percent for the mouse, shrew, rabbit, and wren, due to their relatively small home ranges (Section 3.1). However, for the deer, hawk, and raccoon, the area use factor was set at 0.004, 0.002, and 0.01 (or 0.4, 0.2, and 1 percent), respectively, based on these species' relatively large home ranges (518, 842, and 156 hectares, or 1,280, 2,081, and 385 acres, respectively), compared with the size of the site (approximately 5 acres [Figure 1-2]).

Results of the assessment receptor selection process are presented in detailed biological and ecological descriptions called assessment receptor profiles (ARP). The biologically relevant criteria used to select the seven terrestrial assessment receptors are also discussed and summarized in the ARP (Appendix D).

2.4.2 Aquatic Receptors

The only aquatic habitat at the site is Pipe Creek, which is a small stream adjacent to the western boundary of the AP2 site that flows from the southwest to northeast. Although water may pond in low areas within AP2 itself, these ponds are considered ephemeral in nature, and not true aquatic habitat (Photos 7 and 8 on Figure 2-1). Exposure to aquatic organisms within the creek is assumed to occur via direct exposure to contaminants in the water column and via ingestion of benthic invertebrates as well as prey exposed to contaminants in surface water and sediment.

Potential uptake through the aquatic food chain is evaluated for the raccoon (also considered as a terrestrial receptor) and muskrat (*Ondatra zibethicus*) (medium-sized aquatic herbivorous mammal). An avian aquatic omnivore such as the mallard (*Anas platyrhynchos*) is not evaluated due to the limited amount of aquatic habitat associated with the creek.

Aquatic organisms represent some of the prey base for aquatic receptors (represented by the raccoon and muskrat). An aquatic food web is presented on Figure 2-5. The raccoon has been documented at the site (Section 2.1) and has a potential high abundance and wide distribution at the site, and sufficient toxicological information is available in the literature for comparative and interpretive purposes. The muskrat is also likely to be found at PBOW (see Table 2-2). Although Pipe Creek may be too small of a water body to support muskrat populations, this receptor is conservatively included to represent mammalian aquatic herbivores. Both the raccoon and muskrat have readily available exposure data, as summarized in the *Wildlife Exposure Factors Handbook* (EPA, 1993).

Results of the assessment receptor selection process, including a summary of the relevant biological criteria used, are presented in the ARPs (Appendix D).

2.5 Ecological Site Conceptual Model

Pictorial representations of the evaluated food webs are presented on Figures 2-4 and 2-5. The accompanying text presented in Section 3.1 is intended to clarify the ecological site conceptual models (ESCM). The ESCMs trace the contaminant pathways through both abiotic components and biotic food web components of the environment. The ESCMs present all potentially complete exposure pathways. The ESCMs have been used as a tool for judging the appropriateness and usefulness of the selected measurement endpoints in evaluating the assessment endpoints and for identifying sources of uncertainty in the exposure characterization.

3.0 Exposure Characterization

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 is presented in this section, considering both current and reasonably plausible future use of the site. Exposure characterization is critical in further evaluating the risk of chemicals identified as COPECs during the screening process (Section 2.2). The exposure assessment has been conducted by linking the magnitude (concentration) and distribution (locations) of the contaminants detected in the media sampled during the investigation, evaluating pathways by which chemicals may be transported through the environment, and determining the points at which organisms found in the study area may contact contaminants.

3.1 Exposure Analysis

An exposure analysis was performed that combines the spatial and temporal distribution of the ecological receptors with those of the COPECs to evaluate exposure. The exposure analysis focuses on the bioavailable chemicals and the means by which the ecological receptors are exposed (e.g., exposure pathways). The focus of the analysis is dependent on the assessment receptors being evaluated as well as the assessment and measurement endpoints.

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. All of these components have been addressed within this SLERA. If any of these components is not complete, then contaminants in the affected media do not constitute an environmental risk at the site. The major fate and transport properties associated with typical site contaminants are described in subsequent sections. These properties directly affect a contaminant's behavior in each of the exposure pathway components.

Ecological routes of exposure for biota may be direct (bioconcentration) or through the food web via the consumption of contaminated organisms (biomagnification). Direct exposure routes include dermal contact, absorption, inhalation, and ingestion. Examples of direct exposure include animals incidentally ingesting contaminated soil or sediment (e.g., during burrowing or dust-bathing activities), animals ingesting surface water, plants absorbing contaminants by uptake from contaminated sediment or soil, and the dermal contact of aquatic organisms with contaminated surface water or sediment. Given the scarcity of available data for wildlife dermal and inhalation exposure pathways, potential risk from these pathways is not estimated in this

SLERA. In addition, these pathways are generally considered to be incidental for most species, with the possible exceptions of burrowing animals and dust-bathing birds.

Food web exposure can occur when terrestrial or aquatic fauna consume contaminated biota. Examples of food web exposure include animals at higher trophic levels consuming plants or animals that bioaccumulate contaminants.

Bioavailability is an important contaminant characteristic that influences the degree of chemical-receptor interaction. The bioavailability of a chemical refers to the degree to which a receptor is able to absorb a chemical from the environmental medium. A chemical's bioavailability is a function of several physical and chemical factors such as grain size, organic carbon content, water hardness, and pH.

Daily doses of COPECs for vertebrate receptors were calculated using standard exposure algorithms. These algorithms incorporate species-specific natural history parameters (i.e., feeding rates, water ingestion rates, dietary composition, etc.) and also use site-specific area use factors, as follows:

$$Total\ Daily\ Dose = \left(\frac{\left([Soil_j * IR_{soil}] + [Water_j * IR_{water}] + \left[\sum_{i=1}^{N} B_{ji} * P_i * IR_{food} \right] \right)}{Body\,Weight} \right) * AUF \qquad \text{Eq. 3.1}$$

where:

$Soil_j$	=	Concentration of COPEC "j" in soil
$Water_j$	=	Concentration of COPEC "j" in surface water
B_{ji}	=	Concentration of COPEC "j" in food type "i"
IR_{soil}	=	Soil ingestion rate
IR_{water}	=	Surface water ingestion rate
IR_{food}	=	Food ingestion rate
P_i	=	Proportion of food $type_i$ in receptor diet
AUF	=	Area use factor (equal to area of exposure unit/home range of receptor
Body Weight	=	Body weight of receptor.

Sediment may replace soil in Equation 3.1 for aquatic or semi-aquatic receptors.

The first step in estimating exposure rates for terrestrial wildlife involves the calculation of feeding and drinking rates for site receptors. EPA (1993) includes a variety of exposure information for a number of avian, herptile, and mammalian species. Information regarding feeding and drinking rates and dietary composition are available for many species or may be estimated using allometric equations (Nagy, 1987). Data have also been gathered on incidental ingestion of soil and is incorporated for the receptor species. Literature values for animal-specific sediment ingestion are used if available. However, such values generally are not available in the literature. Where sediment ingestion rates could not be found, the animal-specific incidental soil ingestion rate is used for sediment ingestion as well, if the receptor's life history profile suggests a significant aquatic component (e.g., raccoons' use of surface water in foraging activities). This information is summarized in Table 3-1.

To estimate dose associated with ingested food items, concentrations of COPECs in the vegetation or prey in the species' diet is estimated using bioaccumulation factors (BAF) (sometimes referred to as bioconcentration factors [BCF]). BAFs are regression models or scalar variables that reflect the potential for the COPECs to be present in food items at concentrations different from (usually greater than) the ambient environment. Differences in concentration are due to chemical-specific properties of the COPEC that affect its tendency to bioaccumulate in tissue, balanced by the innate ability of the species to regulate body burden levels of the chemical via metabolic and excretory processes.

Selection of appropriate BAFs is a critical component to food chain modeling. General approaches for BAF selection have been discussed in Sample and Suter (1994), EPA (1999a), U.S. Army Environmental Center (2005) and EPA (2008). An approach that is consistent with these sources was followed in the selection of BAFs for PBOW. The general hierarchy for selection of BAFs based on types of sources, is as follows:

1. Use of regression equations derived from paired field- or laboratory-based measurements

2. Ratio-derived BAFs developed based on paired data of tissue concentrations compared to media concentrations where the BAF is equal to the tissue concentration divided by the concentration in the abiotic medium.

3. Modeled equilibrium partitioning-derived BAFs based on physical or chemical characteristics

4. Assumptions based on values common to chemical class.

Both U.S. Army Environmental Center (2005) and EPA (1999a) support the use of ratio BAFs in preference to equilibrium partitioning-based BAFs, which are typically calculated based on factors such as log octanol-water partition coefficient (K_{ow}) values, fraction of organic carbon in soil, or percent of lipids in invertebrates.

Other general recommendations provided in EPA (2008) were also followed, including the following:

- For selection of ratio-based BAFs, median values are selected over maximum or other high-end BAFs.
- BAFs for accumulation of polynuclear aromatic hydrocarbons (PAH) into mammalian prey are assumed to equal zero due to the high metabolic breakdown of PAHs in mammals.

Regression equations used to calculate prey tissue concentrations of a specific chemical typically take the following general equation form:

$$\text{Ln}\,(C_{food}) = \text{slope value} \times \ln\,(C_{abiotic\_media}) + \text{intercept value} \qquad \text{Eq. 3.2}$$

where:

C_{food}	=	Concentration of chemical in food type
$C_{abiotic\_media}$	=	Concentration of chemical in abiotic media.

Ratio BAFs can be generally presented as follows:

$$C_{food} = \text{BAF} \times (C_{abiotic\_media}) \qquad \text{Eq. 3.3}$$

where:

C_{food}	=	Concentration of chemical in food type
$C_{abiotic\_media}$	=	Concentration of chemical in abiotic media
BAF	=	Constant.

BAFs calculated based on equilibrium partitioning typically use a physical constant of a chemical to generate a BAF. A generalized form for this calculation would be as follows:

$$\text{Log (BAF)} = \text{slope value} \times \text{Log}\,(K_{ow}) + \text{intercept value} \qquad \text{Eq. 4}$$

where:

Log (BAF)	=	Log of the BAF for chemical in food type

BAFs calculated based on equilibrium partitioning are applied in the same fashion as ratio-based BAFs to generate a tissue concentration value. Any K_{ow} values needed for BAFs based on equilibrium partitioning are obtained from the Syracuse Research Corporation Web site (http://www.syrres.com/esc/est_kowdemo.htm).

Finally, where ratio-based BAFs are missing and where no equilibrium partitioning method has been developed for calculating BAFs, other methods, such as using BAFs for chemicals in the same class as surrogates, may be presented for establishing ratio-based BAFs.

For the current SLERA, PBOW-specific BAFs that were developed as part of the Red Water Ponds Phase II baseline ecological risk assessment (BERA) (IT, 2001b) were used for the AP2 food chain model, when available. Site-specific soil-to-earthworm and sediment-to-benthic invertebrate BAFs were developed in this BERA based on 28-day bioaccumulation studies performed using the earthworm species *Eisenia foetida* or the invertebrate species *Lumbriculus variegates*, respectively, and soil or sediment samples collected from the PBOW Red Water Ponds area. Both reasonable maximum exposure (RME) and central tendency (CT) BAFs were estimated in the Red Water Ponds risk assessment. The RME BAFs were based on all tissue concentration results, even if blank related, and the CT BAFs were based on blank-corrected tissue results. Although EPA recommends that median values be selected over maximum or other high-end BAFs, the RME sediment-to-aquatic invertebrate and soil-to-worm BAFs were conservatively selected over the CT BAFs as the selected BAFs for the AP2 SLERA, when available. The Red Water Ponds BERA also developed CT and RME BAFs for surface water-to-fish for two different PBOW sites, the West Area Red Water Ponds and Pentolite Road (IT, 2001b). These values were also adopted for use in the AP2 SLERA. When two values were available for a given chemical from the two areas, the average of the RME values was used as the BAF for the AP2 SLERA.

The hierarchies used to select BAFs specific to the various types of biota are presented below. Chemical-specific BAFs (or the regression equation used to calculate COPEC concentrations) for COPECs selected using the respective hierarchies are presented in Tables 3-2 through 3-6.

Table 3-2 presents the soil-to-plants BAFs for COPECs at AP2. Soil-to-plants BAFs are also used to evaluate sediment-to-plant uptake at PBOW. Soil-to-plants BAFs are selected using the following specific hierarchy of sources:

1. EPA (2008) selected regressions
2. Efroymson, et al. (2001) regressions
3. EPA (2008) recommended median BAFs
4. International Atomic Energy Agency (IAEA) (1994) BAFs
5. Baes, et al. (1984) BAFs (these values were often updated in the more recent IAEA [1994] publication).

Table 3-3 presents the soil-to-invertebrates (earthworms) BAFs for COPECs at AP2. Soil-to-invertebrates BAFs are selected using the following hierarchy of sources:

1. PBOW site-specific BAFs (IT, 2001b)
2. EPA (2008) selected regressions
3. Sample, et al. (1998a) regressions
4. Sample, et al. (1998a) median BAFs
5. Equilibrium BAF calculation method in EPA (2008) based on Jager (1998).

Table 3-4 presents the soil-to-mammals BAFs for COPECs at AP2. Soil-to-mammals BAFs are selected using the following hierarchy or sources:

1. PBOW site-specific BAFs (IT, 2001b)
2. EPA (2008) or Sample, et al., (1998b) selected regressions
3. EPA (2008) referenced BAFs (Note: per EPA [2008], a BAF of zero is used for all PAHs, TNT, and RDX.)
4. Sample, et al. (1998b) median BAFs
5. IAEA (1994) BAFs
6. Baes, et al. (1984) BAFs (these values were often updated in the newer IAEA [1994] publication)
7. EPA (1999b) maximum calculated BAFs/BCFs for feeding guilds.

Table 3-5 presents the sediment-to-aquatic invertebrates BAFs for COPECs at AP2. Sediment-to-aquatic invertebrates BAFs are selected using the following hierarchy of sources:

1. PBOW site-specific BAFs (IT, 2001b)
2. Ratio BAFs from Bechtel Jacobs Company, LLC (1998)
3. Ratio BAFs from EPA (1999b)
4. Ratio BAFs from other literature sources
5. Conservative default based on median BAF for PCBs from Bechtel-Jacobs Corporation, LLC (1998).

Table 3-6 presents the surface water-to-fish BAFs for COPECs at AP2. Surface water-to-fish BAFs are selected using the following hierarchy:

1. PBOW site-specific BAFs (IT, 2001b)
2. EPA (1999b) ratio BAFs

3. EPA (1989b) ratio BAFs
4. RAIS database (ORNL, 2008 on-line)
5. Equilibrium partitioning equation (Bintein and Devillers, 1993).

It should be noted that the BAFs presented in EPA (1989a and 1999b) are presented in units of milligrams per kilogram (mg/kg) (wet) per milligrams per liter (mg/L). These BAFs were adjusted to BAFs with dry weight units of mg/kg(dry) per mg/L by dividing by the proportion of solids of a fish (20 percent, as detailed in Table C-5 of EPA (2000).

Ingestion rates for receptor species are typically developed as a quantity of wet weight material ingested. Soil analytical data results are typically reported on a dry weight basis. Literature-derived BAFs are often a mixture of dry weight to wet weight and dry weight to dry weight values. To avoid underestimating or overestimating food concentrations based on confusion over dry weight versus wet weight, final food concentrations are adjusted in the SLERA to report concentrations on a dry weight basis. Although it was not necessary to convert food intake rates from wet weight to dry weight in this SLERA, the moisture contents of the invertebrate and vegetative material in the receptor species' diets from the EPA's *Wildlife Exposure Factors Handbook* (EPA, 1993) can be used for this conversion, as follows:

- Earthworms - 84 percent
- Fruit - 77 percent
- Roots/young grass - 82 percent
- Seeds - 9.3 percent
- Fruit/young grass - 78 percent.

Exposure to four categories of environmental media are addressed in the SLERA, as discussed in the following subsections.

Soil Exposure Pathway. Soil exposure pathways are potentially important for terrestrial plants and animals at the site. For non-burrowing animals, exposure to soil from a depth of 0 to 1 foot bgs was considered, as this soil depth would represent the depth of regular exposure. For burrowing animals such as the shrew, exposure to soil from a depth of 0 to 6 feet bgs was considered. It is noted that although the shrew itself may not actually burrow to a depth of 6 feet, there may be other burrowing mammals that do burrow this deep. For plants and herbivores feeding on deep-rooted plants (e.g., the white-tailed deer, which is assumed to ingest leaves of trees translocating COPECs from subsoils), exposure to soil from a depth of 0 to 6 feet bgs (or the water table surface) was also evaluated because most feeder roots are located within this depth. Thus, the shrew and the white-tailed deer (Figure 2-4), were evaluated for exposure to deeper (0 to 6 feet bgs) soil. All other receptors exposed to soil were evaluated for exposure to concentrations in surface (0 to 1 foot bgs) soil.

Environmental conditions such as soil moisture, soil pH, and cation exchange capacities significantly influence whether potential soil contaminants remain chemically bound in the soil matrix or can be chemically mobilized (in a bioavailable form) and released for plant absorption. Generally, neutral to alkaline soils (soil pH of 6.5 or greater) restrict the absorption of toxic metals, making pathway completion to plants difficult.

Sediment Exposure Pathway. Sediment consists of materials precipitated or settled out of suspension in surface water or native soils underlying flowing or standing surface water bodies. Potential contaminant sources for sediment include over-ground transport from the AP2 area, and contaminated surface water, groundwater, and soil. The release mechanisms include surface water runoff, groundwater discharge, and airborne deposition. Potential receptors of chemicals in contaminated sediment include aquatic flora and fauna. Direct exposure routes for contaminated sediment include contact by benthic-dwelling organisms such as amphipod invertebrates, uptake by aquatic flora, and ingestion by aquatic fauna. Indirect exposure pathways from sediment include consumption of bioaccumulated contaminants by consumers in the food chain. Chemical bioavailability of many nonpolar organic compounds (e.g., polychlorinated biphenyls and pesticides) decreases with increasing concentrations of total organic carbon in the sediment; however, these compounds can still bioaccumulate up the food chain (Landrum and Robbins, 1990).

Surface Water Exposure Pathway. Surface water represents a potential transport medium for COPECs. Potential sources for contaminated surface water include over-ground transport from the AP2 area, contaminated soil/sediment and groundwater, and deposition of airborne contaminants. The release mechanisms include surface runoff, leaching, and groundwater seepage. Potential receptors of contaminated surface water include terrestrial and aquatic fauna and aquatic flora. Exposure routes for contaminated surface water include ingestion by terrestrial fauna and uptake and absorption by aquatic flora and fauna. Consumption of bioaccumulated contaminants constitutes a potential indirect exposure pathway for faunal receptors. Chemical bioavailability of some metals and other chemicals is controlled by water hardness, pH, and total suspended solids.

Groundwater Exposure Pathway. Groundwater represents a potential transport medium for COPECs. Potential contaminant sources for groundwater include contaminated soil and buried or stored waste. The release mechanism for contaminants into groundwater is direct transfer of contaminants from waste materials to water as water passes through the materials.

Groundwater itself is not an exposure point in ecological risk assessments, although contaminant transport along the shallow groundwater pathway may be considered an exposure route to aquatic life, wetlands, and some wildlife where the groundwater discharges to surface water. This pathway is of importance to aquatic and wetland receptors if groundwater is found to be discharging to surface water. Because this scenario is unlikely at AP2, groundwater was not directly evaluated in this SLERA. However, surface water samples were collected from Pipe Creek during the wet season in May 2009, which is when groundwater discharge to Pipe Creek is most likely. Thus, the surface water evaluation considers potential impact from contaminants that may be present in groundwater, under exposure conditions in an aquatic habitat.

3.2 Exposure Characterization Summary

The estimated chemical intakes for each exposed receptor group under each exposure pathway and scenario are presented in the risk characterization spreadsheets in Appendix E. These intake estimates are combined with the COPEC toxicity values, discussed in the following section, to derive estimates and characterize potential ecological risk. The uncertainties associated with the estimation of chemical intake are discussed in Section 5.2.

4.0 Ecological Effects Characterization

The ecological effects characterization primarily describes the development of TRVs.

Development of Toxicity Reference Values. TRVs focusing on the growth, survival, and reproduction of species and/or populations have been developed for the AP2 SLERA. Empirical data are available for the specific receptor-endpoint combinations in some instances. Data on surrogate species and/or on endpoints other than the NOAEL and LOAEL were considered as necessary. The NOAEL is a dose of each COPEC that will produce no known adverse effects in the test species. The NOAEL was judged to be an appropriate toxicological endpoint because it would provide the greatest degree of protection to the receptor species. In addition, the LOAEL was used as a point of comparison for risk management decisions. In instances where data are unavailable for a site-associated COPEC, toxicological information for surrogate chemicals or groups of chemical were used. Safety factors were used to adjust for these differences and extrapolate risks to the site's receptors at the NOAEL and/or LOAEL endpoint. This process is described in the following paragraphs.

Toxicity information pertinent to identified receptors has been gathered for those analytes identified as COPECs. Because the measurement endpoint ranges from the NOAEL to the LOAEL, preference has been given to chronic studies noting concentrations at which no adverse effects were observed and those for which the lowest concentrations associated with adverse effects were observed. As previously noted, where data are unavailable for the exposure of a receptor to a COPEC, data for a surrogate chemical or group of chemicals were considered for use in the SLERA.

Whenever possible, studies that use the site-specific target wildlife receptors were utilized. When studies for these species were not available, alternative species studies were used. TRVs are not applied across classes under any circumstances (e.g., a TRV for a bird species may not be used to estimate hazard for a mammal species). In instances where TRVs for multiple avian or mammalian species are supported, the TRV for the most similar species to the measurement receptor based on feeding strategy and physiological attributes were used in the SLERA. For example, for mercury, which was identified as a COPEC in soil, mammalian TRVs based on both mink and mouse test species data are available. The mink TRV was used in the food chain model to evaluate the raccoon measurement receptor because both the mink and the raccoon are carnivores/omnivores that forage along stream corridors, whereas the mouse TRV was used for the other mammalian measurement receptors due to closer taxonomic similarity (e.g., short-tailed shrew) and/or foraging patterns (e.g., cottontail rabbit, white-tailed deer). Avian TRVs based on multiple test organisms were also available for two other COPECs, lead and selenium, and were evaluated for specific measurement receptors as follows:

COPEC	TRV Test Species	Measurement Receptor
Lead	Quail	Marsh Wren
Lead	Kestrel	Red-Tailed Hawk
Selenium	Duck	Marsh Wren
Selenium	Owl	Red-Tailed Hawk

Using the relevant toxicity information, TRVs were calculated for each of the COPECs. TRVs represent NOAELs and LOAELs with the safety factors presented in Wentsel, et al. (1996) applied to toxicity information that was derived from studies other than no-effects or lowest-effects studies (Figure 4-1).

Because NOAELs and LOAELs for the selected wildlife receptor species are based on data from test species that are usually different from the species of concern, a mathematical adjustment to the TRVs has often been performed in the past (e.g., Sample, et al., 1996) using a power function of the ratio of body weights. This practice is often referred to as allometric scaling. Alternately, uncertainty factors have also been used to account for the differences in species' sensitivities to chemicals. However, in recent years, these practices have been discouraged by most scientific and regulatory groups. Recent reviews of these practices (e.g., EPA, 2008; Allard, et al., 2009) have concluded that the use of allometric scaling of TRVs does not reflect a sound application of toxicological or ecological risk practices because supporting data for this practice are limited, and the ratio relationships used for the mathematical conversions were developed based on acute (rather than chronic) toxicity data. These reviews further conclude that uncertainty factors based on an arbitrary multiplier should not be used without a scientific basis for their application (Allard, et al., 2009). Therefore, the use of toxicity data without adjustments as reported in the literature is regarded as the most technically sound approach and is adopted for this SLERA. The TRVs used for this SLERA are summarized in Tables 4-1 and 4-2 for mammals and birds, respectively.

Exposure rate TRVs provide a reference point for the comparison of toxicological effects upon exposure to a contaminant and are compared against calculated receptor doses. TRVs are not used for evaluating community-based receptors such as plants or invertebrates.

5.0 Risk Characterization

The risk characterization phase integrates information on exposure, exposure-effects relationships, and defined or presumed target populations. The result is a determination of the likelihood, severity, and characteristics of adverse effects to environmental stressors present at a site. Qualitative and semiquantitative approaches were used to estimate the likelihood of adverse effects occurring as a result of exposure of the selected site receptors to COPECs. Because potential adverse affects to terrestrial and aquatic plants and invertebrates have been qualitatively assessed during the initial COPEC screening step, the risk characterization focuses on potential impacts to assessment receptors (Section 2.3).

For the semiquantitative predictive assessment, TRVs and exposure rates have been calculated and are used to generate hazard quotients (HQ) (Wentsel, et al., 1996). HQs are calculated by summing intake doses across all exposure pathways for each chemical for a given receptor and dividing by the TRV. Given the inherent uncertainties associated with the input values, HQs are rounded in this SLERA to a single significant figure for values below 10, and a whole number for values greater than 10. HQs for those chemicals that have a similar mode of toxicological action are typically summed to account for cumulative effects; however, no groups of COPECs with similar toxicity mechanisms were identified for this SLERA, and HQs for multiple chemicals were not summed. HQs are a means of estimating the potential for adverse effects to organisms at a contaminated site, and for assessing the potential that toxicological effects will occur among site receptors.

5.1 Predictive Risk Estimation for Terrestrial and Aquatic Wildlife

The risk estimation was performed through a series of quantitative HQ calculations that compare receptor-specific exposure values with TRVs. The HQs are compared to HQ guidelines for assessing the risk posed from contaminants. HQs less than or equal to 1 represent no probable risk, HQs from 1 up to but less than 10 represent a low potential for environmental effects, HQs from 10 up to but less than 100 represent a significant potential that effects could result from greater exposure, and HQs greater than 100 represent the highest potential for expected effects (Wentsel, et al., 1996). It should be noted that OEPA considers HQs greater than 1 to be potentially significant. It should also be noted that HQs are not measured of risk, are not population-based statistics, and are not linearly scaled statistics. Therefore, an HQ above 1, even exceedingly so, does not definitively indicate that there is even one individual expressing the toxicological effect associated with a given chemical to which it was exposed (Tannenbaum, 2005; Bartell, 1996).

Table 5-1 summarizes the NOAEL and LOAEL-based HQs for the eight evaluated assessment receptors. Only thallium had an HQ greater than 1 when rounded for any receptor species. The HQ for thallium did not exceed 10 for the deer mouse (HQ = 5.95) and only slightly exceeded 10 (HQ = 13.4) for the short-tailed shrew. The LOAEL-based HQ for thallium did not exceed 1 when rounded for either receptor. Therefore, thallium is considered to have a low potential for adverse effects. Thallium was detected at concentrations greater than its BSC of 1.3 mg/kg in 11 out of 40 soil samples. However, all 11 of these detections were from the 1996 historical sampling event. Of the 15 soil samples collected during the most recent sampling event in 2009, only 8 had detectable concentrations of thallium. The MDC of these eight samples was 0.47 mg/kg, which is well below the thallium BSC of 1.3 mg/kg and ESV of 1 mg/kg. The apparent reason for the reported exceedances in the 1996 samples is that they were analyzed using inductively coupled plasma spectrometry (ICP) without mass spectrometry (MS). The 2009 samples used the combined ICP/MS method, which attained much lower reporting limits. False positives are common using ICP alone. It is likely that the reported detections among the 1996 samples were all false positives.

Because the 2009 sample locations overlap the same general area as the 1996 samples, thallium concentrations are determined not to be elevated at AP2, and this chemical is not recommended for further evaluation.

5.2 Uncertainty Analysis

A number of factors contribute to the overall variability and uncertainty inherent in ecological risk assessments. Variability is due primarily to measurement error. Laboratory media analyses and receptor study design are the major sources of this kind of error. Uncertainty, on the other hand, is associated primarily with deficiency or irrelevancy of effects, exposure, or habitat data to actual ecological conditions at the site. Species physiology, feeding patterns, and nesting behavior are poorly predictable; therefore, all toxicity information derived from toxicity testing, field studies, or observation have uncertainties associated with them. Laboratory studies conducted to obtain site-specific, measured information often suffer from poor relevance to the actual exposure and uptake conditions on site (i.e., bioavailability, exposure, assimilation, etc., are generally greater under laboratory conditions as compared to field conditions). Calculating an estimated value based on a large number of assumptions is often the only alternative to the accurate, albeit costly, method of direct field or laboratory observation, measurement, or testing. Finally, habitat- or site-specific species may be misidentified if, for example, the observational assessment results are based on only one or even two brief site reconnaissance surveys.

The uncertainty analysis lists:

- Many of the major assumptions made for the SLERA; the direction of bias caused by each assumption, i.e., whether the uncertainty results in an overestimate or underestimate of risk
- The likely magnitude of impact as high, medium, low, or unknown
- Where possible, a description of recommendations for minimizing the identified uncertainties if the SLERA progresses to higher level assessment phases.

The most important uncertainties associated with this SLERA are discussed in the following subsections.

Assumptions of bioavailability. The assumption that COPECs are 100 percent bioavailable likely overestimates the potential for adverse effects. The duration that has lapsed since the contaminant release affects bioavailability as the contaminant becomes sequestered or transformed within the environmental media. Sequestration, transformation, and bioavailability are influenced by medium characteristics including pH, temperature, and organic carbon content.

Use of laboratory-derived or empirically estimated partitioning and transfer factors. The use of laboratory-derived or empirically estimated partitioning and transfer factors to predict COPEC concentrations in plants, invertebrates, prey species, and sediment likely overestimates potential risks. As discussed previously, the incorporation of COPECs into the food chain is influenced by the characteristics of the exposure medium, which likely differs from that used in the laboratory to derive partitioning and transfer factors.

Use of laboratory-derived toxicity reference values. The use of laboratory-derived TRVs may overestimate or underestimate the potential for adverse effects. The method of administration of the contaminant in the laboratory is significantly different than that experienced in the wild by the receptors.

Use of the HQ method to estimate risks to populations or communities. The calculation of HQs also introduces uncertainty. The following limitations associated with HQs (Tannenbaum, et al., 2003) are noted:

- HQs are not measures of risk.
- HQs are not population based.

- HQs are not linearly scaled.
- HQs are often produced that are unrealistically high and toxicologically impossible (e.g., estimated HQs greater than 1,000, although HQs generated for the AP2 SLERA do not appear to fall into this category).
- Trace soil concentrations of inorganic chemicals (including concentrations well below background levels) can lead to HQ threshold exceedances.

Sampling and Analytical Limitations. It is not possible to completely characterize the nature and extent of contamination on any site. Uncertainties arise from limits on the number of locations that can be sampled. The sampling protocol used at AP2, however, was designed to optimize efficiency of the sampling effort and reduce uncertainty by providing coverage of the affected area using historical data and site knowledge to focus on the most likely contaminated areas. This approach will bias potential soil contaminant concentrations higher than that for the entire region to provide a more conservative estimate of potential risk. The sampling and analytical data are considered sufficient to conclude that the potential for adverse impacts associated with chemicals present at the site is very low.

State-of-the-practice laboratory methods were used for analysis of the remedial investigation samples collected in 2009. SI samples, also used in this AP2 SLERA, were collected in 1996. The ICP method used for certain metals in the 1996 data resulted in relatively high reporting limits and tended to result in false positives when compared with the ICP/MS method used in the 2009 remedial investigation samples. Among these metals is thallium, which was a COPEC in AP2 soil. The MDC among the 2009 soil samples is only 0.939 mg/kg, which is less than the BSC. This means that based on the 2009 data, thallium would not be identified as a COPC. Therefore, use of the 1996 analytical data appears to have introduced a high bias to the resulting risk calculations.

Selection and Quantification of Chemicals of Potential Ecological Concern. Uncertainty associated with the processes used to identify COPECs and estimate EPCs arises from the following:

- Identifying background chemicals. Metals are judged to be present at concentrations comparable to background if the MDC does not exceed the BSC, or if statistical testing demonstrates that the site data and background data are drawn from the same population. Statistical testing of site data versus background was performed for this SLERA. Some organic chemicals, such as PAHs, may be considered to be anthropogenic background. The inclusion of ambient anthropogenic compounds in the SLERA may impart a conservative bias towards the risk assessment. However, PAHs were not identified as

COPECs at this site. Soil background values were compared with concentrations of metals detected in AP2 sediment in this SLERA. The use of soil background values for comparison to concentrations detected in sediment results in some added uncertainty to the SLERA. Naturally occurring levels of metals can differ in soil and sediment because the presence of metals in the sediment matrix can be affected by factors such as pH of the sediment and overlying water, oxidation/reduction conditions, sediment texture, presence/absence of organic matter, dissolved oxygen levels, etc. Although the concentrations of naturally occurring metals in soil and sediment may differ somewhat, soil background values can provide a reasonable point of reference for determining concentrations in sediment that may be associated with contamination and that warrant further consideration. Because concentrations in "true" background sediment may be higher or lower than their equivalent BSCs in soil, the direction of bias is unknown.

- Estimated EPCs are uncertain. For statistical purposes, if a constituent is positively identified at a site and has at least a single detection, all the samples with nondetects are assumed to have a value equal to half the reporting limit and are included in the data set, although identified for the ProUCL software (EPA, 2009) as nondetects. However, typical laboratory methods are able to detect concentrations of a chemical well below the reporting limit, or even half the reporting limit. Therefore, although the exact concentration of a nondetect chemical is unknown, the use of half the reporting limit as a surrogate concentration likely overestimates the actual concentration and introduces a conservative bias into the risk assessment. Computed 95 percent UCL values are only estimates of the actual UCLs associated with each data set. Examples of factors affecting the uncertainty of these estimates include the number of samples, proportion of nondetects, conformance with an assumed mathematical distribution, imprecision of laboratory data, elevated detection limits (from dilutions, matrix interference, etc.), and statistical methodology. For some data sets, the MDC was used for the UCL. Uncertainties associated with the statistical determination of EPCs for the COCs in each medium are as follows:

  – A limited number of samples may not completely characterize the site because they provide less information about the population from which they are drawn than do larger sample sets. Accordingly, small sets tend to have a greater variability, which results in the calculation of wide confidence intervals on the mean concentration and high EPCs. In some cases, the 95 percent UCL was greater than the MDC; thus, the MDC was chosen as the EPC. High confidence limits may introduce a conservative bias into the risk assessment.

  – Biased soil sampling is a common practice at contaminated sites for the purposes of identifying nature and extent of contamination and to reduce the potential for Type I errors when performing environmental investigations (i.e., concluding that a site is clean when it really is not). The biased sampling approach likely overestimates chemical concentrations, resulting in greater chemical concentrations and predicted risk. The AP2 sampling strategy was not strongly biased, however, and this uncertainty is considered minor for this particular SLERA.

- Laboratory analytical techniques have a degree of uncertainty associated with them. These uncertainties are documented by using data qualifiers to reflect the degree of certainty of measurement. For example, some data were estimated (e.g., J-qualified), while other data were rejected (i.e., R-qualified). The direction of bias is unclear.

