Final
Screening Level Ecological Risk Assessment

Acid Area 1

Former Plum Brook Ordnance Works
Sandusky, Ohio

Prepared for:

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
NASHVILLE, TENNESSEE
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COMPLETION OF INDEPENDENT TECHNICAL REVIEW

Jacobs Engineering Group, Inc. has completed the Final Screening Level Ecological Risk Assessment, Former Plum Brook Ordnance Works, Sandusky, Ohio. Notice is hereby given that an independent technical review has been conducted that is appropriate to the level of risk and complexity inherent in the project, as defined in the Quality Control Plan. During the independent technical review, compliance with established policy principles and procedures, utilizing justified and valid assumptions, was verified. This included review of assumptions; methods, procedures, and material used in analyses; alternatives evaluated; the appropriateness of data used and level of data obtained; and reasonableness of the results, including whether the product meets the customer's needs consistent with law and existing Corps policy.

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CERTIFICATION OF INDEPENDENT TECHNICAL REVIEW

All comments provided from the review of the Draft version have been incorporated and the response to these comments have been reviewed and evaluated to ensure the concerns have been addressed and responses are appropriate. Responses to comments are included in the Appendicies

Comment:

Comment:

Comment:

Comment:

All concerns resulting from independent technical review of the project have been considered.

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(Signature)

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List of Acronyms and Abbreviations

amsl	above mean sea level
ARP	assessment receptor profile
AST	aboveground storage tank
BAF	bioaccumulation factor
BCF	bioconcentration factor
bgs	below ground surface
Bldg.	Building
BSC	background screening concentration
BTAG	Biological Technical Assistance Group
CELRN	U.S. Army Corps of Engineers, Nashville District
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	contaminant of concern
COPEC	chemicals of potential ecological concern
DNAP	(Ohio) Division of Natural Areas and Preserves
DERP	Defense Environmental Restoration Program
DNT	dinitrotoluene
EC_{20}	effective concentration for 20 percent
ECSM	ecological conceptual site model
EDQL	ecological data quality level
EPC	exposure-point concentration
FCM	food chain multiplier
ft	foot or feet
FUDS	Formerly Used Defense Site
H_o	null hypotheses
HQ	hazard quotient
IT	IT Corporation
Jacobs	Jacobs Engineering
kg	kilogram
KM	Kaplan-Meier
K_{oc}	soil adsorption coefficient
K_{ow}	octanol/water partition coefficient
LC_{50}	lethal concentration to 50 percent

LD_{50}	lethal dose to 50 percent
LOAEL	lowest observed adverse effect level
MDC	maximum detected concentration
mg/kg	milligrams per kilogram
mg/kg-day	milligram per kilogram per day
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
NOAEL	no observed adverse effect level
NWI	National Wetland Inventory
ODNR	Ohio Department of Natural Resources
OEPA	Ohio Environmental Protection Agency
OME	Ontario Ministry of the Environment and Energy
PAH	polycyclic aromatic hydrocarbon
PBOW	Plum Brook Ordnance Works
PCB	polychlorinated biphenyl
RA	risk assessment
RBSC	risk-based screening criteria
RBSEV	risk-based screening ecotoxicity value
RI	remedial investigation
RTE	rare, threatened, or endangered
RTEC	Registry of Toxic Effects Concentrations
SI	site investigation
SLERA	screening level ecological risk assessment
SVOC	semivolatile organic compound
TNT	trinitrotoluene
TRV	toxicity reference value
UCL	upper confidence limit
UCL_{95}	95 percent upper confidence limit
U.S.C.	United States Code
USACE	U.S. Army Corps of Engineers
U.S. EPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service

UTL	upper tolerance limit
VOC	volatile organic compound
WQC	(Ohio EPA) Water Quality Criteria

EXECUTIVE SUMMARY

This screening level ecological risk assessment (SLERA) was prepared to evaluate the potential for adverse effects to ecological receptors from exposure to hazardous substance releases at Acid Area 1, located at the former Plum Brook Ordnance Works (PBOW), Sandusky, Erie County, Ohio. This SLERA was prepared in accordance with the *Baseline Human Health Risk Assessment and Ecological Risk Assessment Work Plans* (Jacobs, 2008), and is consistent with U.S. Environmental Protection Agency (USEPA) and Ohio EPA – Division of Emergency and Remedial Response (OEPA, 2003) guidance and with the procedures established in the Baseline Ecological Risk Assessment Work Plan for TNT Areas A & C soil (IT Corporation, 2001). The results of this assessment may be used to determine whether remediation or additional investigation is warranted at the site.

Acid Area 1 is located in the central portion of PBOW, adjacent to Taylor Road, between Maintenance Road and Fox Road, covering an area approximately 20 acres in size. The Acid Area 1 physical features include an open field bounded by a drainage ditch to the south with scattered overgrowth throughout. Two railroad grades run east-west through the site: one on the southern perimeter and one through the northern portion of the site. The original service road encircles the site. The road is in fair condition and clear of vegetation. Buildings 302, 308, and 310 are the only remaining original structures at the site. All other buildings and tanks have been removed.

Four drainage features are present at the site. The drainage ditch to the south is located approximately 40 ft south of the service road and drains to the west, parallel to the site, discharging into Ransom Brook west of the site. This drainage feature has little relief adjacent to the site. Another drainage ditch originates on site on the north central portion of the site and drains to the north. This drainage feature is approximately 30 to 40 ft wide and 15 to 18 ft deep just north of the Acid Area 1 site. A third drainage ditch originates in a low swampy area in the west central portion of the site and drains to the west into Ransom Brook. The fourth drainage ditch originates at a ponded area with a man-made dike in the northwest corner of the site, which also drains west into Ransom Brook. Flowing water has been observed in all four drainage ditches during the wet season in early to mid spring. All but the northern drainage ditch dry up by mid summer including the ponded area and the swampy area (Jacobs, 2006).

Ecological surveys were performed in the spring and fall of 2008. The predominant community types observed at Acid Area 1 were Upland Old Fields, Shrub Thickets, Successional Woods, Marsh, and Scrub/Shrub Wetlands. During the ecological survey, Acid Area 1 was examined for vegetative stress, including plants displaying stunted growth, poor foliage growth, tissue discoloration, and a loss of leaf coverage. Vegetative stress attributable to chemicals was not observed. Based on site reconnaissance information, it does not appear that significant ecological threats exist at the site as there is no definitive absence of biota or animal life in areas expected to support these ecological components. No threatened or endangered species were found in Acid Area 1.

The primary objective of this SLERA is to evaluate the potential for adverse effects posed to ecological receptors as a result of possible hazardous substance releases. This objective was met by characterizing the ecological communities in the vicinity of the site, determining the particular hazardous substances released, identifying pathways for receptor exposure, and estimating the magnitude of the potential for adverse effects to identified receptors. This

SLERA addresses the potential for adverse effects to the vegetation, wildlife, aquatic life, threatened and endangered species, and wetlands and other sensitive habitats associated with the site. There is limited habitat for fish in the area of concern as the small drainage ditches within and adjacent to the area are intermittent with the exception of the drainage to the north-northeast of the site.

The chemicals of potential ecological concern (COPECs), the ecosystems and receptors at risk, the ecotoxicity of the contaminants known or suspected to be present, and observed or anticipated ecological effects were evaluated in two steps: (1) a screening assessment and (2) a predictive assessment. Ecological endpoints addressed in both steps were identified.

Assessment receptor species were selected based on the likelihood of finding the species at Acid Area 1. Historical information, site reconnaissance, and the availability of toxicological data were used to select terrestrial and aquatic receptor species. The assessment receptors were selected for evaluation during the predictive SLERA. Seven representative assessment receptor species that are expected or possible in the vicinity of Acid Area 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, including herbivory, omnivory, and carnivory.

The assessment endpoints for Acid Area 1 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, and aquatic benthic invertebrates." The corresponding null hypothesis (H_o) 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 populations of terrestrial invertebrates, herbivorous mammals, omnivorous mammals, insectivorous mammals and birds, carnivorous birds, benthic invertebrates, omnivorous aquatic mammals, and omnivorous aquatic birds."

For assessments, measurable responses to stressors, collectively termed toxicity reference values (TRVs), 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 COPEC TRVs 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 (low, medium, or high) 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 potential adverse effects from environmental stressors present at a site. Qualitative and semiquantitative approaches were taken to estimate the likelihood of adverse

effects occurring as a result of potential exposure of the assessment receptors to COPECs. Potential adverse affects to terrestrial plants were qualitatively assessed by comparing plant toxicity benchmarks with COPEC concentrations. Potential adverse impacts to aquatic biota were qualitatively assessed by comparing sediment quality criteria for the protection of aquatic life to sediment COPEC concentrations. Surface water data were not used in the assessment because data were not available as the drainage ditches are intermittent and were dry at the time of sampling.

For the semiquantitative predictive assessment, TRVs and estimated exposure rates were used to generate hazard quotients (HQs) by dividing the receptor exposure rate for each contaminant by the TRV. HQs 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.

Soil COPEC impacts to terrestrial plants are estimated to be generally insignificant as no vegetative stress was observed on site. Terrestrial receptors are predicted to incur low hazards from exposure to PCBs (PCB-1254 and PCB-1260) and vanadium based on the NOAEL-based HQ approach (Section 5.3). Estimated HQs for four of the terrestrial receptors (deer mouse, short-tailed shrew, marsh wren, and raccoon) are less than 10 indicating a low potential for adverse affects. HQs are less than 1.0 for white-tailed deer, eastern cottontail, and red-tailed hawk.

Aquatic receptors are predicted to incur low hazards from exposure to 2-methylnaphthalene, anthracene, and fluoranthene in sediment based on the NOAEL-based HQ approach. These COPECs were not identified as COPECs in surface water. Estimated HQs for the raccoon are less than 10 indicating a low potential for adverse affects. HQs are less than 1.0 for the mallard duck. It is important to note that aquatic habitat is limited at Acid Area 1 and is not of high quality due to the size and ephemeral nature of most of the drainages.

Text

1.0 INTRODUCTION

This screening level ecological risk assessment (SLERA) was prepared to evaluate the potential for adverse effects to ecological receptors from exposure to hazardous substance releases at Acid Area 1, located at the former Plum Brook Ordnance Works (PBOW), Sandusky, Erie County, Ohio (Figures 1-1 and 1-2). The results of this assessment may be used to determine whether remediation or additional investigation is warranted at the site.

This SLERA was prepared by Jacobs Engineering Group (Jacobs) under contract DACW62-03-D-0009, Delivery Order #9. This work is being conducted for the U.S. Army Corp of Engineers (USACE) under the Defense Environmental Restoration Program (DERP) – Formerly Used Defense Sites (FUDS). The Army is the executive agent for the FUDS program and the USACE manages and directs the program's administration. Investigations at PBOW under DERP-FUDS are being managed by the USACE Huntington District and technically overseen by the USACE Nashville District (CELRN).

This SLERA was prepared in accordance with the *Ecological Risk Assessment Work Plans* (Jacobs, 2008), and is consistent with U.S. Environmental Protection Agency (U.S. EPA) and Ohio EPA (OEPA) – Division of Emergency and Remedial Response (OEPA, 2003) guidance and with the procedures established in the Baseline Ecological Risk Assessment Work Plan for TNT Areas A & C soil (IT Corporation [IT], 2001).

The primary objective of this SLERA is to evaluate the potential for adverse effects posed to ecological receptors as a result of possible hazardous substance releases. This objective was met by characterizing the ecological communities in the vicinity of the site, determining the particular hazardous substances released, identifying pathways for receptor exposure, and estimating the magnitude of the potential for adverse effects to identified receptors. This SLERA addresses the potential for adverse effects to the vegetation, wildlife, aquatic life, threatened and endangered species, and other sensitive habitats associated with the site. There is limited habitat for fish in the area of concern because the drainage ditches within and adjacent to the area are intermittent with the exception of drainage ditch located to the north, northeast of the site.

Concentrations of chemicals measured in relevant environmental media including soil and sediment were used to develop this SLERA, including problem formulation (Section 2.0); exposure characterization (Section 3.0); ecological effects characterization (Section 4.0); risk characterization (Section 5.0); and summary and conclusions (Section 6.0). These subtasks are described in greater detail in the following sections.

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

2.0 PROBLEM FORMULATION

The screening assessment H_o is stated as follows:

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

If one or more of these H_o are accepted, a predictive assessment is not triggered. All four H_o must be rejected for a predictive assessment to be triggered. The first three H_o were tested with the results of the ecological site description (Section 2.1). The fourth H_o was tested with the results of COPEC selection (Sections 2.2 and 2.3).

Where a predictive assessment was triggered, terrestrial and aquatic ecological conceptual site models were developed, as appropriate, and additional problem formulation tasks were performed, as described in Sections 2.4 to 2.6.

2.1 Ecological Site Description

This ecological site description section includes a general discussion of site background, surface water resources, wetlands, vegetative communities, a species inventory, and a discussion of threatened and endangered species.

2.1.1 General Site Background

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 area surrounding PBOW is mostly agricultural and residential (IT, 2001). 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, except during the annual deer hunting season.

PBOW, comprising approximately 6,453 acres, 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.

The Lake Plains region is over 69% cropland, 2.7% pasture land, and 10.5% forest (Ohio Department of Natural Resources [ODNR], 1985). However, since the Trojan Powder Company operated the site in the early 1940s and agricultural production on the land ceased, undeveloped portions of the former PBOW have become second generation forest and open fields.

The ground surface at Acid Area 1 is relatively flat, with minimal slope toward the drainage ditches to the north, south, and west. Elevations at the site range from 629 to 640 feet (ft) above mean sea level (amsl). The acid production areas were in operation from 1941 to 1945 to produce oleum, sulfuric acid, and nitric acid for the manufacture of trinitrotoluene (TNT). Two railroad grades run east-west through the site: one on the southern perimeter and one through the northern portion of the site. The original service road encircles the site. The road is in fair condition and clear of vegetation. Buildings (Bldgs.) 302, 308, and 310 are the only remaining original structures at the site. All other buildings and tanks have been removed.

A records review was conducted by IT Corporation (IT) in preparation for a site investigation (SI) of the Acid Areas (IT 1998). The records review indicated that no previous investigations had been conducted at Acid Area 1. Available drawings of the site were used to identify some facility components. A review of the 1958 aerial photographs revealed several buildings and aboveground storage tanks (ASTs) at Acid Area 1. The majority of the site facilities were dismantled between 1958 and 1963.

Acid Area 1 consisted of eight buildings (Bldgs. 301-304, Bldgs. 306-308, and Bldg. 310), 43 ASTs, and two rail lines (Figure 1-3). Buildings 302 Sulphuric Acid Concentration Plant, 308 Ammonia Oxidation Plant, and 310 are the only remaining original structures at the site. The National Aeronautics and Space Administration (NASA) constructed a metal building between former Bldgs. 301 and 302. This metal building was formerly used by NASA as an incinerator, but is currently used for equipment storage.

No information was obtained during the IT records review to indicate the type of process conducted at each building; however, identification of five storage areas was determined from the drawings: Oleum Storage (12 tanks), Concentrating Mix Storage (six tanks), Sulfuric Acid Sales (12 tanks), TNT Residual Acid Storage (five tanks), and Mixed Storage (eight horizontal tanks) as shown on Figure 1-3. Based on the location of the Oleum Storage, Sulfuric Acid Sales Storage, and Mixed Storage in close proximity to the rail line, the stored material was likely transferred directly to and from tanker cars or containers on a routine basis.

An SI of Acid Area 1 was conducted in 1998 by IT to determine the existence and nature of contamination, and to evaluate potential risks to human health and the environment (IT, 1998). Fifteen soil borings were completed to characterize lithology and to collect soil samples for off-site laboratory analysis. Total depths of these borings ranged from 4 to 10 ft below ground surface (bgs).

A remedial investigation (RI) was performed May 2007 through May 2008 to define the extent of soil contamination and to evaluate impacts to the groundwater, surface water, and sediment in the vicinity of Acid Area 1. A total of 45 soil samples were collected from 23 locations, which

were placed adjacent to buildings and storage tanks. A total of 15 co-located surface water and sediment samples were collected from the drainage ditches. At least one upgradient and one downgradient sample was collected from each of the four drainage ditches.