The use of the 95 percent UCL as the EPC is likely to underestimate the EPC in 5 percent of the cases and overestimate exposure in 95 percent of cases, imparting an overall conservative bias to the risk assessment. It should be noted that some COPEC MDCs measured in sediment and surface water were used as EPCs due to the limited number of samples; an additional sampling effort could potentially reduce the hazard estimate.

6.0 Risk Summary and Conclusions

Chemicals detected in soil, surface water, and sediment were screened against conservative benchmark values and other criteria to identify COPECs in media present at AP2. Four chemicals in soil, four chemicals in surface water, and one chemical in sediment were identified as COPECs for further evaluation. A food chain model was used to evaluate the potential hazard associated with exposure to these chemicals by representative measurement receptors. Only thallium resulted in HQ values greater than 1. However, thallium is not considered to be a final COPEC for the site, because HQ values using conservative values did not exceed 10 when rounded, and a review of the data indicated that all elevated thallium detections originated from historical data collected over 15 years ago. The historical data were obtained using a laboratory method (ICP) that often results in false positives for thallium. Samples collected in 2009 and analyzed using updated laboratory methods (ICP/MS) did not exceed background or ecological screening values. Therefore, the potential for adverse ecological impacts is considered to be negligible at this site, and no chemicals are selected for further evaluation for protection of the environment at AP2.

7.0 References

Allard, P., A. Fairbrother, B.K. Hope, R.N. Hull, M.S. Johnson, L. Kapustka, G. Mann, B. McDonald, and B.E. Sample, 2009, ***Recommendations for the Development and Application of Wildlife Toxicity Reference Values***, Integrated Environmental Assessment and Management 6:28-37.

Baes, C. E., R. D. Sharp, A. L. Sjoreen, and R. W. Shor, 1984, ***A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides Through Agriculture***, ORNL-5786, September.

Bartell, S.M., 1996, "Ecological/Environmental Risk Assessment Principles and Practices," Kulluru, R., Bartell, S., Pitblado, R., et al. (eds), Risk Assessment and Management Handbook, McGraw-Hill, NY.

Bechtel Jacobs Company LLC, 1998, ***Biota Sediment Accumulation Factors for Invertebrates: Review and Recommendations for the Oak Ridge Reservation***, BJC/OR-112.

Dames and Moore, Inc., 1997, ***TNT Areas Site Investigation, Final Report, Plum Brook Ordnance Works/NASA, Sandusky, Ohio***, April.

Efroymson, R. A., B. E. Sample, and G. W. Suter, 2001, "Uptake of Inorganic Chemicals From Soil by Plant Leaves: Regressions of Field Data," ***Environ. Toxicol. Chem.*** 20: 2561-2571.

Efroymson, R.A., G.W. Suter II, B.E. Sample, and D.S. Jones, 1997a, ***Preliminary Remediation Goals for Ecological Endpoints***, Oak Ridge National Laboratory. Report No. ES/ER/TM-162/R2.

Efroymson, R.A., G.W. Suter II, and M.E. Will, 1997b, ***Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process, 1997 Revision***, Oak Ridge National Laboratory. Report No. ES/ER/TM-126/R2.

Efroymson, R.A., G.W. Suter II, Wooten, A.C., and M.E. Will, 1997c, ***Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants, 1997 Revision***, Oak Ridge National Laboratory. Report No. ES/ER/TM-85/R3.

International Atomic Energy Agency (IAEA), 1994, ***Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Temperate Environments***, Technical Reports Services No. 364, June 24.

IT Corporation (IT), 2001a, ***TNT Areas A and C Remedial Investigation, Former Plum Brook Ordnance Works, Sandusky, Ohio, Volume 3, Ecological Risk Assessment,*** Final, November.

IT Corporation (IT), 2001b, ***Redwater Pond Areas Baseline Ecological Risk Assessment, Plum Brook Ordnance Works, Sandusky, Ohio,*** prepared for U.S. Army Corps of Engineers, Nashville District, April.

IT Corporation (IT), 1998, ***Site Investigation of Acid Areas, Plum Brook Ordnance Works, Sandusky, Ohio.***

Jacobs Engineering Group, Inc., 2010, ***Revised Final Ecological Screening Level Risk Assessment, Reservoir No. 2 Burning Ground, Former Plum Brook Ordnance Works***, February.

Jager, T., 1998, "Mechanistic Approach for Estimating Bioconcentration of Organic Chemicals in Earthworms," ***Environ. Toxicol. Chem.***, 17: 2080-2090.

Lafferty, M. B., 1979, ***Ohio's Natural Heritage***, The Ohio Academy of Sciences, Columbus, Ohio.

Landrum, P.F. and J.A. Robbins, 1990, "Bioavailability of Sediment-Associated Contaminants to Benthic Invertebrates," in ***Sediments: Chemistry and Toxicity of In-Place Pollutants***, R. Baudo, J.P. Giesy and II, Muntau Eds., Chelsea, Michigan: Lewis, 1990, pp. 237-263.

MacDonald, D.D., C.G. Ingersoll, and T.A. Berger, 2000, ***Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems***¸ Arch. Environ. Contam. Toxicol. 39: 20-31.

Nagy, K.A., 1987, "Field Metabolic Rate and Food Requirement Scaling in Mammals and Birds," ***Ecological Monographs***, Vol. 57, pp.111-128.

National Aeronautics and Space Administration (NASA), 1995, ***Biological Inventory of Plum Brook Station, 1994***, Office of Environmental Programs, NASA Lewis Research Center, Cleveland, Ohio.

Ohio Department of Natural Resources (ODNR), 2010, Letter from Ms. Debbie Woischke - Ecological Analyst, Division of Natural Areas and Preserves, to Mr. Jon Lindberg – Shaw Group, May 26.

Ohio Department of Natural Resources (ODNR), 1995, ***Biological Inventory of Plum Brook Station, 1994***, prepared for Office of Environmental Programs, NASA Lewis Research Center, Cleveland, Oho, prepared by ODNR under contract to The Bionetics Corporation, Brookpark, Ohio.

Ohio Department of Natural Resources (ODNR), 1985, ***Ohio Resources Inventory,*** Joint Publication of ODNR, Division of Soil and Water Conservation and USDA Soil Conservation Service, Columbus, Ohio, 28 pp.

Ohio Environmental Protection Agency (OEPA) 2008, ***Guidance for Conducting Ecological Risk Assessments***, Division of Emergency and Remedial Response, Columbus, OH.

Omernik, J. M., 1986, ***Ecoregions of the United States***, Corvallis Environmental Research Laboratory, EPA.

Ontario Ministry of Environment and Energy, 1993, ***Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario***, ISBN 0-7729-9248-7.

Peterjohn, B. G., and D. L. Rice, 1991, ***The Ohio Breeding Bird Atlas***, The Ohio Department of Natural Resources, Division of Natural Areas and Preserves, Columbus, Ohio.

Sample, B. E., J. J. Beauchamp, R. A. Efroymson, G. W. Suter II, and Ashwood, 1998a, ***Development and Validation of Bioaccumulation Models for Earthworms***, ES/ER/TM-220.

Sample, B. E., J. J. Beauchamp, R. A. Efroymson, G. W. Suter II, 1998b, ***Development and Validation of Bioaccumulation Models for Small Mammals,*** ES/ER/TM-219.

Sample, B. E. and G. W. Suter, II, 1994, ***Estimating Exposure of Terrestrial Wildlife to Contaminants***, Oak Ridge National Laboratory, Oak Ridge, Tennessee, ES/ER/TM-125.

Sample, B.E., D.M. Opresko, and G.W. Suter II, 1996, ***Toxicological Benchmarks for Wildlife: 1996 Revision***, prepared for the U.S. Department of Energy by Health Sciences Research Division, Oak Ridge National Laboratory.

Shaw Environmental, Inc. (Shaw), 2005, ***2004 Groundwater Data Summary and Evaluation Report, Final,*** *Former Plum Brook Ordnance Works, Sandusky, Ohio*, April.

Suter, G.W., 1993, ***Ecological Risk Assessment***, Lewis Publishers, Boca Raton, Florida.

Tannenbaum, L., 2005, ***A Critical Assessment of the Ecological Risk Assessment Process: A Review of Misapplied Concepts***, Integrated Environmental Assessment and Management, 1(1): 66-72.

Tannenbaum, L.V., M.S. Johnson, M. and Bazar, 2003, *Application of the Hazard Quotient Method in Remedial Decisions: A Comparison of Human and Ecological Risk Assessments*, ***Human and Ecological Risk Assessment***, Volume 9, No. 1, Pages 387-401.

U.S. Army Corps of Engineers (USACE), 1995, ***Site Management Plan, Plum Brook Ordnance Works, Sandusky, Ohio, Part B, Areas of Concern***, September.

U.S. Army Environmental Center, 2005, ***A Guide to Screening Level Ecological risk Assessment: Technical Document for Ecological Risk Assessment***, Department of the Army, U.S. Army Biological Technical Assistance Group.

U.S. Environmental Protection Agency (EPA), 2009, ***ProUCL Version 4.00.04***, Office of Research and Development, Technology Support Center Characterization and Monitoring Branch, Las Vegas, Nevada, February, on line at http://www.epa.gov/esd/tsc/form.htm.

U.S. Environmental Protection Agency (EPA), 2008, ***Guidance for Developing Ecological Soil Screening Levels***, Office of Solid Waste and Emergency Response, Directive 92857.7-55, Washington, D.C., SSL values on line at: http://epa.gov/ecotox/ecossl/index.html.

U.S. Environmental Protection Agency (EPA), 2003, ***U.S. EPA Region 5 RCRA Ecological Screening Levels (ESL)***, Website version last updated August 22, 2003: http://www.epa.gov/reg5rcra/ca/edql.htm.

U.S. Environmental Protection Agency (EPA), 2002, ***Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites***, OWSER 9285.6-10, December.

U.S. Environmental Protection Agency (EPA), 2000, ***Bioaccumulation Testing and Interpretation for the Purpose of Quality Assessment: Status and Needs***, Bioaccumulation Analysis Workgroup, Washington, DC.

U.S. Environmental Protection Agency (EPA), 1999a, ***Issuance of Final Guidance: Ecological Risk Assessment and Risk Management Principles for Superfund Sites***, OSWER Directive 9285.7-28P, October.

Environmental Protection Agency (EPA), 1999b, ***Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities***, EPA530-D-99-001A. November.

U.S. Environmental Protection Agency (EPA), 1997, ***Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments***, EPA/540-R-97-006.

U.S. Environmental Protection Agency (EPA), 1996, ***Region 5 Biological Technical Assistance Group (BTAG) Ecological Risk Assessment Bulletin No. 1***, Chicago, Illinois.

U.S. Environmental Protection Agency (EPA), 1993, ***Wildlife Exposure Factors Handbook***, Vols. I and II, Office of Research and Development, Washington, DC, EPA/600/R-93/187a.

U.S. Environmental Protection Agency (EPA), 1989a, ***Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A)***, Interim Final, Office of Emergency and Remedial Response, Washington, D.C., EPA/540/1-89/002.

U.S. Fish and Wildlife Service, 2010, Wetlands Mapper, http://www.fws.gov/wetlands/Data/Mapper.html.

Wentsel, R.S., T.W. LaPoint, M. Simini, R.T. Checkai, D. Ludwig, and L.W. Brewer, 1996, ***Tri-Service Procedural Guidelines for Ecological Risk Assessments,*** U.S. Army Edgewood Research, Development, and Engineering Center, Aberdeen Proving Ground, Maryland.

TABLES

Table 2-1

Plant Species Observed at Power House 2 Ash Pits
Plum Brook Ordnance Works, Sandusky, Ohio

Scientific Name	Common Name
Vegetation observed during June 2, 2009 site walk	
Acer negundo	box elder
Ailanthus altissima	tree of heaven
Alliaria petiolata	garlic mustard
Allium canadense	wild garlic
Allium vineale	field garlic
Ambrosia artemesiifolia	annual ragweed
Apocynum cannabinum	dogbane
Asclepias syriaca	common milkweed
Boehmeria cylindrica	small spike false nettle
Bromus inermis	smooth brome
Carex radiata	eastern star sedge
Carex tribuloides	blunt broom sedge
Carya ovata	shagbark hickory
Circaea lutetiana	southern broad-leaved enchanters nightshade
Cirsium arvense	creeping thistle
Convolvulus arvensis	hedge bindweed
Cornus drummondii	rough dogwood
Dactylis glomerata	orchard grass
Eleagnus angustifolia	autumn olive
Elymus sp.	wild rye
Erigeron annuus	fleabane
Eupatorium rugosum	white snakeroot
Eupatorium sp.	Joe pye weed
Fraxinus pennsylvanica	green ash
Galium aparine	cleavers
Galium asprellum	rough bedstraw
Glecoma hederacea	ground ivy
Gleditsia triacanthos	honeylocust
Glyceria striata	fowl manna grass
Hemerocallus fulva	daylily
Hesperis matronalis	dame's rocket
Impatiens capensis	jewelweed
Leersia virginica	white grass
Lonicera japonica	Japanese honeysuckle
Lysimachia nummularia	moneywort
Maclura pomifera	osage orange
Medicago lupulina	black medick
Melilotus sp.	sweet clover
Mentha piperita	peppermint
Onoclea sensibilis	sensitive fern
Oxalis stricta	sorrel
Parthenocissus quinquefolia	Virginia creeper

Table 2-1

Plant Species Observed at Power House 2 Ash Pits
Plum Brook Ordnance Works, Sandusky, Ohio

Scientific Name	Common Name
Pilea pumila	clearweed
Platanus occidentalis	sycamore
Poa compressa	Canada bluegrass
Polygonum virginianum	Virginia knotweed
Populus deltoides	cottonwood
Pyrus coronaria	crabapple
Quercus imbricaria	shingle oak
Quercus palustris	pin oak
Ranunculus sceleratus	cursed crowfoot
Ribes americanum	American currant
Rosa multiflora	multiflora rose
Rubus occidentalis	black raspberry
Salix nigra	black willow
Scutellaria lateriflora	mad dog skullcap
Teucrium canadense	Germander
Toxicodendron radicans	poison ivy
Tradescantia ohioensis	Ohio spiderwort
Trifolium repens	white clover
Ulmus americana	American elm
Verbesina alternifolia	wingstem
Viola canadensis	Canada violet
Viola cucullata	violet
Vitis aestivalis	summer grape
Vitis riparia	riverbank grape
Vegetation observed during September 9, 2009 site walk	
Acalypha rhomboidea	three-seeded mercury
Acer negundo	box-elder
Agrimonia parviflora	small-flowered groovebur
Ailanthus altissima	tree of heaven
Alliaria petiolata	garlic mustard
Ambrosia artemesiifolia	annual ragweed
Apocynum cannabinum	dogbane
Asclepias syriaca	common milkweed
Aster lateriflorus	calico aster
Aster sp.	aster
Boehmeria cylindrica	small spike false nettle
Bromus inermis	smooth brome
Carex bromoides	brome-like sedge
Carex radiata	eastern star sedge
Carex tribuloides	blunt broom sedge
Carya ovata	shagbark hickory
Catalpa speciosa	catalpa
Celtis occidentalis	hackberry
Cephalanthus occidentalis	common buttonbush

Table 2-1

Plant Species Observed at Power House 2 Ash Pits
Plum Brook Ordnance Works, Sandusky, Ohio

Scientific Name	Common Name
Cichorium intybus	chickory
Cinna arundinacea	wood reed grass
Circaea lutetiana	southern broad-leaved enchanters nightshade
Cirsium arvense	creeping thistle
Convolvulus arvensis	hedge bindweed
Cornus drummondii	rough dogwood
Dactylis glomerata	orchard grass
Eleagnus angustifolia	autumn olive
Elymus villosus	wild rye
Elymus virginicus	Virginia wild rye
Equisetum arvense	field horsetail
Erigeron annuus	fleabane
Eupatorium rugosum	white snakeroot
Euphorbia supina	milk purslane
Fraxinus pennsylvanica	green ash
Galium aparine	cleavers
Glecoma hederacea	ground ivy
Gleditsia triacanthos	honeylocust
Glyceria striata	fowl manna grass
Hemerocallus fulva	daylily
Impatiens capensis	jewelweed
Laportea canadensis	wood nettle
Leersia virginica	white grass
Leptoloma cognatum	fall witch grass
Lonicera japonica	Japanese honeysuckle
Lysimachia nummularia	moneywort
Maclura pomifera	osage orange
Medicago lupulina	black medick
Melilotus sp.	sweet clover
Onoclea sensibilis	sensitive fern
Oxalis stricta	sorrel
Panicum virgatum	switch grass
Parthenocissus quinquefolia	Virginia creeper
Pilea pumila	clearweed
Platanus occidentalis	sycamore
Poa compressa	Canada bluegrass
Polygonum hydropiper	marshpepper smartweed
Polygonum pennsylvanicum	Pennsylvania smartweed
Polygonum virginianum	Virginia knotweed
Populus deltoides	cottonwood
Pyrus coronaria	crabapple
Quercus imbricaria	shingle oak
Quercus palustris	pin oak

Table 2-1

Plant Species Observed at Power House 2 Ash Pits
Plum Brook Ordnance Works, Sandusky, Ohio

Scientific Name	Common Name
Ribes americanum	American currant
Riccia sp.	liverwort
Rosa multiflora	multiflora rose
Rubus occidentalis	black raspberry
Salix nigra	black willow
Scutellaria lateriflora	mad dog skullcap
Setaria faberi	foxtail grass
Setaria glauca	yellow foxtail
Solanum nigrum	black nightshade
Teucrium canadense	germander
Toxicodendron radicans	poison ivy
Trifolium repens	white clover
Triosteum aurantiacum	wild coffee
Tussilago farfara	coltsfoot
Ulmus americana	American elm
Verbena urticifolia	white vervain
Verbesina alternifolia	wingstem
Viola canadensis	Canada violet
Viola cucullata	violet
Vitis aestivalis	summer grape
Vitis riparia	riverbank grape

Table 2-2

Mammals Observed On Site and Likely to be Found in Erie County, Ohio
Plum Brook Ordnance Works, Sandusky, Ohio

Family Name	Scientific Name	Common Name	Observed On Site [a]
Didelphidae	*Didelphis virginiana*	Virginia opossum	X
Talpidae	*Condylura cristata*	star-nosed mole (**T**)	
	Parascalops breweri	hairy-tailed mole	
	Scalopus aquaticus	Eastern mole	
Verspertilionidae	*Myotis keenii*	Keen's bat	
	M. lucifugus	little brown bat	
	M. sodalis	Indiana bat **(E*)**	
	Eptesicus fuscus	big brown bat	
	Lasionycteris noctivagans	silver-haired bat	
	Lasiurus borealis	red bat	
	L. cinereus	hoary bat	
	Nycticeius humeralis	evening bat	
	Pipistrellus subflavus	Eastern pipistrelle	
Leporidae	*Sylvilagus floridanus*	cottontail rabbit	X
Sciuridae	*Glaucomys volans*	Southern flying squirrel	
	Marmota monax	woodchuck	
	Sciurus carolinensis	gray squirrel	
	S. niger	fox squirrel	
	Spermophilus tridecemlineatus	thirteen-lined ground squirrel	
	Tamias striatus	Eastern chipmunk	
	Tamiasciurus hudsonicus	red squirrel	X
	Blarina brevicauda	short-tailed shrew	

Table 2-2

Mammals Observed On Site and Likely to be Found in Erie County, Ohio Plum Brook Ordnance Works, Sandusky, Ohio

Family Name	Scientific Name	Common Name	Observed On Site [a]
	Cryptotis parva	least shrew	
	Sorex cinereus	masked shrew	
Castoridae	*Castor canadensis*	beaver	
Cricetidae	*Microtus pennsylvanicus*	meadow vole	
	Mus musculus	house mouse	
	Ondatra zibethicus	muskrat	
	Peromyscus leucopus	white-footed mouse	
	P. maniculatus	deer mouse	
	Rattus norvegicus	Norway rat	
	Synaptomys cooperi	Southern bog lemming	
	Zapus hudsonius	meadow jumping mouse	
Procyonidae	*Procyon lotor*	raccoon	X
Mustelidae	*Mephitis mephitis*	striped skunk	
	Mustela frenata	long-tailed weasel	
	M. nivalis	least weasel	
	M. vison	mink	
	Taxidea taxus	Badger (**T**)	
Canidae	*Canis latrans*	coyote	
	Urocyon cinereoargenteus	gray fox	
	Vulpes vulpes	red fox	
Cervidae	*Odocoileus virginianus*	white-tailed deer	X

Mammals likely to be found in Erie County based on information presented in
Gottschang, J. L., 1981, *A Guide to the Mammals of Ohio*, Ohio State University Press, 176 pages.
T - Ohio threatened species.
E* - Federally endangered species.

[a] Shaw Site Reconnaissance, April 29, June 2, and September 9, 2009.

Table 2-3

Birds Observed On Site and/or Likely to be Found
In Erie County, Ohio
Plum Brook Ordnance Works, Sandusky, Ohio

Family Name[a]	Scientific Name[b]	Common Name[c]	Status and Frequency
Ardeidae	*Ardea herodias*	great blue heron	(1) Regular visitor at ponds, streams, and ditches.
	Bublucus ibis	cattle egret (**E**)	(1) Rare visitor in short grass areas
	Butorides striatus	green heron	(1) Confirmed breeder, rare at ponds, streams.
	Casmerodius albus	great egret	(1) Regular visitor at ponds, streams, and ditches.
	Nycticorax nycticorax	black-crowned night heron (**T**)	(1) Regular visitor at ponds, streams, and ditches.
Anserinae	*Branta canadensis*	Canada goose	(1) Confirmed breeder; uncommon around ponds.
Anatinae	*Aix sponsa*	Wood duck	(1) Confirmed breeder, uncommon around ponds.
	Anas discors	blue-winged teal	Confirmed and/or probable breeder in county.
	A. platyrhynchos	mallard	(1) Confirmed breeder, uncommon at ponds, streams.
	A. rubripes	American black duck	(1) Possible breeder, rare at ponds, streams, ditches.
Merginae	*Lophodytes cucullatus*	hooded merganser	Confirmed and/or probable breeder in county.
Accipitrinae	*Accipiter striatus*	sharp-shinned hawk	Confirmed and/or probable breeder in county.
Buteoninae	*Buteo jamaicensis*	red-tailed hawk	Confirmed and/or probable breeder in county.
	B. lineatus	red-shouldered hawk	Confirmed and/or probable breeder in county.
	B. platypterus	broad-winged hawk	Confirmed and/or probable breeder in county.
	Haliaeetus leucocephalus	bald eagle (**T**)	Confirmed and/or probable breeder in county.
Anatidae	*Cygnus buccinator*	Trumpeter swan (**E**)	(1) Rare migrant seen flying toward lake.
Falconinae	*Falco sparverius*	American kestrel	Confirmed and/or probable breeder in county.
Phasianidae	*Colinus virginianus*	Northern bobwhite quail	Confirmed and/or probable breeder in county.
	Phasianus colchicus	ring-necked pheasant	Confirmed and/or probable breeder in county.
Rallidae	*Gallinula chloropus*	common moorhen	Confirmed and/or probable breeder in county.
	Porzana carolina	Sora	Confirmed and/or probable breeder in county.
Cathartidae	*Cathartes aura*	turkey vulture	Possible breeder in county.

Table 2-3

Birds Observed On Site and/or Likely to be Found In Erie County, Ohio Plum Brook Ordnance Works, Sandusky, Ohio

Family Name[a]	Scientific Name[b]	Common Name[c]	Status and Frequency
Charadriidae	*Charadrius vociferus*	killdeer	Confirmed and/or probable breeder in county.
Scolopacidae	*Actitis macularia*	spotted sandpiper	Confirmed and/or probable breeder in county.
	Bartramia longicauda	upland sandpiper (**T**)	(1) Confirmed breeder, rare in grassy areas.
	Gallinago gallinago	common snipe	Confirmed and/or probable breeder in county.
	Scolopax minor	American woodcock	(1) Confirmed breeder, uncommon in moist woodlots.
Larinae	*Larus argentatus*	herring gull	(1) Regular visitor.
	L. delawarensis	ring-billed gull	(1) Regular visitor.
Columbidae	*Columba livia*	rock dove	(1) Confirmed breeder, very common.
	Zenaida macroura	mourning dove	(1) Confirmed breeder, very common.
Cuculidae	*Coccyzus americanus*	yellow-billed cuckoo	(1)(2*) Confirmed breeder, uncommon in woodlots, shrubs.
	C. erythropthalmus	black-billed cuckoo	(1) Probable breeder, rare in woodlots & shruby areas.
Tytonidae	*Bubo virginianus*	great horned owl	(1)(2) Confirmed breeder, uncommon in woodlots.
	Otus asio	Eastern screech-owl	(1) Confirmed breeder, common in woodlots, shrubs.
	Strix varia	barred owl	Confirmed and/or probable breeder in county.
Caprimulgidae	*Chordeiles minor*	common nighthawk	(1) Possible breeder, rare.
Apodidae	*Chaetura pelagica*	chimney swift	(1) Confirmed breeder, uncommon.
Trochilidae	*Archilochus colubris*	ruby-throated hummingbird	(1) Confirmed breeder, uncommon in woodlots, shrubs.
Alcedinidae	*Ceryle alcyon*	belted kingfisher	(1) Confirmed breeder, rare around ponds, streams.

Table 2-3

Birds Observed On Site and/or Likely to be Found In Erie County, Ohio Plum Brook Ordnance Works, Sandusky, Ohio

Family Name[a]	Scientific Name[b]	Common Name[c]	Status and Frequency
Picidae	*Colaptes auratus*	Northern flicker	(1) Confirmed breeder, common in woodlots.
	Dryocopus pileatus	pileated woodpecker	Confirmed and/or probable breeder in county.
	Melanerpes carolinus	red-bellied woodpecker	(1) (2*) Confirmed breeder, common in mature woods.
	M. erythrocephalus	red-headed woodpecker	(1) Confirmed breeder, uncommon in mature woods.
	Picoides pubescens	downy woodpecker	(1)(2*) Confirmed breeder, common in woodlots.
	P. villosus	*hairy woodpecker*	(1) Confirmed breeder, uncommon in large woodlots.
Tyrannidae	*Contopus virens*	Eastern wood-pewee	(1)(2*) Confirmed breeder, very common in large woodlots.
	Empidonax alnorum	alder flycatcher	(1) Possible breeder, rare in shrubby wet areas.
	E. minimus	least flycatcher (**T**)	(1) Probable breeder, rare in shrubby areas.
	E. traillii	willow flycatcher	(1) Confirmed breeder, very common in shrubby areas.
	E. virescens	Acadian flycatcher	(1) Confirmed breeder, uncommon in mature woodlots.
	Myiarchus crinitus	great crested flycatcher	(1) Confirmed breeder, common in large woodlots.
	Sayornis phoebe	Eastern phoebe	(1) (2*) Confirmed breeder, common near stream bridges.
	Tyrannus tyrannus	Eastern kingbird	(1) Confirmed breeder, very common - open shrub area.
Alaudidae	*Eremophila alpestris*	horned lark	(1) Probable breeder, rare in grassland, cultiv. fields.
Hirundinidae	*Hirundo pyrrhonota*	cliff swallow	Confirmed and/or probable breeder in county.
	H. rustica	barn swallow	(1) Confirmed breeder, very common near vacant bldgs.
	Progne subis	purple martin	(1) Probable breeder, rare.
	Riparia riparia	bank swallow	(1) Rare migrant or visitor.
	Stelgidopteryx seripennis	Northern rough-winged swallow	(1) Confirmed breeder, rare along streams, ditches.
	Tachycineta bicolor	tree swallow	(1) Confirmed breeder, rare around ponds.

Birds Observed On Site and/or Likely to be Found In Erie County, Ohio Plum Brook Ordnance Works, Sandusky, Ohio

Family Name[a]	Scientific Name[b]	Common Name[c]	Status and Frequency
Corvidae	*Corvus brachyrhynchos*	American crow	(1)(2) Confirmed breeder, very common in woodlots.
	Cyanocitta cristata	blue jay	(1)(2*) Confirmed breeder, abundant in woods.
Paridae	*Parus atricapillus*	black-capped chickadee	(1) Confirmed breeder, common in woodlots.
	P. bicolor	tufted titmouse	(1)(2) Confirmed breeder, common in woodlots.
Sittidae	*Sitta carolinensis*	white-breasted nuthatch	(1) Confirmed breeder, uncommon in woodlots.
Troglodytidae	*Cistothorus palustris*	marsh wren	(1) Possible breeder, rare in wetlands with cattails.
	C. platensis	sedge wren	(1) Confirmed breeder, common in old grassy fields.
	Thryothorus ludovicianus	Carolina wren	(1) Probable breeder, rare in shrubby areas & woodlots.
	Troglodytes aedon	house wren	(1)(2*) Confirmed breeder, abundant in shrubby areas.
	T. troglodytes	winter wren	(1) Rare migrant.
Mimidae	*Dumetella carolinensis*	gray catbird	(1)(2*) Confirmed breeder, abundant in shrubby areas.
	Mimus polyglottos	Northern mockingbird	(1) Confirmed breeder, rare in shrubby areas.
	Toxostoma rufum	brown thrasher	(1) Confirmed breeder, common in shrubby areas.
Turdidae	*Catharus fuscescens*	veery	(1) Confirmed breeder, uncommon in large woodlots.
	Hylocichla mustelina	wood thrush	(1)(2) Confirmed breeder, very common in large woodlots.
	Sialia sialis	Eastern bluebird	(1) Confirmed breeder, common in openfields & edges.
	Turdus migratorius	American robin	(1)(2*) Confirmed breeder, abundant everywhere.
Sylviidae	*Polioptila caerulea*	blue-gray gnatcatcher	(1)(2*) Confirmed breeder, uncommon in woodlots.
	Regulus calendula	ruby-crowned kinglet	(1) Rare migrant.
Bombycillidae	*Bombycilla cedrorum*	cedar waxwing	(1) Confirmed breeder, very common everywhere.
Sturnidae	*Sturnus vulgaris*	European starling	(1) Confirmed breeder, abundant everywhere.

Table 2-3

Birds Observed On Site and/or Likely to be Found In Erie County, Ohio Plum Brook Ordnance Works, Sandusky, Ohio

Family Name[a]	Scientific Name[b]	Common Name[c]	Status and Frequency
Vireonidae	*Vireo bellii*	Bell's vireo	Confirmed and/or probable breeder in county.
	V. flavifrons	yellow-throated vireo	(1)(2*) Confirmed breeder, uncommon in mature woodlots.
	V. gilvus	warbling vireo	(1) Confirmed breeder, common in large woodlots.
	V. griseus	white-eyed vireo	(1) Confirmed breeder, uncommon in shrubby areas.
	V. olivaceus	red-eyed vireo	(1)(2*) Confirmed breeder, very common in woodlots.
Parulidae	*Dendroica cerulea*	cerulean warbler	(1) Possible breeder, rare in mature woodlots.
	D. dominica	yellow-throated warbler	(1) Confirmed and/or probable breeder in county.
	D. pensylvanica	chestnut-sided warbler	(1) Probable breeder, uncommon in shrubby areas.
	D. petechia	yellow warbler	(1) Confirmed breeder, abundant in shrubby areas.
	D. virens	*black-throated green warbler*	(1) Possible breeder, rare in mature woodlots.
	Geothylpis trichas	common yellowthroat	(1) Confirmed breeder, abundant in shrub areas, fields.
	Icteria virens	yellow-breasted chat	(1) Confirmed breeder, uncommon in shrubby areas.
	Mniotilta varia	black and white warbler	(1) Possible breeder, rare in mature woodlots.
	Oporornis formosus	Kentucky warbler	(1) Possible breeder, rare in mature woodlots.
	Protonotaria citrea	prothonotary warbler	Confirmed and/or probable breeder in county.
	Seiurus aurocapillus	overbird	(1) Probable breeder, rare in mature woodlots.
	S. motacilla	Louisiana waterthrush	Confirmed and/or probable breeder in county.
	Setophaga ruticilla	American redstart	(1) Probable breeder, rare in shrubby areas & woodlots.
	Vermivora leucobronchialis	Brewster's warbler	(1) Possible breeder, rare in shrubby areas and edges.
	V. pinus	blue-winged warbler	(1) Confirmed breeder, common in shrubby areas.
	Wilsonia citrina	hooded warbler	Confirmed and/or probable breeder in county.

Table 2-3

Birds Observed On Site and/or Likely to be Found
In Erie County, Ohio
Plum Brook Ordnance Works, Sandusky, Ohio

Family Name[a]	Scientific Name[b]	Common Name[c]	Status and Frequency
Icteridae	*Agelaius phoeniceus*	red-winged blackbird	(1) Confirmed breeder, abund. in grasslands, streams.
	Dolichonyx oryzivorus	bobolink	(1) Confirmed breeder, uncommon in grasslands.
	Icterus galbula	Northern oriole	(1) Confirmed breeder, uncommon in open woods.
	I. spurius	orchard oriole	(1) Confirmed breeder, common in open woods & edges.
	Molothrus ater	brown-headed cowbird	(1)(2) Confirmed breeder, abundant everywhere.
	Quiscalus quiscula	common grackle	(1) Confirmed breeder, abundant everywhere.
	Sturnella magna	Eastern meadowlark	(1) Confirmed breeder, common in grasslands.
Ploceidae	*Passer domesticus*	house sparrow	(1) Confirmed breeder, uncommon near buildings.
Thraupidae	*Piranga olivacea*	scarlet tanager	(1)(2*) Possible breeder, rare on open woods.
	P. ruba ruba	summer tanager	(1) Confirmed breeder, common in mature woodlots.
Fringillidae	*Ammodramus henslowii*	Henslow's sparrow	(1) Probable breeder, rare in old fields.
	A. savannarum	grasshopper sparrow	(1) Confirmed breeder, common in grasslands.
	Cardinalis cardinalis	Northern cardinal	(1)(2*) Confirmed breeder, abundant everywhere.
	Carduelis tristis	American goldfinch	(1)(2*) Confirmed breeder, abundant in shrubby areas.
	Carpodacus mexicanus	house finch	(1) Confirmed breeder, uncommon around buildings.
	Melospiza georgiana	swamp sparrow	(1) Confirmed breeder, rare in wet fields and ditches.
	M. melodia	song sparrow	(1) Confirmed breeder, abundant everywhere.
	Passerculus sandwichensis	Savannah sparrow	(1) Confirmed breeder, common in grasslands.
	Passerina cyanea	indigo bunting	(1) Confirmed breeder, abundant everywhere.
	Pheucticus ludovicianus	rose-breasted grosbeak	(1) Confirmed breeder, common in woodlots & edges.
	Pipilo erythrophthalmus	Eastern towhee	(1)(2) Confirmed breeder, very common in woodlots, edges.

Table 2-3

Birds Observed On Site and/or Likely to be Found In Erie County, Ohio Plum Brook Ordnance Works, Sandusky, Ohio

(Page 7 of 7)

Family Name[a]	Scientific Name[b]	Common Name[c]	Status and Frequency
	Pooecetes gramineus	vesper sparrow	(1) Confirmed breeder, uncommon in grassland & fields.
	Spiza amercana	dickcissel	Confirmed and/or probable breeder in county.
	Spizella passerina	chipping sparrow	(1) Confirmed breeder, common in open woods & lawns.
	S. pusilla	field sparrow	(1) Confirmed breeder, abundant in grasslands, shrubs.
	Zonotrichia albicollis	white-throated sparrow	(1) Late migrant, rare.

[a] Family names from Peterson, R. T., 1947, *A Field Guide to the Birds*, Sponsored by the National Audubon Society, Houghton Mifflin Company, Boston, Massachusetts.
[b] Peterjohn, B. G. and D. L. Rice, 1991, *The Ohio Breeding Bird Atlas*, The Ohio Department of Natural Resources, Division of Natural Areas and Preserves, Columbus, Ohio, 416 pages.
[c] E - Ohio Endangered species; T - Ohio Threatened species.

Observation References:

(1) *Biological Inventory of Plum Brook Station* (Ohio Department of Natural Resources, 1994).

(2) Observed during Shaw Site Reconnaissance on April 29, June 2, and/or September 9, 2009. An asterisk (*) indicates the species was detected during the June site visit, and is likely using the site for breeding.

Table 2-4

Reptiles Observed On Site and Likely to be Found in Erie County, Ohio
Plum Brook Ordnance Works, Sandusky, Ohio

Family Name	Scientific Name	Common Name	Observed On Site
Chelydridae	*Chelydra serpentina*	snapping turtle	(1)
Kinosternidae	*Sternotherus odoratus*	musk turtle	
Emydidae	*Chrysemys picta*	painted turtle	(1)
	Emys blandingii	Blanding's turtle	(1)
	Terrapene carolina	box turtle	(1)
Colubridae	*Elaphe vulpina*	fox snake	(1)
	Heterodon platyrhinos	hog-nosed snake	
	Nerodia septemvittata	queen snake	
	N. sipedon sipedon	water snake	(1)
	Opheodrys vernalis	green snake	(1)
	Storeria dekayi	Dekay's brown snake	(1)
	Thamnophis butleri	Butler's garter snake	(1)
	T. sauritus	ribbon snake	
	T. sirtalis	common garter snake	(1)

References:

Conant, R. and J. T. Collins, 1991, *Reptiles and Amphibians, Eastern/Central North America*, Peterson Field Guide, Third Edition, Houghton Mifflin Company, Boston.

Pfingsten, R. A. and F. L. Downs (eds.), 1989, *Salamanders of Ohio*, Ohio Biological Survey Bulletin, New Series, Vol. 7, No. 2, 315 pages, 29 pls.

Wright, A. H. and A. A. Wright, 1957, *Handbook of Snakes of the United States and Canada*, Volumes I and II, Comstock Publishing Associates, Ithaca and London, 1105 pages.

Reference for on-site observation:
(1) *Biological Inventory of Plum Brook Station* (Ohio Department of Natural Resources, 1995).

Table 2-5

Amphibians Observed On Site and Likely to be Found in Erie County, Ohio
Plum Brook Ordnance Works, Sandusky, Ohio

Family Name	Scientific Name	Common Name	Observed On Site
Ambystomatidae	*Ambystoma texanum*	smallmouth salamander	(1)
	Plethodon cinereus	redback salamander	(1)
Bufonidae	*Bufo americanus*	American toad	(1)
Hylidae	*Acris gryllus*	cricket frog	(1)
	Hyla versicolor	gray treefrog	(1)
	Pseudacris crucifer	spring peeper	(1)
	P. triseriata	chorus frog	(1)
Ranidae	*Rana catesbeiana*	bullfrog	(1)
	R. clamitans	green frog	(1)
	R. pipiens	Northern leopard frog	(1)

References:

Conant, R. and J. T. Collins, 1991, *Reptiles and Amphibians, Eastern/Central North America* , Peterson Field Guide, Third Edition, Houghton Mifflin Company, Boston.

Pfingsten, R. A. and F. L. Downs (eds.), 1989, *Salamanders of Ohio* , Ohio Biological Survey Bulletin, New Series, Vol. 7, No. 2, 315 pages, 29 pls.

Reference for on-site observation:

(1) *Biological Inventory of Plum Brook Station* (Ohio Department of Natural Resources, 1995).

Table 2-6

Fish Species Observed at Plum Brook Ordnance Works
Plum Brook Ordnance Works, Sandusky, Ohio

Family Name	Scientific Name	Common Name	Observed On Site	Habitat[a]
Catostomidae	*Catostomus commersoni*	white sucker	(1)	lotic
Centrarchidae	*Lepomis cyanellus*	green sunfish	(1)	lentic, lotic
	Lepomis species	green sunfish hybrid	(1)	lentic
	L. gibbosus	pumpkinseed sunfish	(1)	lentic
	L. macrochirus	bluegill	(1)	lentic
	Micropterus salmoides	largemouth bass	(1)	lentic
Cyprinidae	*Campostoma anomalum*	central stoneroller	(1)	lotic
	Carassius auratus	goldfish	(1)	lentic
	Luxilus chrysocephalus	striped shiner	(1)	lotic
	Pimephales notatus	bluntnose minnow	(1)	lotic
	P. promelas	fathead minnow	(1)	lotic
	Semotilus atromaculatus	creek chub	(1)	lotic
Gasterosteidae	*Culaea inconstans*	brook stickleback	(1)	lotic
Ichtaluridae	*Ameiurus melas*	black bullhead	(1)	lentic

[a] Lotic - Flowing water such as brooks, ditches, and creeks.
Lentic - Still waters such as ponds and lakes.

Reference for on-site observation:
(1) *Biological Inventory of Plum Brook Station* (Ohio Department of Natural Resources, 1994).

Table 2-7

Summary of Samples Evaluated in the Ecological Risk Assessment
Power House 2 Ash Pits, Plum Brook Ordnance Works
Sandusky, Ohio

Location	Sample Number		Sample Date	Depth (ft)	Analyses
Soil Samples					
ASH PIT 2-SB01	AP0100	REG	15-Jan-09	0 - 1	Exp, Metals, PCB, SVOC
ASH PIT 2-SB02	AP0103	REG	16-Jan-09	0 - 1	Exp, Metals, PCB, SVOC
ASH PIT 2-SB03	AP0108	REG	18-Jan-09	0 - 1	Exp, Metals, PCB, SVOC
ASH PIT 2-SB04	AP0111	REG	18-Jan-09	0 - 1	Exp, Metals, PCB, SVOC
ASH PIT 2-SB05	AP0114	REG	16-Jan-09	0 - 1	Exp, Metals, PCB, SVOC
ASH PIT 2-SB06	AP0117	REG	15-Jan-09	0 - 1	Exp, Metals, PCB, SVOC
ASH PIT 2-SB07	AP0120	REG	16-Jan-09	0 - 1	Exp, Metals, PCB, SVOC
ASH PIT 2-SB07	AP0121	FD	16-Jan-09	0 - 1	Exp, Metals, PCB, SVOC
ASH PIT 2-SB08	AP0125	REG	16-Jan-09	0 - 1	Exp, Metals, PCB, SVOC
PH2SO01	4010	REG	28-Sep-96	0 - 0.5	Cyanide, Metals, Pest, PCB, SVOC, VOC
PH2SO02	4030	REG	29-Sep-96	0 - 0.5	Cyanide, Metals, Pest, PCB, SVOC, VOC
PH2SO03	4050	REG	29-Sep-96	0 - 0.5	Cyanide, Metals, Pest, PCB, SVOC, VOC
PH2SO04	4070	REG	28-Sep-96	0 - 0.5	Cyanide, Metals, Pest, PCB, SVOC, VOC
PH2SO05	4090	REG	28-Sep-96	0 - 0.5	Cyanide, Metals, Pest, PCB, SVOC, VOC
PH2SO06	4110	REG	29-Sep-96	0 - 0.5	Cyanide, Metals, Pest, PCB, SVOC, VOC
PH2SO07	4130	REG	29-Sep-96	0 - 0.5	Cyanide, Metals, Pest, PCB, SVOC, VOC
PH2SO08	4150	REG	28-Sep-96	0 - 0.5	Cyanide, Metals, Pest, PCB, SVOC, VOC
PH2SO09	4170	REG	29-Sep-96	0 - 0.5	Cyanide, Metals, Pest, PCB, SVOC, VOC
PH2SO10	4190	REG	29-Sep-96	0 - 0.5	Cyanide, Metals, Pest, PCB, SVOC, VOC
PH2SO11	4210	REG	29-Sep-96	0 - 0.5	Cyanide, Metals, Pest, PCB, SVOC, VOC
PH2SO12	4230	REG	29-Sep-96	0 - 0.5	Cyanide, Metals, Pest, PCB, SVOC, VOC
ASH PIT 2-SB01	AP0101	REG	15-Jan-09	3 - 5	Exp, Metals, PCB, SVOC
ASH PIT 2-SB02	AP0104	REG	16-Jan-09	3 - 5	Exp, Metals, PCB, SVOC
ASH PIT 2-SB02	AP0105	FD	16-Jan-09	3 - 5	Exp, Metals, PCB, SVOC
ASH PIT 2-SB03	AP0109	REG	18-Jan-09	3 - 5	Exp, Metals, PCB, SVOC
ASH PIT 2-SB04	AP0112	REG	18-Jan-09	3 - 5	Exp, Metals, PCB, SVOC
ASH PIT 2-SB05	AP0115	REG	16-Jan-09	3 - 5	Exp, Metals, PCB, SVOC
ASH PIT 2-SB06	AP0118	REG	15-Jan-09	3 - 5	Exp, Metals, PCB, SVOC
ASH PIT 2-SB07	AP0123	REG	16-Jan-09	3 - 5	Exp, Metals, PCB, SVOC
ASH PIT 2-SB08	AP0126	REG	16-Jan-09	3 - 5	Exp, Metals, PCB, SVOC
PH2SO01	4020	REG	28-Sep-96	2 - 3	Cyanide, Metals, Pest, PCB, SVOC, VOC
PH2SO02	4040	REG	29-Sep-96	2 - 3	Cyanide, Metals, Pest, PCB, SVOC, VOC
PH2SO03	4060	REG	29-Sep-96	2 - 3	Cyanide, Metals, Pest, PCB, SVOC, VOC
PH2SO04	4080	REG	28-Sep-96	2 - 3	Cyanide, Metals, Pest, PCB, SVOC, VOC
PH2SO04	4081	FD	28-Sep-96	2 - 3	Cyanide, Metals, Pest, PCB, SVOC, VOC
PH2SO05	4100	REG	28-Sep-96	2 - 3	Cyanide, Metals, Pest, PCB, SVOC, VOC
PH2SO06	4120	REG	29-Sep-96	2 - 3	Cyanide, Metals, Pest, PCB, SVOC, VOC
PH2SO07	4140	REG	29-Sep-96	2 - 3	Cyanide, Metals, Pest, PCB, SVOC, VOC
PH2SO08	4160	REG	28-Sep-96	2 - 3	Cyanide, Metals, Pest, PCB, SVOC, VOC
PH2SO08	4161	FD	28-Sep-96	2 - 3	Cyanide, Metals, Pest, PCB, SVOC, VOC
PH2SO09	4180	REG	29-Sep-96	2 - 3	Cyanide, Metals, Pest, PCB, SVOC, VOC
PH2SO10	4200	REG	29-Sep-96	2 - 3	Cyanide, Metals, Pest, PCB, SVOC, VOC
PH2SO11	4220	REG	29-Sep-96	2 - 3	Cyanide, Metals, Pest, PCB, SVOC, VOC
PH2SO12	4240	REG	29-Sep-96	3 - 4	Cyanide, Metals, Pest, PCB, SVOC, VOC
Sediment Samples					
ASH PIT 2-SD01	AP1000	REG	24-May-09	0 - 0.5	Exp, Metals, PCB, SVOC
ASH PIT 2-SD02	AP1001	REG	24-May-09	0 - 0.5	Exp, Metals, PCB, SVOC
ASH PIT 2-SD03	AP1002	REG	24-May-09	0 - 0.5	Exp, Metals, PCB, SVOC
ASH PIT 2-SD04	AP1003	REG	25-May-09	0 - 0.5	Exp, Metals, PCB, SVOC
ASH PIT 2-SD04	AP1004	FD	25-May-09	0 - 0.5	Exp, Metals, PCB, SVOC
ASH PIT 2-SD05	AP1006	REG	25-May-09	0 - 0.5	Exp, Metals, PCB, SVOC
Surface Water Samples					
AP2-SW01	AP2000	REG	24-May-09	NA	Exp, Metals, PCB, SVOC
AP2-SW02	AP2001	REG	24-May-09	NA	Exp, Metals, PCB, SVOC
AP2-SW03	AP2002	REG	24-May-09	NA	Exp, Metals, PCB, SVOC
AP2-SW03	AP2003	FD	24-May-09	NA	Exp, Metals, PCB, SVOC
AP2-SW04	AP2005	REG	25-May-09	NA	Exp, Metals, PCB, SVOC
AP2-SW05	AP2006	REG	25-May-09	NA	Exp, Metals, PCB, SVOC

FD - Field duplicate.
Exp - Explosives.
NA - Not applicable.
Pest - Organochlorine pesticides.
PCB - Polychlorinated biphenyls.
SVOC - Semivolatile organic compounds.
VOC - Volatile organic compounds.

Table 2-8

Statistical Summary and COPEC Selection of Chemicals Detected in Total Soil (0 to 6 Feet bgs)
Power House 2 Ash Pits, Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Detection Frequency	Percent Detection	Range of Values, mg/kg: Detected Concentrations Minimum	VQ	Maximum	VQ	Reporting Limits Minimum	Maximum	Mean (mg/kg)	BSC [a] (mg/kg)	ESV [b] (mg/kg)	COPEC? [c,d]	Distribution [e]	95% UCL [e] (mg/kg)	EPC [f] (mg/kg)	EPC 0-1' soil depth [g] (mg/kg)
Inorganics																
Aluminum	40 / 40	100	3.52E+03		1.50E+04		1.75E+00	3.57E+01	8.55E+03	1.55E+04	pH Dependent	N (b)			---	---
Antimony	15 / 40	38	2.27E-01	J	9.58E-01		4.39E-01	1.07E+01	2.62E+00	9.30E+00	0.27	N (b)			---	---
Arsenic	40 / 40	100	3.60E+00		2.68E+01	J	8.77E-01	1.80E+00	1.03E+01	3.65E+01	18	N (b)			---	---
Barium	40 / 40	100	2.99E+01		1.41E+02		1.75E-01	3.57E+01	7.98E+01	8.26E+02	330	N (a)			---	---
Beryllium	33 / 40	83	5.90E-01		1.69E+01	J	1.75E-01	8.90E-01	4.23E+00	1.00E+00	21	N (a)			---	---
Cadmium	8 / 40	20	2.93E-01	J	1.40E+00		4.39E-01	8.90E-01	3.76E-01		0.36	Y	Normal	5.32E-01	5.32E-01	6.50E-01
Calcium	40 / 40	100	3.51E+02		4.72E+04	J	4.39E+00	8.91E+02	6.48E+03	5.23E+04	Nutrient	N (c)			---	---
Chromium	40 / 40	100	1.90E+00		2.21E+01	J	4.39E-01	1.80E+00	1.14E+01	2.90E+01	26	N (a)			---	---
Cobalt	40 / 40	100	3.90E+00	J	2.47E+01		3.51E-01	8.90E+00	1.15E+01	1.16E+02	13	N (b)			---	---
Copper	40 / 40	100	8.30E+00		3.86E+01		4.39E-01	4.50E+00	2.11E+01	5.62E+01	28	N (b)			---	---
Iron	40 / 40	100	1.05E+04		1.09E+05		1.93E+00	3.79E+01	3.35E+04	2.34E+05	pH Dependent	N (b)			---	---
Lead	40 / 40	100	4.64E+00		5.07E+01		3.30E-01	5.99E-01	1.56E+01	4.86E+01	11	N (d)			---	---
Magnesium	40 / 40	100	3.12E+02	J	1.01E+04	J	1.75E+00	8.91E+02	2.43E+03	1.04E+04	Nutrient	N (c)			---	---
Manganese	40 / 40	100	8.21E+01	J	1.56E+03	J	1.75E-01	2.70E+00	3.50E+02	3.51E+03	220	N (b)			---	---
Mercury	26 / 40	65	1.12E-02	J	1.40E-01		1.94E-02	5.90E-02	4.27E-02	8.50E-02	0.00051	Y	Gamma	5.28E-02	5.28E-02	7.96E-02
Nickel	40 / 40	100	1.05E+01		4.19E+01		2.63E-01	7.10E+00	2.42E+01	5.51E+01	38	N (b)			---	---
Potassium	39 / 40	98	3.23E+02		2.26E+03		2.19E+01	8.91E+02	9.77E+02	3.39E+03	Nutrient	N (c)			---	---
Selenium	21 / 40	53	6.40E-01		2.60E+00		5.40E-01	1.20E+00	9.12E-01	2.00E+00	0.52	Y	Normal	1.22E+00	1.22E+00	1.66E+00
Silver	5 / 40	13	1.20E+00		2.00E+00		4.39E-01	1.80E+00	6.25E-01	1.11E+01	4.2	N (a)			---	---
Sodium	16 / 40	40	1.84E+01		1.19E+02		8.77E+00	8.91E+02	2.24E+02		Nutrient	N (c)			---	---
Thallium	21 / 40	53	3.00E-01	J	8.50E+00		4.39E-01	1.80E+00	1.26E+00	1.30E+00	1	Y	Approx. Gamma	1.67E+00	1.67E+00	1.68E+00
Vanadium	39 / 40	98	7.50E+00		2.69E+01		1.75E-01	8.90E+00	1.69E+01	4.09E+01	7.8	N (b)			---	---
Zinc	40 / 40	100	3.53E+01		1.27E+02		2.19E+00	3.60E+00	6.71E+01	3.22E+02	46	N (b)			---	---
Cyanide																
Cyanide, total	3 / 24	13	7.10E-01		9.30E-01		5.40E-01	8.90E-01	3.92E-01		1.33	N (a)			---	---
Polychlorinated biphenyls (PCB)																
Aroclor 1016	1 / 40	3	5.25E-01	J	5.25E-01	J	3.60E-02	5.90E-02	3.44E-02		0.371	N (e)			---	---
Aroclor 1260	1 / 40	3	1.62E-02	J	1.62E-02	J	3.60E-02	5.90E-02	2.18E-02		0.371	N (a)			---	---
Organochlorine Pesticides																
DDE, 4,4'-	7 / 24	29	2.40E-03		7.40E-03		1.80E-03	3.00E-03	2.15E-03		0.021	N (a)			---	---
DDT, 4,4'-	8 / 24	33	2.60E-03		7.10E-03		1.80E-03	3.00E-03	2.22E-03		0.021	N (a)			---	---
Methoxychlor	2 / 24	8	6.10E-03		6.50E-03		3.60E-03	5.90E-03	2.53E-03		0.0199	N (a)			---	---
Semivolatile Organic Compounds																
Acenaphthylene	1 / 40	3	1.10E-01	J	1.10E-01	J	3.60E-01	5.90E-01	2.16E-01		29	N (a)			---	---
Anthracene	1 / 40	3	5.80E-02	J	5.80E-02	J	3.60E-01	5.90E-01	2.15E-01		29	N (a)			---	---
Benzo(a)anthracene	5 / 40	13	3.07E-02		1.30E-01	J	3.60E-01	5.90E-01	1.98E-01		1.1	N (a)			---	---
Benzo(a)pyrene	3 / 40	8	8.44E-02	J	1.70E-01	J	3.60E-01	5.90E-01	2.10E-01		1.1	N (a)			---	---
Benzo(b)fluoranthene	2 / 40	5	1.30E-01	J	1.60E-01	J	3.60E-01	5.90E-01	2.15E-01		1.1	N (a)			---	---
Benzo(ghi)perylene	1 / 40	3	1.30E-01	J	1.30E-01	J	3.60E-01	5.90E-01	2.16E-01		1.1	N (a)			---	---
Benzo(k)fluoranthene	1 / 40	3	2.30E-01	J	2.30E-01	J	3.60E-01	5.90E-01	2.19E-01		1.1	N (a)			---	---
Benzoic acid	2 / 16	13	6.22E-01		1.43E+00		3.80E-01	4.99E-01	3.14E-01		NSV	N (a)			---	---
Bis(2-ethylhexyl)phthalate	2 / 40	5	6.60E-02	J	9.50E-02	J	3.60E-01	5.90E-01	2.12E-01		0.925	N (a)			---	---
Chrysene	4 / 40	10	6.39E-02	J	1.60E-01	J	3.60E-01	5.90E-01	2.05E-01		1.1	N (a)			---	---
Di-n-butyl phthalate	2 / 40	5	6.60E-02	J	1.70E-01	J	3.60E-01	5.90E-01	2.15E-01		200	N (a)			---	---
Fluoranthene	8 / 40	20	5.99E-02	J	3.00E-01	J	3.60E-01	5.90E-01	1.96E-01		1.1	N (a)			---	---
Indeno(1,2,3-cd)pyrene	1 / 40	3	1.20E-01	J	1.20E-01	J	3.60E-01	5.90E-01	2.16E-01		1.1	N (a)			---	---
Naphthalene	3 / 40	8	4.44E-02	J	5.59E-02	J	3.60E-01	5.90E-01	2.06E-01		29	N (a)			---	---
Phenanthrene	4 / 40	10	6.30E-02	J	1.00E-01	J	3.60E-01	5.90E-01	2.03E-01		29	N (a)			---	---
Pyrene	8 / 40	20	4.40E-02	J	2.50E-01	J	3.60E-01	5.90E-01	1.90E-01		1.1	N (a)			---	---
Volatile Organic Compounds																
Acetone	4 / 24	17	1.30E-02	J	1.20E-01		2.20E-02	1.80E-01	4.49E-02		2.5	N (a)			---	---
Bromomethane	1 / 24	4	1.10E-03	J	1.10E-03	J	1.10E-02	8.90E-02	1.93E-02		0.235	N (a)			---	---
Methylene chloride	1 / 24	4	5.20E-02	J	5.20E-02	J	5.40E-03	4.50E-02	1.17E-02		4.05	N (a)			---	---
Toluene	2 / 24	8	1.10E-02		1.80E-02	J	5.40E-03	4.50E-02	9.91E-03		200	N (a)			---	---

Table 2-8

Statistical Summary and COPEC Selection of Chemicals Detected in Total Soil (0 to 6 Feet bgs)
Power House 2 Ash Pits, Plum Brook Ordnance Works
Sandusky, Ohio

			Range of Values, mg/kg														
			Detected Concentrations				Reporting Limits										EPC
Chemical	Detection Frequency	Percent Detection	Minimum	VQ	Maximum	VQ	Minimum	Maximum	Mean (mg/kg)	BSC [a] (mg/kg)	ESV [b] (mg/kg)	COPEC? [c,d]	Distribution [e]	95% UCL [e] (mg/kg)	EPC [f] (mg/kg)	0-1' soil depth [g] (mg/kg)
Xylenes, total	1 / 24	4	6.50E-03		6.50E-03		5.40E-03	4.50E-02	9.86E-03		10	N (a)			---	---

BSC - Background screening criterion.
COPEC - Chemical of potential ecological concern.
EPC - Exposure point concentration.
ESV - Ecological screening value.
J - The compound/analyte was positively identified; the reported result is the estimated concentration of the compound/analyte detected in the sample analyzed
mg/kg - milligrams per kilogram.
VQ - Validation qualifier.
NSV - No screening value.
UCL - Upper confidence limit.

[a] IT Corporation (IT), 1998, ***Site Investigation of Acid Areas***, Plum Brook Ordnance Works, Sandusky, Ohio, August.
[b] ESVs and their sources are in Appendix B.
[c] N = Chemical is not chosen as a COPEC:
(a) = maximum detected concentration is less than the ESV.
(b) = maximum detected concentration is less than the BSC.
(c) = essential nutrient.
(d) = statistical test shows background and site data to be the same; see Appendix C.
(e) = infrequently detected (fewer than 5 percent of all samples)
[d] Y = Chemical is chosen as COPEC.
[e] 95% UCL determined using ProUCL Version 4.00.04 (EPA, 2009, ProUCL Version 4.00.04, Office of Research and Development, Technology Support Center Characterization and Monitoring Branch, Las Vegas, Nevada, April, on line at http://www.epa.gov/esd/tsc/form.htm). UCLs are calculated only for chemicals selected as COPECs
[f] Concentration used in risk assessment equal to 95% UCL or maximum detected concentration, whichever is lower.
[g] The EPC for the COPEC at the 0-1 foot soil depth range is used as the exposure concentration for some ecological receptors. See text for details.

Table 2-9

Statistical Summary and COPEC Selection of Chemicals Detected in Surface Water
Power House 2 Ash Pits
Plum Brook Ordnance Works
Sandusky, Ohio

Chemical	Detection Frequency	Percent Detection	Range of values, µg/L: Detected Conc Minimum	VQ	Detected Conc Maximum	VQ	Reporting Limits Minimum	Reporting Limits Maximum	Arithmetic Mean µg/L	ESV [a] µg/L	COPEC? [b,c]	Distribution [d]	95% UCL [d] µg/L	EPC [e] µg/L
Metals														
Aluminum	5 / 5	100	359		1030	J	200	200	6.01E+02	8.70E+01	Y	Normal	8.70E+02	8.70E+02
Barium	5 / 5	100	43.9		50.9	J	200	200	4.70E+01	4.00E+00	Y	Normal	4.97E+01	4.97E+01
Calcium	5 / 5	100	75900		80700		1000	1000	7.83E+04	Nutrient	N (b)			---
Cobalt	1 / 5	20	1.2	J	1.2	J	50	50	2.02E+01	2.30E+01	N (a)			---
Iron	5 / 5	100	376		1060		300	300	7.22E+02	1.00E+03	N (b)			---
Lead	2 / 5	40	2.9	J	2.9	J	5	10	2.66E+00	1.17E+00	Y	Nonparametric	2.87E+00	2.87E+00
Magnesium	5 / 5	100	19800		21400		5000	5000	2.08E+04	Nutrient	N (b)			---
Manganese	5 / 5	100	52.75		102		15	15	7.08E+01	1.20E+02	N (a)			---
Nickel	1 / 5	20	6.2	J	6.2	J	40	40	1.72E+01	2.90E+01	N (a)			---
Potassium	5 / 5	100	2900		4400	J	10000	20000	3.42E+03	Nutrient	N (b)			---
Sodium	5 / 5	100	30300		34800		10000	20000	3.26E+04	Nutrient	N (b)			---
Vanadium	5 / 5	100	1.65	JJ	3.1	J	50	50	2.23E+00	1.20E+01	N (a)			---
Zinc	5 / 5	100	8.1	J	12.4	J	20	20	1.06E+01	6.57E+01	N (a)			---
Semivolatile Organic Compounds														
Bis(2-ethylhexyl)phthalate	1 / 5	20	2	J	2	J	4.8	4.8	2.32E+00	1.20E-01	Y	Nonparametric	2.49E+00	2.00E+00

ESV - Ecological screening value.
EPC - Exposure point concentration.
COPEC - Chemical of potential ecological concern.
µg/L - Micrograms per liter.
VQ - Validation qualifier.
J - The compound/analyte was positively identified; the reported result is the estimated concentration of the compound/analyte detected in the sample analyzed

[a] ESVs and their sources are in Appendix B.
[b] N = Chemical is not chosen as a COPEC:
(a) = maximum detected concentration is less than the ESV.
(b) = essential nutrient.
[c] Y = Chemical is chosen as COPEC.
[d] 95% UCL determined using ProUCL Version 4.00.04 (EPA, 2009, ProUCL Version 4.00.04, Office of Research and Development, Technology Support Center Characterization and Monitoring Branch, Las Vegas, Nevada, April, on line at http://www.epa.gov/esd/tsc/form.htm). UCLs are calculated only for chemicals selected as COPECs
[e] Concentration used in risk assessment equal to 95% UCL or maximum detected concentration, whichever is lower.

Table 2-10

Statistical Summary and COPEC Selection of Chemicals Detected in Sediment
Power House 2 Ash Pits, Plum Brook Ordnance Works
Sandusky, Ohio

			Range of Values, mg/kg												
	Detection	Percent	Detected Concentrations				Reporting Limits		Mean	BSC [a]	ESV [b]			95% UCL [e]	EPC [f]
Chemical	Frequency	Detection	Minimum	VQ	Maximum	VQ	Minimum	Maximum	mg/kg	mg/kg	mg/kg	COPC? [c,d]	Distribution [e]	(mg/kg)	mg/kg
Inorganics															
Aluminum	5 / 5	100	3.64E+03		7.42E+03		1.20E+01	1.50E+01	5.86E+03	1.55E+04	NSV	N (b)			---
Arsenic	5 / 5	100	3.90E+00		1.01E+01	J	4.75E-01	9.50E-01	6.35E+00	3.65E+01	9.79E+00	N (b)			---
Barium	5 / 5	100	2.28E+01		6.71E+01	J	1.20E+01	1.50E+01	4.63E+01	8.26E+02	NSV	N (b)			---
Beryllium	5 / 5	100	3.60E-01		5.60E-01		3.00E-01	3.60E-01	4.70E-01	1.00E+00	NSV	N (b)			---
Cadmium	4 / 5	80	2.40E-01	J	5.65E-01		2.40E-01	4.80E-01	3.35E-01	NA	9.90E-01	N (a)			---
Calcium	5 / 5	100	7.66E+03		2.70E+04		3.00E+02	3.60E+02	1.67E+04	5.23E+04	NSV	N (c)			---
Chromium	5 / 5	100	6.40E+00		1.17E+01		5.95E-01	7.30E-01	8.97E+00	2.90E+01	4.34E+01	N (a)			---
Cobalt	5 / 5	100	6.20E+00	J	1.20E+01		3.00E+00	3.60E+00	8.19E+00	1.16E+02	5.00E+01	N (a)			---
Copper	5 / 5	100	9.60E+00		2.21E+01		1.50E+00	1.80E+00	1.51E+01	5.62E+01	3.16E+01	N (b)			---
Iron	5 / 5	100	1.04E+04		3.91E+04	J	5.95E+00	1.20E+01	1.85E+04	2.34E+05	NSV	N (b)			---
Lead	5 / 5	100	7.90E+00		1.22E+01	JJ	5.95E+00	1.20E+01	9.65E+00	4.86E+01	3.58E+01	N (a)			---
Magnesium	5 / 5	100	1.95E+03		7.47E+03	J	3.00E+02	3.60E+02	5.08E+03	1.04E+04	NSV	N (c)			---
Manganese	5 / 5	100	1.27E+02		6.08E+02		9.90E-01	4.45E+00	2.90E+02	3.51E+03	4.60E+02	N (b)			---
Mercury	4 / 5	80	1.60E-02	J	2.50E-02	J	9.80E-02	1.20E-01	2.62E-02	8.50E-02	1.80E-01	N (a)			---
Nickel	5 / 5	100	1.57E+01		2.51E+01		2.40E+00	2.90E+00	1.81E+01	5.51E+01	2.27E+01	N (b)			---
Potassium	5 / 5	100	4.98E+02	J	1.66E+03		6.00E+02	1.50E+03	1.03E+03	3.39E+03	NSV	N (c)			---
Selenium	5 / 5	100	3.90E-01	J	1.00E+00	J	5.95E+00	1.20E+01	7.85E-01	2.00E+00	NSV	N (b)			---
Silver	1 / 5	20	8.30E-02	J	8.30E-02	J	5.95E-01	7.30E-01	2.79E-01	1.11E+01	5.00E-01	N (a)			---
Sodium	5 / 5	100	5.48E+01	J	1.64E+02	JJ	6.00E+02	1.50E+03	1.17E+02	NA	NSV	N (c)			---
Vanadium	5 / 5	100	9.40E+00		1.52E+01		3.00E+00	6.00E+00	1.26E+01	4.09E+01	NSV	N (b)			---
Zinc	5 / 5	100	2.70E+01	J	5.73E+01		1.20E+00	1.50E+00	4.06E+01	3.22E+02	1.21E+02	N (a)			---
Explosives															
2,4,6-Trinitrotoluene	1 / 5	20	6.47E-02	J	6.47E-02	J	1.55E-01	1.90E-01	8.14E-02		NSV	Y	Normal	9.22E-02	6.47E-02
Semivolatiles Organic Compounds															
Fluoranthene	2 / 5	40	5.25E-02	J	5.47E-02	J	2.05E-01	2.60E-01	8.49E-02		4.23E-01	N (a)			---

BSC - Background screening criterion. The soil BSC is used for sediment in this evaluation. See text for details.
COPEC - Chemical of potential ecological concern.
EPC - Exposure point concentration.
ESV - Ecological screening value.
J - The compound/analyte was positively identified; the reported result is the estimated concentration of the compound/analyte detected in the sample analyzed.
mg/kg - Milligrams per kilogram.
NSV - No screening value available.
VQ - Validation qualifier.

[a] Soil background screening concentrations are used for sediment. See text for details.
[b] ESVs and their sources are in Appendix B.
[c] N = Chemical is not chosen as a COPEC:
(a) = maximum detected concentration is less than the ESV.
(b) = maximum detected concentration is less than the BSC.
(c) = essential nutrient.
[d] Y = Chemical is chosen as COPEC.
[e] 95% UCL determined using ProUCL Version 4.00.04 (EPA, 2009, ProUCL Version 4.00.04, Office of Research and Development, Technology Support Center Characterization and Monitoring Branch, Las Vegas, Nevada, April, on line at http://www.epa.gov/esd/tsc/form.htm). UCLs are calculated only for chemicals selected as COPECs.
[f] Concentration used in risk assessment equal to 95% UCL or maximum detected concentration, whichever is lower.

Table 3-1

Data Used to Model Exposure in the Indicator Wildlife Species
Power House 2 Ash Pits, Plum Brook Ordnance Works
Sandusky, Ohio

Indicator Species	Class/ Order	Average Body Weight[a] (kg)	Average Home Range[a] (ha)	Dietary Intake[a] (kg[dw]/day)	Soil/Sed. Intake (kg[dw]/day)	Water Intake (L/day)[b]	Trophic Level	Dietary Composition[a] (percent)
Deer mouse (*Peromyscus maniculatus*)	Mammalia/ Rodentia	0.0148	0.062	0.0028[d]	0.000056 (2%)	0.0022	Omnivore	Terr. Inverts. : 39 Plants: 61
Eastern cottontail *(Sylvilagus floridanus)*	Mammalia/ Lagomorpha	1.132	3.1	0.096[d]	0.006 (6.3%)	0.11	Herbivore	Plants: 100
Short-tailed shrew *(Blarina brevicauda)*	Mammalia/ Insectivora	0.015	0.39	0.0022[d]	0.00023 (10.4%)	0.0023	Insectivore	Terr. Inverts.: 100
White-tailed deer (*Odocoileus virginianus*)	Mammalia/ Artiodactyla	61[c]	518[c]	2.0[d]	0.04 (2%)	4	Herbivore	Plants: 100
Marsh wren (*Cistothorus palustris*)	Aves/ Passeriformes	0.01	0.054	0.0029[d]	0.000058 (2%)	0.0027	Insectivore	Terr. Inverts.: 100
Red-tailed hawk (*Buteo jamaicensis*)	Aves/ Falconiformes	0.957	842	0.057[d]	0.00114 (2%)	0.057	Carnivore	Rabbits: 25.3 Shrews: 25.3 Mice: 25.3 Birds: 24
Muskrat [e] (*Ondata zibethicus*)	Mammalia/ Rodentia	1.174	0.13	0.352	negligible	0.11	Herbivore	Aquatic plants: 100
Raccoon (*Procyon lotor*)	Mammalia/ Carnivora	5.1	156	0.26 [d]	0.024 (9.4%) (assumed 50% soil and 50% sediment)	0.43	Omnivore	Aq. Inverts.: 21 Terr. Inverts.: 30 Mice: 5 Plants: 42 (50% terrestrial, 50% aquatic) Fish: 2

[a] From EPA (1993), except as noted.