Ecological surveys were performed by Jacobs's ecologists and their subcontractor in the spring and fall of 2008. Prior to arrival at the site, personnel obtained relevant information on the site including topographic, township, county, and other appropriate maps, and determined the location of potential ecological units such as streams, creeks, ponds, grasslands, forest, and wetlands at or near the site. Additionally, the 1994 biological inventory of PBOW (National Aeronautics and Space Administration [NASA], 1995) that identified the locations of threatened and endangered species at PBOW was reviewed. 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. Jacobs's personnel also used the reconnaissance to evaluate the site for more subtle indications of potential effects from contaminant release.

2.1.2 Surface Water

Four drainage features are present at the site. The drainage ditch to the south is located approximately 40 ft south of the service road and drains to the west, parallel to the site, discharging into Ransom Brook west of the site. This drainage feature has little relief adjacent to the site. Another drainage ditch originates on site on the north central portion of the site and drains to the north. This drainage feature is approximately 30 to 40 ft wide and 15 to 18 ft deep just north of the Acid Area 1 site. A third drainage ditch originates in a low swampy area in the west central portion of the site and drains to the west into Ransom Brook. The fourth drainage ditch originates at a ponded area with a man-made dike in the northwest corner of the site, which also drains west into Ransom Brook. Flowing water has been observed in all four drainage ditches during the wet season in early to mid spring. All but the northern drainage ditch dry up by mid summer including the ponded area and the swampy area.

2.1.3 Wetlands

According to the National Wetland Inventory (NWI) Maps for the area (U.S. Fish and Wildlife Service [USFWS], 1977), there are no designated wetlands at the Acid Area 1 site. It should be noted that the accuracy of NWI maps are limited, especially in relatively flat landscapes such as PBOW because minor depressions often contain isolated wetlands not easily identified through air photo interpretation, which is the process used by the USFWS in preparing NWI maps. As discussed in the following section, small wetland areas do exist at the site.

2.1.4 Vegetative Communities

The predominant community types observed at Acid Area 1 are Upland Old Fields, Shrub Thickets, and Successional Woods.

Figure 2-1 is a general habitat map that presents the type and extent of biological communities within the site. The ecological survey is provided in Appendix A. A general description of each predominant vegetative community type is provided below.

Upland Old Fields. These areas are dominated by grasses and herbs and have been recently disturbed by mowing and/or brush hogging. Scattered shrubs, small trees, and groups of shrubs also occur in these areas.

Shrub Thickets. Dense areas of shrub thickets are present at Acid Area 1. *Cornus racemosa* (gray dogwood) dominates most of these areas. *Eleagnus umbellata* (autumn olive) is also common. Small trees and saplings also are present within the shrub thickets.

Successional Woods. Successional woods comprise small and moderate sized trees, primarily *Fraxinus pennsylvanica* (green ash), *Acer negundo* (box elder), and *Populus deltoids* (cottonwood). These areas generally have moderate to dense shrubby understory. The herbaceous layer is dense in most areas. *Carex* spp. (sedges) dominate most of the understory.

Marsh. Small areas of marsh are found within Acid Area 1. These areas are generally dominated by cattails, with other species such as sedges and bulrushes also occurring. All of these areas were either created by, or influenced by, past disturbances.

Scrub/Shrub Wetlands. Several areas of scrub/shrub wetlands are found within Acid Area 1. The drainage ditch along the south side of this site is also a scrub/shrub wetland. These areas contain *Cornus racemosa* (gray dogwood) along with herbaceous species such as sedges and horsetails.

2.1.5 Species Inventory

Based on information from ODNR (1995) and information collected during the site reconnaissance in May and October of 2008, species lists were prepared for plants, mammals, birds, reptiles, amphibians, and fish. Of the 365 plant species documented at the 6,453 acre former PBOW by the ODNR, 151 of the common plant species frequently observed at Acid Area 1 are listed in Table 2-1. The ecological survey is provided in Appendix A.

Of the 43 species of mammals that may be found in the region based on species range maps, white-tailed deer were observed onsite during the ecological surveys. Numerous deer tracks were also observed during the site reconnaissance. Mammal signs observed included the eastern fox squirrel, coyote, and raccoon. It is likely that other species are present but were not observed due to the short duration of the field visits.

Of the 129 species of birds that may be found in the region based on species range maps, 105 species (81 percent) have been recorded at the former PBOW by the ODNR during their multiyear studies. Twenty eight bird species were documented at Acid Area 1 during the ecological surveys performed by Jacobs. Of the species recorded by the ODNR, 49 were neotropical migrants and would not be expected to nest at the former PBOW. ODNR (1995) notes that, of the top 50 bird species recorded at the former PBOW, only 6 were ground nesters and 3 others occasionally nest on the ground.

The large deer population that feeds on much of the ground cover at the former PBOW limits the cover available for nesting birds which results in increased predation for these ground nesting species (ODNR, 1995). Current burning practices used by NASA limit ground cover over the eastern portion of PBOW. Burning has not been conducted in the Acid Area 1 vicinity

for at least 10 years (Long, 2008). Former burning practices are not expected to have an impact on the current presence of species at Acid Area 1, as any ground cover affected by previous burning would have had ample time to recover. The 15 most abundant bird species recorded at the former PBOW by the ODNR included the American robin; red-winged blackbird; European starling; song sparrow; common grackle; field sparrow; American goldfinch; indigo bunting; blue jay; common yellowthroat; brown-headed cowbird; house wren; gray catbird; northern cardinal; and cedar waxwing. All of the bird species were observed during the ecological surveys with the exception of the cedar waxwing and indigo bunting (Table 2-1).

Of the 14 species of reptile that may be found in the region based on species range maps, 10 species (71%) have been observed at the former PBOW, including turtles and snakes (ODNR, 1995). During the ecological surveys, no reptiles were observed at Acid Area 1.

Of the 10 species of amphibians that may be found in the region based on species range maps, nine species (90%) have been observed at the former PBOW (ODNR, 1995), including salamanders, toads, and frogs. No amphibians were observed at Acid Area 1 during the ecological surveys.

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. However, none are expected to be present at Acid Area 1 given the limited quality of surface water habitat available to support fish.

In addition to the wildlife discussed above, additional species observed during site reconnaissance visits included ants (active ant mounds), yellow jackets, honey bees, cicadae, monarch butterfly, Japanese beetles, and unidentified moth species.

Figures 2-2 and 2-3, respectively, provide simplified terrestrial and aquatic food webs for Acid Area 1 as ecological conceptual site models (ECSMs).

2.1.6 Threatened and Endangered Species Information

According to an Ohio Division of Natural Areas and Preserves (DNAP) review of their natural heritage maps and files (Woischke, 1998), there are records of legal status threatened or endangered species within a 2-mile radius of the site. These species include the following:

- Sedge wren (*Cistothorus platensis*) - endangered
- Dwarf bulrush (*Lipocarpha micrantha*) - threatened
- Twisted yellow-eye-grass (*Ayris torta*) - threatened
- Field sedge (*Carex conoidea*) - threatened
- Least St. John's-wort (*Hypericum gymnanthum*) - endangered
- Flat-leaved rush (*Juncus platyphyllus*) - endangered
- Bushy aster (*Aster dumosus*) - threatened

In addition, based on information contained in ODNR (1995), there are several species of threatened or endangered plants, potentially threatened plants, threatened or endangered birds and one endangered mammal that have been recorded at PBOW, as follows:

- Grove sandwort (*Arenaria laterijlora*) - threatened
- Thin-leaved sedge (*C. cephaloidea*) - endangered
- Ashy sunflower (*Helianthus mollis*) - 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
- Winter wren (*Trogoldytes troglodytes*) - endangered
- Cattle egret (*Bublucus ibis*) - endangered
- Black-crowned night heron (*Aycticorax nycticorax*) - threatened
- Trumpeter swan (*Cygnus buccinator*) - endangered
- Upland sandpiper (plover) (*Bartramia longicauda*) - threatened
- Indiana bat (*Myotis sodalis*) - endangered

Also, wild white lettuce, a species considered extinct in Ohio but common in prairie states was recently found on site, although not in the vicinity of Acid Area 1 (Peecook, 1998).

Based on the ecological surveys conducted by Jacobs, no threatened or endangered species were found in Acid Area 1.

2.2 Selection of Chemicals of Potential Ecological Concern

COPECs are the chemicals that were identified as site-related and potentially capable of contributing significantly to risk, and were carried forward to quantitative evaluation in the SLERA (Table 2-2). The following subsections describe the process for their identification. Prior to initiation of the SLERA, a list of chemicals present in site samples was compiled. This initial list included all chemicals detected in any site medium. COPECs were selected from this list as described in the following sections.

2.2.1 Data Organization

The data for each chemical were sorted by medium. For ecological impacts, soil from 0 to 5 ft bgs was considered for the evaluation at Acid Area 1. The 0 to 5 ft depth interval was selected for three primary reasons: (1) to maintain consistency with other PBOW ecological risk assessments that used this depth interval; (2) to include potential exposure to the shrew, a representative burrowing insectivorous mammal; and (3) to increase the size of the total soil database by including samples collected from a depth interval of 4 to 5 ft; although the shrew may not actually burrow to a depth of 5 ft, there may be other burrowing mammals that do burrow this deep. Chemicals that were not detected at least once in a medium were not included in the risk assessment. Available background data were determined for each medium. Sources of background information include data from previous investigations.

Analytical data may have 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 (U.S. EPA, 1989):

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.

N — The analysis indicates an analyte for which there is presumptive evidence to make a tentative identification.

NJ — The analysis indicates a "tentatively identified analyte", and the reported value represents its approximate concentration.

UJ — The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

R — Quality control indicates that the data are unusable (chemical may or may not be present).

B — Inorganic chemicals: the concentration is less than the contract-required detection limit but greater than the instrument detection limit. Organic chemicals: the concentration in the sample is not sufficiently higher than the concentration in the blank, using the five-times, ten-times (5x, 10x) rule, whereby a chemical is considered a nondetect unless its concentration exceeds five or ten times the blank concentration. For common laboratory contaminants (acetone, 2-butanone [methyl ethyl ketone], methylene chloride, toluene, and the phthalate esters), the sample concentration must exceed 10 times the blank concentration to be considered a detection.

"J", "N", and "NJ" qualified data were used in the SLERA; "R" data and "B" qualified data were not used. The handling of "U" qualified data (nondetects) in the SLERA is described in

Section 2.2.2. Where confidence was reasonably high that the chemical was present but the actual concentration was somewhat in question, the data generally were used.

Occasionally, chemicals were analyzed under two different analytical programs. For example, the dinitrotoluenes (DNTs) were analyzed by U.S. EPA Method 8330 for nitroaromatics as well as U.S. EPA Method 8270B for semivolatile organic compounds (SVOCs). U.S. EPA Method 8330 provides concentration values for total DNT, but does not provide isomer-specific data. U.S. EPA Method 8270B, on the other hand, provides concentrations for 2,4- and 2,6-DNT isomers, but does not provide a value for total DNT. For each medium evaluated it was necessary to choose the results provided by one analytical method rather than both to avoid double-counting and overestimating ecological hazard. The value for the method considered more sensitive to that specific analyte was used in lieu of the value from the less sensitive method when multiple analytical results were available for an analyte from more than one method. In most cases, the method with the lower detection limit and reporting limit was the more sensitive method.

2.2.2 Developing Exposure-Point Concentrations

The exposure-point concentration (EPC) is a conservative estimate of the average concentration of a COPC, statistically calculated from the analytical results of all samples for a particular environmental medium within an exposure unit.

Because of the uncertainty associated with characterizing contamination in environmental media, both the mean and the upper confidence limit (UCL) of the mean are usually estimated for each COPC in each medium of interest. The UCL of the mean computed at a 95 percent confidence level is generally referred to as the 95 percent UCL of the arithmetic mean (UCL_{95}).

Concentrations of analytes in environmental samples are determined by using established analytical methods and accurately calibrated laboratory instrumentation. These methods and instruments have practical limits in their ability to accurately report very low and very high analyte concentrations. Each laboratory data value is typically reported with two associated limits; a detection limit and a quantitation limit. The detection limit is the minimum concentration of the analyte that can be differentiated from the normal, random noise of an analytical method or instrument. The quantitation limit, sometimes referred to as the reporting limit, is the minimum concentration of the analyte that can be reliably quantified. Laboratories sometimes report numerical values for analyte concentrations that are greater than the detection limit but less than the quantitation limit. These values are often referred to as "trace level concentrations" and are only rough approximations of the true analyte concentration.

Very high analyte concentrations can cause serious damage to some analytical instruments. Samples with known or suspected high analyte concentrations may be diluted before analysis to lower the analyte concentrations to levels that can be safely analyzed. The analyzed concentration values are then adjusted by the dilution factor to properly represent the analyte concentration in the original undiluted sample.

When a sample is diluted, the detection limits and quantitation limits for that sample must be adjusted by the dilution factor. For example, if a sample is diluted by a factor of 10 (the sample volume is increased to 10 times the original sample by dilution with a solvent before analysis), then the corresponding detection limit and quantitation limit must be multiplied by a factor of 10.

The detection limits and quantitation limits used in this project have been adjusted for dilutions and are referred to as sample detection limits and sample quantitation limits to indicate that the limits are specific to each individual sample and analytical method. These sample detection and quantitation limits may have also been adjusted by the laboratory for percent moisture in soil and sediment samples. Samples with higher moisture content will have higher sample detection and quantitation limits when the data are reported on a dry-weight basis.

For some analytical methods, the presence of even one analyte with a very high concentration in a sample may necessitate the use of a large dilution that will result in elevated sample detection and quantitation limits for all analytes in that sample for that analytical method. This is especially true for organic analyses using gas-chromatography and mass-spectrometer methods such as for dioxins/furans, nitroaromatics, PCBs, PAHs, volatile organic compounds (VOCs), and SVOCs. For these methods a lower dilution for the non-detected analytes cannot be used without possible damage to the analytical instruments. Large dilutions of 1,000 or even 5,000 times may be required for some samples from heavily contaminated areas. These large dilutions result in two significant complications for statistical computations.

- Some analytes may be present in a sample at significant concentrations, but are reported as non-detects with elevated sample detection limits because of dilutions.

- Elevated sample detection limits, even for true non-detects, can cause a high-bias in computed UCL_{95} estimates. The magnitude of this high-bias can be significant and is unpredictable for most non-parametric UCL methods.

The proper handling of non-detect data points in statistical computations is critical for the generation of realistic UCL_{95} estimates. Analytical laboratory data sets used for UCL_{95} estimates can be classified as full, left-censored, or interval-censored data sets.

- A full data set is one in which every data point has a value that is assumed, for the purposes of statistical computations, to accurately represent the true analyte concentration in each sample. All data values in a full data set are considered to be positive detections because each reported concentration is greater than the associated sample quantitation limit.

- A left-censored data set is one in which some of the data points cannot be reported with an accurately known value. The non-detects in a laboratory data set are known as censored values. Laboratory data non-detects are called left-censored because the data are reported as "less-than" some value, usually the sample detection limit. These "less-than" data are said to be censored at the detection limit. The only information known about the numerical value of a censored data point is that the true concentration is less than the censoring value.

- Interval-censored data sets contain data points that are reported as being between two censoring values. Many laboratories report estimated data as "trace-level values" with concentrations between the sample detection limit and the sample quantitation limit. These trace-level values are intended to represent concentrations that are believed by the laboratory to be positive detections, above the sample detection limit, but have concentrations too small to be accurately quantified. These interval censored data can be evaluated by some statistical methods as being greater than a lower censoring level

(the sample detection limit) and less than higher censoring level (the sample quantitation limit).

The interval-censored data values for this project were evaluated as though they were positive detections. Trace-level values reported as greater than the sample detection limit but less than the sample quantitation limit are assumed to be detected, uncensored values. For this project, all data sets were considered to be either full or left-censored.

The U.S. EPA statistical software package ProUCL Version 4.0 was used to compute estimated UCL_{95} concentrations for all data sets containing four or more distinct detected values. ProUCL uses numerous parametric and nonparametric statistical methods to compute UCLs. Parametric methods assume that the data set being evaluated fits closely to a known, predictable data distribution. Nonparametric methods do not rely on the data set fitting a specific distribution.