[b] Allometric equations for mammals and birds from EPA (1993), as follows:

Mammals: WI (water ingestion; L/day) = 0.099 $Wt^{0.90}$ (kg), where Wt = body weight.

Birds: WI (L/day) = 0.059 $Wt^{0.67}$ (kg).

[c] Information is from *A Guide to the Mammals of Ohio* (Gottschang, 1981).

[d] Allometric equation for mammals: FI (kg/day) = 0.0687 $Wt^{0.822}$ for shrew, deer, and raccoon; FI (g/day) = 0.621 $Wt^{0.564}$ for rodents (deer mouse); and FI (g/day) = 0.577 $Wt^{0.727}$ for small herbivores (cottontail).
Allometric equation for birds: FI (kg/day) = 0.0582 Wt0.651 (EPA, 1993), where FI = food ingestion (dry weight) and Wt = body weight. Allometric equations from EPA (1993).

[e] Exposure parameters obtained from OEPA-DERR (2008) Ecological Risk Assessment Guidance Document, Revised April 2008, On line: http://www.epa.ohio.gov/portals/30/rules/RR-031.pdf.

References

U.S. Environmental Protection Agency (EPA), 1993, Wildlife Exposure Factors Handbook, Vols. I and II, Office of Research and Development, Washington, DC, EPA/600/R-93/187a.

Table 3-2

Bioaccumulation Factors or Regression Equations Utilized for the Soil-to-Plant and Sediment-to-Aquatic Plant Pathways
Power House 2 Ash Pits, Plum Brook Ordnance Works
Sandusky, Ohio

COPEC in Soil	EPA, 2005				Other		Regression	Recommended	Source
	Minimum BAF/BCF	Median BAF/BCF	90th Percentile BAF/BCF[b]	Maximum BAF/BCF	BAF/BCF (1)		Equation (2)	BAF/BCF	
Inorganics									
Cadmium	0.0087	0.59	3.3	23	0.35	a	ln (AGP)=0.546(ln[soil])-0.475	Regression Equation	EPA (2008), Table 4a
Mercury	0.0015	0.65	5.0	12	0.55	a	ln (AGP)=0.54(ln[soil])-1.00	Regression Equation	Efroymson et al. (2001)
Selenium	0.02	0.67	3	77	0.025	a	ln (AGP)=1.104(ln[soil])-0.677	Regression Equation	EPA (2008), Table 4a
Thallium	--	--	--	--	0.0022	d	--	0.0022	Baes (1984)
Nitroaromatics									
2,4,6-Trinitrotoluene	--	--	--	--	4.23	b	--	4.23	EPA (2008), Table 4a

Notes:

1. For inorganic chemicals without BAF/BCF data, BAF/BCFs were derived from the Baes et al. (1984) and IAEA (1994) data.
2. Efroymson, R.A., et. al., 2001, *Uptake of Inorganic Chemicals from Soil by Plant Leaves: Regressions of Field Data*, Environ. Tox. Chem., 20:2561-2571 for AGP (above ground plant tissue concentration) and Travis and Arms (1988) for BCF.

-- indicates that a BAF/BCF or regression equation is not available.

[a] Average of the vegetative and reproductive transfer factors presented in Baes et al. (1984); note: value from this reference used if no appropriate value available from IAEA (1994).

[b] From USEPA (2008).

[c] IAEA (1994); note: value from this reference used, compared with Baes et al. (1984), as IAEA (1994) is more current.
International Atomic Energy Agency (IAEA), 1994, Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Temperate Environments, Technical Report Series No. 364, Vienna.

[d] Average of the vegetative and reproductive transfer factors presented in Baes et al. (1984); note: value from this reference used if no appropriate value available from IAEA (1994).

References:

Baes, C. F., R.D. Sharp, A.L. Sjoreen and R. W. Shor (1984). A review and analysis of parameters for assessing transport of environmentally released radionuclides through agriculture. ORNL-5786, September 1984.

Efroymson, R.A., et. al., 2001, *Uptake of Inorganic Chemicals from Soil by Plant Leaves: Regressions of Field Data*, Environ. Tox. Chem., 20:2561-2571

EPA, 2008, *Guidance for Developing Ecological Soil Screening Levels (Eco-SSL)*, Office of Solid Waste and Emergency Response, Directive 92857.7-55, Washington, D.C.

Table 3-3

Bioaccumulation Factors or Regressions Equations Utilized for the Soil-to-Earthworm Pathway
Power House 2 Ash Pits, Plum Brook Ordnance Works
Sandusky, Ohio

Constituent	PBOW Site-Specific BCF [a]	Sample, et al. 1998 Median BAF/BCF	Sample, et al. 1998 90th Percentile BAF/BCF	Sample, et al. 1998 Maximum BAF/BCF	Beyer, 1990 BAF/BCF	Regression Equation	Recommended BAF/BCF	Source of BAF/BCF	Rationale for BAF/BCF
Inorganics									
Cadmium	--	7.708	40.69	190	--	ln (EW)=0.795(ln[soil])+2.114	Regression Equation	USEPA 2008, Table 4a	Chemical-specific regression equation
Mercury	--	1.693	20.625	33	--	ln (EW)=0.33(ln[soil])+0.078	Regression Equation	Sample et al. 1998	Chemical-specific regression equation
Selenium	--	0.985	1.34	13.733	--	ln (EW)=0.733(ln[soil])-0.075	Regression Equation	USEPA 2008, Table 4a	Chemical-specific regression equation
Thallium	--	--	--	--	--	--	0.3	See Footnote b.	Median value for inorganics from Sample et al., 1998.

-- indicates that a BAF/BCF or regression equation is not available.
BAF - Bioaccumulation factor.
BCF - Bioconcentration factor.
PAH - Polynuclear aromatic hydrocarbon

[a] IT Corporation (IT), 2001, *Redwater Pond Areas Baseline Ecological Risk Assessment, Plum Brook Ordnance Works, Sandusky, Ohio*, prepared for U.S. Army Corps of Engineers, Nashville District, April.

[b] For inorganic chemials lacking BAFs, the geometric mean of available inorganic chemical Median BAF/BCFs from Sample et al. (1998) were calculated based on the data provided below, and used as surrogate values:

	Median BAF/BCF
Aluminum	0.043
Arsenic	0.224
Barium	0.091
Beryllium	0.045
Cadmium	7.708
Chromium	0.306
Cobalt	0.122
Copper	0.515
Iron	0.036
Lead	0.266
Manganese	0.054
Mercury	1.693
Molybdenum	0.953
Nickel	1.059
Selenium	0.985
Silver	2.045
Strontium	0.087
Vanadium	0.042
Zinc	3.201
Geometric Mean	**0.30**

References:

Sample, B. E, et. al., 1998, *Development and Validation of Bioaccumulation Models for Earthworms*, ES/ER/TM-220.
EPA, 2008, *Guidance for Developing Ecological Soil Screening Levels (Eco-SSL)*, Office of Solid Waste and Emergency Response, Directive 92857.7-55, Washington, D.C

Table 3-4

Bioaccumulation Factors or Regression Equations Utilized for the Soil-to-Mammal/Bird[a] Pathway
Power House 2 Ash Pits, Plum Brook Ordnance Works
Sandusky, Ohio

Constituent	Sample et al., (1998) Insectivore Median BAF/BCF	Herbivore Median BAF/BCF	Omnivore Median BAF/BCF	General[b] Median BAF/BCF	General[b] Maximum BAF/BCF	General[b] 90^{th} percentile BAF/BCF	USEPA (1999) Maximum BAF/BCF Avian or Mammal	Other BAF/BCF		Regression Equation	Recommended BAF/BCF	Rationale for Recommended BAF
Inorganics												
Cadmium	2.105	0.1258	0.1217	0.3333	69.561	3.9905	--	--	--	ln (M)=0.4723(ln[soil]) -1.2571	Regression	USEPA (2008)-Attach 4-1, Table 4a
Mercury	1.046	0.0239 [d]	0.0543	0.0543	1.046	0.192	--	--	--	--	0.192	"General: 90th Percentile" used because of uncertainties regarding the type of mammalian prey items.
Selenium	0.7241	0.0221 [e]	0.2062	0.1619	1.754	1.1867	--			ln (M)=0.3764(ln[soil]) -0.4158	Regression	USEPA (2008)-Attach 4-1, Table 4a
Thallium	--	--	0.1124	0.1124	0.123	0.1227	--	--	--	--	0.1227	"General: 90th Percentile" used because of uncertainties regarding the type of mammalian prey items.

-- indicates that a BAF/BCF is not available.
BAF - Bioaccumulation factor.
BCF - Bioconcentration factor.

[a] Bird BAF/BCF values were based on the recommended small mammal BAF/BCF values, as bird uptake values are not readily available.
[b] "General" indicates that the combination dataset used for insectivore, herbivore, and omnivore receptors was used to estimate a "general" receptor BAF/BCF value.
[d] Only one BAF/BCF value available for exposure to mercury in soil (median is also 90th percentile value and maximum value).
[e] Mean value presented, as median value not given in Sample et al. (1998).

References:

Sample et al., 1998, *Development and Validation of Bioaccumulation Models for Small Mammals,* ES/ER/TM-219.
EPA, 2008, *Guidance for Developing Ecological Soil Screening Levels (Eco-SSL)* , Office of Solid Waste and Emergency Response, Directive 92857.7-55, Washington, D.C.
EPA, 1999, *Screening level ecological risk assessment protocol for hazardous waste combustion facilities* , August, EPA530-D-99-001A.

Table 3-5

Bioaccumulation Factors Utilized for the Sediment-to-Benthic Invertebrate Pathway Power House 2 Ash Pits, Plum Brook Ordnance Works Sandusky, Ohio

Constituent	PBOW Site-Specific BCFs [a]	Bechtel Jacobs (1998)			EPA (1999) BAF/BCF	Other BAF/BCF	Recommended BAF/BCF	Rationale for Recommended BAF/BCF
		Median BAF/BCF (dry weight)	90th Percentile BAF/BCF (dry weight)	Maximum BAF/BCF (dry weight)	(dry weight)	(dry weight)	(dry weight)	
Explosives								
2,4,6-Trinitrotoluene	--	--	--	--	--	--	4.67	Conservative default based on the median value for PCBs from Bechtel (1998)

-- indicates that a BAF/BCF or regression equation is not available.
BAF - Bioaccumulation factor.
BCF - Bioconcentration factor.

[a] IT Corporation (IT), 2001, *Redwater Pond Areas Baseline Ecological Risk Assessment, Plum Brook Ordnance Works, Sandusky, Ohio*, prepared for U.S. Army Corps of Engineers, Nashville District, April.

References:

Bechtel Jacobs Company LLC, 1998, *Biota Sediment Accumulation Factors for Invertebrates: Review and Recommendations for the Oak Ridge Reservation*, BJC/OR-112.
(Depurated and nondepurated results used).

Table 3-6

Bioaccumulation Factors and Regression Equations Utilized for the Surface Water-to-Fish Pathway Power House 2 Ash Pits, Plum Brook Ordnance Works Sandusky, Ohio

Constituent	PBOW Site-Specific BCFs [a]	EPA (1999) BAF/BCF [b] (dry weight)	EPA (1989) BAF/BCF [c] (dry weight)	RAIS Database [d] (dry weight)	Regression Equation	Recommended BCF	Rationale for Recommended BAF/BCF
Inorganic Chemicals							
Aluminum	780	13.5	--	2,500	--	780	Site specific BCF used (IT, 2001)
Barium	146	3165	--	20	--	146	Site specific BCF used (IT, 2001)
Lead	63.8	0.45	895	1,500	--	63.8	Site specific BCF used (IT, 2001)
Semivolatile Organics							
bis(2-Ethylhexyl)phthalate	--	350	--	2,940	--	350	EPA (1999)

-- indicates that a BAF/BCF or regression equation is not available.
BAF - Bioaccumulation factor.
BCF - Bioconcentration factor.

[a] Values are from IT, 2001. The listed BCF is the average of the West Area Red Water Pond reasonable maximum exposure value, and the average of the BCFs for the three aquatic organisms evaluated for the Pentolite Road area.

[b] Values are from EPA, 1999, adjusted to dry weight by multiplying by a factor of 5.

[c] Values are from EPA, 1989, and assumed to be in wet weight; adjusted to dry weight by multiplying by a factor of 5.

[d] Values are from Risk Assessment Information System (RAIS), current as of June 2010. Values were assumed to be in wet weight and were adjusted to dry weight by multiplying by a factor of 5.

References:

EPA, 1999, *Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA530-D-99-001A (Peer Review Draft).

EPA, 1989, *Assessing Human Health Risks from Chemically Contaminated Fish and Shellfish*, EPA503-8-89-002.

Risk Assessment Information System (RAIS), on-line database, current as of June 2007, http://rais.ornl.gov

Bintein, S., and J. Devillers, 1992, *Nonlinear Dependence of Fish Bioconcentration on n-Octanol/Water Partition Coefficient*, CTIS.

IT Corporation (IT), 2001, *Redwater Pond Areas Baseline Ecological Risk Assessment, Plum Brook Ordnance Works, Sandusky, Ohio*, prepared for U.S. Army Corps of Engineers, Nashville District, April.

Table 4-1

Toxicity Reference Values for Mammals
Power House 2 Ash Pits, Plum Brook Ordnance Works
Sandusky, Ohio

	Toxicity Value	NOAEL (mg/kg/d)	Test Species	Reference	Toxicity Value	LOAEL (mg/kg/d)	Test Species	Reference
Inorganics								
Aluminum	--	1.93	mouse	Sample, et al. (1996)	--	19.30	mouse	Sample, et al. (1996)
Barium	--	5.1	rat	Sample, et al. (1996)	--	19.8	rat	Sample, et al. (1996)
Cadmium	--	1.0	rat	Sample, et al. (1996)	--	10	rat	Sample, et al. (1996)
Lead	--	8.0	rat	Sample, et al. (1996)	--	80	rat	Sample, et al. (1996)
Mercury (mink)	--	1.0	mink	Sample, et al. (1996)	1.0 (NOAEL)	5.0	mink	Sample, et al. (1996)
Mercury (mouse)	--	13.2	mouse	Sample, et al. (1996)	--	132.0	mouse	Sample, et al. (1996)
Selenium	--	0.2	rat	Sample, et al. (1996)	--	0.33	rat	Sample, et al. (1996)
Thallium	--	0.0074	rat	Sample, et al. (1996)	--	0.074	rat	Sample, et al. (1996)
Organics								
2,4,6-Trinitrotoluene (2,4,6-TNT)	--	0.2	dog (beagle)	USACHPPM (2000)	--	2.0	dog (beagle)	USACHPPM (2000)
Bis(2-ethylhexyl)phthalate	--	18.3	mouse	Sample, et al. (1996)	--	183		Sample, et al. (1996)

REFERENCES

Sample, B. E., D. M. Opresko, and G. W. Suter II. 1996, Toxicological Benchmarks for Wildlife, 1996 Revision, Risk Assessment Program, Health Sciences Research Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

USACHPPM, 2000, Standard Practice for Wildlife Toxicity Reference Values, Environmental Health Risk Assessment Program and Health Risk Assessment Program and Health Effects Research Program, Aberdeen Proving Ground, Maryland, October.

Table 4-2

Toxicity Reference Values for Birds
Power House 2 Ash Pits, Plum Brook Ordnance Works
Sandusky, Ohio

COPEC	Toxicity Value	NOAEL (mg/kg/d)	Test Species	Reference	Toxicity Value	LOAEL (mg/kg/d)	Test Species	Reference
Inorganics								
Aluminum	--	110	ringed dove	Sample, et al. (1996)	--	1100	ringed dove	Sample, et al. (1996)
Barium	--	20.8	chicks	Sample, et al. (1996)	--	41.7	chicks	Sample, et al. (1996)
Cadmium	--	1.45	mallard duck	Sample, et al. (1996)	--	20	mallard duck	Sample, et al. (1996)
Lead (quail)	--	1.13	Japanese quail	Sample, et al. (1996)	--	11.3	Japanese quail	Sample, et al. (1996)
Lead (kestrel)	--	3.85	Am. Kestrel	Sample, et al. (1996)	--	38.50	Am. Kestrel	Sample, et al. (1996)
Mercury	--	0.45	Japanese quail	Sample, et al. (1996)	--	0.90	Japanese quail	Sample, et al. (1996)
Selenium (duck)	--	0.5	mallard duck	Sample, et al. (1996)	--	1.0	mallard duck	Sample, et al. (1996)
Selenium (owl)		0.44	screech owl	Sample, et al. (1996)		1.5	screech owl	Sample, et al. (1996)
Thallium	--	0.35	starling	LANL (2005)		3.5	starling	LANL (2005)
Organics								
2,4,6-Trinitrotoluene (2,4,6-TNT)	7	0.7	Bobwhite quail	USACHPPM (2000)	178	17.8	Bobwhite quail	USACHPPM (2000)
Bis(2-ethylhexyl)phthalate	--	1.11	ringed dove	Sample, et al. (1996)	--	11.10	ringed dove	Sample, et al. (1996)

REFERENCES

Los Alamos National Laboratory (LANL), 2005, ECORISK Database (Release 2.2), Environmental Restoration Project, Los Alamos National Laboratory, Los Alamos, NM, September.

Sample, B. E., D. M. Opresko, and G. W. Suter II, 1996, Toxicological Benchmarks for Wildlife, 1996 Revision, Risk Assessment Program, Health Sciences Research Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

USACHPPM, 2000, Standard Practice for Wildlife Toxicity Reference Values, Environmental Health Risk Assessment Program and Health Effects Research Program, Aberdeen Proving Ground, Maryland, October.

Table 5-1

Wildlife EEQs for All Food Chain Receptors
Power House 2 Ash Pits
Plum Brook Ordnance Works
Sandusky, Ohio

COPEC	Deer Mouse		Short-tailed Shrew		Cottontail Rabbit		Marsh Wren		White-tailed Deer		Raccoon		Red-Tailed Hawk		Muskrat	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Metals																
Aluminum	6.70E-02	6.70E-03	6.91E-02	6.91E-03	2.86E-02	2.86E-03	2.13E-03	2.13E-04	1.15E-04	1.15E-05	5.15E-03	5.15E-04	1.13E-06	1.13E-07	4.22E-02	4.22E-03
Barium	1.45E-03	3.73E-04	1.49E-03	3.84E-04	6.17E-04	1.59E-04	6.44E-04	3.21E-04	2.49E-06	6.42E-07	2.95E-05	7.59E-06	3.42E-07	1.70E-07	9.12E-04	2.35E-04
Cadmium	4.93E-01	4.93E-02	7.44E-01	7.44E-02	2.95E-02	2.95E-03	1.18E+00	8.54E-02	5.78E-05	5.78E-06	1.26E-03	1.26E-04	2.42E-05	1.75E-06	0.00E+00	0.00E+00
Lead	5.34E-05	5.34E-06	5.51E-05	5.51E-06	2.28E-05	2.28E-06	6.86E-04	6.86E-05	9.20E-08	9.20E-09	6.97E-07	6.97E-08	1.07E-07	1.07E-08	3.36E-05	3.36E-06
Mercury	3.46E-03	3.46E-04	4.61E-03	4.61E-04	4.14E-04	4.14E-05	3.03E-01	1.52E-01	7.39E-07	7.39E-08	1.09E-04	2.18E-05	5.37E-06	2.68E-06	0.00E+00	0.00E+00
Selenium	1.04E+00	6.28E-01	8.78E-01	5.32E-01	2.73E-01	1.66E-01	7.99E-01	3.99E-01	4.18E-04	2.53E-04	2.34E-03	1.42E-03	2.70E-04	7.93E-05	0.00E+00	0.00E+00
Thallium	**5.95E+00**	5.95E-01	**1.34E+01**	1.34E+00	8.21E-01	8.21E-02	4.46E-01	4.46E-02	6.42E-04	6.42E-05	2.16E-02	2.16E-03	9.82E-05	9.82E-06	0.00E+00	0.00E+00
Explosives																
2,4,6-Trinitrotoluene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.10E-04	4.10E-05	0.00E+00	0.00E+00	4.10E-01	4.10E-02
Semivolatile Organics																
Bis(2-ethylhexyl) phthalate	1.62E-05	1.62E-06	1.67E-05	1.68E-06	6.92E-06	6.93E-07	4.86E-04	4.86E-05	2.79E-08	2.80E-09	6.25E-07	6.26E-08	2.58E-07	2.58E-08	1.02E-05	1.02E-06

COPEC - Chemical of potential ecological concern
LOAEL - Lowest observed adverse effect level
NOAEL - No observed adverse effect level

Shaded cells indicate a hazard quotient greater than 1, when rounded.

FIGURES

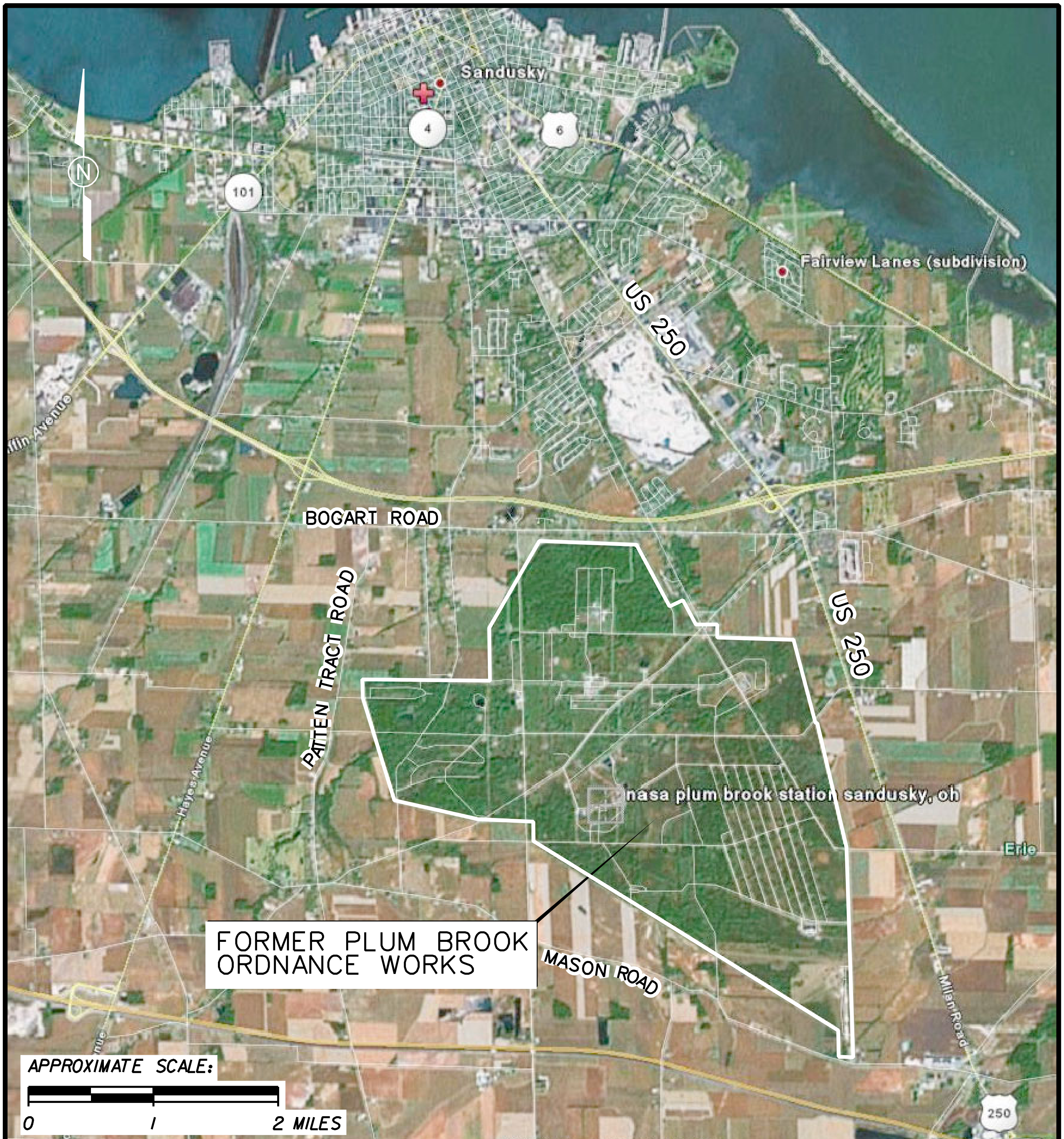

FIGURE 1-1

PBOW VICINITY MAP

POWERHOUSE 2 ASH PITS
SCREENING LEVEL ECOLOGICAL
RISK ASSESSMENT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

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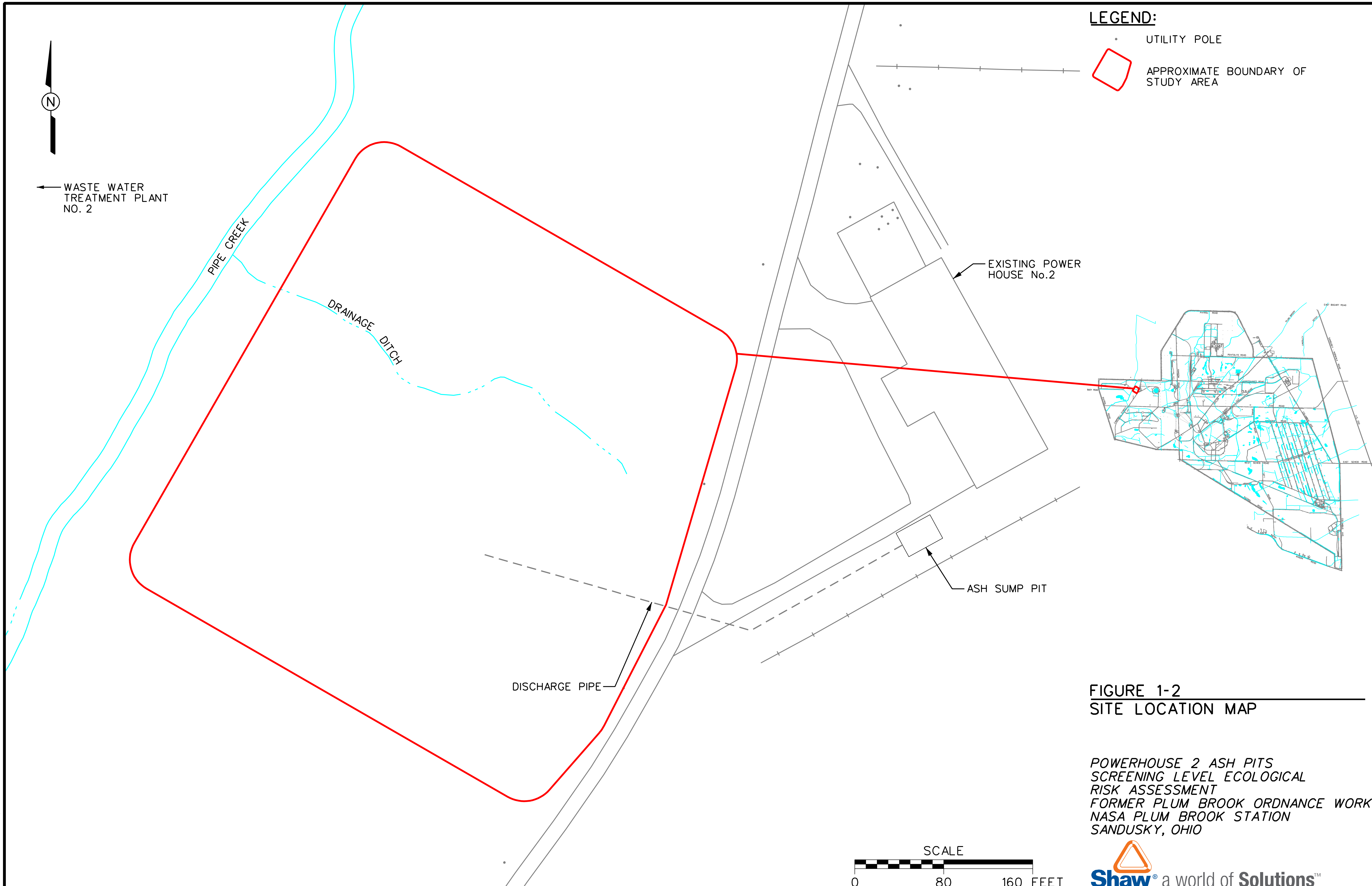

FIGURE 1-2
SITE LOCATION MAP

POWERHOUSE 2 ASH PITS
SCREENING LEVEL ECOLOGICAL
RISK ASSESSMENT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

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Figure 2-1

Photo 1. Edge of forest at Power House 2 Ash Pits (September, 2009).

Photo 2. Edge of forest at Power House 2 Ash Pits (September, 2009).

Figure 2-1

Photo 3. Forest and understory at Power House 2 Ash Pits, showing disturbed understory from well installation and other remedial investigation activities (May, 2009).

Photo 4. Forest and understory at Power House 2 Ash Pits, showing disturbed understory resulting from well installation and other remedial investigation activities (June, 2009).

Figure 2-1

Photo 5. Understory of forest at Power House 2 Ash Pits (September, 2009).

Photo 6. Canopy of forest at Power House 2 Ash Pits (September, 2009).

Figure 2-1

Photo 7. Forest and understory at Power House 2 Ash Pits, showing ponded water (May, 2009).

Photo 8. Ponded water at Power House 2 Ash Pits (May, 2009).