ProUCL computes parametric UCLs using normal, lognormal, and gamma distributions. Nonparametric UCLs are computed using a variety of methods including maximum likelihood estimation, central limit theorem, jackknife, bootstrap, Kaplan-Meier (KM), and regression on order statistics. Maximum likelihood estimation and regression on order statistics methods are sometimes referred to as semi-parametric methods. These two methods use techniques to estimate or assume temporary surrogate values for censored data points before computing estimated UCLs.

Detailed descriptions of the statistical methods used in ProUCL are available in the following two documents:

- ProUCL Version 4.0 User Guide (U.S. EPA/600/R-07/038, April 2007, www.epa.gov) (U.S. EPA, 1997b)
- ProUCL Version 4.0 Technical Guide (U.S. EPA/600/R-07/041, April 2007, www.epa.gov) (U.S. EPA, 1997c)

The ProUCL User Guide acknowledges that at one time the U.S. EPA recommended using one-half the detection limit as replacement values for non-detects when only a small percentage of the data were non-detects. This has become the traditional approach for many projects and is known as the "DL/2" method. The U.S. EPA now advises against using DL/2 for any statistical calculations. Several studies have shown that DL/2 frequently results in unrealistic statistical results. Several nonparametric statistical methods are now recommended for data sets with non-detects (censored data sets). Since many work plans still reference the DL/2 method it has been included in ProUCL Version 4.0 but with the following comment "Note: DL/2 is not a recommended method."

ProUCL computes estimated UCLs using two slightly different approaches depending on whether the data set to be evaluated is a full data set or a censored data set.

Full Data Sets

- Raw statistics are computed (i.e., minimum, maximum, mean, median).

- Data set is tested for normal distribution, lognormal distribution, and gamma distribution.
- Parametric UCLs are computed as appropriate.
- Nonparametric UCLs are computed as appropriate.
- Recommended UCLs are listed based on logic programmed into ProUCL.

Censored Data Sets

- Raw statistics are computed based on the detected data points only.
- Data set is tested for normal, lognormal, and gamma distributions using the detected data points only.

Note: For data sets with multiple detection limits for non-detects, all data less than the largest non-detect detection limit are considered non-detects. This includes positive detections with values less than the maximum non-detect detection limit. If non-detects exist for samples with very large dilutions, a large percentage of the detected data may be considered to be non-detect at an elevated detection limit. This approach is known as "censoring at the highest detection limit."

- Parametric UCLs are computed as appropriate, treating all values less than the largest non-detect detection limit as non-detects.
- Nonparametric UCLs are computed as appropriate, treating all values less than the largest non-detect detection limit as non-detects --- except for the KM, regression on order statistics, and DL/2 methods. KM and regression on order statistics are able to handle multiple detection limits (Kaplan and Meier, 1958). The DL/2 method simply uses one-half the sample detection limit for each non-detect value.
- Recommended UCLs are listed based on logic programmed into ProUCL.

For data sets with multiple detection limits for non-detects, ProUCL recommends using the KM method UCLs. For this project, essentially all data sets with more than one non-detect have multiple detection limits for the non-detect samples. The KM UCLs are therefore recommended for data sets in this project that have more than one non-detect sample.

Analytical data from field duplicates were joined with parent sample results to yield one result for use in the statistical manipulations as follows:

- Use the average value of the field duplicate and parent sample results if both are positive detections.
- Use the average value of field duplicate and parent sample detection limits if both are non-detects.

- Use the detected value if one sample is a positive detection and the other is a non-detect.

The UCL_{95} or maximum detected concentration (MDC), whichever is smaller, was selected as the EPC and is understood to represent a conservative estimate of average for use in the risk assessment (RA) or in various transport models used to estimate exposure.

2.2.3 Frequency of Detection

Chemicals that are detected infrequently may be artifacts in the data that do not reflect site related activity or disposal practices. Such chemicals were not included in the risk evaluation. Generally, chemicals that are detected only at low concentrations in less than 5% of the samples from a given medium are dropped from further consideration unless their presence is expected based on historical information for the site. For the current assessment, nitroaromatics were not eliminated as COPECs because this group of constituents is site related.

2.2.4 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 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. No members of this latter group were selected as site-related chemicals; therefore, an exposure analysis for essential nutrients was not performed (Appendix B).

2.2.5 Background Screening

For background screening, the MDC was compared to the PBOW chemical-specific background screening concentration (BSC) for soil. BSCs for soil established as part of the acid areas investigation (IT, 1998) were used for this RA. BSCs for soil were reported as the 95 percent upper tolerance limit (UTL) for lognormal data sets or the 95th percentile for datasets with a nonparametric distribution.

Background screening also applies to certain organic compounds that are part of normal background concentrations. Such chemicals may include VOCs and PAHs, a class of organic compounds that form from natural or anthropogenic combustion of organic matter including fossil fuels and are generally ubiquitous in the environment. Airborne PAHs associated with non-Department of Defense sources may be deposited on soil and leach to groundwater.

Background screening was applied to each inorganic constituent whose MDC exceeded the risk-based screening criteria (RBSC) and that could not be characterized as an infrequently detected analyte. Background screening consisted of comparing the MDC of the site data set to the BSC. Background screening was not used to eliminate COPECs. Comparison of COPEC concentrations to background levels is discussed in Section 5.4.

2.2.6 Comparison to Risk-Based Screening Ecotoxicity Values

A comparison was made between EPCs of chemicals in sampled media and the risk-based screening ecotoxicity value (RBSEV) for ecological endpoints following recommendations received from OEPA and as discussed in U.S. EPA Region 5 Biological Technical Assistance Group (BTAG) Bulletin No. 1 (U.S. EPA, 1996a). Chemicals that exceeded the RBSEVs, or for which no RBSEV is available, were retained as COPECs. The following RBSEVs or RBSEV hierarchy, as noted, were used for the ecological evaluation:

- **Soil.** Soil (surface and subsurface soil) screening values were selected using the following hierarchy: (1) Preliminary Remediation Goals for Ecological Endpoints (Efroymson et. al., 1997a); (2); Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process (Efroymson, Suter, and Will, 1997b); (3) Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants (Efroymson et. al., 1997c); and (4) Ecological Data Quality Levels (EDQLs)(U.S. EPA, 1999a). 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) Ohio EPA Water Quality Criteria (WQC) for the protection of aquatic life; (2) Preliminary Remediation Goals for Ecological Endpoints (Efroymson et. al., 1997a); and (3) EDQLs (U.S. EPA, 1999a). A hierarchy was not used because this type of approach would potentially eliminate important surface water COPECs, as OEPA WQC do not consider food-chain effects.

- **Sediment**. Sediment screening values were selected using the following hierarchy: (1) EDQLs (U.S. EPA, 1999a); (2) Preliminary Remediation Goals for Ecological Endpoints (Efroymson et. al., 1997a); and (3) Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario (Ontario Ministry of the Environment and Energy [OME], 1993).

The results of the screening and the selected COPECs with RBSEVs for ecological endpoints of concern are presented in Table 2-2. COPECs were selected for further consideration in the SLERA only if the MDC exceeded the available RBSEV. If no RBSEV was available, the constituent was carried forward for consideration in the SLERA unless it was within background or if it was detected in less than 5 percent of the samples for a given medium.

2.3 Results of the Data Evaluation

Previous investigations at Acid Area 1 confirmed the presence of soil contamination from former PBOW operations. The sampling locations for these investigations are provided in Figure 2-4. The objective of the soil investigation conducted under the RI (Jacobs, 2006) was to evaluate the presence of soil contamination at additional former site facilities not previously sampled. Surface water and sediment samples were collected from the drainage ditches in and adjacent to Acid Area 1; a total of 15 surface water and sediment samples were collected.

Table 2-2 provides the following information for each detected chemical for each medium at Acid Area 1:

- Chemical name,
- Frequency of detection,
- Range of detected concentrations,
- Range of detection limits,
- Estimate of the mean of the site concentrations including detected and non-detected compounds,
- Appropriate BSC (background),
- Appropriate RBSEV, and
- Selection/exclusion of chemical as a COPEC.

Surface Soil. A maximum of 38 surface soil samples and 37 subsurface soil samples were collected at Acid Area 1. For the ecological screening of soil, a maximum of 61 surface soil and subsurface soil samples were used in the ecological risk assessment. Depths for the samples were from surface to five ft bgs. Chemicals detected in soils include nitroaromatics, metals, PAHs, PCBs, and VOCs. None of the 61 samples were tested for all detected compounds with the exception of metals, PAHs, and VOCs. For the remainder of the analyses, 41 samples were tested for nitroaromatics (except for 2-amino-4,6-dinitrotoluene and 4-nitrotoluene, which was tested for in 39 samples) and 54 samples were analyzed for PCBs. Specific compounds exceeding soil RBSEVs are identified in Table 2-2.

Surface water. Metals are the primary chemicals detected in the 12 surface water samples collected from Acid Area 1. Nitroaromatics, PAHs, and VOCs were generally not detected with the exception of one or two locations. PCBs were not detected in any of the surface water samples. Specific compounds exceeding surface water RBSEVs are identified in Table 2-2.

Sediment. Chemicals detected in the 15 sediment samples collected at Acid Area 1 include metals, PAHs, PCBs, and VOCs. Specific compounds exceeding sediment RBSEVs are identified in Table 2-2.

2.4 Selection of Assessment Receptors

Assessment receptors were selected to represent receptor groups (e.g., insectivorous mammals) known or likely to be present at the site. The assessment receptors were selected for evaluation during the predictive SLERA. The selection process focused on species, groups of species, or functional groups, rather than higher organization levels such as communities or ecosystems. This focuses the exposure characterization on species or components that are the most likely to be affected by the toxicological and mobility characteristics of the COPECs and also focuses on those COPECs that are most likely to produce greater effects in the on-site ecosystem. Site biota was organized into two major functional groups: terrestrial and aquatic. 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 (waterfowl and fish), aquatic invertebrates, and wetland/terrestrial mammals. Species presence at the site was determined by a literature

review and the ecology survey (Sections 2.1.5 and 2.1.6) prior to identification of target receptor species.

Primary criteria for selecting appropriate assessment receptors included, but were 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 the COPECs given their mode of toxicity, propensity to bioaccumulate, etc.
- 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 (RTE) by a governmental organization or may represent a critical habitat for RTE species. Based on the availability of species-specific data, an RTE surrogate species may have been selected. 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 they will be present at the site or that habitats present at the site could support the species.

It is important that sufficient toxicological information be available in the literature for the receptor species or that a closely related species be selected. While the ecological communities at the site have species with many desirable characteristics for use as receptor species, not all of these species have been used extensively for toxicological testing.

2.4.1 Terrestrial Receptors

Seven representative assessment receptor species that are expected or possible in the vicinity of Acid Area 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, including herbivory, omnivory, and carnivory. Potential impacts to terrestrial plants are considered in Section 5.1. The seven 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). The marsh wren was selected as a surrogate for the sedge wren, an Ohio endangered species that has been documented in the general area and a species that may be expected on site given the availability of some preferred nesting habitat.

The deer mouse, shrew, Eastern cottontail, and marsh wren represent the prey base for the larger predators of the area, represented by the red-tailed hawk. A terrestrial food web is presented in Figure 2-2. Many of these species have limited home ranges, particularly the deer mouse, cottontail, shrew, and marsh wren, which make them particularly vulnerable to exposure from site contaminants. All of the selected terrestrial receptor species have a potentially 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. In addition, all of the selected species are likely to occur after site remediation, if risk management decisions require it. 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 (U.S. EPA, 1993).

Larger mammal species were generally not selected as sensitive receptors due to their large home ranges; however, the far-ranging 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 was bounded by the predicted risks to the selected terrestrial indicator receptors. Area use factors were conservatively set to 100 percent for the mouse, shrew, rabbit, wren, and raccoon, due to their relatively small home ranges. For the deer and hawk, the area use factor was set at 0.02 (2%) and 0.01 (1%), respectively, based on these two species' relatively large home ranges (518 and 842 hectares, or 1,280 and 2,081 acres, respectively), compared with the size of the site (25 acres).

Results of the assessment receptor selection process are presented in detailed biological and ecological descriptions called assessment receptor profiles (ARPs). Additionally, the biologically relevant criteria used to select the 7 terrestrial assessment receptors are discussed and summarized in the ARPs (Appendix C).

2.4.2 Aquatic Receptors

The only aquatic habitats at the site are the surface water drainages on the northern side and southern side of the site. Exposure to aquatic organisms within the water bodies and/or wetlands was assumed to occur via direct exposure to contaminants in the water column and via ingestion of benthic invertebrates exposed to contaminants in surface water and sediment. Potential effects to macroinvertebrates and phytoplankton (algae) were assessed using available surface water and sediment quality criteria for the protection of aquatic life (Section 5.2). Potential uptake through the food chain was evaluated for two representative receptors, consisting of the raccoon (also considered as a terrestrial receptor) and the mallard duck (*Anas platyrhynchos*) (medium-sized aquatic omnivore).

Aquatic organisms represent some of the prey base for aquatic receptors (represented by the mallard and raccoon). A food web is presented in Figure 2-3. The selected receptor species have relatively small home ranges, which makes them particularly vulnerable to exposure to site contaminants. Foraging factors were set to two and six percent for the mallard and raccoon, respectively, because of the limited amount of surface water and sediment at the site (less than about 1 acre, Section 2.1.2). It should be noted that the term foraging factor is similar to the term area use factor that is used for terrestrial receptors. Both of the selected aquatic receptor

species have been documented near the site, have a potential high abundance and wide distribution at the site, and sufficient toxicological information (with the exception of the mallard bird species) was available in the literature for comparative and interpretive purposes. In addition, both of the selected species are likely to occur after site remediation (if risk management decisions require it) and both are important to the stability of the local ecological food-chain and biotic community. Finally, the selected species have readily available exposure data, as summarized in the Wildlife Exposure Factors Handbook (U.S. EPA, 1993).

The biological relevant criteria used to select the aquatic assessment receptors are discussed and summarized in the ARPs in Appendix C.

2.5 Ecological Endpoint (Assessment and Measurement) Identification

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 such as the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) (United States Code [U.S.C.] Title 42, Section 9601 [42 U.S.C. 9601] et seq.) and the National Environmental Policy Act (NEPA) (42 U.S.C. 4321 et seq.). Other legislation includes the Endangered Species Act 16 U.S.C. 1531-1544 and the Migratory Bird Treaty Act 16 U.S.C. 703-711. To determine whether these protection goals are met at the site, assessment and measurement endpoints were 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, non-domesticated receptors. In the SLERA process, the risks to individuals are assessed only if they are protected under the Endangered Species Act, are species that are candidates for protection, or are species that are considered rare. The results of this SLERA may be used to determine whether remediation or additional investigation is warranted at the site to protect populations of ecological receptors.

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) definable in clear, operational terms (Suter, 1993). Selected assessment endpoints should 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. Information gained during the site reconnaissance was used to assist in the selection of assessment and

measurement endpoints. These endpoints, formal expressions of the environmental values to be protected (Suter, 1993), were used to focus the goals of the SLERA (Table 2-3).

Measurement endpoints for this SLERA are based on toxicity values from the available literature and not on statistical or arithmetic summaries of actual field or laboratory observations or measurements. Where possible, receptors and endpoints were 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 were 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.

2.5.1 Assessment Endpoints

The assessment endpoints for Acid Area 1 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, aquatic benthic invertebrates, omnivorous aquatic mammals, and omnivorous aquatic birds." The corresponding H_o 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 populations 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 Acid Area 1. Historical information, site reconnaissance, and the availability of toxicological data were used to select terrestrial and aquatic receptor species. These receptor species are depicted in food web ECSMs in Figures 2-2 and 2-3. 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 detailed species selection at the base of the food web (i.e., specific terrestrial/benthic invertebrates or aquatic vertebrates). Thus, generic terrestrial invertebrates, benthic invertebrates, and aquatic sediment-dwelling organisms 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 (Section 3.1). These tissue concentrations were then used as input values for exposure to higher trophic level receptors through the dietary ingestion route. Brief life-history descriptions for the selected area receptor species are provided in Appendix C.

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.

In terrestrial species, bioconcentration may occur in plants and invertebrates, and higher food chain receptors may bioaccumulate COPECs through the ingestion of food items.