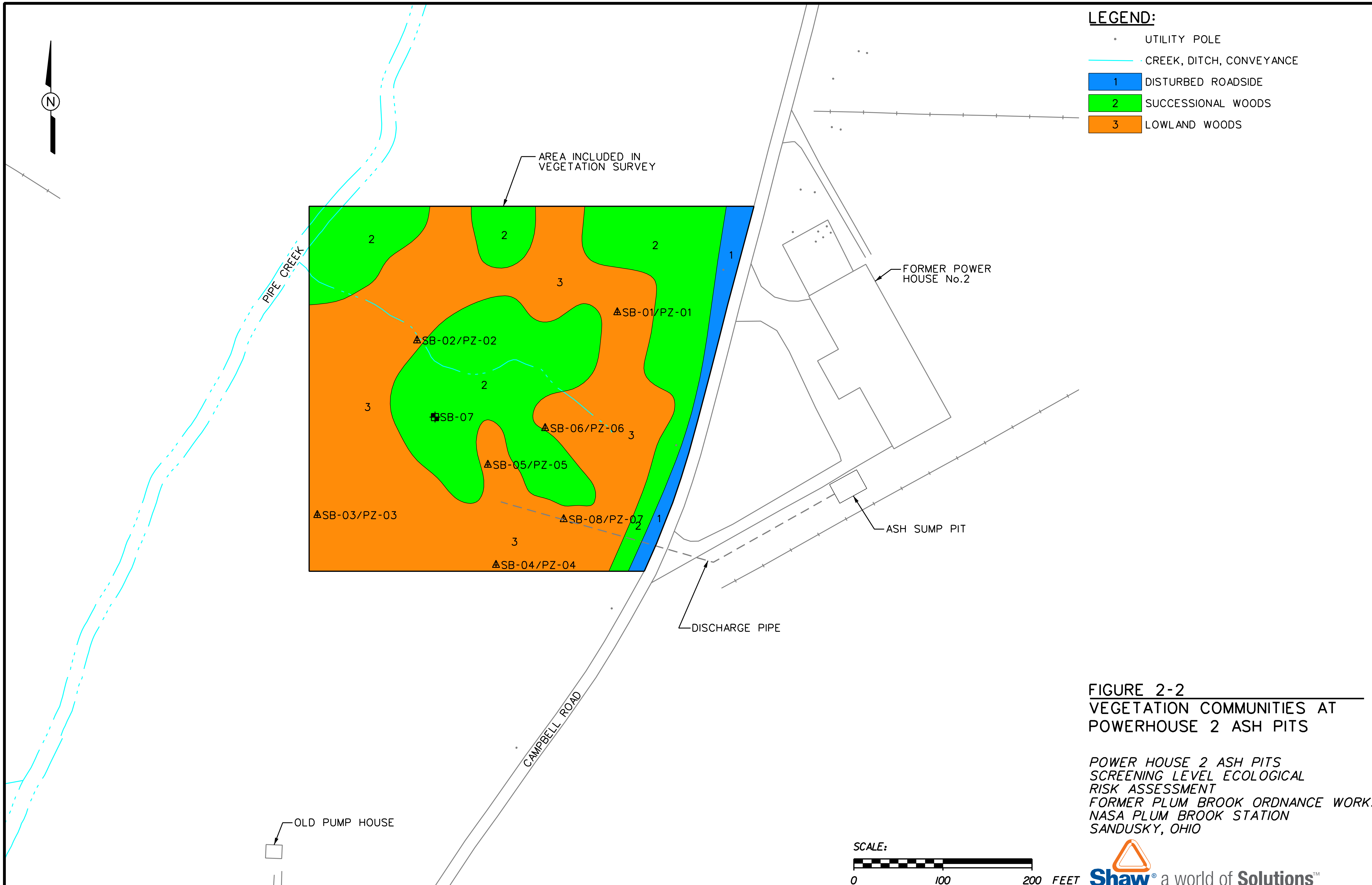

FIGURE 2-2
VEGETATION COMMUNITIES AT POWERHOUSE 2 ASH PITS

POWER HOUSE 2 ASH PITS
SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

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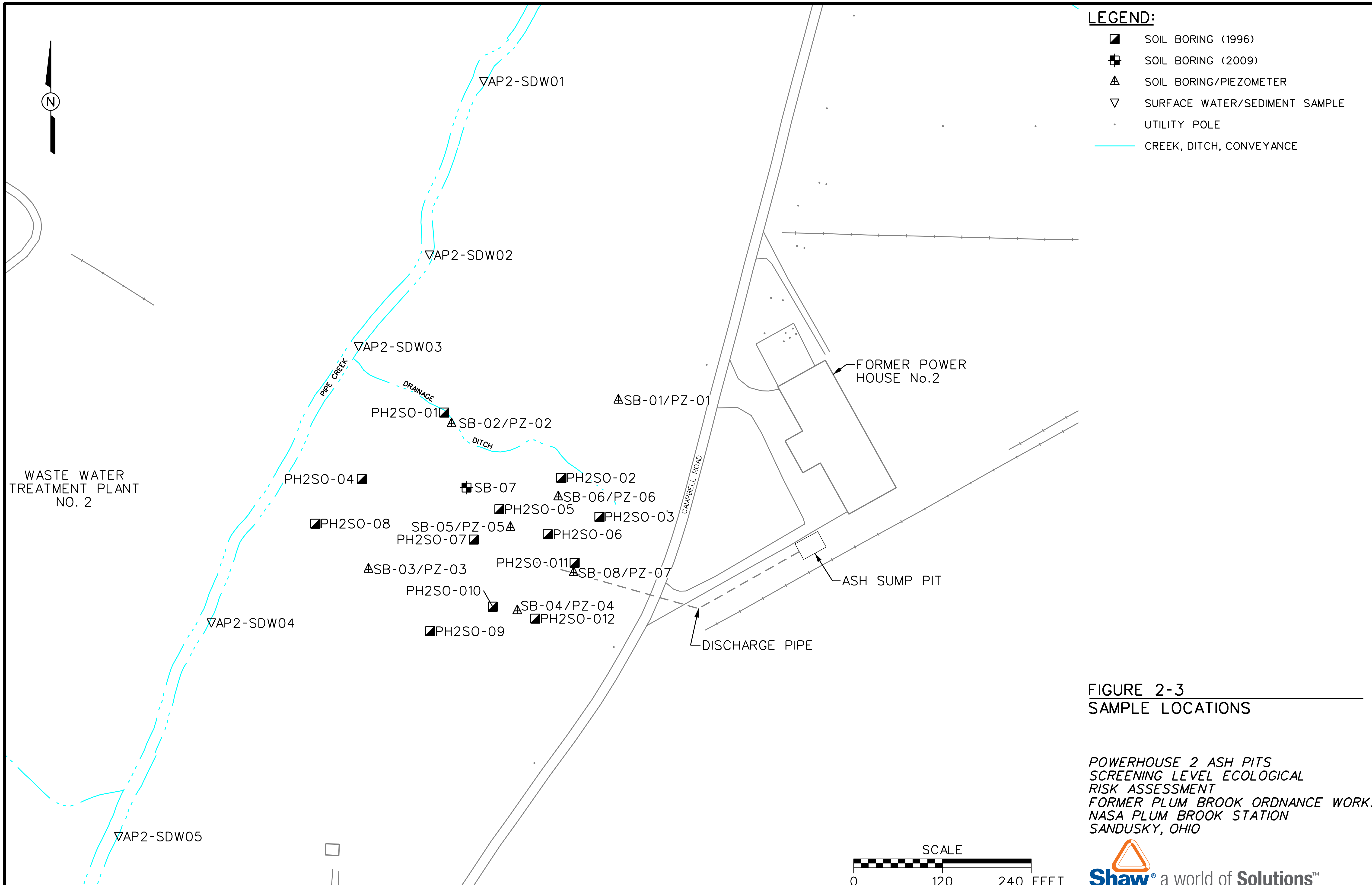

FIGURE 2-3
SAMPLE LOCATIONS

POWERHOUSE 2 ASH PITS
SCREENING LEVEL ECOLOGICAL
RISK ASSESSMENT
FORMER PLUM BROOK ORDNANCE WORKS
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SANDUSKY, OHIO

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Figure 2-4

Simplified Terrestrial Food Web Conceptual Site Model (CSM)
Power House 2 Ash Pits
Plum Brook Ordnance Works, Sandusky, Ohio

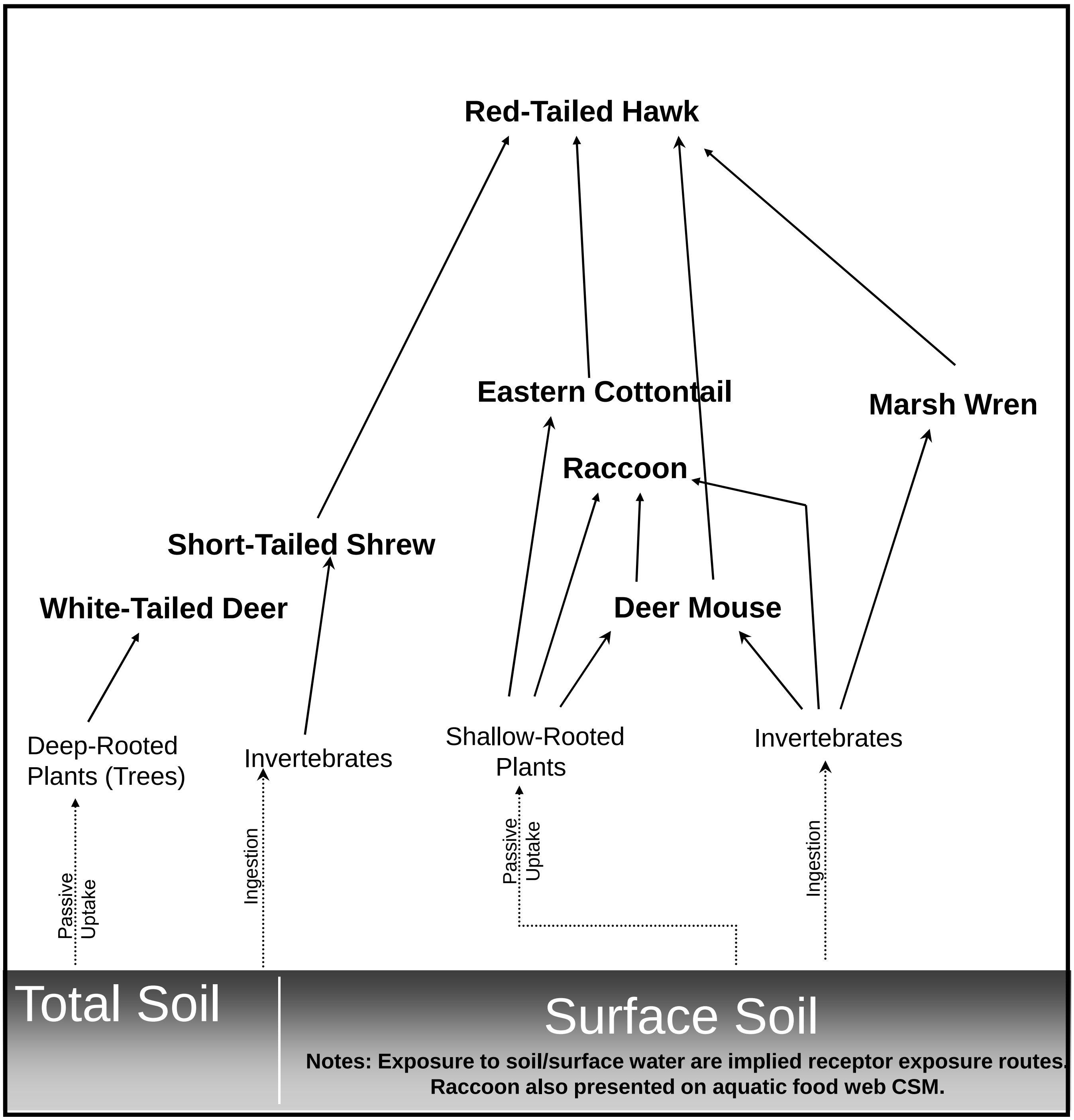
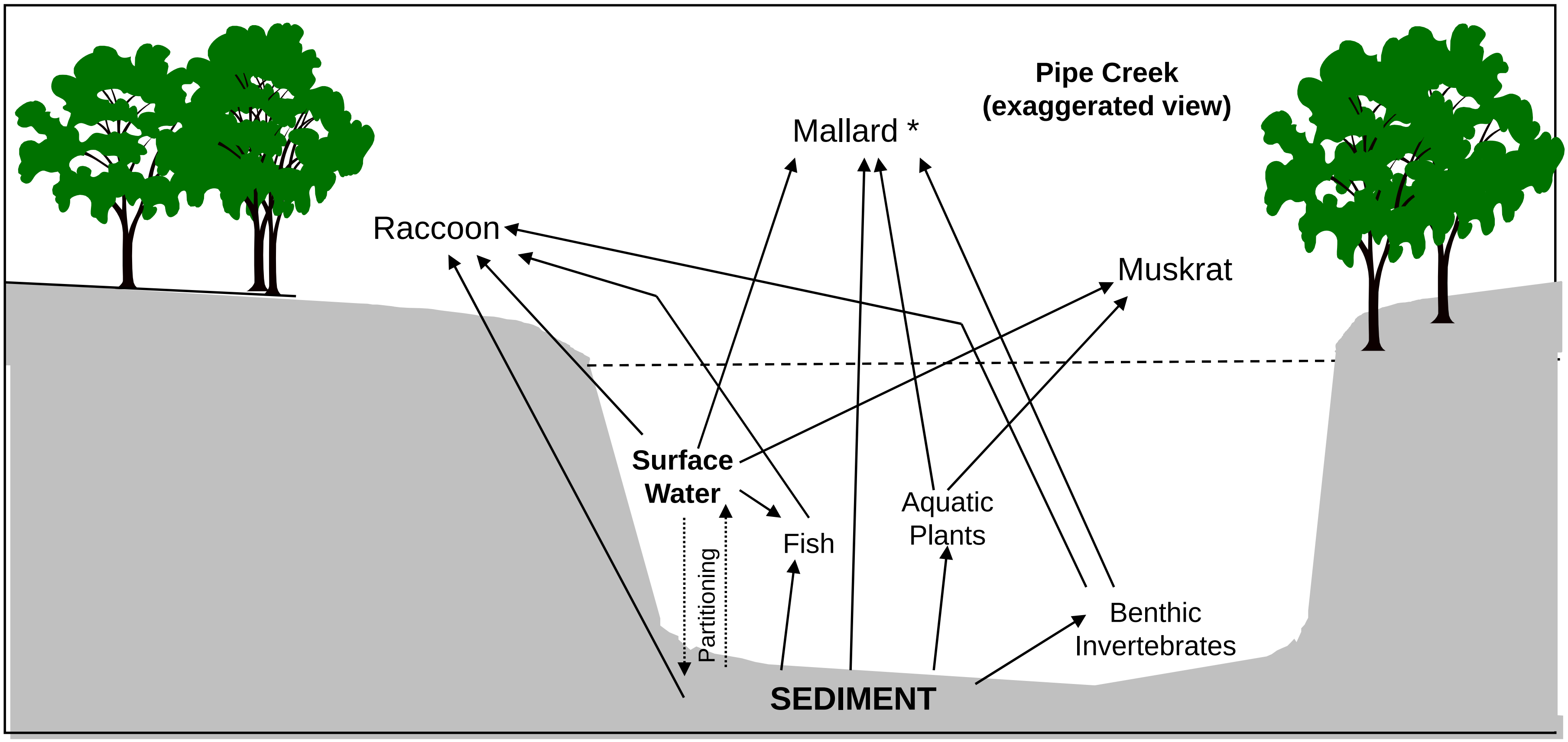


Figure 2-5

Simplified Aquatic Food Web Conceptual Site Model (CSM)
Power House 2 Ash Pits
Plum Brook Ordnance Works, Sandusky, Ohio

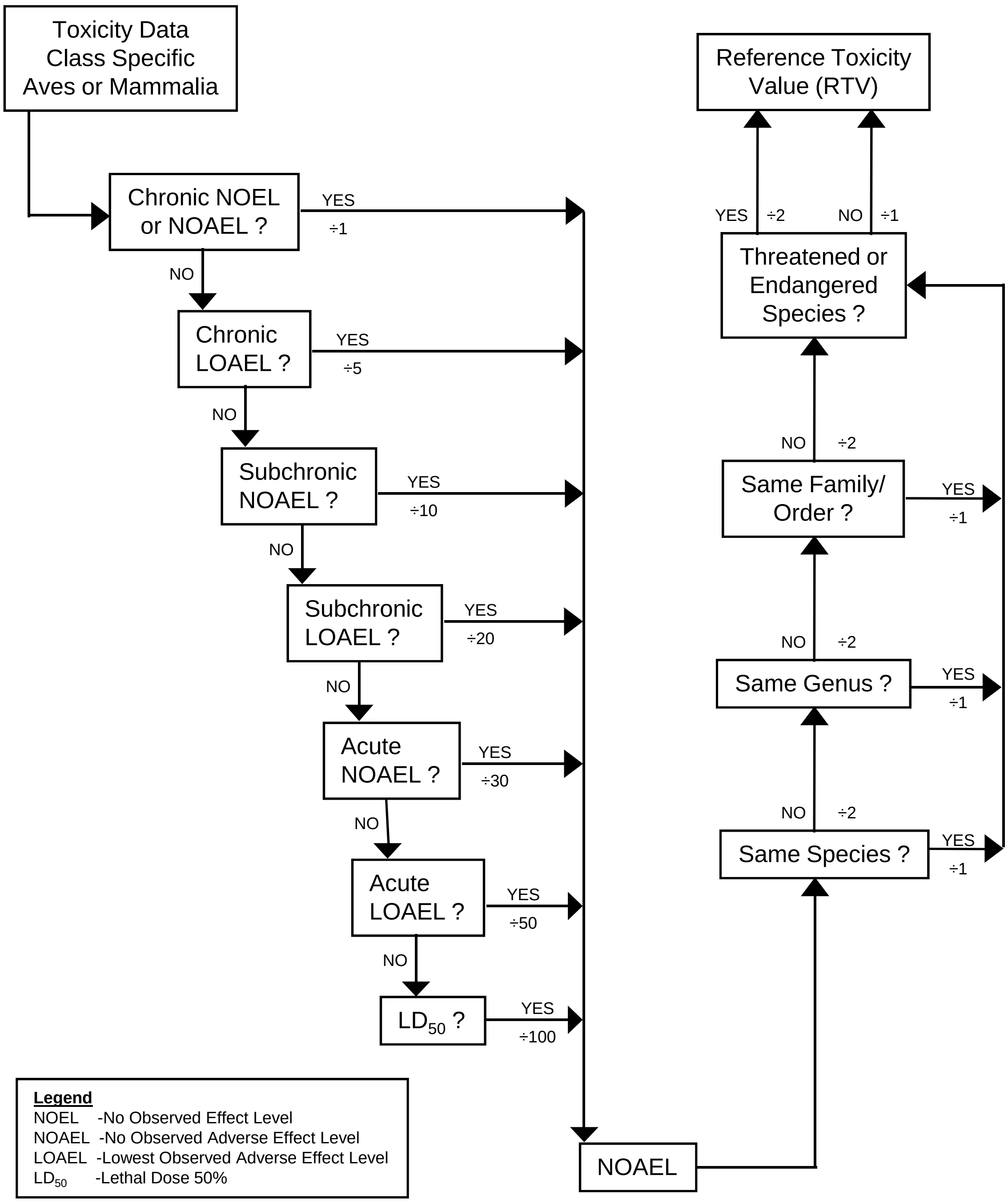


Note: The raccoon is also presented on terrestrial food web CSM.

*** = The mallard is not evaluated in the risk assessment.**

Figure 4-1

Procedural Flow Chart for Deriving Toxicity Reference Values (TRV) from Class-Specific Toxicity Data Plum Brook Ordnance Works, Sandusky, Ohio



Legend
NOEL -No Observed Effect Level
NOAEL -No Observed Adverse Effect Level
LOAEL -Lowest Observed Adverse Effect Level
LD_{50} -Lethal Dose 50%

Credit: Adapted from Ford et al. (1992) in *Tri-Service Procedural Guidelines for Ecological Risk Assessments*, 1996

APPENDIX A

VASCULAR PLANT SPECIES DOCUMENTED ON SITE

Appendix A

Vascular Plant Species Documented On Site
Power House 2 Ash Pits
Plum Brook Ordnance Works, Sandusky, Ohio

Scientific Name	Common Name	Relative Frequency[a]	Rank[b]	Habitat	Observed On Site[c]
Acalypha rhomboidea	Three-seeded mercury	NA		NA	2
Acer negundo	box-elder maple	Frequent		Stream banks, ditches, and moist woods	1,2
**Acer platanoides*	Norway maple	Occasional		Disturbed woods	1
Acer rubrum	red maple	Common		Dry to moist woods	1
Acer saccharinum	Silver maple	Rare		Dry to moist woods	3
Acer saccharum	Sugar maple	Occasional		Dry to moist woods	3
**Achillea millefolium*	Yarrow	Frequent		Dry fields, roadsides, and about buildings	1
Acorus calamus	Sweet flag	Rare		Wet ditches	3
Agalinis purpurea	purple false-foxglove	Frequent		Moist openings and ditches	1
Agrimonia parviflora	southern agrimony	Frequent		Moist fields and ditches	1,2
**Agropyron repens*	Quack grass	Frequent		Old fields and roadsides	3
Agrostis hyemalis	Ticklegrass	Occasional		Dry, grassy fields and shaley openings	1
**Agrostis gigantea*	Redtop	Common		Moist fields, ditches, and roadsides	1
Agrostis perennans	autumn bent-grass	Frequent		Dry woods and borders on shale	1
Ailanthus altissima	tree of heaven	NA		NA	2
Alisma subcordatum	water-plantain	Occasional		Ponds and ditches	1
**Alliaria petiolata*	garlic mustard	Frequent		Dry to moist wood lots	1,2
Allium canadense	Wild garlic	Occasional		Successional woods	3
Allium canadense	Field garlic	NA		NA	2
Ambrosia artemisiifolia	common ragweed	Frequent, occasional		Dry fields and roadsides	1,2
Ambrosia trifida	giant ragweed	Occasional		Dry fields and roadsides	1
Andropogon gerardii	big bluestem	Frequent, 0ccasional		Dry to moist fields and roadsides	1
**Andropogon virginicus*	broom-sedge	Occasional, frequent		Dry fields and roadsides	1

Appendix A

Vascular Plant Species Documented On Site
Power House 2 Ash Pits
Plum Brook Ordnance Works, Sandusky, Ohio

Scientific Name	Common Name	Relative Frequency[(a)]	Rank[(b)]	Habitat	Observed On Site[(c)]
Antennaria parlinii	pussy-toes	Occasional		Dry fields and openings, especially on shale	1
**Anthoxanthum odoratum*	vernal-grass	Occasional		Dry fields and openings, especially on shale	1
Apocynum cannabinum	Dogbane	Frequent		Dry to moist fields and roadsides	1,2
**Arabidopsis thaliana*	mouse-ear cress	Occasional		Road berms and about buildings	1
**Arctium minus*	Burdock	Occasional		Disturbed fields and about buildings	1
Arenaria lateriflora	grove sandwort	Rare	T	Woods along Ransom Brook north of reactor	1
Arisaema triphyllum	Jack-in-the-pulpit	Rare		Moist to dry woods	3
Aristida dichotoma	Churchmouse grass	Occasional		Dry fields and openings	1
Aristida longespica	slimspike triple-awned grass	Common		Dry fields and openings	1
Aristida oligantha	prairie triple-awned grass	Occasional		Dry openings and roadsides	1
**Artemisia ludoviciana var. gnaphaloides*	white sage	Occasional		Grassy roadsides	1
Asclepias hirtella	prairie milkweed	Common		Dry to moist openings	1
Asclepias incarnata	Swamp milkweed	Occasional		Wet ditches	3
Asclepias sullivantii	Sullivant's milkweed	Rare		Moist field along Patrol Road south of Scheid Road	1
Asclepias syriaca	common milkweed	Frequent		Dry to moist fields and roadsides	1,2
Asclepias tuberosa	butterfly-weed	Occasional		Dry openings and roadsides	1
Aster ericoides	white heath aster	Rare, frequent		Grassy strip along Patrol Road southeast of Taft Road	1
Aster laevis	smooth aster	Rare		White oak grove on Taft Road	1
Aster lateriflorus	calico aster	Common, frequent		Moist woods and thickets	1,2
Aster novae-angliae	New England aster	Occasional		Dry fields and roadsides	1
Aster pilosus	common white aster	Common		Dry fields, roadsides, and about buildings	1
Aster sagittifolius	Arrow-leaved aster	Frequent		Woods and fields	3

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Scientific Name	Common Name	Relative Frequency[a]	Rank[b]	Habitat	Observed On Site[c]
Aster umbellatus	flat-top aster	Frequent, rare		Dry to moist fields and roadsides	1
Baptisia lactea	prairie false indigo	Occasional	P	Dry openings in bunker area	1
Baptisia tinctoria	yellow false indigo	Occasional		Dry openings in bunker area	1
**Berberis thunbergii*	Japanese barberry	Occasional, rare		Woodland borders	1
Bidens coronata	northern tickseed-sunflower	Common		Moist fields and ditches	1
Bidens frondosa	Beggar ticks	Rare		Ditches	3
Boehmeria cylindrica	false nettle	Occasional		Ponds and ditches	1,2
Botrychium virginianum	Rattlesnake fern	Occasional		Successional woods	3
**Brassica nigra*	black mustard	Occasional		Roadsides	1
**Bromus inermis*	smooth brome	Frequent		Dry to moist fields and roadsides	1,2
Bromus pubescens	Brome	Occasional		Dry fields	3
**Bromus tectorum*	downy chess	Occasional		Dry openings and roadsides on shale	1
Cacalia atriplicifolia	pale Indian-plantain	Occasional		Dry fields and roadsides; woods	1
Calamagrostis canadensis	blue-joint	Occasional		Moist fields and ditches	1
Callitriche heterophylla	water-starwort	Occasional		Pond margins and seasonally-moist depressions	1
Calystegia sepium	Hedge bindweed	Occasional		Fields	3
**Campsis radicans*	trumpet-vine	Occasional		Disturbed openings and roadsides	1
**Capsella bursa-pastoris*	shepherd's-purse	Occasional		Roadsides and about buildings	1
**Cardamine hirsuta*	bitter-cress	Occasional		Roadsides and about buildings	1
**Carduus nutans*	musk-thistle	Occasional, frequent		Dry fields and roadsides	1
Carex aggregata	sedge	Occasional		Moist woods	3

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Scientific Name	Common Name	Relative Frequency[(a)]	Rank[(b)]	Habitat	Observed On Site[(c)]
Carex alata	broad-winged sedge	Rare	P	Grassy field along Patrol Road south of Scheid Road, also in grassy strip between Patrol Road and artificial pond southeast of Taft Road	1
Carex amphibola	NA	Occasional		Thickets and woods borders	1
Carex annectens var. annectens	NA	Occasional		Moist, grassy fields	1
Carex annectens var. xanthocarpa	yellow-fruited sedge	Occasional		Moist, grassy fields	1
Carex blanda	NA	Frequent		Moist woods	1
Carex bromoides	Brome-like sedge	NA		NA	2
Carex cephaloidea	thin-leaf sedge	Rare	E	Woods border along Pentolite Road west of reactor	1
Carex complanata var. hirsutella	NA	Frequent		Dry fields and woods borders	1
Carex conoidea	field sedge	Rare	T	Grassy depression along Taft Road south of North Magazine Road	1
Carex cristatella	NA	Occasional		Moist fields and ditches	1
Carex festucacea	fescue sedge	Occasional		Moist, grassy fields	1
Carex gracillima	NA	Occasional		Moist woods	1
Carex granularis	meadow sedge	Common		Moist, grassy fields and ditches	1
Carex hirtifolia	NA	Rare		Disturbed oak woods along angling road	1
Carex hystericina	Bottlebrush sedge	Rare		Moist depression along Taft Road	1
Carex pensylvanica	Pennsylvania sedge	Common		Dry woods	1
Carex radiata	Eastern star sedge	NA		NA	2
Carex rosea	NA	Frequent		Dry to moist woods	1
Carex scoparia	NA	Frequent		Moist, grassy fields	1
Carex stipata	NA	Frequent		Moist fields and ditches	1

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Scientific Name	Common Name	Relative Frequency[(a)]	Rank[(b)]	Habitat	Observed On Site[(c)]
Carex stricta	tussock sedge	Occasional		Moist fields and ditches	1
Carex swanii	Swan's sedge	Occasional		Dry, grassy fields	1
Carex tribuloides	NA	Occasional		Moist, grassy fields and ditches	1,2
Carex umbellata	NA	Occasional		Well-drained, grassy fields on sandy soil	1
Carex vulpinoidea	fox sedge	Common		Moist fields, ditches, and about ponds	1
Carya ovata	shagbark hickory	Rare		Sandy soil along fence at far southeast boundary	1,2
Catalpa speciosa	Catalpa	NA		NA	2
Celastrus orbiculatus	Bittersweet	Occasional		Thickets and woods borders	3
Celtis occidentalis	Hackberry	Occasional		dry to moist woods and borders	1,2
Cephalanthus occidentalis	Buttonbush	Occasional		Moist depressions and ditches	1,2
Cerastium arvense	field chickweed	Rare		White oak grove along Taft Road	1
**Cerastium fontanum*	mouse-ear chickweed	Frequent		Road berms and about buildings	1
**Cerastium semidecandrum*	NA	Occasional		Road berms and about buildings	1
**Chaenorrhinum minus*	dwarf snapdragon	Occasional		Road berms and about buildings	1
Chamaecrista fasciculata	partridge-pea	Occasional		Dry openings on shale	1
**Chrysanthemum leucanthemum*	ox-eye daisy	Frequent		Dry to moist fields and roadsides	1
**Cichorium intybus*	Chicory	Occasional		Roadsides	1,2
Circaea lutetiana	Southern broad-leaved enchanter's nightshade	Frequent		Woods	3
Cinna arundinacea	Wood reed grass	Occasional		Woods	2
Circaea lutetiana	southern broad-leaved enchanters nightshade	NA		NA	2
**Cirsium arvense*	Canada thistle	Common		Disturbed fields and roadsides	1,2
Cirsium discolor	prairie thistle	Frequent, occasional		Grassy fields and roadsides	1

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Scientific Name	Common Name	Relative Frequency[(a)]	Rank[(b)]	Habitat	Observed On Site[(c)]
**Cirsium vulgare*	bull thistle	Frequent		Disturbed fields and roadsides	1
Clinopodium vulgaris	wild basil	Occasional		Dry roadsides and openings	1
**Confolvulus arvensis*	field bindweed	Occasional		Disturbed fields and roadsides	1,2
**Convallaria majalis*	lilly-of-the-valley	Rare		Grassy field along Columbus Avenue	1
Conyza canadensis	Horseweed	Frequent		Dry fields and roadsides	1
Cornus amomum	swamp dogwood	Frequent, occasional		Moist fields and thickets	1
Cornus drummondii	rough-leaved dogwood	Frequent		Moist borders, thickets, and roadsides	1,2
Cornus florida	flowering dogwood	Occasional		Woodland borders and roadsides	1
Cornus racemosa	gray dogwood	Frequent		Dry fields and roadsides	1
**Coronilla varia*	crown-vetch	Occasional, common		Grassy fields and roadsides	1
Crataegus mollis	downy hawthorn	Frequent		Thickets and woodland borders	1
Crataegus punctata	dotted hawthorn	Frequent		Thickets and woodland borders	1
Cryptotaenia canadensis	honewort	Occasional, rare		Dry to moist woods	1
Cuscuta gronovii	dodder	Frequent		Moist fields and ditches	1
**Cyperus esculentus*	yellow nutgrass	Occasional, frequent		Moist, disturbed openings	1
Cyperus flavescens	Umbrella sedge	occasional		Old fields and waste places	3
Cyperus strigosus	umbrella-sedge	Frequent		Moist openings, ponds, and ditches	1
**Dactylis glomerata*	orchard-grass	Occasional		Dry to moist fields and roadsides	1,2
Danthonia spicata	poverty-grass	Occasional		Dry openings over shale	1
Datura stramonium	jimson-weed	Occasional		Disturbed openings and roadsides	1
**Daucus carota*	wild carrot	Frequent		Dry fields and roadsides	1
Desmodium canescens	Tick trefoil	Occasional		Fields	3
**Dianthus armeria*	Deptford pink	Occasional, rare		Dry openings and roadsides on shale	1

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Scientific Name	Common Name	Relative Frequency[a]	Rank[b]	Habitat	Observed On Site[c]
Digitaria cognatum (Leptoloma cognatum)	N/A	Occasional		Old fields	3
Diodia teres	buttonweed	Occasional		Dry openings over shale	1
**Dipsacus fullonum*	common teasel	Frequent		Dry, disturbed openings and roadsides	1
**Draba verna*	early whitlow-wort	Occasional		Dry roadsides and about buildings	1
Dryopteris carthusiana	spinulose woodfern	Frequent		Moist woods and shaded borders	1
**Eleagnus umbellata*	autumn-olive	Occasional		Roadsides and woodland borders	1,2
Eleocharis acicularis	needle spikerush	Frequent		Margins of artificial pond	1
Eleocharis erythropoda	red-footed spikerush	Occasional		Moist openings and ditches	1
Eleocharis obtusa	NA	Common		Moist openings and ditches	1
Eleocharis smallii	Small's spikerush	Frequent		Margins of artificial pond	1
Eleocharis tenuis	NA	Frequent		Moist openings and ditches	1
Elymus virginica	Wild rye	Occasional		Moist to dry woods	2
**Elytrigia repens*	quack-grass	Frequent		Dry fields and roadsides	1
Equisetum arvense	horsetail	Frequent		Moist openings, roadsides, and ditches	1,2
Equisetum hyemale	scouring-rush	Occasional		Moist roadsides and ditches	1
Eragrostis frankii	NA	Occasional		Moist openings and ditches	1
Eragrostis spectabilis	showy lovegrass	Occasional		Dry to moist fields	1
Erechtites hieracifolia	Pilewort	Common		Disturbed woods, borders, and roadsides	1
Erigeron anuus	Fleabane	NA		NA	2
Erigeron philadelphicus	Philadelphia fleabane	Frequent, occasional		Roadsides and borders	1
Erigeron strigosus	smooth fleabane	Occasional		Dry openings and roadsides	1
Eupatorium perfoliatum	Boneset	Occasional, frequent		Moist fields, ponds, and ditches	1
Eupatorium purpureum	purple joe-pye-weed	Occasional		Borders of moist woods, fields	1,2

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Scientific Name	Common Name	Relative Frequency[a]	Rank[b]	Habitat	Observed On Site[c]
Eupatorium rugosum	White snake root	Common		Woods and fields	2
Euphorbia corollata	Flowering spurge	Occasional		Dry fields	1
Euphorbia maculata	Prostrate spurge	Occasional		Dry openings, road berms, and about buildings	1
Euphorbia supina	Milk purslane	NA		NA	2
Euthamia graminifolia	grass-leaved goldenrod	Common		Dry to moist fields and roadsides	1
**Festuca elatior*	tall fescue	Occasional		Roadsides and grassy fields	1
**Festuca obtusa*	Fescue	Common		Old fields	3
Fragaria virginiana	wild strawberry	Frequent		Dry to moist fields and roadsides	1
Fraxinus americana	white ash	Frequent		Dry to moist woods and borders	1
Fraxinus pensylvanica	green ash	Frequent, common		Moist woods and stream banks	1,2
Galine aparine	Cleavers	Occasional		Moist woods and borders	1,2
Galium asperellum	Rough bedstraw	NA		NA	2
Galium circaezans	wild licorice	Rare		Dry woods	1
Galium tinctorium	Southern bedstraw	Rare		Moist depression along Taft Road	1
Gentianopsis crinita	Fringed gentian	Occasional	P	Old fields along ditch banks, small groups and scattered individuals in northeast portion of TNT area A	3
Gerardia tenuifolia	Slender gerardia	Frequent		Disturbed fields	3
Geranium maculatum	Wild geranium	Occasional		Successional woods	3
Geum vernum	spring avens	Occasional		Moist woods and borders	1
Geum virginianum	white avens	Occasional		Woods borders and roadsides	1
**Glecoma hederacea*	ground-ivy	Frequent		Moist openings, roadsides, and about buildings	1,2
Gleditsia triacanthos	honey-locust	Occasional, rare		Dry to moist woods and borders	1,2
Glyceria striata	manna-grass	Occasional		Moist woods and about ponds	1,2

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Scientific Name	Common Name	Relative Frequency[a]	Rank[b]	Habitat	Observed On Site[c]
Gnaphalium obtusifolium	Cudweed	Frequent, occasional		Dry openings on shale, fields	1
Gratiola virginiana	round-fruited hedge-hyssop	Rare	P	ca 20 plants; moist, shaded ground by pond west of Snake Road	1
Hackelia virginiana	Virginia stickseed	Rare		Woods	3
Hedyotis caerula	Bluets	Occasional		Dry openings and roadsides on shale	1
Helenium autumnale	Sneezeweed	Occasional		Disturbed fields	3
Helenium flexuosum	Southern sneezeweed	Occasional		Moist, open ground and ditches	1
Helianthus mollis	ashy sunflower	Rare	T	ca 200 plants in grassy field south and southwest of junction of Fox and Patrol Roads; the exact number of individuals in this population is uncertain since excessive browsing by deer has reduced the plants to leafy tufts.	1
Helianthus tuberosus	Jerusalem artichoke	Occasional		Old fields	3
Hemerocallus fulva	Daylily	NA		NA	2
Hesperis matronalis	Dame's rocket	NA		NA	2
Hibiscus moscheutos	rose-mallow	Rare		Moist swale along Ransom Road	1
**Hieracium piloselloides*	king-devil	Frequent		Dry openings on shale, fields	1
Hypericum gentianoides	orange-grass	Frequent		Dry openings	1
Hypericum gymnanthum	least St. John's-wort	Rare	E	ca 50 plants; moist, open ground along Patrol Road south of Fox Road	1
Hypericum majus	tall St. John's-wort	Rare	P	Moist, shaded ground by pond west of Snake Road	1
Hypericum mutilum	little St. John's-wort	Frequent		Moist openings, ponds, and ditches	1
**Hypericum perforatum*	dotted St. John's-wort	Frequent		Disturbed fields and roadsides	1
Hypericum punctatum	St. Johns wort	Rare		Fields	3

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Scientific Name	Common Name	Relative Frequency[a]	Rank[b]	Habitat	Observed On Site[c]
Hypoxis hirsuta	yellow-eyed-grass	Occasional		Grassy fields	1
Hystrix patula	Bottlebrush grass	Occasional		Woods	3
Impatiens capensis	Jewelweed	NA		NA	2
**Inula helenium*	Elecampane	Rare		Moist roadside along Taft Road	1
Ipomoea pandurata	wild sweet-potato	Occasional		Dry openings over shale	1
Iris versicolor	Northern blue flag	Occasional		Moist woods and ditches	1
Isanthus brachiatus	false pennyroyal	Rare		Moist opening on limestone, west of Snake Road and south of North Magazine Road	1
Juglans nigra	black walnut	Rare		A few young trees at edge of grassy field southwest of junction of Fox and Patrol Roads, woods (2b)	1
Juncus acuminatus	NA	Common		Moist openings and ditches	1
Juncus biflorus	NA	Occasional		Moist openings and ditches	1
Juncus brachycarpus	NA	Occasional		Moist openings	1
Juncus canadensis	Canada rush	Frequent		Moist openings	1
Juncus dudleyi	Dudley's rush	Frequent		Moist openings	1
Juncus effusus	Common rush	Frequent		Moist openings, ponds, and ditches	1
Juncus marginatus	NA	Occasional		Moist openings	1
Juncus nodosus	rush	Occasional		Old fields and ditches	3
Juncus tenuis	path rush	Frequent, occasional		Dry openings, road berms, and about buildings	1
Juncus torreyi	Torrey's rush	Occasional		Moist fields	3
**Lamium purpureum*	dead-nettle	Frequent		Disturbed fields, roadsides, and about buildings	1
Laportea Canadensis	Wood nettle	NA		NA	2
*Lathyrus latifolius**	Everlasting pea	Occasional		Old fields	3
Leersia oryzoides	rice cutgrass	Occasional		Moist fields and ditches	1