2.5.2 Measurement Endpoints

Measurement endpoints are 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 in toxicity tests; individual abundance; species diversity; and the presence or absence of indicator data in field surveys of existing impacts (U.S. EPA, 1997a).

For assessments, measurable responses to stressors may include lowest observed adverse effect levels (LOAEL), no observed adverse effect levels (NOAEL), lethal concentration to 50 percent (LC_{50}) of the test population, lethal dose to 50 percent (LD_{50}) of the test population, or effective concentration for 20 percent (EC_{20}) of the test population, collectively termed toxicity reference values (TRVs) (see Section 4.2 for further explanation). In addition, critical effect values for surface water, sediment and soil were selected as measurement endpoints (Table 2-3). The most appropriate measurement endpoints were chosen based on exposure pathways as well as ecotoxicity of the contaminant.

2.6 Ecological Conceptual Site Models

Pictorial representations of potential exposure through the food web are presented in Figures 2-2 and 2-3. The ECSMs trace the contaminant pathways through both abiotic components and biotic food web components of the environment. The ECSMs present all potentially complete exposure pathways. The ECSMs were 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

Estimates of the nature, extent, and magnitude of potential exposure to COPECs present at Acid Area 1 were developed for both current and reasonably plausible future assessment receptors. Exposure characterization is critical in further evaluating the risk from potential exposure to contaminants identified as COPECs. The exposure assessment was conducted by linking the magnitude (concentration) and distribution (locations) of the contaminants detected in environmental media, evaluating pathways by which chemicals may be transported through the environment, and determining the points at which assessment receptors may contact contaminants. The concepts of bioaccumulation, bioconcentration, and biomagnification are used throughout this document. These terms are defined by U.S. EPA (1997a) as follows:

- **Bioaccumulation.** General term describing a process by which chemicals are taken up by an organism either directly from exposure to a contaminated medium or by consumption of food containing the chemical.

- **Bioconcentration.** A process by which there is a net accumulation of a chemical directly from an exposure medium into an organism.

- **Biomagnification.** Result of the process of bioaccumulation and biotransfer by which tissue concentrations of chemicals in organisms at one trophic level exceed tissue concentrations in organisms at the next lower trophic level in a food chain.

3.1 Exposure Analysis

An exposure analysis combining the spatial and temporal distribution of the assessment receptors and the COPECs was performed to evaluate potential exposure. The exposure analysis focused on the amount of the COPECs assumed to be bioavailable and the pathways by which the ecological receptors would be exposed. The focus of the analysis was dependent on the assessment receptors evaluated and the assessment and measurement endpoints.

Contamination of biota could result from exposure to one or more COPECs. Bioavailability is an important contaminant characteristic that influences the degree of chemical-receptor interaction. Bioavailable substances are those that a receptor can extract from the environment. Bioavailability of a chemical is a function of its physical and chemical environmental factors including grain size and organic carbon content and its tendency to partition between one environmental medium and another (e.g., soil to water) or to the receptor.

Exposure pathways for biota may be direct (bioconcentration) or through the food web via the consumption of contaminated organisms (bioaccumulation and biomagnification). Direct exposure routes include ingestion, inhalation, dermal contact, and absorption. 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. 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.

Exposure pathways consist of four primary components: source and mechanism of contaminant release, transport or exposure 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 are addressed in this SLERA. The major fate and transport properties associated with site contaminants are presented in subsequent sections. These properties directly affect a contaminant's behavior in each of the exposure pathway components.

For terrestrial faunal receptors, calculation of exposure rates relied upon determination of an organism's exposure to COPECs found in surface soil and on transfer factors used to estimate potential food-chain exposure. Exposure rates for terrestrial wildlife receptors were based on ingestion of contaminants from these media and from consumption of other organisms. Given the scarcity of available data for dermal and inhalation exposure of wildlife, potential risk from these pathways was not estimated. In addition, dermal and inhalation pathways were generally considered to be incidental for most species, with the possible exception of burrowing animals and dust-bathing birds.

The first step in estimating exposure rates for terrestrial wildlife involved the determination of food ingestion and drinking water intake rates for assessment receptors. U.S. EPA (1993) includes exposure parameters for a number of avian and mammalian species. Available data for feeding and watering rates and dietary composition were obtained for species, or were estimated using allometric equations (Nagy, 1987). Data gathered on incidental ingestion of soil were also incorporated for the assessment receptors. Species-specific exposure parameters are presented in Table 3-1.

Equations have been developed for terrestrial vertebrate receptors accounting for exposure via incidental ingestion of contaminated soil, ingestion of contaminated water, ingestion of plants grown in contaminated soil, and prey items. Singular equations have been developed for soil to plant uptake and for animal bioaccumulation (transfer factors). The basic equation for estimating dose through the dietary pathway is:

$$D_p = \sum_{k=1}^{m} (C_k \cdot F_k \cdot I_k)/W \qquad \textbf{Eq 3 .1}$$

where:

D_p = the potential average daily dose (milligram per kilogram per day [mg/kg-day])

C_k = the average COPEC concentration in the kth food type (milligrams per kilogram [mg/kg] dry weight)

F_k = the fraction of the kth food type that is contaminated

I_k = the ingestion rate of the kth food type (kilogram [kg] dry weight/day)

W = the body weight of the receptor (kg wet weight)

For aquatic faunal receptors, the calculation of exposure rates depends on the contaminant concentration in water and sediment, food-chain multipliers, bioconcentration factors (BCF), and bioaccumulation factors (BAF). If appropriate, an evaluation can be made of the time each organism spends associated with surface water or sediment pore water in order to modify exposure rates; however, this approach was not used in this SLERA.

Adjustments were made for potential biomagnification of contaminants through aquatic trophic levels. Food chain multipliers (FCMs), derived by U.S. EPA (1995) were used to assess the possibility of contaminant magnification through site receptors. The FCMs are multiplied by chemical-specific BCFs to obtain BAFs. The SLERA used laboratory-measured BCF values obtained from the scientific literature or calculated for organic compounds (Table 3-2) using the following equation (U.S. EPA, 1995):

$$BCF = K_{ow} \qquad \textbf{Eq. 3.2}$$

where:

BCF = Bioconcentration Factor

K_{ow} = chemical-specific octanol/water partition coefficient.

Where possible, octanol-water partition coefficient (K_{ow}) values for appropriate COPECs were obtained from the literature or from databases and are listed among the fate and transport properties within the COPEC profiles.

The BCF is dependent upon a chemical-specific K_{ow} that relates to a chemical's tendency to partition to a polar versus nonpolar solution. U.S. EPA has established a relationship between the K_{ow} and the FCM such that as the K_{ow} increases, the FCM increases correspondingly.

For sediment or soil, the percent carbon present is critical to partitioning. For these matrices, the K_{ow} was converted to a soil adsorption coefficient (K_{oc}) value (U.S. EPA, 1996b) as follows:

$$Log\, K_{oc} = 0.00028 + (0.983x \log K_{ow}) \qquad \textbf{Eq. 3.3}$$

where:

K_{oc} = chemical-specific organic carbon partition coefficient

K_{ow} = chemical-specific octanol/water partition coefficient

This equation was chosen because it is the best fit for site-related compounds (semivolatile, nonionizing organic compounds).

Per U.S. EPA (1995) guidance, aquatic BAFs were estimated by one of four methods, listed in order of preference:

- A measured BAF for an inorganic or organic chemical derived from a field study.

- A predicted BAF for an organic chemical derived from a field-measured biota-sediment accumulation factor.
- A predicted BAF for an inorganic or organic chemical derived from a laboratory-measured BCF and a FCM.
- A predicted BAF for an organic chemical derived from a K_{ow} and an FCM.

The U.S. EPA guidance notes that for chemicals for which no K_{ow} is available and for which no BCF is calculable, a default FCM of 1.0 should be used (U.S. EPA, 1995). Accordingly, for inorganics not thought to biomagnify and/or for which no literature value was available, the value of 1.0 was used at each trophic level.

In addition to the aquatic food web, FCMs were also related to an organism's trophic status as predator/prey, producer/consumer, etc., in the terrestrial food web. Although exposures of terrestrial floral and faunal receptors are significant considerations for many hazardous waste sites, well accepted models for predicting the fate of many contaminants in terrestrial systems are less developed. Trophic level compartments and transfer between compartments based on uptake, storage, and loss processes are not as well defined in terrestrial systems as in aquatic systems. In addition, the relationship between K_{ow} and bioconcentration is less well delineated by trophic level in terrestrial ecosystems. For this SLERA, soil-to-plant and food-to-muscle BAFs were obtained from U.S. EPA's *Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities* (1999b) or estimated for organic constituents using the log K_{ow} relationships developed by Travis and Arms (1988). Soil-to-insect BAFs were obtained from U.S. EPA (1999b) or based on log K_{ow} relationships developed by Connell and Markwell (1990). Inorganic constituent BAFs were obtained from U.S. EPA (1999b) or based on literature values such as those found in Baes, et al. (1984), International Atomic Energy Agency (1994), and Ma (1982).

Literature values for receptor-specific sediment ingestion rates were used, where available; however, such values generally were not available. Where sediment ingestion rates could not be found, the receptor-specific incidental soil ingestion rate was used for sediment ingestion as well, where the receptor's life history profile suggested a significant aquatic component.

Tissue concentrations in vertebrate prey species were estimated from the daily intake of the COPECs through the use of transfer factors obtained from U.S. EPA (1999b) (Table 3-2). The total concentration of COPEC intake (including ingested soil and surface water) was then used in the calculation of tissue concentrations in prey species and the dietary exposure rate in all assessment receptors.

Exposure to four categories of environmental media are addressed in this 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 animal exposure, only surface soil samples were used. For burrowing animals such as the shrew, surface and subsurface soil samples were used.

For plant exposure, surface and subsurface soil samples were used because feeder roots may reach deeply into the subsurface. Thus, the white-tailed deer was assumed to ingest vegetation translocating COPECs from subsoils (Figure 2-4).

Environmental conditions including 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. Literature values for soil-to-plant transfer rates for inorganic soil contaminants were used (Table 3-2).

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 buried or stored waste, and contaminated surface water, groundwater, and soil. The release mechanisms include storm-water runoff, groundwater discharge, and airborne deposition. Potential receptors to 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, such as PCBs 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 exposure and transport medium for COPECs. Potential sources for contaminated surface water include buried or stored waste, contaminated soil and groundwater, and deposition of airborne contaminants. Release mechanisms include stormwater 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 represents a potential indirect exposure pathway for faunal receptors. Piscivorous receptor's exposure to fish was not quantified because of the lack of suitable habitat for fish at the site. 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 is not an exposure medium for ecological receptors. However, contaminant transport along the shallow groundwater pathway was considered an exposure route to aquatic life, wetlands, and some wildlife where the groundwater discharges to surface water. A groundwater assessment was not included in this SLERA because surface water samples collected at the point of potential exposure were more appropriate to use.

3.2 Exposure Characterization Summary

The estimated chemical intakes for each potentially exposed assessment receptor for each exposure pathway and scenario are presented in Tables 3-3 through 3-10 for the area within Acid Area 1. The intake estimates were combined with the COPEC TRVs, discussed in the following section, to derive estimates of potential adverse ecological effects. The uncertainties associated with the estimation of potential adverse effects are discussed in Section 5.4. The basis for each uncertainty has been identified, with the degree of uncertainty estimated qualitatively (low, medium, or high) or quantitatively, and the impact of the uncertainty estimated qualitatively (overestimate or underestimate, as appropriate).

4.0 ECOLOGICAL EFFECTS CHARACTERIZATION

The ecological effects characterization includes the selection of literature benchmark values and TRVs.

4.1 Selection of Literature Benchmark Values

Appropriate sources for literature benchmark values included *Toxicological Benchmarks for Wildlife* (Sample, et al., 1996); *Development of Toxicity Reference Values for Conducting Ecological Risk Assessments at Naval Facilities in California* (Engineering Field Activity, West, 1998); *Review of the Navy - EPA Region 9 BTAG Toxicity Reference Values for Wildlife* (CH2M-Hill, 2000); and LD_{50} values from databases such as the Registry of Toxic Effects Concentrations (RTEC) (extrapolated to chronic NOAEL or LOAEL values using recommended Tri-Service [Wentsel et al., 1996] uncertainty factors). The primary source of benchmark values for this SLERA was Sample et al. (1996).

4.2 Selection of Toxicity Reference Values

The primary source of TRVs for this SLERA was Sample et al. (1996). These TRVs focus on the growth, survival, and reproduction of species and/or populations. TRVs were available for the specific receptor-endpoint combinations in most instances. However, for some COPECs, data on surrogate species was used. The NOAEL is the dose for a COPEC that has produced no known adverse effects in the test species. The NOAEL was judged to be an appropriate toxicological endpoint since it provides the greatest degree of protection to the receptor species. In instances where TRVs were unavailable for a site-associated COPEC, toxicological information for surrogate chemicals was used. This process is described in the following paragraphs.

Toxicity information pertinent to identified receptors was gathered for those analytes identified as COPECs. As previously noted, where data were unavailable for the exposure of a receptor to a COPEC, data for a surrogate chemical (e.g., benzo(a)pyrene for other PAHs) were gathered for use in the SLERA. No TRVs were calculated for this SLERA (Table 4-1).

Test species body weights used for COPEC TRVs are provided in Table 4-1. These factors were used together to derive a final adjusted TRV, also presented in Table 4-1. TRV uncertainties are discussed in Section 5.4.

Exposure rate TRVs provide a reference point for the comparison of potential toxicological effects from exposure to a contaminant. To complete this comparison, receptor exposures to site contaminants were calculated or, as in the case of plant receptors, exposure was estimated using the soil concentration.

The potential toxicity of essential nutrients is assessed in Appendix B, with maximum tolerance levels presented for several essential nutrients.

The equilibrium partitioning approach has been used by the U.S. EPA and OME in the preparation of sediment quality criteria for the protection of aquatic life. These criteria were used, as available, to assess sediment risks to aquatic receptors.

5.0 RISK CHARACTERIZATION

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 potential adverse effects from environmental stressors present at a site. Qualitative and semiquantitative approaches were taken to estimate the likelihood of adverse effects occurring as a result of potential exposure of the assessment receptors to COPECs. Potential adverse affects to terrestrial plants were qualitatively assessed by comparing plant toxicity benchmarks with COPEC concentrations. Potential adverse impacts to aquatic biota were qualitatively assessed by comparing sediment quality criteria for the protection of aquatic life to sediment COPEC concentrations.

For the semiquantitative predictive assessment, TRVs and estimated exposure rates were used to generate hazard quotients (HQs) by dividing the receptor exposure rate for each contaminant by the TRV. HQs 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.

5.1 Terrestrial Plant Impact Assessment

The EPCs were compared with available benchmark concentrations developed for the protection of terrestrial plants to assess the potential impact of COPEC concentrations in surface soil on terrestrial plant species in Acid Area 1. These benchmark concentrations are to serve primarily for contaminant screening. If chemical concentrations reported in soils that support vigorous and diverse plant communities exceed one or more of the benchmarks concentrations, or if a benchmark is exceeded by background soil concentrations, it is generally safe to assume the benchmark is a poor measure of risk to the plant community at that site (Efroymson, et al. 1997c). As shown in Table 2-2, benchmarks were exceeded by the COPEC EPC for multiple constituents. Additionally, benchmarks were not available for some of the COPECs retained for the SLERA. However, no signs of vegetative stress were noted in Acid Area 1 based on site reconnaissance surveys performed in May and October 2008 (Section 2.1.4). No risks or adverse affects to plants are predicted.

5.2 Aquatic Biota Impact Assessment

To assess the potential impact of COPEC concentrations in surface water and sediment on aquatic biota, the EPCs from Acid Area 1 were compared with available benchmark concentrations developed for the protection of aquatic life. As shown in Table 2-2, sediment concentrations for select metals, PAHs, PCBs, and few VOCs were initially identified as sediment COPECs. The VOCs identified as COPECs are commonly associated with laboratory contamination. No explosives were detected in the sediment samples. It is important to note that aquatic habitat is limited at Acid Area 1 and is not of high quality due to the size and ephemeral nature of most of the drainages. Therefore, irrespective of what chemicals and their concentrations were detected, threats to waterfowl, fish, and terrestrial receptors that feed from aquatic resources (e.g., raccoon) would not be and could not realized. No risks or adverse affects to aquatic resources are predicted.

5.3 Predictive Risk Estimation for Terrestrial Wildlife

Estimates of potential for risks associated with exposure to Acid Area 1 environmental media were evaluated (Tables 5-1 through 5-8) through a series of quantitative HQ calculations that compared receptor-specific exposure values with TRVs. The HQs were compared according 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 adverse ecological effects. HQs from 10 up to but less than 100 represent a significant potential that effects could result from greater exposure. HQs greater than 100 represent the highest potential for expected effects (Wentsel, et al., 1996). OEPA considers HQs greater than 1.0 to be potentially significant. It should also be noted that HQs are not measures of risk, are not population-based statistics, nor are they linearly scaled statistics. Additionally, the use of HQs to predict risk is questionable and may or may not substantiate risk. Accordingly, an HQ above 1, even exceedingly so, does not necessarily mean that there is even one individual expressing the toxicological effect associated with a given chemical to which it was exposed (Bartell, 1996).

Conservative NOAEL-based HQs greater than or equal to 1.0 for terrestrial receptors at Acid Area 1 are presented below. The Eastern cottontail, white-tailed deer, and red-tailed hawk did not have any HQs greater than 1.0.

Deer Mouse	**HQ** (Table 5-4)
2,4-Dinitrotoluene	1.0
Vanadium	3.0
PCB-1254	2.0
PCB-1260	6.0
Short-Tailed Shrew	**HQ** (Table 5-1)
Vanadium	3.0
PCB-1254	2.0
PCB-1260	7.0
Marsh Wren	**HQ** (Table 5-3)
Vanadium	3.0
PCB-1254	3.0
PCB-1260	8.0
Raccoon	**HQ** (Table 5-7)
2-Methylnaphthalene	4.0
Anthracene	7.0
Fluoranthene	5.0

Important routes of exposure for COPEC in soils were invertebrate and plant intake.

Conservative NOAEL-based HQs greater than or equal to 1.0 for aquatic receptors at Acid Area 1 are presented below. The mallard duck did not have any HQs greater than 1.0.

Raccoon	HQ (Table 5-7)
2-Methylnaphthalene	4.0
Anthracene	7.0
Fluoranthene	5.0

COPECs from sediment, rather than surface water, were risk drivers. The most important route of exposure was aquatic invertebrate intake.

5.4 Uncertainty Analysis

The results of the SLERA are influenced to some degree by variability and uncertainty. In theory, investigators might reduce variability by increasing sample size of the media or species sampled. Alternatively, uncertainty within the risk analysis can be reduced by using species-specific and site-specific data to better quantify contamination of media, vegetation, and prey through direct field measurements, toxicity testing of site-specific media, and field studies using site-specific receptor species. Detailed media, prey, and receptor field studies are costly; therefore, the preliminary predictive analyses of risk were conducted to limit the potential use of these resource-intensive techniques to only those COPECs that continue to show a relatively high potential for ecological risk. The results of the screening and predictive assessments are considered conservative because assessment criteria were developed based on conservative assumptions. This has the effect of maximizing the likelihood of accepting a false positive (Type I error: the rejection of a true H_o) and simultaneously minimizing the likelihood of accepting a true negative (Type II error: the acceptance of a false H_o).

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 will 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; and,

- where possible, a description of recommendations for minimizing the identified uncertainties if the SLERA progresses to higher level assessment phases (U.S. EPA, 1992a).

The uncertainty analysis identifies and, where possible, quantifies the uncertainty in the individual preliminary scoping assessment, problem formulation, exposure and effects assessment, and risk characterization of this SLERA. 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 since the contaminant release occurred affects bioavailability as contaminants become sequestrated 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 pore water likely overestimates potential risks. As discussed above, 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 over- or under-estimate 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. There are also limitations to the HQ approach that stem from uncertainties in both the numerator (the estimate of dose or exposure and the denominator (the TRV) used to calculate the HQ. For example, TRV values are based on toxicity tests performed under laboratory conditions, which may or may not account for factors that can influence toxicity in the field. Also, some TRVs are based on limited and sometimes internally inconsistent toxicity data, and TRVs may not be available for all receptors of concern at a site. Therefore, some TRVs may be relatively uncertain, especially when extrapolation of findings across different species is required. In addition, estimation of actual exposure levels is often difficult (especially for terrestrial receptors) due to lack of site-specific data on intake rates, home ranges, etc. (U.S. EPA, 2009).

Because of these potential limitations, the HQ approach is best considered to be a screening-level means of evaluation. That is, if an HQ is above a level of concern, this an indication that effects may be occurring, but further studies (e.g., direct observation of exposed receptors) are sometimes needed in order to confirm if this is really the case (U.S. EPA, 2009).

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 Acid Area 1, however, was designed to optimize efficiency of the sampling effort and reduce uncertainty by focusing on areas around former process buildings, storage structures, and potential transfer piping. Focusing on these most likely contaminated areas 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 sufficient to identify PCBs as the major contaminants in soil and sediments in Acid Area 1. Vanadium was also identified as a risk driver in soil at Acid Area 1. However, mean concentrations of vanadium across Acid Area 1 are less than background values.

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:

1. 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 RA. All inorganic constituents detected in environmental media were initially carried through the ecological risk assessment to provide a conservative estimate of potential risks associated with exposure to site media. However after this was completed, the MDCs for all metals in soils and sediments were compared to their respective background criteria with several metals having maximum detected concentrations greater than background. Only lead had a mean concentration greater than its background concentration but lead is not a risk driver in soils or sediments. Vanadium was determined to be a risk driver in soils but its mean concentration in soil is less than its background value. Some organic chemicals, such as PAHs, may be considered to be anthropogenic background. A limited number of PAHs were identified in soil, surface water, and sediment at Acid Area 1. There are no site-specific background data for the PAHs, and several were selected as contaminants of concern (COCs) in sediment. 2-methylnaphthalene, acenaphthene, and naphthalene were identified as risk drivers for sediments associated with Acid Area 1.

2. Estimated EPCs are uncertain. For statistical purposes, if a constituent is positively identified at a site and has at least a single positive hit, all the samples with nondetects are assumed to have a value equal to half the reporting limit and are included in the data set. This process may introduce a conservative bias into the risk assessment. Computed UCL_{95} 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. The confidence of computed UCLs for this project were qualitatively evaluated and identified as high, moderate, low, and indeterminate. For indeterminate data sets, the MDC was used for the UCL. Uncertainties associated with the statistical determination of EPCs for the COCs in each medium are:

    a. 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 UCL_{95} was greater than the maximum value for the

SLERA; thus, the maximum value was chosen as the EPC. High confidence limits may introduce a conservative bias into the risk assessment.

b. 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.

Consistent with U.S. EPA guidance (1992b), the UCL_{95} was used for the EPC. Therefore, the exposure assessment is likely to underestimate the EPCs in 5 percent of the cases and overestimate exposures in 95 percent of cases, imparting an overall conservative bias to the risk assessment. It should be noted that many of the maximum concentrations of COPECs measured in sediment were used as source-term concentrations due to the limited number of samples; an additional sampling effort could potentially reduce the hazard estimate.

6.0 SUMMARY AND CONCLUSIONS

This section briefly summarizes the results of the SLERA and interprets the results in light of the uncertainties associated with their estimation. Conclusions are derived from the risk assessment based on the responses to the assessment hypotheses.

The predictive assessment results may serve as the foci of discussions among risk managers and regulatory agencies concerning the potential need for additional investigation at Acid Area 1 to reduce the uncertainty associated with ecological risk estimates. The uncertainties associated with this SLERA likely resulting in an overestimation of the potential for adverse ecological effects include: assuming that COPECs are 100 percent bioavailable; use of laboratory-derived or empirically-estimated partitioning and transfer factors to predict COPEC concentrations in plants, invertebrates, prey species, and sediment pore water; use of laboratory-derived TRVs; and use of the HQ method to estimate risks to populations or communities. It is important to note that many conservative assumptions and modeling approaches were used in the predictive assessment, and that actual hazards to wildlife may be orders of magnitude lower than predicted herein. Estimated HQs greater than 1000 should be considered particularly suspect.

Soil COPEC impacts to terrestrial plants are estimated to be generally insignificant as no vegetative stress was observed on site. Terrestrial receptors are predicted to incur low hazards from exposure to PCBs (PCB-1254 and PCB-1260) and vanadium based on the NOAEL-based HQ approach (Section 5.3). Estimated HQs for four of the terrestrial receptors (deer mouse, short-tailed shrew, marsh wren, and raccoon) are less than 10 indicating a low potential for adverse affects. HQs are less than 1.0 for white-tailed deer, eastern cottontail, and red-tailed hawk.

Aquatic receptors are predicted to incur low hazards from exposure to 2-methylnaphthalene, anthracene, and fluoranthene in sediment based on the NOAEL-based HQ approach. These COPECs were not identified as COPECs in surface water. Estimated HQs for the raccoon are less than 10 indicating a low potential for adverse affects. HQs are less than 1.0 for the mallard duck. Additionally, it is important to note that aquatic habitat is limited at Acid Area 1 and is not of high quality due to the size and ephemeral nature of most of the drainages.

Based on the results of the NOAEL-based HQ approach, uncertainties associated with estimates of EPCs and potential COPEC toxicity, and on the fact that no wildlife RTE species have been confirmed at the site, remedial actions at Acid Area 1 to address ecological concerns do not appear to be warranted at this time.

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Tables

TABLES

Table 2-1. Species of Flora Observed at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio, May 14 and October 2, 2008

Scientific Name	Common Name
Flora	
Acalypha rhomboidea	rhombic three-seeded mercury
Acer negundo	box elder
Acer rubrum	red maple
Achillea millefolium	yarrow
Agalinus tenuifolia	foxglove
Agrimonia parviflora	small-flowered groovebur
Agrostis alba	redtop
Alisma plantago-aquatica	broad-leaved water plantain
Alliaria petiolata	garlic mustard
Andropogon virginicus	broom sedge
Anemone virginiana	thimbleweed
Apocynum cannabinum	dogbane
Asclepias syriaca	common milkweed
Asplenium playtneuron	ebony spleenwort
Aster lateriflorus	calico aster
Aster novae-angliae	New England aster
Aster praealtus	willow-leaf aster
Bidens frondosa	beggar ticks
Boehmeria cylindrica	small-spike false-nettle
Botrychium virginianum	grape fern
Brassica nigra	yellow rocket
Capsella bursa-pastoris	shepherd's purse
Carduus nutans	nodding thistle
Carex blanda	eastern woodland sedge
Carex frankii	Frank's sedge
Carex hirtifolia	sedge
Carex radiata	sedge
Carex tribuloides	broom sedge
Carex vulpinoidea	fox sedge
Chelone glabra	white turtlehead
Circaea lutetiana	southern broad-leaved enchanters nightshade
Cirsium arvense	creeping thistle
Cirsium muticum	swamp thistle
Claytonia virginica	spring beauty
Cornus amomum	silky dogwood
Cornus racemosa	gray dogwood
Crypotaenia canadensis	honewort

Table 2-1. Species of Flora Observed at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio, May 14 and October 2, 2008

Scientific Name	Common Name
Dactylis glomerata	orchard grass
Daucus carota	Queen Anne's lace
Desmodium paniculatum	panicled tick trefoil
Dichanthelium clandestinum	deer-tongue grass
Dipsacus sylvestris	teasel
Eleagnus umbellata	autumn olive
Eleocharis acicularis	needle spike-rush
Elymus riparius	river bank wild rye
Epilobium coloratum	purple-leaved willow herb
Equisetum arvense	field horsetail
Equisetum hyemale	scouring rush
Eragrostis sp.	love grass
Erechtites hieraciifolia	fireweed
Erigeron philadelphicus	common fleabane
Eupatorium album	white thorough-wort
Eupatorium maculatum	Joe pye weed
Eupatorium perfoliatum	boneset
Eupatorium rugosum	white snakeroot
Euphorbia maculata	upright spotted spurge
Euphorbia nutans	eyebane
Euthamia graminifolia	fragrant flat-topped goldenrod
Festuca arundinacea	fescue
Fragaria virginiana	strawberry
Fraxinus pennsylvanica	green ash
Galium aparine	cleavers
Galium asprellum	rough bedstraw
Galium tinctorium	stiff marsh bedstraw
Geum laciniatum	rough avens
Gnathalium obtusifolium	catfoot
Hordeum jubatum	foxtail barley
Hypericum perforatum	St. John's wort
Juncus effusus	soft rush
Juncus torreyi	Torrey's rush
Juniperus virginiana	red cedar
Leersia oryzoides	rice cutgrass
Lemna minor	lesser duckweed
Lepidium campestre	pepper grass
Ligustrum vulgare	privet

Table 2-1. Species of Flora Observed at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio, May 14 and October 2, 2008

Scientific Name	Common Name
Lonicera tatarica	Tartarian honeysuckle
Ludwigia alternifolia	bushy seedbox
Ludwigia palustris	water purslane
Lycopus americana	bugle weed
Lycopus virginicus	Virginia bugle weed
Medicago lupulina	black medick
Melilotus sp.	sweet clover
Mimulus ringens	Allegheny monkey flower
Monarda fistulosa	wild bergamot
Morus alba	Mulberry
Nepeta cataria	catnip
Onoclea sensibilis	sensitive fern
Panicum dichotomiflorum	fall panicgrass
Panicum virgatum	switch grass
Parthenocissus quinquefolia	Virginia creeper
Penstemon digitalis	beard-tongue
Phalaris arundinacea	reed canary grass
Phryma leptostachya	lopseed
Plantago lanceolata	English plantain
Plantago major	common plantain
Poa alsodes	blue grass
Podophyllum peltatum	mayapple
Polygonum cuspidatum	Japanese knotweed
Polygonum pennsylvanicum	Pennsylvania smartweed
Polygonum virginianum	Virginia knotweed
Populus deltoides	cottonwood
Potentilla norvegica	Norwegian cinquefoil
Potentilla simplex	old field cinquefoil
Prunus americana	wild plum
Prunus serotina	black cherry
Pycnanthemum tenuifolium	slender mountain mint
Pyrus coronaria	crabapple
Quercus palustris	pin oak
Ranunculus abortivus	kidney-leaf buttercup
Ranunculus recurvatus	cursed crowfoot
Rosa multiflora	multiflora rose
Rosa setigera	prairie rose
Rubus allegheniensis	Allegheny blackberry

Table 2-1. Species of Flora Observed at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio, May 14 and October 2, 2008

Scientific Name	Common Name
Rubus flagellaris	dewberry
Rubus occidentalis	black raspberry
Rudbeckia hirta	black-eyed Susan
Rumex acetosella	sheep sorrel
Rumex crispus	curly dock
Salix amygdaloides	peachleaf willow
Salix exigua	sandbar willow
Salix nigra	black willow
Sambucus canadensis	common elder
Satureja vulgaris	wild basil
Scirpus atrovirens	green bulrush
Scirpus cyperinus	wool grass
Scirpus validus	soft-stem bulrush
Senecio aureus	golden alexanders
Setaria glauca	yellow bristle grass
Solidago canadensis	Canada goldenrod
Solanum carolinense	horse nettle
Solanum nigrum	black nightshade
Taraxacum officinale	dandelion
Teucrium canadense	American germander
Thelypteris palustris	marsh fern
Toxicodendron radicans	poison ivy
Tragopogon porrifolius	salsify
Trifolium hybridium	alsike clover
Trifolium repens	white clover
Typha angustifolia	narrow-leaf cattail
Typha x glauca	hybrid cattail
Ulmus americana	American elm
Urtica dioicia	stinging nettle
Verbascum blattaria	moth mullein
Verbascum thapsus	woolly mullein
Verbena urticifolia	white vervain
Verbesina alternifolia	wingstem
Vernonia gigantea	ironweed
Vicia sp.	vetch
Viola papilionacea	blue violet
Vitis aestivalis	summer grape
Vitis riparia	riverbank grape