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Scientific Name	Common Name	Relative Frequency[a]	Rank[b]	Habitat	Observed On Site[c]
Leersia virginica	White grass	NA		NA	2
Lemna minor	little duckweed	Occasional		Ponds and standing water	1
**Lepidium campestre*	field-cress	Occasional		Roadsides and about buildings	1
Lepidium virginicum	poor man's pepper	Frequent		Roadsides, disturbed openings, and about buildings	1
Leptoloma cognatum	fall witch grass	NA		NA	2
Lespedeza capitata	bush-clover	Occasional		Dry fields	1
Leucospora multifida	NA	Rare		Moist opening on limestone, west of Snake Road and south of North Magazine Road	1
Liatris scariosa var. novae-angliae	northern blazing-star	Rare		Dry ground along Patrol Road at Olemacher Ditch	1
Liatris spicata	spiked blazing-star	Occasional		Moist openings	1
**Linaria vulgaris*	butter-and-eggs	Occasional		Roadsides and about buildings	1
Lindernia dubia	false pimpernel	Occasional		Moist openings, ditches, and pond margins	1
Linum medium	wild flax	Frequent		Dry to moist openings	1
Linum virginianum	Virginia flax	Rare		About pond in northern bunker area	1
Lobelia siphilitica	Great lobelia	Frequent		Moist fields	3
Lonicera japonica	Japanese honeysuckle	Occasional		Fields and disturbed areas	2
**Lonicera maackii*	Amur honeysuckle	Rare		Roadsides and thickets along Columbus Avenue near Scheid Ditch	1
**Lonicera morrowii*	Asiatic honeysuckle	Frequent		Thickets, borders, and roadsides	1
**Lonicera tatarica*	Tatarian honeysuckle	Frequent, common		Thickets, borders, and roadsides	1
**Lotus corniculatus*	bird's-foot trefoil	Occasional		Grassy fields and road berms	1
Ludwigia alternifolia	rattlebox	Occasional		Ponds and ditches	1
Ludwigia palustris	water-purslane	Frequent, occasional		Ponds and ditches	1

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Scientific Name	Common Name	Relative Frequency[a]	Rank[b]	Habitat	Observed On Site[c]
Ludwigia polycarpa	NA	Rare		Moist, shaded ground by pond on Snake Road	1
Lycopus americanus	American water-horehound	Frequent		Ponds and ditches	1
Lycopus uniflorus	northern water-horehound	Frequent		Moist woods and shaded borders	1
Lysimachia terrestris	swamp loosestrife	Occasional		Moist openings	1,2
Lythrum alatum	prairie loosestrife	Occasional		Moist openings	1
Maclura pomifera	osage-orange	Occasional		Disturbed woods and borders	1,2
**Matricaria matricarioides*	pineapple-weed	Occasional		Roadsides and about buildings	1
**Medicago lupulina*	Black medic	Occasional		Old fields and disturbed areas	2
**Melilotus alba*	white sweet-clover	Occasional, frequent		Disturbed fields and roadsides	1
**Melilotus officinalis*	yellow sweet-clover	Occasional		Disturbed fields and roadsides	1,2
Mentha piperita	peppermint	NA		NA	2
Mentha spicata	Spearmint	Occasional		Moist fields	3
Mimulus ringens	monkey-flower	Occasional, rare		Moist openings and ditches	1
Monarda fistulosa	bergamont	Occasional		Grassy fields	1
Morus alba	Mulberry	Occasional		Fields and thickets	3
Muhlenbergia frondosa	muhly grass	Frequent		Moist fields and ditches	1
Myrica pensylvanica	Bayberry	Rare	E	One individual in old field in northern portion of area	3
Najas flexilis	northern naiad	Occasional		Artificial ponds	1
**Najas minor*	Eurasian naiad	Frequent		Artificial ponds	1
**Nepeta cataria*	catnip	Occasional, frequent		Roadsides and weedy openings	1
Nyssa sylvatica	blackgum	Occasional		Thickets and woods borders	1
Oenothera biennis	evening-primrose	Frequent		Dry fields, roadsides, and about buildings	1
Oenothera tetragona	northern sundrops	Frequent		Moist, grassy fields	1

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Scientific Name	Common Name	Relative Frequency[a]	Rank[b]	Habitat	Observed On Site[c]
Onoclea sensibilis	Sensitive fern	frequent		Wet areas	2
Osmunda cinnamomea	cinnamon fern	Rare		Depressions in moist woods along angling road	1
Osmunda regalis	royal fern	Occasional		Depressions in moist woods	1
**Oxalis europea*	Sorrel	Common		Old fields and disturbed areas	3
Oxalis stricta	sorrel	NA		NA	2
Oxalis violacea	purple wood-sorrel	Occasional		Drier oak woods and borders on shale	1
Panicum dichotomiflorum	Panic grass	Frequent		Fields	3
Panicum flexile	wiry witch-grass	Rare		Moist opening on limestone, west of Snake Road and south of North Magazine Road	1
Panicum lanuginosum	hairy panic-grass	common		Dry, grassy fields and roadsides	1
Panicum oligosanthes	sand panic-grass	Occasional		Dry, grassy fields	1
Panicum rigidulum	stiff panic-grass	Frequent		Moist openings and ditches	1
Panicum virgatum	switch-grass	Occasional		Dry fields	1,2
Parietaria pensylvanica	pellitory	Occasional		Dry, disturbed wood lots and borders	1
Paronychia fastigata	forked chickweed	Occasional		Dry woods and borders on shale	1
Parthenocissus quinquefolia	Virginia-creeper	Occasional		Dry to moist woods borders and thickets	1,2
Parthenocissus vitacea	grape-woodbine	Rare		Dry opening north of Center Magazine Road	1
**Pastinaca sativa*	wild parsnip	Occasional		Roadsides	1
Penstemon digitalis	tall white beard-tongue	Frequent		Grassy fields and roadsides	1
Phalaris arundinacea	reed canary-grass	Common		Moist fields and ditches	1
**Phleum pratense*	timothy	Frequent		Disturbed fields and roadsides	1
Phragmites australis	reed-grass	Occasional, rare		Moist openings and ditches	1

Scientific Name	Common Name	Relative Frequency[(a)]	Rank[(b)]	Habitat	Observed On Site[(c)]
Phryma leptostachya	lopseed	Rare		Edge of woods along Scheid Ditch near Columbus Avenue; successional woods	1
Phytolacca americana	pokeberry	Occasional, rare		Moist woods and borders	1
Pilea pumila	clearweed	NA		NA	2
**Plantago lanceolata*	English plantain	Frequent		Disturbed openings and about buildings	1
**Plantago major*	broad-leaved plantain	Frequent		Road berms and about buildings (1) disturbed areas and old fields (2a)	1
Platanthera lacera	ragged fringe-orchid	Rare		Ditch along south Patrol Road	1
Platanus occidentalis	sycamore	Occasional, frequent		Moist woods and stream banks, fields and waste areas	1,2
**Poa annua*	early bluegrass	Common		Road berms and about buildings	1
**Poa compressa*	Canada bluegrass	Frequent		Dry openings, especially on shale, and roadsides	1,2
Podophyllum peltatum	may-apple	Occasional		Dry to moist woods	1
Polygala sanguinea	blood milkwort	Frequent		Moist openings	1
Polygala verticillata	whorled milkwort	Occasional		Moist openings	1
**Polygonum caespitosum*	NA	Rare		Moist, shaded ground in bunker area	1
**Polygonum hydropiper*	water-pepper	Occasional		Margins of ponds	1,2
Polygonum hydropiperoides	false water-pepper	Occasional		Wet ditches and pond margins	1
Polygonum pennsylvanicum	Pennsylvania smartweed	NA		NA	2
Polygonum sagittatum	arrow-leaved tearthumb	Occasional		Moist thickets and ditches	1
Polygonum scandens	climbing false buckwheat	Occasional		Thickets and roadsides	1
Polygonum virginianum	Virginia knotweed	Common		Moist to dry woods	2
Populus deltoides	cottonwood	Frequent, common		Moist woods, borders, and stream banks	1,2
Potamogeton diversifolius	snailseed pondweed	Frequent		Artificial ponds	1

Appendix A

Vascular Plant Species Documented On Site
Power House 2 Ash Pits
Plum Brook Ordnance Works, Sandusky, Ohio

Scientific Name	Common Name	Relative Frequency[(a)]	Rank[(b)]	Habitat	Observed On Site[(c)]
Potamogeton foliosus	leafy pondweed	Occasional		Artificial ponds	1
Potamogeton nodosus	longleaf pondweed	Occasional		Artificial ponds	1
Potentilla simplex	cinquefoil	Frequent		Dry openings and roadsides on shale	1
Prunella vulgaris	self-heal	Occasional, frequent		Roadsides and about buildings	1
Prunus americana	wild plum	Occasional		Thickets and roadsides	1
Prunus serotina	wild black cherry	Frequent, common		Dry to moist woods and borders	1
Pycnanthemum tenuifolium	narrow-leaved mountain-mint	Frequent, common		Moist openings, especially on shale, old fields	1
Pycnanthemum virginianum	Virginia mountain-mint	Occasional		Moist openings and ditches	1
Pyrus coronaria	crab-apple	Frequent		Thickets and borders	1,2
Quercus alba	white oak	Occasional		Dry woods and sandy ridges; a small grove on Taft Road has an unusually pure stand of this species	1
Quercus bicolor	swamp white oak	Frequent		Moist woodlands	1
Quercus imbricaria	shingle oak	Frequent, occasional		Moist to dry woodlands	1,2
Quercus macrocarpa	bur oak	Rare		ca 5 trees on sandy ridge in bunker area south of North Magazine Road; a few trees in area 2a	1
Quercus palustris	pin oak	Common, frequent		Moist woods	1,2
Ranunculus sceleratus	cursed crowfoot	NA		NA	2
Ratibida pinnata	green-headed coneflower	Occasional, frequent		Roadsides and dry fields	1
Rhexia virginica	Virginia meadow-beauty	Occasional	P	Moist openings and pond margins, south of North Magazine Road and along the angling road	1
Ribes americanum	American currant	NA		NA	2
Ribes cynosbati	Gooseberry	Rare		Woods	3
Riccia sp.	liverwort	NA		NA	2

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Vascular Plant Species Documented On Site
Power House 2 Ash Pits
Plum Brook Ordnance Works, Sandusky, Ohio

Scientific Name	Common Name	Relative Frequency[a]	Rank[b]	Habitat	Observed On Site[c]
Robinia pseudoacacia	Black locust	Rare		Old fields and thickets	3
Rosa carolina	pasture rose	Occasional		Dry fields	1
**Rosa multiflora*	multiflora rose	Occasional		Disturbed openings, borders, and thickets	1,2
Rosa setigera	prairie rose	Rare		Grassy roadside and thickets along Patrol Road at Olemacher Ditch	1
Rotala ramosior	toothcup	Occasional		Moist openings and about ponds	1
Rubus allegheniensis	blackberry	Common		Woods, fields, and borders	3
Rubus flagellaris	dewberry	Frequent, common		Dry openings and roadsides on shale, old fields	1
Rubus occidentalis	Black raspberry	common		Dry woods, and borders	2
Rudbeckia hirta	black-eyed susan	Frequent		Dry fields and roadsides	1
**Rumex acetosella*	red sorrel	Occasional		Dry openings over shale	1
**Rumex crispus*	curly dock	Occasional		Roadsides and about buildings	1
Rumex verticillatus	Swamp dock	Rare		Ditches	3
Sagittaria latifolia	broad-leaved arrowhead	Occasional		Ponds and ditches	1
Salix amygdaloides	peachleaf willow	Occasional		Ditches and about ponds	1
Salix discolor	pussy willow	Occasional		Moist openings, ponds, and ditches	1
Salix exigua	sandbar willow	Frequent		Moist openings, stream banks, and ditches	1
Salix nigra	black willow	Common		Moist woods, stream banks, and ditches	1,2
Sambucus canadensis	elder-berry	Frequent, occasional		Moist openings, stream banks, and ditches	1
**Saponaria officinalis*	soapwort	Frequent, occasional		Dry fields, roadsides, and about buildings	1
Sassafras albidum	sassafras	Occasional		Dry woods and borders	1
Schizachyrium scoparium	little bluestem	Frequent		Dry fields and roadsides	1
Scirpus acutus	hardstem bulrush	Rare		Moist depression west of Taft Road	1

Vascular Plant Species Documented On Site
Power House 2 Ash Pits
Plum Brook Ordnance Works, Sandusky, Ohio

Scientific Name	Common Name	Relative Frequency[(a)]	Rank[(b)]	Habitat	Observed On Site[(c)]
Scirpus americanus	Three square	rare		Ditches	3
Scirpus atrovirens	dark green bulrush	Common, occasional		Moist openings, roadsides, and ditches	1
Scirpus cyperinus	woolgrass	Occasional		About artificial ponds	1
Scirpus fluviatilis	river bulrush	Rare		Moist depression west of Taft Road	1
Scirpus pendulus	NA	Occasional		Moist openings	1
Scirpus validus	softstem bulrush	Occasional		Moist openings, ponds, and ditches	1
Scleria triglomerata	tall nut-rush	Rare	P	Moist swale in northern bunker area	1
Scutellaria lateriflora	mad-dog skullcap	Occasional		Moist depressions and ditches	1,2
Senecio aureus	golden ragwort	Occasional		Moist woods borders	1
**Setaria faberi*	nodding foxtail-grass	Occasional, common		Grassy roadsides in the bunker area	1,2
Setaria glauca	Yellow foxtail-grass	NA		NA	2
**Setaria viridis*	green foxtail-grass	Frequent, common		Dry roadsides and about buildings	1
Silphium terebinthinaceum	prairie-dock	Rare		Dry openings at crossing of Patrol Road and Olemacher Ditch	1
Sisyrinchium albidum	prairie blue-eyed-grass	Frequent		Grassy fields	1
Sisyrinchium angustifolium	common blue-eyed-grass	Frequent		Grassy fields	1
**Solanum caroliniense*	horse-nettle	Occasional, common		Dry openings and roadsides	1
**Solanum dulcamara*	bittersweet-nightshade	Occasional		Roadsides, ditches, thickets, and about buildings	1
Solanum nigrum	Black nightshade	Occasional		Fields and waste areas	2
Solidago canadensis	Canada goldenrod	Common		Grassy fields	1
Solidago juncea	early goldenrod	Frequent		Dry to moist fields and roadsides	1
Solidago nemoralis	gray goldenrod	Common		Dry fields and roadsides	1

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Vascular Plant Species Documented On Site
Power House 2 Ash Pits
Plum Brook Ordnance Works, Sandusky, Ohio

Scientific Name	Common Name	Relative Frequency[(a)]	Rank[(b)]	Habitat	Observed On Site[(c)]
Solidago riddellii	Riddell's goldenrod	Rare		Moist opening over limestone, west of Snake Road and south of North Magazine Road	1
Sparganium eurycarpum	giant bur-reed	Rare		Wet ditch along Ransom Road	1
Spartina pectinata	prairie cord-grass	Frequent, occasional		Moist depressions, fields, and ditches	1
Spiranthes ochroleuca	creamy ladies'-tresses	Occasional, rare		Ditches and moist openings	1
Sporobolus asper	tall dropseed	Rare		A single stand in dry opening along angling road	1
Sporobolus neglectus	NA	Frequent		Dry openings and road berms	1
Stachys tenuifolia	Hedge nettle	Occasional		Fields	3
Stellaria longifolia	long-leaved stitchwort	Occasional		Moist, grassy fields	1
**Stellaria media*	chickweed	Common		Road berms and about buildings	1
Symphoricarpos orbiculatus	coralberry	Occasional		Thickets, woods borders, and roadsides	1
**Taraxacum officinalis*	dandelion	Frequent, occasional		Roadsides and about buildings	1
Teucrium canadense	American germander	Occasional		Moist openings	1,2
Thelypteris palustris	marsh fern	Occasional, frequent		Moist depressions and roadsides	1
Toxicodendron radicans	Poison ivy	Frequent		Upland and facultative woods, old fields	2
Tradescantia ohioensis	Ohio spiderwort	Occasional		Old fields	2
**Tragopogon pratensis*	Yellow goatsbeard	Rare		Old fields	3
Triadenum virgnianum	pink St. John's-wort	Rare		Moist swale in northern bunker area	1
Tridens flavus	purpletop	Occasional		Moist fields and roadsides	1
Trifolium hybridum	Alsike clover	Occasional		Fields	3
**Trifolium pratense*	red clover	Occasional		Grassy fields and roadsides	1
**Trifolium repens*	common white clover	Common		Grassy roadsides and about buildings	1,2
Triosteum perfoliatum	Wild coffee	Rare		Fields	2

Appendix A

Vascular Plant Species Documented On Site
Power House 2 Ash Pits
Plum Brook Ordnance Works, Sandusky, Ohio

Scientific Name	Common Name	Relative Frequency[(a)]	Rank[(b)]	Habitat	Observed On Site[(c)]
Tussilago farfara	coltsfoot	NA		NA	2
Typha angustifolia	Narrow-leaved cattail	frequent		Ditches	3
Typha latifolia	broad-leaved cattail	Frequent		Moist openings, ponds, and ditches	1
Ulmus americana	American elm	Occasional		Moist woods and stream banks	1,2
Ulmus rubra	slippery elm	Occasional		Moist woods and stream banks	1
Urtica dioica var. procera	American stinging nettle	Occasional, common		Moist fields and openings	1
**Verbascum blattaria*	moth-mullein	Occasional, rare		Disturbed fields and roadsides	1
**Verbascum thapsus*	common mullein	Frequent, occasional		Disturbed fields	1
Verbena hastata	purple vervain	Frequent		Moist fields, stream banks, and ditches	1
Verbena simplex	prairie vervain	Rare		A single stand in dry opening along angling road	1
Verbena stricta	Vervain	Occasional		Fields	3
Verbena urticifolia	white vervain	Occasional, frequent		Moist woods borders and roadsides	1,2
Verbesina alternifolia	wingstem	Frequent, occasional		Moist woods borders, stream banks, and ditches	1,2
Vernonia gigantea	tall ironweed	Occasional, frequent		Dry to moist fields	1
**Veronica officinalis*	common speedwell	Occasional		Dry openings on shale	1
**Veronica serpyllifolia*	thyme-leaved speedwell	Occasional		Roadsides and about buildings	1
Viburnum lentago	nannyberry	Frequent		Moist thickets and borders	1
Vicia americana	American vetch	Rare		Old field	3
Viola canadensis	Canada violet	NA		NA	2
Viola cucullata	violet	NA		NA	2
Viola lanceolata	lance-leaved violet	Frequent	P	Ditches and moist openings	1
Viola sagittata	arrow-leaved violet	Frequent		Grassy fields and dry banks	1
Viola sororia	common blue violet	Common, occasional		Grassy fields, roadsides, and about buildings	1

Appendix A

Vascular Plant Species Documented On Site
Power House 2 Ash Pits
Plum Brook Ordnance Works, Sandusky, Ohio

Scientific Name	Common Name	Relative Frequency[a]	Rank[b]	Habitat	Observed On Site[c]
Vitis aestivalis	summer grape	NA		NA	2
Vitis riparia	riverbank grape	Frequent		Woods borders, thickets, and stream banks	1,2
Vitis vulpina	fox grape	Occasional		Woods borders and thickets	1
Zanichellia palustris	horned pondweed	Rare		Artificial pond west of Snake Road	1
Zizia aurea	Golden alexanders	Rare		Old fields	3

[a] Common = Species which occur in large numbers throughout.
[b] T = Ohio Threatened Species.
[c] 1 = Biological Inventory of Plum Brook Station (Ohio Department of Natural Resources, 1994).

Frequent = Species regularly encountered, but occurring in lesser numbers than common ones.
Occasional = Species found in several places, but never present in large numbers.
Rare = Species found in few places and in low numbers.
P = Ohio Potentially Threatened Species.
E = Ohio Endangered Species.
2 =Shaw site reconnaissance September 11 and 12, 2000 and May 21, 2001.
3=Observed during a site reconnaissance at another Plum Brook site.
NA – Not available

* Non-native species.

APPENDIX B

ECOLOGICAL SCREENING VALUES

Table B-1

Ecological Screening Values for Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	CAS No.	EPA Eco-SSLs [a] (mg/kg)	Eco Endpoints PRGs [b] (mg/kg)	EPA Region V ESL [c] (mg/kg)	Tox. Benchmark [d] (earthworm only) (mg/kg)	Tox Benchmarks [e] Terrestrial Plants (mg/kg)	Selected ESV (mg/kg)	Reference
Inorganic Analytes								
Aluminum	7429-90-5	pH Dependent	NSV	NSV	NSV	50	pH Dependent	a
Antimony	7440-36-0	0.27	5	0.142	NSV	5	0.27	a
Arsenic	7440-38-2	18	9.9	5.7	60	10	18	a
Barium	7440-39-3	330	283	1.04	NSV	500	330	a
Beryllium	7440-41-7	21	10	1.06	NSV	10	21	a
Cadmium	7440-43-9	0.36	4	0.00222	20	4	0.36	a
Calcium	7440-70-2	NSV	NSV	NSV	NSV	NSV	Nutrient	
Chromium	7440-47-3	26	0.4	0.4	0.4	1	26	a
Chromium, hexavalent	18540-29-9	81	NSV	NSV	NSV	NSV	81	a
Cobalt	7440-48-4	13	20	0.14	NSV	20	13	a
Copper	7440-50-8	28	60	5.4	50	100	28	a
Iron	7439-89-6	pH Dependent	NSV	NSV	NSV	NSV	pH Dependent	a
Lead	7439-92-1	11	40.5	0.0537	500	50	11	a
Magnesium	7439-95-4	NSV	NSV	NSV	NSV	NSV	Nutrient	
Manganese	7439-96-5	220	NSV	NSV	NSV	500	220	a
Mercury	7439-97-6	NSV	0.00051	0.1	0.1	0.3	0.00051	b
Nickel	7440-02-0	38	30	13.6	200	30	38	a
Potassium	7440-09-7	NSV	NSV	NSV	NSV	NSV	Nutrient	
Selenium	7782-49-2	0.52	0.21	0.0276	70	1	0.52	a
Silver	7440-22-4	4.2	2	4.04	NSV	2	4.2	a
Sodium	7440-23-5	NSV	NSV	NSV	NSV	NSV	Nutrient	
Thallium	7440-28-0	NSV	1	0.0569	NSV	1	1	b
Vanadium	7440-62-2	7.8	2	1.59	NSV	2	7.8	a
Zinc	7440-66-6	46	8.5	6.62	200	50	46	a
Cyanide								
Cyanide, Total	57-12-5	NSV	NSV	1.33	NSV	NSV	1.33	c
Polychlorinated Biphenyls								
Aroclor 1016	12674-11-2	NSV	0.371 [f]	0.000332 [f]	NSV	40 [f]	0.371	b
Aroclor 1260	11096-82-5	NSV	0.371 [f]	0.000332 [f]	NSV	40 [f]	0.371	b
Organochlorine Pesticides								
4,4'-DDE	72-55-9	0.021 [g]	NSV	0.596	NSV	NSV	0.021	a
4,4'-DDT	50-29-3	0.021 [g]	NSV	0.0035	NSV	NSV	0.021	a
Methoxychlor	72-43-5	NSV	NSV	0.0199	NSV	NSV	0.0199	c
Semivolatile Organic Compounds								
Acenaphthylene	208-96-8	29	NSV	682	NSV	NSV	29	a
Anthracene	120-12-7	29	NSV	1480	NSV	NSV	29	a
Benzo(a)anthracene	56-55-3	1.1	NSV	5.21	NSV	NSV	1.1	a
Benzo(a)pyrene	50-32-8	1.1	NSV	1.52	NSV	NSV	1.1	a
Benzo(b)fluoranthene	205-99-2	1.1	NSV	59.8	NSV	NSV	1.1	a
Benzo(ghi)perylene	191-24-2	1.1	NSV	119	NSV	NSV	1.1	a
Benzo(k)fluoranthene	207-08-9	1.1	NSV	148	NSV	NSV	1.1	a

Table B-1

Ecological Screening Values for Soil
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	CAS No.	EPA Eco-SSLs [a] (mg/kg)	Eco Endpoints PRGs [b] (mg/kg)	EPA Region V ESL [c] (mg/kg)	Tox. Benchmark [d] (earthworm only) (mg/kg)	Tox Benchmarks [e] Terrestrial Plants (mg/kg)	Selected ESV (mg/kg)	Reference
Benzoic acid	65-85-0	NSV	NSV	NSV	NSV	NSV	NSV	
bis(2-Ethylhexyl)phthalate	117-81-7	NSV	NSV	0.925	NSV	NSV	0.925	c
Chrysene	218-01-9	1.1	NSV	4.73	NSV	NSV	1.1	a
Di-n-butyl phthalate	84-74-2	NSV	200	0.15	NSV	200	200	b
Fluoranthene	206-44-0	1.1	NSV	122	NSV	NSV	1.1	a
Indeno(1,2,3-cd)pyrene	193-39-5	1.1	NSV	109	NSV	NSV	1.1	a
Naphthalene	91-20-3	29	NSV	0.0994	NSV	NSV	29	a
Phenanthrene	85-01-8	29	NSV	45.7	NSV	NSV	29	a
Pyrene	129-00-0	1.1	NSV	78.5	NSV	NSV	1.1	a
Volatile Organic Compounds								
Acetone	67-64-1	NSV	NSV	2.5	NSV	NSV	2.5	c
Bromomethane	74-83-9	NSV	NSV	0.235	NSV	NSV	0.235	c
Methylene chloride	75-09-2	NSV	NSV	4.05	NSV	NSV	4.05	c
Toluene	108-88-3	NSV	200	5.45	NSV	200	200	b
Xylene, Total	1330-20-7	NSV	NSV	10	NSV	NSV	10	c

EPA = U.S. Environmental Protection Agency
ESV = Ecological screening value
NSV = No screening value available
mg/kg = milligrams per kilogram

Priority for Selection of ESVs:
1) EPA Eco-SSL
2) PRG for Eco Endpoints, (Efroymson, et.al, 1997a);
3) EPA Region 5 Ecological Screening Levels;
4) Efroymson, 1997b.

[a] EPA, 2008, Ecological Soil Screening Level (SSL) guidance. On-line at: http://www.epa.gov/ecotox/ecossl/index.html

[b] Efroymson, 1997a, *Preliminary Remediation Goals for Ecological Endpoints*. www.esd.ornl.gov/programs/ecorisk/documents/tm162r2.pdf .

[c] Screening value based on: EPA , 2003, *Region 5 Ecological Screening Level (ESL)*, Website version last updated August 22, 2003: http://www.epa.gov/Region5/rcraca/edql.htm.

[d] Efroymson, R.A., M.E. Will, G.W. Suter, 1997b, Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision, ES/ER/TM-126/R2 (microbial screening values are not included). http://www.esd.ornl.gov/programs/ecorisk/documents/tm126r21.pdf.

[e] Efroymson, R.A., M.E. Will, G.W. Suter, 1997c, Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision, ES/ER/TM-85/R3. http://www.esd.ornl.gov/programs/ecorisk/documents/tm85r3.pdf

[f] Based on the screening value for total PCBs.

[g] Based on the screening value for DDT and metabolites.

Table B-2

Ecological Screening Values for Surface Water
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	CAS No.	Ohio Water Quality Criteria [a] µg/L		Eco PRG [b] µg/L	EPA Region 5 ESV [c] µg/L	Selected Surface Water ESV [d] µg/L
Inorganic Analytes						
Aluminum	7429-90-5	NSV		87	NSV	87
Barium	7440-39-3	220		4	220	4
Calcium	7440-70-2	NSV		NSV	NSV	Nutrient
Cobalt	7440-48-4	24		23	24	23
Iron	7439-89-6	NSV		1000	NSV	1000
Lead	7439-92-1	21	e	3.2	1.17	1.17
Magnesium	7439-95-4	NSV		NSV	NSV	Nutrient
Manganese	7439-96-5	NSV		120	NSV	120
Nickel	7440-02-0	130	e	160	28.9	28.9
Potassium	7440-09-7	NSV		NSV	NSV	Nutrient
Sodium	7440-23-5	NSV		NSV	NSV	Nutrient
Vanadium	7440-62-2	44		20	12	12
Zinc	7440-66-6	300	e	110	65.7	65.7
Semivolatile Organic Compounds						
bis(2-Ethylhexyl)phthalate	117-81-7	NSV		0.12	0.3	0.12

COPEC = Chemical of potential ecological concern
ESV = Ecological screening value
µg/L = microgram per liter
NSV = No screening value available

[a] Ohio Environmental Protection Agency (OEPA, 2002), Division of Surface Water, Water Quality Standards, Chapter 3745-1 of the Ohio Administrative Code, Dec 30. http://www.epa.state.oh.us/dsw/rules/3745-1.html. Value is the Outside Mixing Zone Average value.
[b] *Preliminary Remediation Goals (PRG) for Ecological Endpoints* , (Efroymson et. al., 1997).
[c] Screening value based on: EPA , 2003, *Region 5 Ecological Screening Level* , Website version last updated August 22, 2003: http://www.epa.gov/Region5/rcraca/edql.htm.
[d] Surface water ESVs are selected by choosing the minimum screening value based on the three sources provided.

Table B-3

Ecological Screening Values for Sediment
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	CAS No.	TEC [a] mg/kg	EPA Region 5 ESV [b] mg/kg	Ecological PRG [c] mg/kg	Ontario Sediment Quality Guidelines [d] mg/kg	Selected ESV [e] mg/kg
Inorganic Analytes						
Aluminum	7429-90-5	NSV	NSV	NSV	NSV	NSV
Arsenic	7440-38-2	9.79	9.79	42	6	9.79
Barium	7440-39-3	NSV	NSV	NSV	NSV	NSV
Beryllium	7440-41-7	NSV	NSV	NSV	NSV	NSV
Cadmium	7440-43-9	0.99	0.99	4.2	0.6	0.99
Calcium	7440-70-2	NSV	NSV	NSV	NSV	NSV
Chromium	7440-47-3	43.4	43.4	159	26	43.4
Cobalt	7440-48-4	NSV	50	NSV	50	50
Copper	7440-50-8	31.6	31.6	77.7	16	31.6
Iron	7439-89-6	NSV	NSV	NSV	NSV	NSV
Lead	7439-92-1	35.8	35.8	110	31	35.8
Magnesium	7439-95-4	NSV	NSV	NSV	NSV	NSV
Manganese	7439-96-5	NSV	NSV	NSV	460	460
Mercury	7439-97-6	0.18	0.174	0.7	0.2	0.18
Nickel	7440-02-0	22.7	22.7	38.5	16	22.7
Potassium	7440-09-7	NSV	NSV	NSV	NSV	NSV
Selenium	7782-49-2	NSV	NSV	NSV	NSV	NSV
Silver	7440-22-4	NSV	0.5	1.8	0.5	0.5
Sodium	7440-23-5	NSV	NSV	NSV	NSV	NSV
Vanadium	7440-62-2	NSV	NSV	NSV	NSV	NSV
Zinc	7440-66-6	121	121	270	120	121
Nitroaromatics						
2,4,6-Trinitrotoluene	118-96-7	NSV	NSV	NSV	NSV	NSV
Semivolatile Organic Compounds						
Fluoranthene	206-44-0	NSV	0.423	0.834	0.75	0.423

ESV = Ecological screening value
mg/kg = milligrams per kilogram
NSV = No screening value available

Priority for Selection of ESVs:
1. Threshold effect concentrations (MacDonald et al., 2000)
2. EPA Region 5 ESLs (EPA, 2003)
3. Sediment PRGs (Efroymson, 1997)
4. Sediment quality criteria (OME, 1993)

Table B-3

Ecological Screening Values for Sediment
Plum Brook Ordnance Works, Sandusky, Ohio

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[a] Threshold Effect Concentrations (TECs), MacDonald, et al., 2000 (MacDonald, 2000). Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Arch Environ Contam Toxicol 39:20-31.

[b] Screening value based on: EPA , 2003, *Region 5 Ecological Screening Level* , Website version last updated August 22, 2003: http://www.epa.gov/Region5/rcraca/edql.htm.

[c] Efroymson,et. al., 1997, *Preliminary Remediation Goals for Ecological Endpoints* .

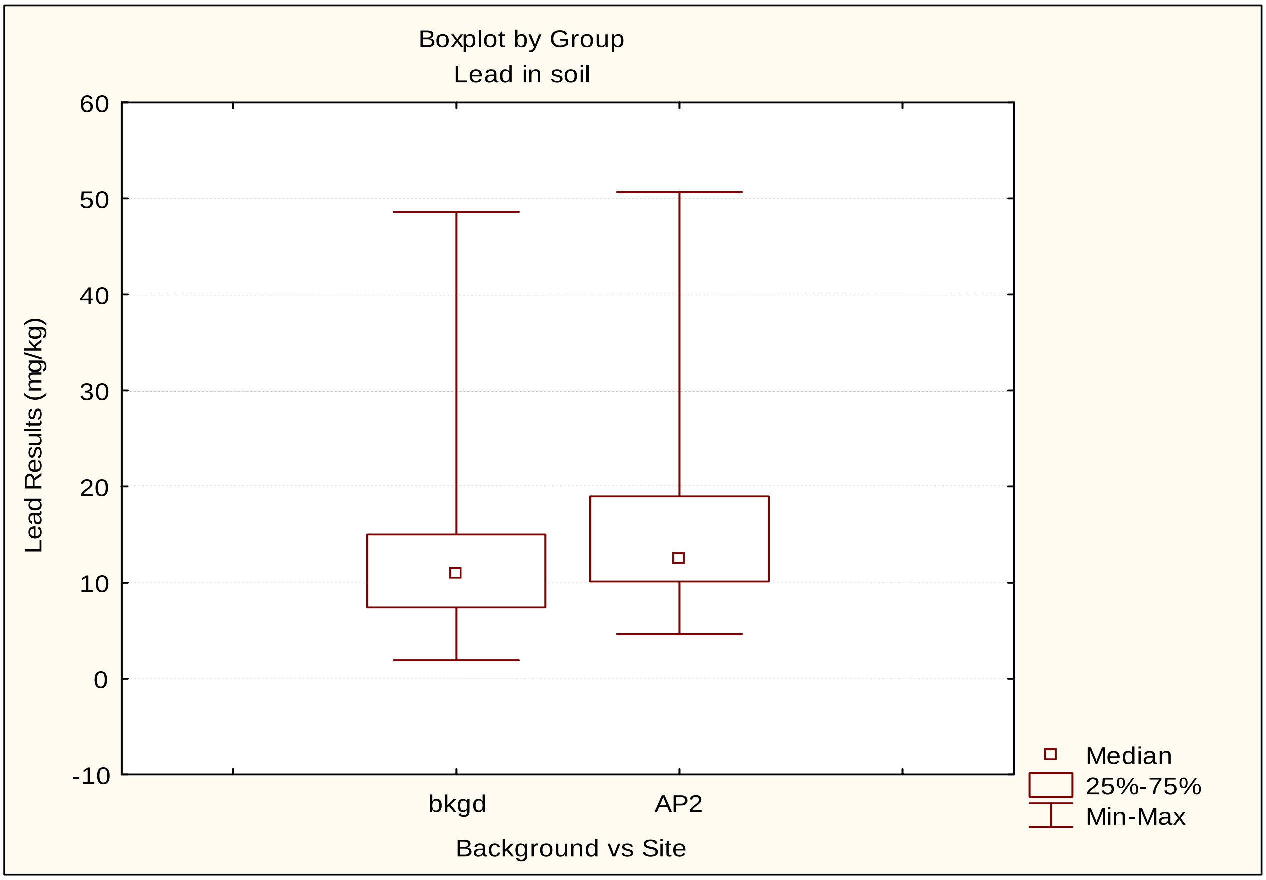
[d] Ontario Ministry of the Environment, 1993 (OME, 1993). Persaud, et al. *Guidelines for the Protection and Management of Aquatic* Sediment Quality in Ontario. August.