Table 2-2. Summary Statistics and COPEC Selection for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Average	Background	Toxicity Screening Level	COPEC	UCL_{95}
Soil													
GC2	Moisture, Percent	22	22	100	PERCENT		12.1	21.8	17.7				
GC2	Nitrogen, Nitrate (as N)	22	0	0	mg/kg	5.7 - 6.4			547				
GC2	Sulfate (as SO4)	22	16	73	mg/kg	12 - 13	13.4	3910	501				
GC2	pH	22	22	100	PH_UNITS		6.3	8.1	7.43				
HE	1,3,5-Trinitrobenzene	41	1	2	ug/kg	80 - 250	300	300	300				
HE	1,3-Dinitrobenzene	41	0	0	ug/kg	80 - 250							
HE	2,4,6-Trinitrotoluene	41	2	5	ug/kg	80 - 250	150	300	200				
HE	2,4-Dinitrotoluene	41	6	15	ug/kg	100 - 250	120	2500	262		1000	YES	507
HE	2,6-Dinitrotoluene	40	0	0	ug/kg	100 - 250					32800		
HE	2-Amino-4,6-Dinitrotoluene	39	1	3	ug/kg	120 - 150	480	480	12000				
HE	2-Nitrotoluene	41	0	0	ug/kg	80 - 250							
HE	3-Nitrotoluene	41	0	0	ug/kg	120 - 250							
HE	4-Amino-2,6-Dinitrotoluene	41	2	5	ug/kg	80 - 250	430	810	439				
HE	4-Nitrotoluene	39	1	3	ug/kg	80 - 100	180	180	180				
HE	HMX	41	0	0	ug/kg	80 - 500							
HE	Nitrobenzene	41	0	0	ug/kg	88 - 250					1310000		
HE	RDX	41	0	0	ug/kg	80 - 500							
HE	Tetryl	41	0	0	ug/kg	80 - 650							
MET	Aluminum	61	61	100	mg/kg		155	19900	9470	15500			
MET	Antimony	61	1	2	mg/kg	2.2 - 7.7	9.5	9.5	9.5	9.3	0.142	YES	
MET	Arsenic	61	60	98	mg/kg	1.3 - 1.3	1.4	18.1	7.0	36.5	5.7		
MET	Barium	61	59	97	mg/kg	24 - 26	20.4	145	57.5	826	1.0		
MET	Beryllium	61	42	69	mg/kg	0.25 - 0.64	0.23	1.1	0.541	1	1.1	YES	0.579
MET	Cadmium	61	32	52	mg/kg	0.23 - 0.64	0.28	6.9	0.657		0.00222	YES	0.802
MET	Calcium	60	60	100	mg/kg		1040	166000	23400	52300			
MET	Chromium	61	60	98	mg/kg	1.3 - 1.3	2.3	50.7	15.4	29	0.4	YES	17.3
MET	Cobalt	61	56	92	mg/kg	5.7 - 6.4	1.5	26.5	7.8	116	0.14		
MET	Copper	61	60	98	mg/kg	2.8 - 2.8	3.7	57.6	17.2	56.2	5.4	YES	19.7
MET	Iron	61	61	100	mg/kg		218	35100	18100	234000			
MET	Lead	61	61	100	mg/kg		4.1	770	68	48.6	0.0537	YES	183
MET	Magnesium	61	59	97	mg/kg	570 - 640	858	18100	4470	10400			
MET	Manganese	61	61	100	mg/kg		3	1070	327	3506			
MET	Mercury	61	40	66	mg/kg	0.013 - 0.042	0.016	0.76	0.0603	0.1	0.00051	YES	0.0873
MET	Nickel	61	59	97	mg/kg	4.6 - 5.1	5.8	57.8	17.9	55.1	13.6	YES	20
MET	Potassium	61	52	85	mg/kg	570 - 640	461	4820	1190	3390			
MET	Selenium	61	4	7	mg/kg	0.57 - 1.5	0.65	1.1	0.685	2	0.0276		
MET	Silver	61	0	0	mg/kg	0.22 - 1.3				11.1	2		
MET	Sodium	61	4	7	mg/kg	220 - 640	263	503	339				
MET	Thallium	61	1	2	mg/kg	0.38 - 1.3	0.77	0.77	0.77	1.3	0.0569		
MET	Vanadium	61	59	97	mg/kg	5.7 - 6.4	9.4	51.7	25.6	40.9	1.59	YES	27.5
MET	Zinc	61	61	100	mg/kg		6.2	271	64.3	322	6.62		

Table 2-2. Summary Statistics and COPEC Selection for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Average	Background	Toxicity Screening Level	COPEC	UCL_{95}
Soil (continued)													
PCB	PCB-1016 (Aroclor 1016)	54	0	0	ug/kg	3.6 - 800							
PCB	PCB-1221 (Aroclor 1221)	54	0	0	ug/kg	3.6 - 800							
PCB	PCB-1232 (Aroclor 1232)	54	0	0	ug/kg	3.6 - 800							
PCB	PCB-1242 (Aroclor 1242)	54	0	0	ug/kg	3.6 - 800							
PCB	PCB-1248 (Aroclor 1248)	54	0	0	ug/kg	3.6 - 800							
PCB	PCB-1254 (Aroclor 1254)	54	27	50	ug/kg	4 - 2900	4.4	7100	1250		371	YES	1720
PCB	PCB-1260 (Aroclor 1260)	54	38	70	ug/kg	4 - 41	4.2	18000	2510		371	YES	4910
SV	1,2,4-Trichlorobenzene	61	3	5	ug/kg	0.12 - 420	0.22	0.74	0.48				
SV	1,2-Dichlorobenzene	61	0	0	ug/kg	0.25 - 420							
SV	1,2-Diphenylhydrazine	39	0	0	ug/kg	28 - 35							
SV	1,3-Dichlorobenzene	61	0	0	ug/kg	0.56 - 420							
SV	1,4-Dichlorobenzene	61	0	0	ug/kg	0.37 - 420							
SV	2,4,5-Trichlorophenol	61	0	0	ug/kg	28 - 420							
SV	2,4,6-Trichlorophenol	61	0	0	ug/kg	37 - 420							
SV	2,4-Dichlorophenol	61	0	0	ug/kg	20 - 420							
SV	2,4-Dimethylphenol	61	0	0	ug/kg	23 - 420							
SV	2,4-Dinitrophenol	61	0	0	ug/kg	140 - 2100							
SV	2,4-Dinitrotoluene	61	5	8	ug/kg	26 - 420	54	870	262		1000		
SV	2,6-Dinitrotoluene	61	0	0	ug/kg	40 - 420					32800		
SV	2-Chloronaphthalene	61	0	0	ug/kg	34 - 420							
SV	2-Chlorophenol	61	0	0	ug/kg	43 - 420							
SV	2-Methylnaphthalene	61	8	13	ug/kg	39 - 420	40	410	123		3240		
SV	2-Methylphenol (o-Cresol)	61	0	0	ug/kg	41 - 420							
SV	2-Nitroaniline	61	0	0	ug/kg	34 - 2100							
SV	2-Nitrophenol	61	0	0	ug/kg	23 - 420							
SV	3,3'-Dichlorobenzidine	61	0	0	ug/kg	33 - 2100					646		
SV	3-Methylphenol	39	0	0	ug/kg	29 - 36							
SV	3-Nitroaniline	61	0	0	ug/kg	50 - 2100							
SV	4,6-Dinitro-2-methylphenol	61	0	0	ug/kg	23 - 2100							
SV	4-Bromophenyl phenyl ether	61	0	0	ug/kg	27 - 420							
SV	4-Chloro-3-methylphenol	61	0	0	ug/kg	29 - 420							
SV	4-Chloroaniline	61	0	0	ug/kg	51 - 420							
SV	4-Chlorophenyl phenyl ether	61	0	0	ug/kg	33 - 420							
SV	4-Methylphenol (p-Cresol)	61	0	0	ug/kg	28 - 420							
SV	4-Nitroaniline	61	0	0	ug/kg	110 - 2100							
SV	4-Nitrophenol	61	0	0	ug/kg	86 - 2100							
SV	Acenaphthene	61	0	0	ug/kg	28 - 420					20000		
SV	Acenaphthylene	61	1	2	ug/kg	21 - 420	150	150	150		682000		
SV	Anthracene	61	3	5	ug/kg	29 - 420	26	120	88.7		1480000		
SV	Benzo(a)anthracene	61	12	20	ug/kg	40 - 420	36	660	133		5210		

Table 2-2. Summary Statistics and COPEC Selection for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Average	Background	Toxicity Screening Level	COPEC	UCL_{95}
Soil (continued)													
SV	Benzo(a)pyrene	61	10	16	ug/kg	25 - 420	21	850	119		1520		
SV	Benzo(b)fluoranthene	61	6	10	ug/kg	33 - 420	94	1400	213		59800		
SV	Benzo(g,h,i)perylene	61	4	7	ug/kg	77 - 420	88	570	120		119000		
SV	Benzo(k)fluoranthene	61	6	10	ug/kg	42 - 420	75	580	136		148000		
SV	Benzoic acid	24	1	4	ug/kg	22 - 26	140	140	140				
SV	Benzyl alcohol	39	0	0	ug/kg	48 - 59							
SV	Butylbenzylphthalate	61	0	0	ug/kg	31 - 420							
SV	Carbazole	61	0	0	ug/kg	38 - 420							
SV	Chrysene	61	13	21	ug/kg	34 - 420	45	810	161		4730		
SV	Di-n-butylphthalate	61	1	2	ug/kg	32 - 420	120	120	120		150		
SV	Di-n-octylphthalate	61	0	0	ug/kg	28 - 420							
SV	Dibenz(a,h)anthracene	61	1	2	ug/kg	64 - 420	160	160	160		18400		
SV	Dibenzofuran	61	0	0	ug/kg	26 - 420							
SV	Diethylphthalate	61	0	0	ug/kg	380 - 880							
SV	Dimethylphthalate	61	0	0	ug/kg	32 - 420							
SV	Fluoranthene	61	16	26	ug/kg	59 - 420	44	1200	171		122000		
SV	Fluorene	61	0	0	ug/kg	28 - 420					122000		
SV	Hexachlorobenzene	61	0	0	ug/kg	37 - 420							
SV	Hexachlorobutadiene	61	0	0	ug/kg	35 - 420							
SV	Hexachlorocyclopentadiene	61	0	0	ug/kg	65 - 2100							
SV	Hexachloroethane	61	0	0	ug/kg	42 - 420							
SV	Indeno(1,2,3-cd)pyrene	61	3	5	ug/kg	49 - 420	43	720	69.8		109000		
SV	Isophorone	61	0	0	ug/kg	30 - 420							
SV	N-Nitroso-di-n-propylamine	61	0	0	ug/kg	58 - 420							
SV	N-Nitrosodimethylamine	39	0	0	ug/kg	100 - 120							
SV	N-Nitrosodiphenylamine	61	0	0	ug/kg	34 - 420							
SV	Naphthalene	61	3	5	ug/kg	34 - 420	64	160	103		99.4	YES	72.1
SV	Nitrobenzene	61	0	0	ug/kg	37 - 420					1310000		
SV	Pentachlorophenol	61	0	0	ug/kg	36 - 2100							
SV	Phenanthrene	61	12	20	ug/kg	25 - 420	57	580	178		45700		
SV	Phenol	61	1	2	ug/kg	38 - 420	45	45	45				
SV	Pyrene	61	13	21	ug/kg	42 - 420	52	960	161		78500		
SV	bis(2-Chloroethoxy)methane	61	0	0	ug/kg	33 - 420							
SV	bis(2-Chloroethyl)ether (2-Chloroethylether)	61	0	0	ug/kg	43 - 420							
SV	bis(2-Chloroisopropyl)ether	61	0	0	ug/kg	54 - 420							
SV	bis(2-Ethylhexyl)phthalate	61	9	15	ug/kg	38 - 410	39	210	95.6		925		
VOC	1,1,1-Trichloroethane	61	7	11	ug/kg	0.6 - 59	1.4	160	7.02				
VOC	1,1,2,2-Tetrachloroethane	61	0	0	ug/kg	0.29 - 32							
VOC	1,1,2-Trichloro-1,2,2-Trifluoroethane	39	0	0	ug/kg	0.37 - 41							
VOC	1,1,2-Trichloroethane	61	1	2	ug/kg	0.23 - 26	0.8	0.8	0.8				
VOC	1,1-Dichloroethane	61	2	3	ug/kg	0.36 - 40	6	33	6.47				

Table 2-2. Summary Statistics and COPEC Selection for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Average	Background	Toxicity Screening Level	COPEC	UCL_{95}
Soil (continued)													
VOC	1,1-Dichloroethene	61	2	3	ug/kg	0.8 - 89	1.5	1.8	1.65				
VOC	1,2,3-Trichlorobenzene	39	0	0	ug/kg	0.28 - 31							
VOC	1,2-Dibromo-3-chloropropane	39	0	0	ug/kg	0.8 - 89							
VOC	1,2-Dibromoethane (EDB)	39	0	0	ug/kg	0.29 - 32							
VOC	1,2-Dichloroethane	61	0	0	ug/kg	0.31 - 34							
VOC	1,2-Dichloropropane	61	0	0	ug/kg	0.31 - 34							
VOC	2-Butanone (Methyl ethyl ketone)	61	8	13	ug/kg	0.94 - 100	2.7	20	7.9		89600		
VOC	2-Hexanone	61	0	0	ug/kg	1.5 - 170							
VOC	4-Methyl-2-pentanone (Methyl isobutyl ketone)	61	0	0	ug/kg	0.39 - 43					443000		
VOC	Acetone	61	20	33	ug/kg	4 - 150	20	270	43.6		2500		
VOC	Benzene	61	16	26	ug/kg	0.42 - 35	0.43	5.3	2.12		255		
VOC	Bromochloromethane	39	0	0	ug/kg	0.28 - 31							
VOC	Bromodichloromethane	61	0	0	ug/kg	0.2 - 22							
VOC	Bromoform	61	0	0	ug/kg	0.67 - 74							
VOC	Bromomethane	61	0	0	ug/kg	0.48 - 53							
VOC	Carbon Disulfide	61	15	25	ug/kg	1.2 - 96	1.4	30	4.09		94.1		
VOC	Carbon tetrachloride	61	0	0	ug/kg	0.59 - 65							
VOC	Chlorobenzene	61	0	0	ug/kg	1.7 - 180							
VOC	Chloroethane	61	0	0	ug/kg	0.74 - 82							
VOC	Chloroform	61	0	0	ug/kg	0.37 - 41							
VOC	Chloromethane	61	1	2	ug/kg	0.35 - 39	1.2	1.2	1.2				
VOC	Cyclohexane	39	21	54	ug/kg	0.49 - 40	0.9	46	5.51				
VOC	Dibromochloromethane	61	0	0	ug/kg	0.23 - 25							
VOC	Dichlorodifluoromethane	39	0	0	ug/kg	0.74 - 82							
VOC	Ethylbenzene	61	8	13	ug/kg	0.5 - 56	0.89	3	1.89		5160		
VOC	Isopropylbenzene (Cumene)	39	0	0	ug/kg	0.59 - 65							
VOC	Methyl Acetate	39	5	13	ug/kg	1.1 - 120	2.1	460	23.6				
VOC	Methylcyclohexane	39	22	56	ug/kg	0.27 - 15	0.26	3300	126				
VOC	Methylene Chloride	61	3	5	ug/kg	0.42 - 46	2.3	3.2	2.67		4050		
VOC	Styrene	61	0	0	ug/kg	0.23 - 26							
VOC	Tert-Butyl Methyl Ether (MTBE)	39	0	0	ug/kg	0.21 - 24							
VOC	Tetrachloroethene (PCE)	61	1	2	ug/kg	0.65 - 72	240	240	240				
VOC	Toluene	61	13	21	ug/kg	0.78 - 67	1.2	56	3.63		5450		
VOC	Total 1,2-Dichloroethene	22	2	9	ug/kg	5.7 - 6.4	4	7.4	4.15				
VOC	Trichloroethene (TCE)	61	5	8	ug/kg	0.57 - 63	1.2	35	2.59				
VOC	Trichlorofluoromethane	39	0	0	ug/kg	0.64 - 70							
VOC	Vinyl chloride	61	0	0	ug/kg	0.74 - 82							
VOC	Xylenes, Total	61	14	23	ug/kg	0.63 - 42	1.1	200	9.77		10000		
VOC	cis-1,2-Dichloroethene	39	0	0	ug/kg	0.8 - 89							
VOC	cis-1,3-Dichloropropene	61	0	0	ug/kg	0.33 - 37							
VOC	trans-1,2-Dichloroethene	39	0	0	ug/kg	0.74 - 82							
VOC	trans-1,3-Dichloropropene	61	0	0	ug/kg	0.21 - 24							

Table 2-2. Summary Statistics and COPEC Selection for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Average	Background	Toxicity Screening Level	COPEC	UCL_{95}
Surface Water													
HE	1,3,5-Trinitrobenzene	12	0	0	ug/L	0.072 - 0.086							
HE	1,3-Dinitrobenzene	12	0	0	ug/L	0.072 - 0.086							
HE	2,4,6-Trinitrotoluene	12	0	0	ug/L	0.072 - 0.086							
HE	2,4-Dinitrotoluene	12	0	0	ug/L	0.094 - 0.11							
HE	2,6-Dinitrotoluene	12	0	0	ug/L	0.094 - 0.11							
HE	2-Amino-4,6-Dinitrotoluene	12	1	8	ug/L	0.11 - 0.13	0.24	0.24	0.24				
HE	2-Nitrotoluene	12	0	0	ug/L	0.072 - 0.086							
HE	3-Nitrotoluene	12	0	0	ug/L	0.11 - 0.2							
HE	4-Amino-2,6-Dinitrotoluene	12	1	8	ug/L	0.074 - 0.086	0.4	0.4	0.4				
HE	4-Nitrotoluene	12	0	0	ug/L	0.072 - 0.086							
HE	HMX	12	0	0	ug/L	0.072 - 0.086							
HE	Nitrobenzene	12	0	0	ug/L	0.079 - 0.095							
HE	RDX	12	3	25	ug/L	0.074 - 0.086	0.081	0.5	0.148				
HE	Tetryl	12	1	8	ug/L	0.072 - 0.086	0.24	0.24	0.24				
MET	Aluminum	12	8	67	ug/L	100 - 100	317	10200	1390		87	YES	6540
MET	Antimony	12	0	0	ug/L	5 - 5							
MET	Arsenic	12	3	25	ug/L	3 - 3	4	49.3	8.33		148		
MET	Barium	12	12	100	ug/L		11.6	194	59.2		4	YES	93.8
MET	Beryllium	12	0	0	ug/L	1 - 1							
MET	Cadmium	12	0	0	ug/L	1 - 1							
MET	Calcium	12	12	100	ug/L		84500	271000					
MET	Chromium	12	2	17	ug/L	2 - 2	2.1	12.7	3.0		42		
MET	Cobalt	12	4	33	ug/L	3 - 3	6.15	12.8	8.3				
MET	Copper	12	1	8	ug/L	4 - 4	21.9	21.9	21.9		1.58	YES	
MET	Iron	12	12	100	ug/L		76.7	50000			1	YES	18900
MET	Lead	12	5	42	ug/L	1.5 - 1.5	1.6	29.9	4.7				
MET	Magnesium	12	12	100	ug/L		18100	64600					
MET	Manganese	12	12	100	ug/L		64.6	8840			120	YES	3380
MET	Mercury	12	1	8	ug/L	0.08 - 0.08	0.11	0.11	0.11				
MET	Nickel	12	9	75	ug/L	3 - 3	3.4	51.7	14.5		28.9	YES	48
MET	Potassium	12	12	100	ug/L		957	46200					
MET	Selenium	12	1	8	ug/L	3 - 3	3.8	3.8	3.8				
MET	Silver	12	0	0	ug/L	1 - 1							
MET	Sodium	12	12	100	ug/L		3430	19300					
MET	Thallium	12	2	17	ug/L	3 - 3	3.7	4.3	4				
MET	Vanadium	12	2	17	ug/L	3 - 3	3.3	19	4.6		19		
MET	Zinc	12	7	58	ug/L	5 - 5	7	71.6	18.4		59	YES	27.9
PCB	PCB-1016 (Aroclor 1016)	12	0	0	ug/L	0.1 - 0.12							
PCB	PCB-1221 (Aroclor 1221)	12	0	0	ug/L	0.1 - 0.12							
PCB	PCB-1232 (Aroclor 1232)	12	0	0	ug/L	0.1 - 0.12							

Table 2-2. Summary Statistics and COPEC Selection for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Average	Background	Toxicity Screening Level	COPEC	UCL_{95}
Surface Water (continued)													
PCB	PCB-1242 (Aroclor 1242)	12	0	0	ug/L	0.1 - 0.12							
PCB	PCB-1248 (Aroclor 1248)	12	0	0	ug/L	0.1 - 0.12							
PCB	PCB-1254 (Aroclor 1254)	12	0	0	ug/L	0.1 - 0.12							
PCB	PCB-1260 (Aroclor 1260)	12	0	0	ug/L	0.1 - 0.12							
SV	1,2,4-Trichlorobenzene	12	0	0	ug/L	0.14 - 0.14							
SV	1,2-Dichlorobenzene	12	0	0	ug/L	0.17 - 0.17							
SV	1,2-Diphenylhydrazine	12	0	0	ug/L	0.64 - 0.68							
SV	1,3-Dichlorobenzene	12	0	0	ug/L	0.21 - 0.21							
SV	1,4-Dichlorobenzene	12	0	0	ug/L	0.12 - 0.12							
SV	2,4,5-Trichlorophenol	8	0	0	ug/L	0.46 - 0.49							
SV	2,4,6-Trichlorophenol	7	0	0	ug/L	0.68 - 0.72							
SV	2,4-Dichlorophenol	8	0	0	ug/L	0.41 - 0.43							
SV	2,4-Dimethylphenol	8	0	0	ug/L	0.66 - 0.7							
SV	2,4-Dinitrophenol	7	0	0	ug/L	0.79 - 0.83							
SV	2,4-Dinitrotoluene	12	0	0	ug/L	0.45 - 0.48							
SV	2,6-Dinitrotoluene	12	0	0	ug/L	0.61 - 0.65							
SV	2-Chloronaphthalene	12	0	0	ug/L	0.54 - 0.57							
SV	2-Chlorophenol	8	0	0	ug/L	0.55 - 0.58							
SV	2-Methylnaphthalene	12	0	0	ug/L	0.63 - 0.67							
SV	2-Methylphenol (o-Cresol)	9	1	11	ug/L	0.77 - 0.81	0.95	0.95	0.95				
SV	2-Nitroaniline	12	0	0	ug/L	1.1 - 1.2							
SV	2-Nitrophenol	8	0	0	ug/L	0.68 - 0.72							
SV	3,3'-Dichlorobenzidine	12	0	0	ug/L	0.82 - 0.87							
SV	3-Methylphenol	9	2	22	ug/L	0.71 - 0.75	13	18	13.6				
SV	3-Nitroaniline	12	0	0	ug/L	0.97 - 1							
SV	4,6-Dinitro-2-methylphenol	7	0	0	ug/L	0.68 - 0.72							
SV	4-Bromophenyl phenyl ether	12	0	0	ug/L	0.53 - 0.56							
SV	4-Chloro-3-methylphenol	9	0	0	ug/L	0.54 - 0.57							
SV	4-Chloroaniline	12	0	0	ug/L	0.88 - 0.93							
SV	4-Chlorophenyl phenyl ether	12	0	0	ug/L	0.82 - 0.87							
SV	4-Methylphenol (p-Cresol)	9	2	22	ug/L	0.71 - 0.75	13	18	13.6				
SV	4-Nitroaniline	12	0	0	ug/L	1.9 - 2							
SV	4-Nitrophenol	7	0	0	ug/L	0.77 - 0.81							
SV	Acenaphthene	12	0	0	ug/L	0.58 - 0.62							
SV	Acenaphthylene	12	0	0	ug/L	0.44 - 0.46							
SV	Anthracene	12	0	0	ug/L	0.71 - 0.75							
SV	Benzo(a)anthracene	12	0	0	ug/L	0.84 - 0.89							
SV	Benzo(a)pyrene	12	0	0	ug/L	0.56 - 0.59							
SV	Benzo(b)fluoranthene	12	0	0	ug/L	0.66 - 0.7							
SV	Benzo(g,h,i)perylene	12	0	0	ug/L	1.4 - 1.5							
SV	Benzo(k)fluoranthene	12	0	0	ug/L	0.46 - 0.49							

Table 2-2. Summary Statistics and COPEC Selection for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Average	Background	Toxicity Screening Level	COPEC	UCL_{95}
Surface Water (continued)													
SV	Benzyl alcohol	8	1	12	ug/L	0.69 - 0.74	2.3	2.3	2.3				
SV	Butylbenzylphthalate	12	0	0	ug/L	0.76 - 0.8							
SV	Carbazole	12	0	0	ug/L	0.64 - 0.68							
SV	Chrysene	12	0	0	ug/L	0.94 - 0.99							
SV	Di-n-butylphthalate	12	0	0	ug/L	1.2 - 1.3							
SV	Di-n-octylphthalate	12	0	0	ug/L	0.3 - 0.32							
SV	Dibenz(a,h)anthracene	12	0	0	ug/L	1.6 - 1.7							
SV	Dibenzofuran	12	0	0	ug/L	0.6 - 0.64							
SV	Diethylphthalate	12	0	0	ug/L	0.94 - 1							
SV	Dimethylphthalate	12	0	0	ug/L	0.68 - 0.72							
SV	Fluoranthene	12	0	0	ug/L	0.65 - 0.69							
SV	Fluorene	12	0	0	ug/L	0.51 - 0.54							
SV	Hexachlorobenzene	12	0	0	ug/L	0.44 - 0.46							
SV	Hexachlorobutadiene	12	0	0	ug/L	0.86 - 0.91							
SV	Hexachlorocyclopentadiene	12	0	0	ug/L	0.82 - 0.87							
SV	Hexachloroethane	12	0	0	ug/L	0.42 - 0.45							
SV	Indeno(1,2,3-cd)pyrene	12	0	0	ug/L	1.3 - 1.4							
SV	Isophorone	8	0	0	ug/L	0.51 - 0.54							
SV	N-Nitroso-di-n-propylamine	12	0	0	ug/L	0.83 - 0.88							
SV	N-Nitrosodimethylamine	12	0	0	ug/L	0.83 - 0.88							
SV	N-Nitrosodiphenylamine	12	0	0	ug/L	0.42 - 0.45							
SV	Naphthalene	12	0	0	ug/L	0.42 - 0.44					13		
SV	Nitrobenzene	12	0	0	ug/L	0.57 - 0.61							
SV	Pentachlorophenol	7	0	0	ug/L	0.92 - 0.98							
SV	Phenanthrene	12	0	0	ug/L	0.71 - 0.75							
SV	Phenol	9	1	11	ug/L	0.42 - 0.45	0.65	0.65	0.65				
SV	Pyrene	12	0	0	ug/L	0.6 - 0.64							
SV	bis(2-Chloroethoxy)methane	12	0	0	ug/L	0.48 - 0.51							
SV	bis(2-Chloroethyl)ether (2-Chloroethylether)	12	0	0	ug/L	0.42 - 0.44							
SV	bis(2-Chloroisopropyl)ether	12	0	0	ug/L	0.79 - 0.83							
SV	bis(2-Ethylhexyl)phthalate	12	0	0	ug/L	1.2 - 1.3					0.12		
VOC	1,1,1-Trichloroethane	12	2	17	ug/L	0.15 - 0.15	4.9	14	5.66		11	YES	
VOC	1,1,2,2-Tetrachloroethane	12	0	0	ug/L	0.07 - 0.07							
VOC	1,1,2-Trichloro-1,2,2-Trifluoroethane	12	0	0	ug/L	0.22 - 0.22							
VOC	1,1,2-Trichloroethane	12	0	0	ug/L	0.17 - 0.17							
VOC	1,1-Dichloroethane	12	2	17	ug/L	0.15 - 0.15	2.6	3.9	2.71		47		
VOC	1,1-Dichloroethene	12	0	0	ug/L	0.42 - 0.42							
VOC	1,2,3-Trichlorobenzene	12	0	0	ug/L	0.16 - 0.16							
VOC	1,2-Dibromo-3-chloropropane	12	0	0	ug/L	0.28 - 0.28							
VOC	1,2-Dibromoethane (EDB)	12	0	0	ug/L	0.07 - 0.07							
VOC	1,2-Dichloroethane	12	0	0	ug/L	0.15 - 0.15							

Table 2-2. Summary Statistics and COPEC Selection for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Average	Background	Toxicity Screening Level	COPEC	UCL_{95}
Surface Water (continued)													
VOC	2-Butanone (Methyl ethyl ketone)	12	1	8	ug/L	1.2 - 1.2	2.5	2.5	2.5				
VOC	2-Hexanone	12	0	0	ug/L	0.83 - 0.83							
VOC	4-Methyl-2-pentanone (Methyl isobutyl ketone)	12	0	0	ug/L	1.4 - 1.4							
VOC	Acetone	12	5	42	ug/L	1.1 - 1.1	2.9	22	7.13				
VOC	Benzene	12	0	0	ug/L	0.11 - 0.11							
VOC	Bromochloromethane	12	0	0	ug/L	0.31 - 0.31							
VOC	Bromodichloromethane	12	0	0	ug/L	0.086 - 0.086							
VOC	Bromoform	12	0	0	ug/L	0.24 - 0.24							
VOC	Bromomethane	12	0	0	ug/L	0.33 - 0.33							
VOC	Carbon Disulfide	12	0	0	ug/L	0.13 - 0.13							
VOC	Carbon tetrachloride	12	1	8	ug/L	0.14 - 0.14	0.46	0.46	0.46				
VOC	Chlorobenzene	12	0	0	ug/L	0.28 - 0.28							
VOC	Chloroethane	12	0	0	ug/L	0.38 - 0.38							
VOC	Chloroform	12	1	8	ug/L	0.1 - 0.1	0.15	0.15	0.15				
VOC	Chloromethane	12	0	0	ug/L	0.4 - 0.4							
VOC	Cyclohexane	12	0	0	ug/L	0.18 - 0.18							
VOC	Dibromochloromethane	12	0	0	ug/L	0.08 - 0.08							
VOC	Dichlorodifluoromethane	12	0	0	ug/L	0.24 - 0.24							
VOC	Ethylbenzene	12	0	0	ug/L	0.14 - 0.14							
VOC	Isopropylbenzene (Cumene)	12	0	0	ug/L	0.034 - 0.034							
VOC	Methyl Acetate	12	0	0	ug/L	0.87 - 0.87							
VOC	Methylcyclohexane	12	0	0	ug/L	0.2 - 0.2							
VOC	Methylene Chloride	12	0	0	ug/L	0.26 - 0.26							
VOC	Styrene	12	0	0	ug/L	0.22 - 0.22							
VOC	Tert-Butyl Methyl Ether (MTBE)	12	0	0	ug/L	0.17 - 0.17							
VOC	Tetrachloroethene (PCE)	12	0	0	ug/L	0.14 - 0.14							
VOC	Toluene	12	0	0	ug/L	0.18 - 0.32							
VOC	Trichloroethene (TCE)	12	2	17	ug/L	0.28 - 0.28	1.7	4.9	1.97		47		
VOC	Trichlorofluoromethane	12	0	0	ug/L	0.15 - 0.15							
VOC	Vinyl chloride	12	0	0	ug/L	0.19 - 0.19							
VOC	Xylenes, Total	12	0	0	ug/L	0.21 - 0.21							
VOC	cis-1,2-Dichloroethene	12	1	8	ug/L	0.44 - 0.44	0.91	0.91	0.91				
VOC	cis-1,3-Dichloropropene	12	0	0	ug/L	0.13 - 0.13							
VOC	trans-1,2-Dichloroethene	12	0	0	ug/L	0.4 - 0.4							
VOC	trans-1,3-Dichloropropene	12	0	0	ug/L	0.22 - 0.22							