APPENDIX C

WILCOXON RANK SUM TEST RESULTS AND BOX PLOTS FOR LEAD

Appendix C

Wilcoxon Rank Sum Test Results and Box Plots for Concentrations of Lead in Background Samples Vs. Power House 2 Ash Pits



Summary Statistics for the Wilcoxon Rank Sum Test for Lead in Background Compared With Ash Pit 2

	Rank Sum	Rank Sum	U	Z	p-level	Z	p-level	Valid N	Valid N	2*1sided
Lead	730.0000	1481.000	379.0000	-1.85036	0.064263	-1.85059	0.064230	26	40	0.064944

APPENDIX D

ASSESSMENT RECEPTOR PROFILES

Appendix D

Assessment Receptor Profiles

Eastern Cottontail (Sylvilagus floridanus). These medium-size grazing herbivores are found over most of the eastern half of the United States and southern Canada, and have been widely introduced into the western U.S. Environmental Protection Agency ([EPA], 1993). The eastern cottontail is unique to the genus because of the large variety of habitats that it occupies, including glades and woodlands, deserts, swamps, prairies, hardwood forests, rain forests, and boreal forests (EPA, 1993). Open grassy areas are generally are used for grazing at night, whereas dense, heavy cover typically is used for shelter during the day (EPA, 1993). During the summer seasons these rabbits consume herbaceous plants (e.g. grasses, clover, timothy, and alfalfa), whereas winter diet typically consists of woody vines, shrubs and trees (e.g.. birch, maple, and apple) (EPA, 1993). Home range is 3 to 20 acres, with larger ranges in the summer and smaller ranges in the winter (Burt and Grossenheider, 1980). Populations fluctuate from 1 to 4 cottontail per four acres to several per acre in winter conditions (Burt and Grossenheider, 1980). The eastern cottontail breeds from February through September and usually produces 3 to 4 litters per year of 1 to 9 young (usually 4 to 5); however, this rabbit's' death rate vies with its birth rate, and few rabbits live for more than one year (Whitaker, 1995). The average longevity is 1.25 years (EPA, 1993).

References:

Burt, W. H. and R. P. Grossenheider, 1980, "A Field Guide to Mammals," ***Peterson Field Guide Series***, Hougton Mifflin Co., Boston.

U.S. Environmental Protection Agency (EPA), 1993, ***Wildlife Exposure Factors Handbook***, Office of Health and Environmental Assessment, Office of Research and Development, EPA/600/R93/187a.

Whitaker Jr., J. O., 1995, ***The Audubon Society Field Guide to North American Mammals***, Alfred A. Knopf, Inc., New York.

Deer Mouse (Peromyscus maniculatus). This medium-sized mouse is found in the eastern United States from the Hudson Bay to Pennsylvania, the southern Appalachians, central Arkansas, and central Texas. In the west it is found from Mexico to the south Yukon and north-west territories (Whitaker, 1995). Deer mice habitat includes nearly every dry land habitat within its range, including forest, grasslands, or a mixture of the two (Burt and Grossenheider, 1980). Nocturnal and active year-round, these mice construct nests in the ground, trees, stumps, and buildings (Burt and Grossenheider, 1980). Omnivorous, the deer mouse feeds on nuts and seeds (e.g., jewel weed and black cherry pits), fruits, beetles, caterpillars, and other insects. Deer mice may cache their food during the fall and winter in the more northern parts of their range (EPA, 1993). Home range is 0.15 to 3 acres (Burt and Grossenheider, 1980; EPA, 1993). Density of populations is 4 to 12 mice per acre, and average life span is 2 years in the wild (Burt and Grossenheider, 1980). The breeding season is from February to November, depending on latitude. Three to five young are born in each of two to four litters per year (Burt and Grossenheider, 1980). They are greyish to reddish-brown with a white belly, with a distinctly short-haired, bicolor tail (Whitaker, 1995). Weight range is 14.8 (EPA, 1993) to 33 grams (Whitaker, 1995).

References:

Burt, W. H. and R. P. Grossenheider, 1980, "A Field Guide to Mammals," ***Peterson Field Guide Series***, Hougton Mifflin Co., Boston.

U.S. Environmental Protection Agency (EPA), 1993, ***Wildlife Exposure Factors Handbook***, Office of Health and Environmental Assessment, Office of Research and Development, EPA/600/R93/187a.

Whitaker Jr., J. O., 1995, ***The Audubon Society Field Guide to North American Mammals***, Alfred A. Knopf, Inc., New York.

Mallard Duck (Anas platyrhynchos). The mallard duck is widespread throughout most of the United States and is the most abundant of the United States ducks. It is large, migratory duck with an average body size of 58 centimeters from bill to tail tip. Wintering mallards prefer the natural bottom-land wetlands and rivers where water depths are 20 to 40 centimeters. The primary habitat requirement for nesting is thought to be dense grassy vegetation. Nests are generally located within a few kilometers of water (EPA, 1993).

In winter, mallards feed primarily on seeds, invertebrates, agricultural grains and, to a limited extent, leaves, stems, buds, rootlets, and tubers. In spring, females shift mostly to a diet of invertebrates to support molting and egg laying activities. Ducklings also feed mainly on invertebrates to help support their rapid growth rates. Mallards are serially monogamous and remate annually. Each pair of mallards establishes a territory and the drake defends it against other mallards. Average home range size varies, depending upon the type of habitat available. High rates of nest failure require the females to renest persistently, with average clutch size decreasing as the breeding season progresses. Annual adult mortality rates vary with year, depending on location, hunting pressure, age, and sex. Females suffer greater natural mortality rates than do males (EPA, 1993).

The typical home range of the mallard is from 540 to 620 hectares (ha) for adult female and male birds, respectively, for wetlands and river habitat in Minnesota (USEPA, 1993). For the current ERA, an average home range of 580 ha was used. The typical migration schedule is from mid-March through mid-May for the spring migration. The fall migration typically starts in mid-October, and peaks in November (USEPA, 1993).

References:

U.S. Environmental Protection Agency (EPA), 1993, ***Wildlife Exposure Factors Handbook***, Office of Health and Environmental Assessment, Office of Research and Development, EPA/600/R93/187a.

Red-Tailed Hawk (Buteo jamacensis). This carnivorous hawk is one of the most common and widespread members of the genus *Buteo* in the continental United States and Canada (Brown and Amadon, 1968). Red-tailed hawks live in a variety of habitats, such as farmlands, woodlands, mountains, and deserts, as long as there is open country interdispersed with woods, bluffs, or streamside trees. They are primarily carnivorous, feeding on (greater than 85 percent) small rodents, as well as fish. Other prey items include amphibians, reptiles, crayfish, and other birds (Adamcik, et al., 1979; Ehrlich, et al., 1988). Home range has been reported as approximately 66.8 acres, with a population density of 0.16 pairs per acre (Janes, 1984), although EPA (1993) reports an average territory size of 842 hectares (2,080 acres). Breeding population density is one nest per 0.009 acre or one individual per 0.004 acre. Body weight for male red-tails is 1,028.6 to 1,142.9 grams, and for females 1,371.4 to 1,600 grams (Brown and Amadon, 1968), although EPA (1993) reports an average body weight of 957 grams. They typically mate for life or until one of the pair dies, with pairs clinging to territories year after year (Austing, 1964).

References:

Adamcik, R. S., A. W. Todd, and L. B. Keith, 1979, “Demographic and Dietary Responses of Red-Tailed Hawks During a Snowshoe Hare Fluctuation,” ***Canadian Field Naturalist***, Vol. 93, pp. 16-27.

Austing, G. R., 1964, ***The World of the Red-Tailed Hawk***, J. B. Lippincott Co., Philadelphia.

Brown, L. and D. Amadon, 1968, ***Eagles, Hawks, and Falcons of the World***, Vol. 1, McGraw-Hill Book Company, New York.

Ehrlich, P. R., D. S. Dobkin, and D. Wheye, 1988, ***The Birder's Handbook: A field guide to the Natural History of North American Birds***, Simon and Shuster, Inc., New York.

Janes, S. W., 1984, "Influences of Territory Composition and Interspecific Competition on Red-Tailed Hawk Reproductive Success," ***Ecology***, 65:862-870.

U.S. Environmental Protection Agency (EPA), 1993, ***Wildlife Exposure Factors Handbook***, Office of Health and Environmental Assessment, Office of Research and Development, EPA/600/R93/187a.

Raccoon (Procyon lotor). Raccoons are native only in the Americas. Their range extends from the southern edge of the southern provinces of Canada and most of the United States, except for portions of the Rocky Mountain states, central Nevada, and Utah (Whitaker, 1995). The raccoon weighs from 3 to 15 kilograms (Merritt, 1987; EPA, 1993) and has a head and body length of 46 to 71 centimeters and a tail length of 20 to 30 centimeters (Burt and Grossenheider, 1980). The raccoon is nocturnal and solitary, except when breeding or caring for its young. During particularly cold spells, the raccoon may sleep for several days at a time but does not hibernate (Whitaker, 1995). The raccoon is found along lakes near wooded areas or rock cliffs (Burt and Grossenheider, 1980), but prefers wooded streams (Whitaker, 1995). The raccoon is highly omnivorous and is an opportunistic feeder, consuming virtually any animal or plant matter that is available (Merritt, 1987; EPA, 1993). Animal matter predominates the diet during the spring and early summer; plant matter predominates during late summer, autumn, and winter (Merritt, 1987; EPA, 1993). The home range of the raccoon extends up to 3.2 kilometers across, but usually it is less than 1.6 kilometers. Population densities range from one per acre (highest) to one per 15 acres (considered high) (Burt and Grossenheider, 1980). Captive raccoons live for approximately 14 years (Burt and Grossenheider, 1980). Average body weight is 5.1 kilograms (EPA, 1993).

References:

Burt, W. H., and R. P. Grossenheider, 1980, "A Field Guide to Mammals," ***Peterson Field Guide Series***, Hougton Mifflin Co., Boston.

Merritt, J. F., 1987, ***Guide to the Mammals of Pennsylvania***, University of Pittsburgh Press, Pennsylvania.

U.S. Environmental Protection Agency (EPA), 1993, ***Wildlife Exposure Factors Handbook, Volume I of II***, Office of Health and Environmental Assessment, Office of Research and Development, EPA/600/R93/187a.

Whitaker Jr., J. O., 1995, ***The Audubon Society Field Guide to North American Mammals***, Alfred A. Knopf, Inc., New York.

Short-tailed Shrew (Blarina brevicauda). This shrew is the largest found in North America. It is solid grey above and below, with a short tail, and weighs between 15 and 29 grams (Whitaker, 1995). Total length of this shrew is 76 to 102 millimeters (Burt and Grossenheider, 1980). The range of this shrew extends from southeastern Canada and the northeastern U.S. to Nebraska, Missouri, Kentucky, and in the mountains to Alabama (Whitaker, 1995). Preferable habitat for the shrew includes forests, grasslands, marshes, and brushy areas. It will make a nest of dry leaves, grass, and hair beneath logs, stumps, rocks, or debris (Burt and Grossenheider, 1980). This underground tunneler may burrow as deep as 6 feet, and has a voracious appetite, eating one half of its own body weight per day of earthworms, other terrestrial vertebrates, and sometimes young mice (Whitaker, 1995). Mean population densities range from 5.7 in the winter, to 28 per acre in the summer (EPA, 1993). Their home range varies from 0.5 to 1 acre (Burt and Grossenheider, 1980). Longevity is typically around 20 months (EPA, 1993), with five to eight young born to each of two to three litters (Burt and Grossenheider, 1980).

References:

Burt, W. H. and R. P. Grossenheider, 1980, “A Field Guide to Mammals,” ***Peterson Field Guide Series***, Hougton Mifflin Co., Boston.

U.S. Environmental Protection Agency (EPA), 1993, ***Wildlife Exposure Factors Handbook***, Office of Health and Environmental Assessment, Office of Research and Development, EPA/600/R93/187a.

Whitaker Jr., J. O., 1995, ***The Audubon Society Field Guide to North American Mammals***, Alfred A. Knopf, Inc., New York.

White-tailed Deer (Odocoileus virginianus). The white-tailed deer is a member of the Family Cervidae. They are large, even-toed, hoofed mammals with long legs. Their coat is predominantly light brown or chestnut colored, with the underparts being white. Deer are primarily herbivorous grazers and browsers, constantly moving from one food source to the next. The deer’s diet changes seasonally. When available, farm crops such as winter wheat, corn, alfalfa, soy beans, and hay are important components of the species diet. Other top food items include wild crab apples, sumac, grasses, green briar, clover, jewelweed, acorns, and dogwood. In regions where the climate varies from season to season, deer may make annual migrations of 10 to 20 miles in the search for food. However, in Ohio, deer typically have rather small home ranges (2 to 3 square miles) and are reluctant to leave this range. The average weight for the species is 88 kilograms for males and 61 kilograms for females. Breeding season ranges from November through February, with the young offspring born in May and early June. Virtually all yearling and adult does conceive each year, and in Ohio usually carry twins. Triplets and quadruplets have also been recorded Gottschang (1981).

References:

Gottschang, J. L., 1981, ***A Guide to the Mammals of Ohio***, The Ohio State University Press, pp. 143-149.

Marsh Wren (Cistothorus palustris). The marsh wren is a small bird (4 to 4.5 inches in length) which inhabits freshwater cattail marshes and salt marshes. Nesting pairs are not likely to occupy other habitats and the species avoids the wet meadow and sedge meadow habitats preferred by sedge wrens. Marsh wrens breed throughout most of the northern half of the United States and in coastal areas as far south as Florida. The species eats mostly insects, and occasionally snails and other invertebrates. The average body weight is 0.01 kilograms, and the average home range for the species is 0.054 hectares. Because the species is polygamous, there may be more females than males inhabiting a breeding marsh. Densities as high as 120 birds per hectare have been recorded (EPA, 1993). Marsh wrens' nests are globular structures placed at heights of 2 to 5 feet in dense vegetation. The males commonly build dummy nests in addition to the one where the eggs will be laid (Peterjohn and Rice, 1991).

References:

U.S. Environmental Protection Agency (EPA), Office of Research and Development, 1993, ***Wildlife Exposure Factors Handbook***, EPA/600/R-93/187a.

Peterjohn, B. G., and Rice, D. L., 1991, ***The Ohio Breeding Bird Atlas***, The Ohio Department of Natural Resources.

Muskrat (Ondata zibethicus). The muskrat is a member of the Family Muridaee. Muskrats are the most aquatic of this family of rodents, and spend much of their lives in or near bogs, marshes, lakes or streams. Their diet consists primarily of aquatic vegetation (in particular the roots or basal portions of aquatic plants), although they can be omnivorous if other food sources are more common. Marsh grasses, sedges, and cattails are important muskrat food items. They are indigenous and common throughout most of the United States. Muskrats have relatively small home ranges that vary in configuration based on the physical attributes of their aquatic habitat. The average weight for the species is approximately 1.3 kilograms for males and 1.2 kilograms for females during the winter, and 0.9 kg for males and 0.8 kg for females during the spring. Muskrats typically breed during the first spring after birth, and typically produce 1-12 pups, with southern populations producing more litters, but fewer pups per litter compared with northern populations (EPA, 1993).

References:

U.S. Environmental Protection Agency (EPA), Office of Research and Development, 1993, ***Wildlife Exposure Factors Handbook***, EPA/600/R-93/187a.

APPENDIX E

FOOD CHAIN MODEL EXPOSURE DOSES AND HAZARD QUOTIENTS

Table E-1

Chemicals of Potential Concern
Exposure Doses and Hazard Quotients for the Deer Mouse
Power House 2 Ash Pits
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Surface Water Exposure Point Concentration	Units	Sediment Exposure Point Concentration	Units	Surface Soil Exposure Point Concentration	Units	Soil BAF	Fish BAF	Aq. Invert. BAF	Terr. Invert. BAF	Aq. Plant BAF	Terr. Plant BAF	Mammal BAF	Bird BAF	EED Surface Water	EED Sediment	EED Soil	EED Fish	EED Aq. Invert.	EED Terr. Invert.	EED Aq. Plants	EED Terr. Plants	EED Mammals	EED Birds	Total EED	TRV_{NOAEL}	HQ_{NOAEL}	TRV_{LOAEL}	HQ_{LOAEL}
							----------Unitless							----------	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d		mg/kg-d	
Metals																													
Aluminum	8.70E-01	mg/L	0.00E+00	mg/kg	0.00E+00	mg/kg	1.00E+00	780							1.29E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.29E-01	1.93E+00	6.70E-02	1.93E+01	6.70E-03
Barium	4.97E-02	mg/L	0.00E+00	mg/kg	0.00E+00	mg/kg	1.00E+00	146							7.38E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.38E-03	5.10E+00	1.45E-03	1.98E+01	3.73E-04
Cadmium	0.00E+00	mg/L	0.00E+00	mg/kg	6.50E-01	mg/kg	1.00E+00			9.05E+00	NA	7.56E-01	3.57E-01	3.57E-01	0.00E+00	0.00E+00	2.46E-03	0.00E+00	0.00E+00	4.34E-01	NA	5.67E-02	0.00E+00	0.00E+00	4.93E-01	1.00E+00	4.93E-01	1.00E+01	4.93E-02
Lead	2.87E-03	mg/L	0.00E+00	mg/kg	0.00E+00	mg/kg	1.00E+00	6.38E+01							4.27E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.27E-04	8.00E+00	5.34E-05	8.00E+01	5.34E-06
Mercury	0.00E+00	mg/L	0.00E+00	mg/kg	7.96E-02	mg/kg	1.00E+00			5.89E+00	NA	1.18E+00	1.92E-01	1.92E-01	0.00E+00	0.00E+00	3.01E-04	0.00E+00	0.00E+00	3.46E-02	NA	1.08E-02	0.00E+00	0.00E+00	4.57E-02	1.32E+01	3.46E-03	1.32E+02	3.46E-04
Selenium	0.00E+00	mg/L	0.00E+00	mg/kg	1.66E+00	mg/kg	1.00E+00			8.11E-01	NA	5.33E-01	4.81E-01	4.81E-01	0.00E+00	0.00E+00	6.27E-03	0.00E+00	0.00E+00	9.92E-02	NA	1.02E-01	0.00E+00	0.00E+00	2.07E-01	2.00E-01	1.04E+00	3.30E-01	6.28E-01
Thallium	0.00E+00	mg/L	0.00E+00	mg/kg	1.68E+00	mg/kg	1.00E+00			3.00E-01		2.20E-03	1.23E-01	1.23E-01	0.00E+00	0.00E+00	6.37E-03	0.00E+00	0.00E+00	3.73E-02	0.00E+00	4.27E-04	0.00E+00	0.00E+00	4.40E-02	7.40E-03	5.95E+00	7.40E-02	5.95E-01
Explosives																													
2,4,6-Trinitrotoluene	0.00E+00	mg/L	6.47E-02	mg/kg	0.00E+00	mg/kg	1.00E+00		4.67E+00		4.23E+00				0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-01	0.00E+00	2.00E+00	0.00E+00
Semivolatile Organics																													
Bis(2-ethylhexyl) phthalate	2.00E-03	mg/L	0.00E+00	mg/kg	0.00E+00	mg/kg	1.00E+00	350							2.97E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.97E-04	1.83E+01	1.62E-05	1.83E+02	1.62E-06

Intake Equation:

$$Ej = \left(\frac{A}{HR} \left[\sum_{i=1}^{m} \left(\frac{IRi\,x\,Cij}{BW} \right) \right] \right)$$

Where:
Ej = Total Exposure to Chemical
A = Site Area
HR = Home Range
m = Total number of ingested media
i = counter
IRi = Consumption Rate for Medium
Cij = Chemical concentration (j) in medium (I) (mg/kg or mg/L)
BW = Body Weight

Notes:
BAF = Bioaccumulation Factor (may be BCF if this is the only value available)
EED = Estimated Exposure Dose
HQ =Hazard Quotient.
L = LOAEL based; N = NOAEL based
LOAEL = Lowest Observed Adverse Effect Level
NOAEL = No Observed Adverse Effect Level
NA = Not applicable/Not available
BAF (or BCF) values from appropriate text tables (BCF = bioconcentration factor)
Some BAF (or BCF) values based on media regression equations (value in box):
LOAEL and NOAEL values from appropriate toxicity summary tables in the text.
UF = Uncertainty Factor for toxicity factor extrapolation, and Adjusted LOAEL or NOAEL = LOAEL/UF or NOAEL/UF
A "0" entry in the exposure concentration column indicates this chemical not selected as a COPEC for this medium.
Receptor diet data and home range data from appropriate text table.
Exposure point concentrations (EPCs) from appropriate text tables.

Species-Specific Factors

Terrestrial plant diet fraction =	0.61	unitless
Aquatic plant diet fraction =	0	unitless
Plant root diet fraction =	0	unitless
Fish diet fraction =	0	unitless
Aq. Invert diet fraction =	0	unitless
Terr. Invert diet fraction =	0.39	unitless
Mammal diet fraction =	0	unitless
Bird diet fraction =	0	unitless
Soil ingestion rate =	0.000056	kg/d
Sediment ingestion rate =	0	kg/d
Food ingestion rate =	0.0028	kg/d
Body weight =	0.0148	kg
Home range =	0.153	acres
Water intake rate =	0.0022	L/d
Site Area =	5	acres
Area Use Factor (AUF) =	1	unitless
Exposure Frequency (EF) =	1	unitless

Table E-2

Chemicals of Potential Concern
Exposure Doses and Hazard Quotients for the Short-Tailed Shrew
Power House 2 Ash Pits
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Surface Water Exposure Point Concentration	Units	Sediment Exposure Point Concentration	Units	Total Soil Exposure Point Concentration	Units	Soil BAF (Unitless)	Fish BAF (Unitless)	Aq. Invert. BAF (Unitless)	Terr. Invert. BAF (Unitless)	Aq. Plant BAF (Unitless)	Terr. Plant BAF (Unitless)	Mammal BAF (Unitless)	Bird BAF (Unitless)
Metals														
Aluminum	8.70E-01	mg/L	0.00E+00	mg/kg	0.00E+00	mg/kg	1.00E+00	780						
Barium	4.97E-02	mg/L	0.00E+00	mg/kg	0.00E+00	mg/kg	1.00E+00	146						
Cadmium	0.00E+00	mg/L	0.00E+00	mg/kg	5.32E-01	mg/kg	1.00E+00			9.43E+00	NA	8.28E-01	3.97E-01	3.97E-01
Lead	2.87E-03	mg/L	0.00E+00	mg/kg	0.00E+00	mg/kg	1.00E+00	6.38E+01						
Mercury	0.00E+00	mg/L	0.00E+00	mg/kg	5.28E-02	mg/kg	1.00E+00			7.76E+00	NA	1.42E+00	1.92E-01	1.92E-01
Selenium	0.00E+00	mg/L	0.00E+00	mg/kg	1.22E+00	mg/kg	1.00E+00			8.81E-01	NA	5.17E-01	5.84E-01	5.84E-01
Thallium	0.00E+00	mg/L	0.00E+00	mg/kg	1.67E+00	mg/kg	1.00E+00			3.00E-01		2.20E-03	1.23E-01	1.23E-01
Explosives														
2,4,6-Trinitrotoluene	0.00E+00	mg/L	6.47E-02	mg/kg	0.00E+00	mg/kg	1.00E+00		4.67E+00		4.23E+00			
Semivolatile Organics														
Bis(2-ethylhexyl) phthalate	2.00E-03	mg/L	0.00E+00	mg/kg	0.00E+00	mg/kg	1.00E+00	350						

Chemical	EED Surface Water (mg/kg-d)	EED Sediment (mg/kg-d)	EED Soil (mg/kg-d)	EED Fish (mg/kg-d)	EED Aq. Invert. (mg/kg-d)	EED Terr. Invert. (mg/kg-d)	EED Aq. Plants (mg/kg-d)	EED Terr. Plants (mg/kg-d)	EED Mammals (mg/kg-d)	EED Birds (mg/kg-d)	Total EED (mg/kg-d)	TRV_{NOAEL} (mg/kg-d)	HQ_{NOAEL}	TRV_{LOAEL} (mg/kg-d)	HQ_{LOAEL}
Metals															
Aluminum	1.33E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.33E-01	1.93E+00	6.91E-02	1.93E+01	6.91E-03
Barium	7.61E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.61E-03	5.10E+00	1.49E-03	1.98E+01	3.84E-04
Cadmium	0.00E+00	0.00E+00	8.11E-03	0.00E+00	0.00E+00	7.35E-01	NA	0.00E+00	0.00E+00	0.00E+00	7.44E-01	1.00E+00	7.44E-01	1.00E+01	7.44E-02
Lead	4.41E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.41E-04	8.00E+00	5.51E-05	8.00E+01	5.51E-06
Mercury	0.00E+00	0.00E+00	8.05E-04	0.00E+00	0.00E+00	6.01E-02	NA	0.00E+00	0.00E+00	0.00E+00	6.09E-02	1.32E+01	4.61E-03	1.32E+02	4.61E-04
Selenium	0.00E+00	0.00E+00	1.85E-02	0.00E+00	0.00E+00	1.57E-01	NA	0.00E+00	0.00E+00	0.00E+00	1.76E-01	2.00E-01	8.78E-01	3.30E-01	5.32E-01
Thallium	0.00E+00	0.00E+00	2.55E-02	0.00E+00	0.00E+00	7.36E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.91E-02	7.40E-03	1.34E+01	7.40E-02	1.34E+00
Explosives															
2,4,6-Trinitrotoluene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-01	0.00E+00	2.00E+00	0.00E+00
Semivolatile Organics															
Bis(2-ethylhexyl) phthalate	3.07E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.07E-04	1.83E+01	1.67E-05	1.83E+02	1.68E-06

Intake Equation:

$$Ej = \left(\frac{A}{HR} \left[\sum_{i=1}^{m} \left(\frac{IRi\,x\,Cij}{BW} \right) \right] \right)$$

Where:
Ej = Total Exposure to Chemical
A = Site Area
HR = Home Range
m = Total number of ingested media
i = counter
IRi = Consumption Rate for Medium
Cij = Chemical concentration (j) in medium (I) (mg/kg or mg/L)
BW = Body Weight

Notes:
BAF = Bioaccumulation Factor (may be BCF if this is the only value available)
EED = Estimated Exposure Dose
HQ =Hazard Quotient.
L = LOAEL based; N = NOAEL based
LOAEL = Lowest Observed Adverse Effect Level
NOAEL = No Observed Adverse Effect Level
NA = Not applicable/Not available
BAF (or BCF) values from appropriate text tables (BCF = bioconcentration factor)
Some BAF (or BCF) values based on media regression equations (value in box):
LOAEL and NOAEL values from appropriate toxicity summary tables in the text.
UF = Uncertainty Factor for toxicity factor extrapolation, and Adjusted LOAEL or NOAEL = LOAEL/UF or NOAEL/UF
A "0" entry in the exposure concentration column indicates this chemical not selected as a COPEC for this medium.
Receptor diet data and home range data from appropriate text table.
Exposure point concentrations (EPCs) from appropriate text tables.

Species-Specific Factors

Terrestrial plant diet fraction =	0	unitless
Aquatic plant diet fraction =	0	unitless
Plant root diet fraction =	0	unitless
Fish diet fraction =	0	unitless
Aq. Invert diet fraction =	0	unitless
Terr. Invert diet fraction =	1	unitless
Mammal diet fraction =	0	unitless
Bird diet fraction =	0	unitless
Soil ingestion rate =	0.0002288	kg/d
Sediment ingestion rate =	0	kg/d
Food ingestion rate =	0.0022	kg/d
Body weight =	0.015	kg
Home range =	0.96	acres
Water intake rate =	0.0023	L/d
Site Area =	5	acres
Area Use Factor (AUF) =	1	unitless
Exposure Frequency (EF) =	1	unitless

Table E-3

Chemicals of Potential Concern
Exposure Doses and Hazard Quotients for the Cottontail Rabbit
Power House 2 Ash Pits
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Surface Water Exposure Point Concentration	Units	Sediment Exposure Point Concentration	Units	Surface Soil Exposure Point Concentration	Units	Soil BAF	Fish BAF	Aq. Invert. BAF	Terr. Invert. BAF	Aq. Plant BAF	Terr. Plant BAF	Mammal BAF	Bird BAF	EED Surface Water	EED Sediment	EED Soil	EED Fish	EED Aq. Invert.	EED Terr. Invert.	EED Aq. Plants	EED Terr. Plants	EED Mammals	EED Birds	Total EED	TRV_{NOAEL}	HQ_{NOAEL}	TRV_{LOAEL}	HQ_{LOAEL}
								-----------------	-----------------	------Unitless------	-----------------	-----------------	-----------------		mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d		mg/kg-d	
Metals																													
Aluminum	8.70E-01	mg/L	0.00E+00	mg/kg	0.00E+00	mg/kg	1.00E+00	780							5.52E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.52E-02	1.93E+00	2.86E-02	1.93E+01	2.86E-03
Barium	4.97E-02	mg/L	0.00E+00	mg/kg	0.00E+00	mg/kg	1.00E+00	146							3.15E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.15E-03	5.10E+00	6.17E-04	1.98E+01	1.59E-04
Cadmium	0.00E+00	mg/L	0.00E+00	mg/kg	6.50E-01	mg/kg	1.00E+00			9.05E+00	NA	7.56E-01	3.57E-01	3.57E-01	0.00E+00	0.00E+00	2.27E-03	0.00E+00	0.00E+00	0.00E+00	NA	2.72E-02	0.00E+00	0.00E+00	2.95E-02	1.00E+00	2.95E-02	1.00E+01	2.95E-03
Lead	2.87E-03	mg/L	0.00E+00	mg/kg	0.00E+00	mg/kg	1.00E+00	6.38E+01							1.82E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.82E-04	8.00E+00	2.28E-05	8.00E+01	2.28E-06
Mercury	0.00E+00	mg/L	0.00E+00	mg/kg	7.96E-02	mg/kg	1.00E+00			5.89E+00	NA	1.18E+00	1.92E-01	1.92E-01	0.00E+00	0.00E+00	2.78E-04	0.00E+00	0.00E+00	0.00E+00	NA	5.19E-03	0.00E+00	0.00E+00	5.47E-03	1.32E+01	4.14E-04	1.32E+02	4.14E-05
Selenium	0.00E+00	mg/L	0.00E+00	mg/kg	1.66E+00	mg/kg	1.00E+00			8.11E-01	NA	5.33E-01	4.81E-01	4.81E-01	0.00E+00	0.00E+00	5.78E-03	0.00E+00	0.00E+00	0.00E+00	NA	4.89E-02	0.00E+00	0.00E+00	5.47E-02	2.00E-01	2.73E-01	3.30E-01	1.66E-01
Thallium	0.00E+00	mg/L	0.00E+00	mg/kg	1.68E+00	mg/kg	1.00E+00			3.00E-01		2.20E-03	1.23E-01	1.23E-01	0.00E+00	0.00E+00	5.87E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.05E-04	0.00E+00	0.00E+00	6.07E-03	7.40E-03	8.21E-01	7.40E-02	8.21E-02
Explosives																													
2,4,6-Trinitrotoluene	0.00E+00	mg/L	6.47E-02	mg/kg	0.00E+00	mg/kg	1.00E+00		4.67E+00		4.23E+00				0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-01	0.00E+00	2.00E+00	0.00E+00
Semivolatile Organics																													
Bis(2-ethylhexyl) phthalate	2.00E-03	mg/L	0.00E+00	mg/kg	0.00E+00	mg/kg	1.00E+00	350							1.27E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.27E-04	1.83E+01	6.92E-06	1.83E+02	6.93E-07

Intake Equation:

$$Ej = \left(\frac{A}{HR} \left[\sum_{i=1}^{m} \left(\frac{IRi\,x\,Cij}{BW} \right) \right] \right)$$

<u>Where:</u>
Ej = Total Exposure to Chemical
A = Site Area
HR = Home Range
m = Total number of ingested media
i = counter
IRi = Consumption Rate for Medium
Cij = Chemical concentration (j) in medium (I) (mg/kg or mg/L)
BW = Body Weight

Notes:
BAF = Bioaccumulation Factor (may be BCF if this is the only value available)
EED = Estimated Exposure Dose
HQ =Hazard Quotient.
L = LOAEL based; N = NOAEL based
LOAEL = Lowest Observed Adverse Effect Level
NOAEL = No Observed Adverse Effect Level
NA = Not applicable/Not available
BAF (or BCF) values from appropriate text tables (BCF = bioconcentration factor)
Some BAF (or BCF) values based on media regression equations (value in box):
LOAEL and NOAEL values from appropriate toxicity summary tables in the text.
UF = Uncertainty Factor for toxicity factor extrapolation, and Adjusted LOAEL or NOAEL = LOAEL/UF or NOAEL/UF
A "0" entry in the exposure concentration column indicates this chemical not selected as a COPEC for this medium.
Receptor diet data and home range data from appropriate text table.
Exposure point concentrations (EPCs) from appropriate text tables.

Species-Specific Factors

Terrestrial plant diet fraction =	1	unitless
Aquatic plant diet fraction =	0	unitless
Plant root diet fraction =	0	unitless
Fish diet fraction =	0	unitless
Aq. Invert diet fraction =	0	unitless
Terr. Invert diet fraction =	0	unitless
Mammal diet fraction =	0	unitless
Bird diet fraction =	0	unitless
Soil ingestion rate =	0.006048	kg/d
Sediment ingestion rate =	0	kg/d
Food ingestion rate =	0.096	kg/d
Body weight =	1.132	kg
Home range =	7.66	acres
Water intake rate =	0.11	L/d
Site Area =	5	acres
Area Use Factor (AUF) =	0.65274151	unitless

Table E-4

Chemicals of Potential Concern
Exposure Doses and Hazard Quotients for the Marsh Wren
Power House 2 Ash Pits
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Surface Water Exposure Point Concentration	Units	Sediment Exposure Point Concentration	Units	Surface Soil Exposure Point Concentration	Units	Soil BAF	Fish BAF	Aq. Invert. BAF	Terr. Invert. BAF	Aq. Plant BAF	Terr. Plant BAF	Mammal BAF	Bird BAF
							-------------	-------------	-------------	-------------	-------Unitless------	-------------	-------------	-------------
Metals														
Aluminum	8.70E-01	mg/L	0.00E+00	mg/kg	0.00E+00	mg/kg	1.00E+00	780						
Barium	4.97E-02	mg/L	0.00E+00	mg/kg	0.00E+00	mg/kg	1.00E+00	146						
Cadmium	0.00E+00	mg/L	0.00E+00	mg/kg	6.50E-01	mg/kg	1.00E+00			9.05E+00	NA	7.56E-01	3.57E-01	3.57E-01
Lead	2.87E-03	mg/L	0.00E+00	mg/kg	0.00E+00	mg/kg	1.00E+00	6.38E+01						
Mercury	0.00E+00	mg/L	0.00E+00	mg/kg	7.96E-02	mg/kg	1.00E+00			5.89E+00	NA	1.18E+00	1.92E-01	1.92E-01
Selenium	0.00E+00	mg/L	0.00E+00	mg/kg	1.66E+00	mg/kg	1.00E+00			8.11E-01	NA	5.33E-01	4.81E-01	4.81E-01
Thallium	0.00E+00	mg/L	0.00E+00	mg/kg	1.68E+00	mg/kg	1.00E+00			3.00E-01		2.20E-03	1.23E-01	1.23E-01
Explosives														
2,4,6-Trinitrotoluene	0.00E+00	mg/L	6.47E-02	mg/kg	0.00E+00	mg/kg	1.00E+00		4.67E+00		4.23E+00			
Semivolatile Organics														
Bis(2-ethylhexyl) phthalate	2.00E-03	mg/L	0.00E+00	mg/kg	0.00E+00	mg/kg	1.00E+00	350						

Chemical	EED Surface Water	EED Sediment	EED Soil	EED Fish	EED Aq. Invert.	EED Terr. Invert.	EED Aq. Plants	EED Terr. Plants	EED Mammals	EED Birds	Total EED	TRV_{NOAEL}	HQ_{NOAEL}	TRV_{LOAEL}	HQ_{LOAEL}
	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d		mg/kg-d	
Metals															
Aluminum	2.35E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.35E-01	1.10E+02	2.13E-03	1.10E+03	2.13E-04
Barium	1.34E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.34E-02	2.08E+01	6.44E-04	4.17E+01	3.21E-04
Cadmium	0.00E+00	0.00E+00	3.77E-03	0.00E+00	0.00E+00	1.71E+00	NA	0.00E+00	0.00E+00	0.00E+00	1.71E+00	1.45E+00	1.18E+00	2.00E+01	8.54E-02
Lead	7.76E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.76E-04	1.13E+00	6.86E-04	1.13E+01	6.86E-05
Mercury	0.00E+00	0.00E+00	4.62E-04	0.00E+00	0.00E+00	1.36E-01	NA	0.00E+00	0.00E+00	0.00E+00	1.36E-01	4.50E-01	3.03E-01	9.00E-01	1.52E-01
Selenium	0.00E+00	0.00E+00	9.62E-03	0.00E+00	0.00E+00	3.90E-01	NA	0.00E+00	0.00E+00	0.00E+00	3.99E-01	5.00E-01	7.99E-01	1.00E+00	3.99E-01
Thallium	0.00E+00	0.00E+00	9.76E-03	0.00E+00	0.00E+00	1.46E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.56E-01	3.50E-01	4.46E-01	3.50E+00	4.46E-02
Explosives															
2,4,6-Trinitrotoluene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.00E-01	0.00E+00	1.78E+01	0.00E+00
Semivolatile Organics															
Bis(2-ethylhexyl) phthalate	5.40E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.40E-04	1.11E+00	4.86E-04	1.11E+01	4.86E-05

Intake Equation:

$$Ej = \left(\frac{A}{HR} \left[\sum_{i=1}^{m} \left(\frac{IRi\,x\,Cij}{BW} \right) \right] \right)$$

Where:
Ej = Total Exposure to Chemical
A = Site Area
HR = Home Range
m = Total number of ingested media
i = counter
IRi = Consumption Rate for Medium
Cij = Chemical concentration (j) in medium (I) (mg/kg or mg/L)
BW = Body Weight

Notes:
BAF = Bioaccumulation Factor (may be BCF if this is the only value available)
EED = Estimated Exposure Dose
HQ =Hazard Quotient.
L = LOAEL based; N = NOAEL based
LOAEL = Lowest Observed Adverse Effect Level
NOAEL = No Observed Adverse Effect Level
NA = Not applicable/Not available
BAF (or BCF) values from appropriate text tables (BCF = bioconcentration factor)
Some BAF (or BCF) values based on media regression equations (value in box):
LOAEL and NOAEL values from appropriate toxicity summary tables in the text.
UF = Uncertainty Factor for toxicity factor extrapolation, and Adjusted LOAEL or NOAEL = LOAEL/UF or NOAEL/UF
A "0" entry in the exposure concentration column indicates this chemical not selected as a COPEC for this medium.
Receptor diet data and home range data from appropriate text table.
Exposure point concentrations (EPCs) from appropriate text tables.

Species-Specific Factors

Terrestrial plant diet fraction =	0	unitless
Aquatic plant diet fraction =	0	unitless
Plant root diet fraction =	0	unitless
Fish diet fraction =	0	unitless
Aq. Invert diet fraction =	0	unitless
Terr. Invert diet fraction =	1	unitless
Mammal diet fraction =	0	unitless
Bird diet fraction =	0	unitless
Soil ingestion rate =	0.000058	kg/d
Sediment ingestion rate =	0	kg/d
Food ingestion rate =	0.0029	kg/d
Body weight =	0.01	kg
Home range =	0.13	acres
Water intake rate =	0.0027	L/d
Site Area =	5	acres
Area Use Factor (AUF) =	1	unitless
Exposure Frequency (EF) =	1	unitless

Table E-5

Chemicals of Potential Concern
Exposure Doses and Hazard Quotients for the White-Tailed Deer
Power House 2 Ash Pits
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Surface Water Exposure Point Concentration	Units	Sediment Exposure Point Concentration	Units	Total Soil Exposure Point Concentration	Units	Soil BAF	Fish BAF	Aq. Invert. BAF	Terr. Invert. BAF	Aq. Plant BAF	Terr. Plant BAF	Mammal BAF	Bird BAF
								---Unitless---						
Metals														
Aluminum	8.70E-01	mg/L	0.00E+00	mg/kg	0.00E+00	mg/kg	1.00E+00	780						
Barium	4.97E-02	mg/L	0.00E+00	mg/kg	0.00E+00	mg/kg	1.00E+00	146						
Cadmium	0.00E+00	mg/L	0.00E+00	mg/kg	5.32E-01	mg/kg	1.00E+00			9.43E+00	NA	8.28E-01	3.97E-01	3.97E-01
Lead	2.87E-03	mg/L	0.00E+00	mg/kg	0.00E+00	mg/kg	1.00E+00	6.38E+01						
Mercury	0.00E+00	mg/L	0.00E+00	mg/kg	5.28E-02	mg/kg	1.00E+00			7.76E+00	NA	1.42E+00	1.92E-01	1.92E-01
Selenium	0.00E+00	mg/L	0.00E+00	mg/kg	1.22E+00	mg/kg	1.00E+00			8.81E-01	NA	5.17E-01	5.84E-01	5.84E-01
Thallium	0.00E+00	mg/L	0.00E+00	mg/kg	1.67E+00	mg/kg	1.00E+00			3.00E-01		2.20E-03	1.23E-01	1.23E-01
Explosives														
2,4,6-Trinitrotoluene	0.00E+00	mg/L	6.47E-02	mg/kg	0.00E+00	mg/kg	1.00E+00		4.67E+00		4.23E+00			
Semivolatile Organics														
Bis(2-ethylhexyl) phthalate	2.00E-03	mg/L	0.00E+00	mg/kg	0.00E+00	mg/kg	1.00E+00	350						

Chemical	EED Surface Water	EED Sediment	EED Soil	EED Fish	EED Aq. Invert.	EED Terr. Invert.	EED Aq. Plants	EED Terr. Plants	EED Mammals	EED Birds	Total EED	TRV_{NOAEL}	HQ_{NOAEL}	TRV_{LOAEL}	HQ_{LOAEL}
	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d		mg/kg-d	
Metals															
Aluminum	2.23E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.23E-04	1.93E+00	1.15E-04	1.93E+01	1.15E-05
Barium	1.27E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.27E-05	5.10E+00	2.49E-06	1.98E+01	6.42E-07
Cadmium	0.00E+00	0.00E+00	1.36E-06	0.00E+00	0.00E+00	0.00E+00	NA	5.64E-05	0.00E+00	0.00E+00	5.78E-05	1.00E+00	5.78E-05	1.00E+01	5.78E-06
Lead	7.36E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.36E-07	8.00E+00	9.20E-08	8.00E+01	9.20E-09
Mercury	0.00E+00	0.00E+00	1.35E-07	0.00E+00	0.00E+00	0.00E+00	NA	9.62E-06	0.00E+00	0.00E+00	9.76E-06	1.32E+01	7.39E-07	1.32E+02	7.39E-08
Selenium	0.00E+00	0.00E+00	3.11E-06	0.00E+00	0.00E+00	0.00E+00	NA	8.05E-05	0.00E+00	0.00E+00	8.36E-05	2.00E-01	4.18E-04	3.30E-01	2.53E-04
Thallium	0.00E+00	0.00E+00	4.28E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.71E-07	0.00E+00	0.00E+00	4.75E-06	7.40E-03	6.42E-04	7.40E-02	6.42E-05
Explosives															
2,4,6-Trinitrotoluene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-01	0.00E+00	2.00E+00	0.00E+00
Semivolatile Organics															
Bis(2-ethylhexyl) phthalate	5.12E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.12E-07	1.83E+01	2.79E-08	1.83E+02	2.80E-09

Intake Equation:

$$Ej = \left(\frac{A}{HR} \left[\sum_{i=1}^{m} \left(\frac{IRi\, x\, Cij}{BW} \right) \right] \right)$$

Where:
Ej = Total Exposure to Chemical
A = Site Area
HR = Home Range
m = Total number of ingested media
i = counter
IRi = Consumption Rate for Medium
Cij = Chemical concentration (j) in medium (I) (mg/kg or mg/L)
BW = Body Weight

Notes:
BAF = Bioaccumulation Factor (may be BCF if this is the only value available)
EED = Estimated Exposure Dose
HQ =Hazard Quotient.
L = LOAEL based; N = NOAEL based
LOAEL = Lowest Observed Adverse Effect Level
NOAEL = No Observed Adverse Effect Level
NA = Not applicable/Not available
BAF (or BCF) values from appropriate text tables (BCF = bioconcentration factor)
Some BAF (or BCF) values based on media regression equations (value in box):
LOAEL and NOAEL values from appropriate toxicity summary tables in the text.
UF = Uncertainty Factor for toxicity factor extrapolation, and Adjusted LOAEL or NOAEL = LOAEL/UF or NOAEL/UF
A "0" entry in the exposure concentration column indicates this chemical not selected as a COPEC for this medium.
Receptor diet data and home range data from appropriate text table.
Exposure point concentrations (EPCs) from appropriate text tables.

Species-Specific Factors

Terrestrial plant diet fraction =	1	unitless
Aquatic plant diet fraction =	0	unitless
Plant root diet fraction =	0	unitless
Fish diet fraction =	0	unitless
Aq. Invert diet fraction =	0	unitless
Terr. Invert diet fraction =	0	unitless
Mammal diet fraction =	0	unitless
Bird diet fraction =	0	unitless
Soil ingestion rate =	0.04	kg/d
Sediment ingestion rate =	0	kg/d
Food ingestion rate =	2	kg/d
Body weight =	61	kg
Home range =	1280	acres
Water intake rate =	4	L/d
Site Area =	5	acres
Area Use Factor (AUF) =	0.00390625	unitless
Exposure Frequency (EF) =	1	unitless

Table E-6

Chemicals of Potential Concern
Exposure Doses and Hazard Quotients for the Raccoon
Power House 2 Ash Pits
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Surface Water Exposure Point Concentration	Units	Sediment Exposure Point Concentration	Units	Surface Soil Exposure Point Concentration	Units	Soil BAF	Fish BAF	Aq. Invert. BAF	Terr. Invert. BAF	Aq. Plant BAF	Terr. Plant BAF	Mammal BAF	Bird BAF
							----------Unitless----------							
Metals														
Aluminum	8.70E-01	mg/L	0.00E+00	mg/kg	0.00E+00	mg/kg	1.00E+00	780						
Barium	4.97E-02	mg/L	0.00E+00	mg/kg	0.00E+00	mg/kg	1.00E+00	146						
Cadmium	0.00E+00	mg/L	0.00E+00	mg/kg	5.32E-01	mg/kg	1.00E+00			9.43E+00	NA	8.28E-01	3.97E-01	3.97E-01
Lead	2.87E-03	mg/L	0.00E+00	mg/kg	0.00E+00	mg/kg	1.00E+00	6.38E+01						
Mercury	0.00E+00	mg/L	0.00E+00	mg/kg	5.28E-02	mg/kg	1.00E+00			7.76E+00	NA	1.42E+00	1.92E-01	1.92E-01
Selenium	0.00E+00	mg/L	0.00E+00	mg/kg	1.22E+00	mg/kg	1.00E+00			8.81E-01	NA	5.17E-01	5.84E-01	5.84E-01
Thallium	0.00E+00	mg/L	0.00E+00	mg/kg	1.67E+00	mg/kg	1.00E+00			3.00E-01		2.20E-03	1.23E-01	1.23E-01
Explosives														
2,4,6-Trinitrotoluene	0.00E+00	mg/L	6.47E-02	mg/kg	0.00E+00	mg/kg	1.00E+00		4.67E+00		4.23E+00			
Semivolatile Organics														
Bis(2-ethylhexyl) phthalate	2.00E-03	mg/L	0.00E+00	mg/kg	0.00E+00	mg/kg	1.00E+00	350						

Chemical	EED Surface Water	EED Sediment	EED Soil	EED Fish	EED Aq. Invert.	EED Terr. Invert.	EED Aq. Plants	EED Terr. Plants	EED Mammals	EED Birds	Total EED	TRV_{NOAEL}	HQ_{NOAEL}	TRV_{LOAEL}	HQ_{LOAEL}
	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d		mg/kg-d	
Metals															
Aluminum	2.23E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.23E-04	1.93E+00	1.15E-04	1.93E+01	1.15E-05
Barium	1.27E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.27E-05	5.10E+00	2.49E-06	1.98E+01	6.42E-07
Cadmium	0.00E+00	0.00E+00	1.36E-06	0.00E+00	0.00E+00	0.00E+00	NA	5.64E-05	0.00E+00	0.00E+00	5.78E-05	1.00E+00	5.78E-05	1.00E+01	5.78E-06
Lead	7.36E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.36E-07	8.00E+00	9.20E-08	8.00E+01	9.20E-09
Mercury	0.00E+00	0.00E+00	1.35E-07	0.00E+00	0.00E+00	0.00E+00	NA	9.62E-06	0.00E+00	0.00E+00	9.76E-06	1.32E+01	7.39E-07	1.32E+02	7.39E-08
Selenium	0.00E+00	0.00E+00	3.11E-06	0.00E+00	0.00E+00	0.00E+00	NA	8.05E-05	0.00E+00	0.00E+00	8.36E-05	2.00E-01	4.18E-04	3.30E-01	2.53E-04
Thallium	0.00E+00	0.00E+00	4.28E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.71E-07	0.00E+00	0.00E+00	4.75E-06	7.40E-03	6.42E-04	7.40E-02	6.42E-05
Explosives															
2,4,6-Trinitrotoluene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-01	0.00E+00	2.00E+00	0.00E+00
Semivolatile Organics															
Bis(2-ethylhexyl) phthalate	5.12E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.12E-07	1.83E+01	2.79E-08	1.83E+02	2.80E-09

Intake Equation:

$$Ej = \left(\frac{A}{HR}\left[\sum_{i=1}^{m}\left(\frac{IRi\,x\,Cij}{BW}\right)\right]\right)$$

Where:
Ej = Total Exposure to Chemical
A = Site Area
HR = Home Range
m = Total number of ingested media
i = counter
IRi = Consumption Rate for Medium
Cij = Chemical concentration (j) in medium (I) (mg/kg or mg/L)
BW = Body Weight

Notes:
BAF = Bioaccumulation Factor (may be BCF if this is the only value available)
EED = Estimated Exposure Dose
HQ =Hazard Quotient.
L = LOAEL based; N = NOAEL based
LOAEL = Lowest Observed Adverse Effect Level
NOAEL = No Observed Adverse Effect Level
NA = Not applicable/Not available
BAF (or BCF) values from appropriate text tables (BCF = bioconcentration factor)
Some BAF (or BCF) values based on media regression equations (value in box):
LOAEL and NOAEL values from appropriate toxicity summary tables in the text.
UF = Uncertainty Factor for toxicity factor extrapolation, and Adjusted LOAEL or NOAEL = LOAEL/UF or NOAEL/UF
A "0" entry in the exposure concentration column indicates this chemical not selected as a COPEC for this medium.
Receptor diet data and home range data from appropriate text table.
Exposure point concentrations (EPCs) from appropriate text tables.

Species-Specific Factors

Terrestrial plant diet fraction =	0.21	unitless
Aquatic plant diet fraction =	0.21	unitless
Plant root diet fraction =	0	unitless
Fish diet fraction =	0.02	unitless
Aq. Invert diet fraction =	0.21	unitless
Terr. Invert diet fraction =	0.3	unitless
Mammal diet fraction =	0.05	unitless
Bird diet fraction =	0	unitless
Soil ingestion rate =	0.01222	kg/d
Sediment ingestion rate =	0.01222	kg/d
Food ingestion rate =	0.26	kg/d
Body weight =	5.1	kg
Home range =	385	acres
Water intake rate =	0.43	L/d
Site Area =	5	acres
Area Use Factor (AUF) =	0.013	unitless
Exposure Frequency (EF) =	1	unitless

Table E-7

Chemicals of Potential Concern
Exposure Doses and Hazard Quotients for the Red-Tailed Hawk
Power House 2 Ash Pits
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Surface Water Exposure Point Concentration	Units	Sediment Exposure Point Concentration	Units	Surface Soil Exposure Point Concentration	Units	Soil BAF	Fish BAF	Aq. Invert. BAF	Terr. Invert. BAF	Aq. Plant BAF	Terr. Plant BAF	Mammal BAF	Bird BAF	EED Surface Water	EED Sediment	EED Soil	EED Fish	EED Aq. Invert.	EED Terr. Invert.	EED Aq. Plants	EED Terr. Plants	EED Mammals	EED Birds	Total EED	TRV $_{NOAEL}$	HQ $_{NOAEL}$	TRV $_{LOAEL}$	HQ $_{LOAEL}$
							----------Unitless----------								mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d		mg/kg-d	
Metals																													
Aluminum	8.70E-01	mg/L	0.00E+00	mg/kg	0.00E+00	mg/kg	1.00E+00	780							1.24E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.24E-04	1.10E+02	1.13E-06	1.10E+03	1.13E-07
Barium	4.97E-02	mg/L	0.00E+00	mg/kg	0.00E+00	mg/kg	1.00E+00	146							7.11E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.11E-06	2.08E+01	3.42E-07	4.17E+01	1.70E-07
Cadmium	0.00E+00	mg/L	0.00E+00	mg/kg	6.50E-01	mg/kg	1.00E+00			9.05E+00	NA	7.56E-01	3.57E-01	3.57E-01	0.00E+00	0.00E+00	1.86E-06	0.00E+00	0.00E+00	0.00E+00	NA	0.00E+00	2.53E-05	7.98E-06	3.51E-05	1.45E+00	2.42E-05	2.00E+01	1.75E-06
Lead	2.87E-03	mg/L	0.00E+00	mg/kg	0.00E+00	mg/kg	1.00E+00	6.38E+01							4.11E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.11E-07	3.85E+00	1.07E-07	3.85E+01	1.07E-08
Mercury	0.00E+00	mg/L	0.00E+00	mg/kg	7.96E-02	mg/kg	1.00E+00			5.89E+00	NA	1.18E+00	1.92E-01	1.92E-01	0.00E+00	0.00E+00	2.28E-07	0.00E+00	0.00E+00	0.00E+00	NA	0.00E+00	1.66E-06	5.25E-07	2.42E-06	4.50E-01	5.37E-06	9.00E-01	2.68E-06
Selenium	0.00E+00	mg/L	0.00E+00	mg/kg	1.66E+00	mg/kg	1.00E+00			8.11E-01	NA	5.33E-01	4.81E-01	4.81E-01	0.00E+00	0.00E+00	4.75E-06	0.00E+00	0.00E+00	0.00E+00	NA	0.00E+00	8.68E-05	2.74E-05	1.19E-04	4.40E-01	2.70E-04	1.50E+00	7.93E-05
Thallium	0.00E+00	mg/L	0.00E+00	mg/kg	1.68E+00	mg/kg	1.00E+00			3.00E-01		2.20E-03	1.23E-01	1.23E-01	0.00E+00	0.00E+00	4.82E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.25E-05	7.11E-06	3.44E-05	3.50E-01	9.83E-05	3.50E+00	9.83E-06
Explosives																													
2,4,6-Trinitrotoluene	0.00E+00	mg/L	6.47E-02	mg/kg	0.00E+00	mg/kg	1.00E+00		4.67E+00		4.23E+00				0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.00E-01	0.00E+00	1.78E+01	0.00E+00
Semivolatile Organics																													
Bis(2-ethylhexyl) phthalate	2.00E-03	mg/L	0.00E+00	mg/kg	0.00E+00	mg/kg	1.00E+00	350							2.86E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.86E-07	1.11E+00	2.58E-07	1.11E+01	2.58E-08

Intake Equation:

$$Ej = \left(\frac{A}{HR}\left[\sum_{i=1}^{m}\left(\frac{IRi\,x\,Cij}{BW}\right)\right]\right)$$

Where:
Ej = Total Exposure to Chemical
A = Site Area
HR = Home Range
m = Total number of ingested media
i = counter
IRi = Consumption Rate for Medium
Cij = Chemical concentration (j) in medium (I) (mg/kg or mg/L)
BW = Body Weight

Notes:
BAF = Bioaccumulation Factor (may be BCF if this is the only value available)
EED = Estimated Exposure Dose
HQ =Hazard Quotient.
L = LOAEL based; N = NOAEL based
LOAEL = Lowest Observed Adverse Effect Level
NOAEL = No Observed Adverse Effect Level
NA = Not applicable/Not available
BAF (or BCF) values from appropriate text tables (BCF = bioconcentration factor)
Some BAF (or BCF) values based on media regression equations (value in box):
LOAEL and NOAEL values from appropriate toxicity summary tables in the text.
UF = Uncertainty Factor for toxicity factor extrapolation, and Adjusted LOAEL or NOAEL = LOAEL/UF or NOAEL/UF
A "0" entry in the exposure concentration column indicates this chemical not selected as a COPEC for this medium.
Receptor diet data and home range data from appropriate text table.
Exposure point concentrations (EPCs) from appropriate text tables.

Species-Specific Factors

Terrestrial plant diet fraction =	0	unitless
Aquatic plant diet fraction =	0	unitless
Plant root diet fraction =	0	unitless
Fish diet fraction =	0	unitless
Aq. Invert diet fraction =	0	unitless
Terr. Invert diet fraction =	0	unitless
Mammal diet fraction =	0.76	unitless
Bird diet fraction =	0.24	unitless
Soil ingestion rate =	0.00114	kg/d
Sediment ingestion rate =	0	kg/d
Food ingestion rate =	0.057	kg/d
Body weight =	0.957	kg
Home range =	2080	acres
Water intake rate =	0.057	L/d
Site Area =	5	acres
Area Use Factor (AUF) =	0.00240385	unitless
Exposure Frequency (EF) =	1	unitless

Table E-8

Chemicals of Potential Concern
Exposure Doses and Hazard Quotients for the Muskrat
Power House 2 Ash Pits
Plum Brook Ordnance Works, Sandusky, Ohio

Chemical	Surface Water Exposure Point Concentration	Units	Sediment Exposure Point Concentration	Units	Surface Soil Exposure Point Concentration	Units	Soil BAF	Fish BAF	Aq. Invert. BAF	Terr. Invert. BAF	Aq. Plant BAF	Terr. Plant BAF	Mammal BAF	Bird BAF
								----------Unitless----------						
Metals														
Aluminum	8.70E-01	mg/L	0.00E+00	mg/kg	0.00E+00	mg/kg	1.00E+00	780						
Barium	4.97E-02	mg/L	0.00E+00	mg/kg	0.00E+00	mg/kg	1.00E+00	146						
Cadmium	0.00E+00	mg/L	0.00E+00	mg/kg	6.50E-01	mg/kg	1.00E+00			9.05E+00	NA	7.56E-01	3.57E-01	3.57E-01
Lead	2.87E-03	mg/L	0.00E+00	mg/kg	0.00E+00	mg/kg	1.00E+00	6.38E+01						
Mercury	0.00E+00	mg/L	0.00E+00	mg/kg	7.96E-02	mg/kg	1.00E+00			5.89E+00	NA	1.18E+00	1.92E-01	1.92E-01
Selenium	0.00E+00	mg/L	0.00E+00	mg/kg	1.66E+00	mg/kg	1.00E+00			8.11E-01	NA	5.33E-01	4.81E-01	4.81E-01
Thallium	0.00E+00	mg/L	0.00E+00	mg/kg	1.68E+00	mg/kg	1.00E+00			3.00E-01		2.20E-03	1.23E-01	1.23E-01
Explosives														
2,4,6-Trinitrotoluene	0.00E+00	mg/L	6.47E-02	mg/kg	0.00E+00	mg/kg	1.00E+00		4.67E+00		4.23E+00			
Semivolatile Organics														
Bis(2-ethylhexyl) phthalate	2.00E-03	mg/L	0.00E+00	mg/kg	0.00E+00	mg/kg	1.00E+00	350						

Chemical	EED Surface Water	EED Sediment	EED Soil	EED Fish	EED Aq. Invert.	EED Terr. Invert.	EED Aq. Plants	EED Terr. Plants	EED Mammals	EED Birds	Total EED	TRV_{NOAEL}	HQ_{NOAEL}	TRV_{LOAEL}	HQ_{LOAEL}
	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d		mg/kg-d	
Metals															
Aluminum	8.15E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.15E-02	1.93E+00	4.22E-02	1.93E+01	4.22E-03
Barium	4.65E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.65E-03	5.10E+00	9.12E-04	1.98E+01	2.35E-04
Cadmium	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	NA	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00	0.00E+00	1.00E+01	0.00E+00
Lead	2.69E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.69E-04	8.00E+00	3.36E-05	8.00E+01	3.36E-06
Mercury	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	NA	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00	0.00E+00	5.00E+00	0.00E+00
Selenium	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	NA	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-01	0.00E+00	3.30E-01	0.00E+00
Thallium	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.40E-03	0.00E+00	7.40E-02	0.00E+00
Explosives															
2,4,6-Trinitrotoluene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.21E-02	0.00E+00	0.00E+00	0.00E+00	8.21E-02	2.00E-01	4.10E-01	2.00E+00	4.10E-02
Semivolatile Organics															
Bis(2-ethylhexyl) phthalate	1.87E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.87E-04	1.83E+01	1.02E-05	1.83E+02	1.02E-06

Intake Equation:

$$Ej = \left(\frac{A}{HR} \left[\sum_{i=1}^{m} \left(\frac{IRi\,x\,Cij}{BW} \right) \right] \right)$$

Where:
Ej = Total Exposure to Chemical
A = Site Area
HR = Home Range
m = Total number of ingested media
i = counter
IRi = Consumption Rate for Medium
Cij = Chemical concentration (j) in medium (I) (mg/kg or mg/L)
BW = Body Weight

Notes:
BAF = Bioaccumulation Factor (may be BCF if this is the only value available)
EED = Estimated Exposure Dose
HQ =Hazard Quotient.
L = LOAEL based; N = NOAEL based
LOAEL = Lowest Observed Adverse Effect Level
NOAEL = No Observed Adverse Effect Level
NA = Not applicable/Not available
BAF (or BCF) values from appropriate text tables (BCF = bioconcentration factor)
Some BAF (or BCF) values based on media regression equations (value in box):
LOAEL and NOAEL values from appropriate toxicity summary tables in the text.
UF = Uncertainty Factor for toxicity factor extrapolation, and Adjusted LOAEL or NOAEL = LOAEL/UF or NOAEL/UF
A "0" entry in the exposure concentration column indicates this chemical not selected as a COPEC for this medium.
Receptor diet data and home range data from appropriate text table.
Exposure point concentrations (EPCs) from appropriate text tables.

Species-Specific Factors

Terrestrial plant diet fraction =	0	unitless
Aquatic plant diet fraction =	1	unitless
Plant root diet fraction =	0	unitless
Fish diet fraction =	0	unitless
Aq. Invert diet fraction =	0	unitless
Terr. Invert diet fraction =	0	unitless
Mammal diet fraction =	0	unitless
Bird diet fraction =	0	unitless
Soil ingestion rate =	0	kg/d
Sediment ingestion rate =	0	kg/d
Food ingestion rate =	0.352	kg/d
Body weight =	1.174	kg
Home range =	0.32	acres
Water intake rate =	0.11	L/d
Site Area =	5	acres
Area Use Factor (AUF) =	1	unitless
Exposure Frequency (EF) =	1	unitless

RESPONSE TO COMMENTS

Response to Comments
Screening Level Ecological Risk Assessment (SLERA)
for Powerhouse 2 Ash Pits
Plum Brook Ordnance Works, Sandusky, Ohio,
Dated June 21, 2010

Comments by Janusz Byczkowski, Risk Assessor, Ohio Environmental Protection Agency, received August 9, 2010. The reviewer included comments on the baseline human health risk assessment (BHHRA) with those of the SLERA. Responses to comments pertaining solely to the BHHRA are attached to the revised final BHHRA, but are not provided below. The SLERA comments below have been re-numbered accordingly. Comment No. 1 below (Comment No. 4 in the BHHRA and the original comment letter) pertains to both the BHHRA and the SLERA. A longer version of this Response No. 1 that more completely addresses the specific human health examples is included in the Response to Comments that is attached to the BHHRA.

Comment 1: **BHHRA Tables 2-3 to 2-9 and A-2; also SLERA Table 2-9. Some chemicals, whose reporting limits (RL) exceed screening levels (RBSC), have not been selected as chemicals of potential concern (COPC), and thus, they are not included in baseline risk assessment – for example: *"Indeno(1,2,3-cd)pyrene"* in Table 2-4; or *"Cadmium"* in Table 2-7; etc. All chemicals whose RL>RBSC should not be just eliminated from the data set used for baseline risk assessment. Instead, it should be assumed that each of them may be present at a concentration equal to ½ RL, and thus, it should be processed as COPC. Similarly in SLERA, the chemicals whose RL>ESV should be included as COPECs, assuming their concentration = ½ of RL. Please check the data tables for cases of RL>RBSC and/or ESV, and evaluate those that exceed screening levels as COPC in the BHHRA and/or as COPEC in SLERA, assuming that their concentration = ½ of RL.**

Response 1: The data evaluation protocols used in the BHHRA and SLERA are consistent with those which has been performed for PBOW human health and ecological risk assessments for the past decade. These protocols are described in the approved site-specific risk assessment work plans (Shaw, 2010). Further, these approaches are clearly consistent with EPA (1989) guidance which emphasizes the use of positive data and recognizes that the state of the practice is such that achieving RLs that are lower than screening values is not possible for certain chemicals. This guidance even recommends that individual samples with elevated RLs be excluded from the quantitative risk assessment.

The focus of the BHHRA and SLERA is quantitative risk assessment. Please note that the MDCs are used for screening, and that this is the most conservative value that is reasonable to consider in quantitative evaluation as an exposure point concentration (EPC). The ProUCL statistical program, used to estimate EPCs, weighs nondetects differently and will typically not recommend a value that exceeds the MDC. The method that has been used in the BHHRA and SLERA, as described the work plan, ensures that the EPC will not exceed the MDC. Therefore, the use of the MDC as the screening value reflects the "worst case" of the quantitative portion of the risk assessment.

Comment 2: **<u>Page ES-1, Line 7</u>: document states: "...*The primary objective of the assessment was to determine whether the potential for unacceptable risks are posed to ecological receptors as a result of potential hazardous substance releases...*" This statement seems to be *potentially* unclear, especially that the next sentence says: "...*hazardous substances being released from the site...*" Please rephrase the statement of primary objective.**

Response 2: The sentence in question will be changed to state the following: "The primary objective of the assessment was to determine the potential for unacceptable risks to ecological receptors as a result of exposure to chemicals detected at the site."

Comment 3: **<u>Page ES-2, Line 23</u>. This document states: "...*estimate of the likelihood* [...] *of adverse effects to environmental stressors present at the site...*" The meaning of this statement is unclear (it seems to suggest "*effects to stressors*" rather than effects to ecological receptors). Please rephrase this statement.**

Response 3: The sentence in question will be changed to the following: "The result is an estimate of the likelihood, severity, and characteristics of adverse effects to ecological receptors resulting from exposure to environmental stressors present at the site."

Comment 4: **<u>Page ES-3, Line 18; Section 2.4.2, Page 2-18, Line 32; and Appendix D, Page D-4</u>. This document states: "...*Ecological risk from surface water and sediment was primarily evaluated using a food chain model for the selected aquatic assessment receptor (i.e., the raccoon)...*" and then: "...*Potential uptake through the food chain is evaluated for the raccoon (also considered as a terrestrial receptor)...*"**

According to OEPA-DERR (2008), one of the preferred species useful in the generic food web model for surface water and wetland on this Site, would be the aquatic herbivore Muskrat. The muskrat is listed in this document as "*likely to be found in Erie County*" (Table 2-2). On the other hand, the raccoon - actually observed on this Site omnivore, may be not very sensitive as a surface water and wetland -associated receptor. Please add muskrat as the aquatic assessment receptor.

Reference:

OEPA-DERR (2008) ECOLOGICAL RISK ASSESSMENT Guidance Document. Revised April 2008. On line:

http://www.epa.ohio.gov/portals/30/rules/RR-031.pdf

Response 4: The Muskrat will be added as an aquatic receptor.

References Used in Responses

Shaw Environmental, Inc. (Shaw), 2010, ***Baseline Human Health Risk Assessment Work Plan, Garage Maintenance Area (Locomotive Building Area), Plum Brook Ordnance Works, Sandusky, Ohio***, May.

U.S. Environmental Protection Agency (EPA), 1989, ***Risk Assessment Guidance for Superfund***, Volume I, Human Health Evaluation Manual (Part A), Interim Final, Office of Emergency and Remedial Response, Washington, D.C., EPA/540/1-89/002.