Table 2-2. Summary Statistics and COPEC Selection for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Average	Background	Toxicity Screening Level	COPEC	UCL_{95}
Sediment													
HE	1,3,5-Trinitrobenzene	15	0	0	ug/kg	80 - 100							
HE	1,3-Dinitrobenzene	15	0	0	ug/kg	80 - 100					8610		
HE	2,4,6-Trinitrotoluene	15	2	13	ug/kg	80 - 100	230	590	254				
HE	2,4-Dinitrotoluene	15	2	13	ug/kg	100 - 130	240	490	258		14400		
HE	2,6-Dinitrotoluene	15	0	0	ug/kg	100 - 130							
HE	2-Amino-4,6-Dinitrotoluene	15	0	0	ug/kg	120 - 150							
HE	2-Nitrotoluene	15	0	0	ug/kg	80 - 100							
HE	3-Nitrotoluene	15	0	0	ug/kg	120 - 150							
HE	4-Amino-2,6-Dinitrotoluene	15	0	0	ug/kg	80 - 100							
HE	4-Nitrotoluene	15	2	13	ug/kg	80 - 95	110	320	215				
HE	HMX	15	0	0	ug/kg	80 - 100							
HE	Nitrobenzene	15	0	0	ug/kg	88 - 110							
HE	RDX	15	3	20	ug/kg	80 - 95	100	920	206				
HE	Tetryl	15	1	7	ug/kg	80 - 100	100	100	100				
MET	Aluminum	15	15	100	mg/kg		5610	47600		15500			
MET	Antimony	15	0	0	mg/kg	2.4 - 7.8				9.3			
MET	Arsenic	15	15	100	mg/kg		1.7	20.8		36.5	6		
MET	Barium	15	15	100	mg/kg		4.4	105		826			
MET	Beryllium	15	15	100	mg/kg		0.36	13.8		1			
MET	Cadmium	15	11	73	mg/kg	0.26 - 0.28	0.33	3.7	0.876				
MET	Calcium	15	15	100	mg/kg		3140	114000		52300			
MET	Chromium	15	15	100	mg/kg		2	34.4		29	26	YES	19.6
MET	Cobalt	15	15	100	mg/kg		2.8	77.3		116	50		
MET	Copper	15	15	100	mg/kg		9.8	51.7		56.2	16		
MET	Iron	15	15	100	mg/kg		1470	54600		234000	20000		
MET	Lead	15	15	100	mg/kg		5.6	77.3		48.6	31	YES	38.9
MET	Magnesium	15	15	100	mg/kg		482	16200		10400			
MET	Manganese	15	15	100	mg/kg		18.9	722		3506	460		
MET	Mercury	15	15	100	mg/kg		0.0205	2.2		0.1	0.174	YES	1.63
MET	Nickel	15	15	100	mg/kg		9.2	243		55.1	16	YES	74
MET	Potassium	15	14	93	mg/kg	380 - 380	1090	4360	1900	3390			
MET	Selenium	15	2	13	mg/kg	0.73 - 2.3	0.94	1.5	0.983	2			
MET	Silver	15	0	0	mg/kg	0.24 - 0.88				11.1	0.5		
MET	Sodium	15	0	0	mg/kg	240 - 390							
MET	Thallium	15	0	0	mg/kg	0.3 - 0.98				1.3			
MET	Vanadium	15	15	100	mg/kg		2	48.6		40.9			
MET	Zinc	15	15	100	mg/kg		28.5	286		322	120		
PCB	PCB-1016 (Aroclor 1016)	15	0	0	ug/kg	3.9 - 6.4							
PCB	PCB-1221 (Aroclor 1221)	15	0	0	ug/kg	3.9 - 6.4							
PCB	PCB-1232 (Aroclor 1232)	15	0	0	ug/kg	3.9 - 6.4							
PCB	PCB-1242 (Aroclor 1242)	15	0	0	ug/kg	3.9 - 6.4							
PCB	PCB-1248 (Aroclor 1248)	15	0	0	ug/kg	3.9 - 6.4							
PCB	PCB-1254 (Aroclor 1254)	15	14	93	ug/kg	4.9 - 4.9	4.6	750	186		60	YES	488
PCB	PCB-1260 (Aroclor 1260)	15	14	93	ug/kg	5.9 - 5.9	6.5	1800	269		5	YES	807

Table 2-2. Summary Statistics and COPEC Selection for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Average	Background	Toxicity Screening Level	COPEC	UCL_{95}
Sediment (continued)													
SV	1,2,4-Trichlorobenzene	15	0	0	ug/kg	0.17 - 0.5							
SV	1,2-Dichlorobenzene	15	0	0	ug/kg	0.36 - 1							
SV	1,2-Diphenylhydrazine	15	0	0	ug/kg	32 - 52							
SV	1,3-Dichlorobenzene	15	0	0	ug/kg	0.81 - 2.3							
SV	1,4-Dichlorobenzene	15	0	0	ug/kg	0.53 - 1.5							
SV	2,4,5-Trichlorophenol	15	0	0	ug/kg	32 - 52							
SV	2,4,6-Trichlorophenol	15	0	0	ug/kg	42 - 68							
SV	2,4-Dichlorophenol	15	0	0	ug/kg	23 - 37							
SV	2,4-Dimethylphenol	15	0	0	ug/kg	26 - 42							
SV	2,4-Dinitrophenol	15	0	0	ug/kg	160 - 260							
SV	2,4-Dinitrotoluene	15	2	13	ug/kg	29 - 47	93	460	258		14400		
SV	2,6-Dinitrotoluene	15	0	0	ug/kg	46 - 74							
SV	2-Chloronaphthalene	15	0	0	ug/kg	38 - 63							
SV	2-Chlorophenol	15	0	0	ug/kg	49 - 80							
SV	2-Methylnaphthalene	15	1	7	ug/kg	42 - 68	280	280	280		20.2	YES	
SV	2-Methylphenol (o-Cresol)	15	0	0	ug/kg	46 - 76					55.4		
SV	2-Nitroaniline	15	0	0	ug/kg	39 - 63							
SV	2-Nitrophenol	15	0	0	ug/kg	27 - 43							
SV	3,3'-Dichlorobenzidine	15	0	0	ug/kg	38 - 62							
SV	3-Methylphenol	15	1	7	ug/kg	33 - 53	270	270	270				
SV	3-Nitroaniline	15	0	0	ug/kg	57 - 93							
SV	4,6-Dinitro-2-methylphenol	15	0	0	ug/kg	26 - 43							
SV	4-Bromophenyl phenyl ether	15	0	0	ug/kg	31 - 51							
SV	4-Chloro-3-methylphenol	15	0	0	ug/kg	34 - 54							
SV	4-Chloroaniline	15	0	0	ug/kg	58 - 94							
SV	4-Chlorophenyl phenyl ether	15	0	0	ug/kg	37 - 60							
SV	4-Methylphenol (p-Cresol)	15	1	7	ug/kg	32 - 52	270	270	270		20.2	YES	
SV	4-Nitroaniline	15	0	0	ug/kg	120 - 200							
SV	4-Nitrophenol	15	0	0	ug/kg	98 - 160							
SV	Acenaphthene	15	0	0	ug/kg	32 - 52					6.71		
SV	Acenaphthylene	15	0	0	ug/kg	24 - 38					5.87		
SV	Anthracene	15	2	13	ug/kg	33 - 53	41	61	51		57.2	YES	
SV	Benzo(a)anthracene	15	8	53	ug/kg	45 - 69	104	350	204		108	YES	194
SV	Benzo(a)pyrene	15	6	40	ug/kg	28 - 45	91	310	169		150	YES	152
SV	Benzo(b)fluoranthene	15	12	80	ug/kg	39 - 60	59	500	195		150	YES	231
SV	Benzo(g,h,i)perylene	15	1	7	ug/kg	85 - 140	180	180	180		170	YES	180
SV	Benzo(k)fluoranthene	15	10	67	ug/kg	49 - 74	68	380	205		240	YES	214
SV	Benzoic acid	15	0	0	ug/kg	23 - 38					240		
SV	Benzyl alcohol	15	0	0	ug/kg	54 - 88							
SV	Butylbenzylphthalate	15	0	0	ug/kg	36 - 58							
SV	Carbazole	15	0	0	ug/kg	44 - 71							
SV	Chrysene	15	10	67	ug/kg	38 - 59	50	410	218		166	YES	227

Table 2-2. Summary Statistics and COPEC Selection for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Average	Background	Toxicity Screening Level	COPEC	UCL_{95}
Sediment (continued)													
SV	Di-n-butylphthalate	15	0	0	ug/kg	38 - 170							
SV	Di-n-octylphthalate	15	0	0	ug/kg	32 - 53							
SV	Dibenz(a,h)anthracene	15	0	0	ug/kg	73 - 120					33		
SV	Dibenzofuran	15	1	7	ug/kg	30 - 48	91	91	91				
SV	Diethylphthalate	15	0	0	ug/kg	800 - 1300							
SV	Dimethylphthalate	15	0	0	ug/kg	37 - 60							
SV	Fluoranthene	15	9	60	ug/kg	66 - 100	100	640	306		423	YES	333
SV	Fluorene	15	0	0	ug/kg	32 - 51					77.4		
SV	Hexachlorobenzene	15	0	0	ug/kg	42 - 68							
SV	Hexachlorobutadiene	15	0	0	ug/kg	40 - 64							
SV	Hexachlorocyclopentadiene	14	0	0	ug/kg	74 - 120							
SV	Hexachloroethane	15	0	0	ug/kg	47 - 77							
SV	Indeno(1,2,3-cd)pyrene	15	3	20	ug/kg	56 - 90	240	360	313		200	YES	276
SV	Isophorone	15	0	0	ug/kg	34 - 56							
SV	N-Nitroso-di-n-propylamine	15	1	7	ug/kg	68 - 110	620	620	620				
SV	N-Nitrosodimethylamine	15	0	0	ug/kg	110 - 190							
SV	N-Nitrosodiphenylamine	15	0	0	ug/kg	38 - 63							
SV	Naphthalene	15	1	7	ug/kg	39 - 64	210	210	210				
SV	Nitrobenzene	15	0	0	ug/kg	42 - 68							
SV	Pentachlorophenol	15	0	0	ug/kg	41 - 66							
SV	Phenanthrene	15	9	60	ug/kg	28 - 43	46	310	148		204	YES	145
SV	Phenol	15	0	0	ug/kg	43 - 71					49.1		
SV	Pyrene	15	10	67	ug/kg	49 - 75	65	540	270		195	YES	296
SV	bis(2-Chloroethoxy)methane	15	0	0	ug/kg	37 - 61							
SV	bis(2-Chloroethyl)ether (2-Chloroethylether)	15	0	0	ug/kg	49 - 80							
SV	bis(2-Chloroisopropyl)ether	15	0	0	ug/kg	62 - 100							
SV	bis(2-Ethylhexyl)phthalate	15	3	20	ug/kg	45 - 71	50	56	53.3				
VOC	1,1,1-Trichloroethane	15	0	0	ug/kg	0.87 - 2.5							
VOC	1,1,2,2-Tetrachloroethane	15	0	0	ug/kg	0.42 - 1.2							
VOC	1,1,2-Trichloro-1,2,2-Trifluoroethane	15	0	0	ug/kg	0.53 - 1.5							
VOC	1,1,2-Trichloroethane	15	0	0	ug/kg	0.34 - 0.97							
VOC	1,1-Dichloroethane	15	1	7	ug/kg	0.52 - 1.2	2.3	2.3	2.3				
VOC	1,1-Dichloroethene	15	0	0	ug/kg	1.2 - 3.3							
VOC	1,2,3-Trichlorobenzene	15	0	0	ug/kg	0.41 - 1.2							
VOC	1,2-Dibromo-3-chloropropane	15	0	0	ug/kg	1.2 - 3.3							
VOC	1,2-Dibromoethane (EDB)	15	0	0	ug/kg	0.42 - 1.2							
VOC	1,2-Dichloroethane	15	0	0	ug/kg	0.45 - 1.3							
VOC	1,2-Dichloropropane	15	0	0	ug/kg	0.45 - 1.3							
VOC	2-Butanone (Methyl ethyl ketone)	15	7	47	ug/kg	1.4 - 3.9	2.7	53	13.3				
VOC	2-Hexanone	15	0	0	ug/kg	2.2 - 6.4							
VOC	4-Methyl-2-pentanone (Methyl isobutyl ketone)	15	0	0	ug/kg	0.56 - 1.6							

Table 2-2. Summary Statistics and COPEC Selection for Constituents Detected in Environmental Media at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Type	Analyte	Number of Samples	Number of Detects	Percent Detect	Units	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	Average	Background	Toxicity Screening Level	COPEC	UCL_{95}
Sediment (continued)													
VOC	Acetone	15	8	53	ug/kg	19 - 64	19	260	87.7		9.1	YES	116
VOC	Benzene	15	6	40	ug/kg	0.46 - 1.1	0.76	7.8	2.36				
VOC	Bromochloromethane	15	0	0	ug/kg	0.41 - 1.2							
VOC	Bromodichloromethane	15	0	0	ug/kg	0.29 - 0.83							
VOC	Bromoform	15	0	0	ug/kg	0.97 - 2.8							
VOC	Bromomethane	15	0	0	ug/kg	0.7 - 2							
VOC	Carbon Disulfide	15	7	47	ug/kg	1.3 - 3.1	2.6	30	7.13		0.86	YES	10.1
VOC	Carbon tetrachloride	15	0	0	ug/kg	0.85 - 2.4							
VOC	Chlorobenzene	15	0	0	ug/kg	2.4 - 6.9							
VOC	Chloroethane	15	4	27	ug/kg	1.1 - 3	2	9.65	5.34				
VOC	Chloroform	15	0	0	ug/kg	0.53 - 1.5							
VOC	Chloromethane	15	0	0	ug/kg	0.5 - 1.4							
VOC	Cyclohexane	15	7	47	ug/kg	0.52 - 1.2	1.4	29	5.35				
VOC	Dibromochloromethane	15	0	0	ug/kg	0.33 - 0.94							
VOC	Dichlorodifluoromethane	15	0	0	ug/kg	1.1 - 3							
VOC	Ethylbenzene	15	3	20	ug/kg	0.73 - 1.7	0.835	3.5	1.73				
VOC	Isopropylbenzene (Cumene)	15	0	0	ug/kg	0.85 - 2.4							
VOC	Methyl Acetate	15	0	0	ug/kg	1.6 - 4.4							
VOC	Methylcyclohexane	15	7	47	ug/kg	0.29 - 0.68	0.55	37	5.73				
VOC	Methylene Chloride	15	0	0	ug/kg	0.6 - 1.7							
VOC	Styrene	15	0	0	ug/kg	0.34 - 0.97							
VOC	Tert-Butyl Methyl Ether (MTBE)	15	0	0	ug/kg	0.31 - 0.88							
VOC	Tetrachloroethene (PCE)	15	0	0	ug/kg	0.94 - 2.7							
VOC	Toluene	15	5	33	ug/kg	0.83 - 2	2.9	20	4.61				
VOC	Trichloroethene (TCE)	15	2	13	ug/kg	0.82 - 1.9	2	4	3				
VOC	Trichlorofluoromethane	15	0	0	ug/kg	0.92 - 2.6							
VOC	Vinyl chloride	15	0	0	ug/kg	1.1 - 3							
VOC	Xylenes, Total	15	3	20	ug/kg	0.68 - 1.6	1.7	12	2.43				
VOC	cis-1,2-Dichloroethene	15	1	7	ug/kg	1.2 - 3.3	2.8	2.8	2.8				
VOC	cis-1,3-Dichloropropene	15	0	0	ug/kg	0.48 - 1.4							
VOC	trans-1,2-Dichloroethene	15	0	0	ug/kg	1.1 - 3							
VOC	trans-1,3-Dichloropropene	15	0	0	ug/kg	0.31 - 0.88							

Table 2-3. Acid Area 1 Ecological Assessment and Measurement Endpoints
Plum Brook Ordnance Works, Sandusky, Ohio

Assessment Endpoint	Selected Receptor and Exposure Routes	Measurement Endpoint
Protection of long-term survival and reproductive capabilities for soil invertebrates.	Terrestrial Invertebrates Ingestion of soil and direct exposure to soil.	Comparison of soil concentrations to critical effect values.
Protection of long-term survival and reproductive capabilities for herbivorous mammals.	Eastern cottontail (*Sylvilagus floridanus*) White-tailed deer (*Odocoileus virginianus*) Ingestion of plants, water, and incidental soil	Comparison of total daily dose to species-specific toxifity endpoint values.
Protection of long-term survival and reproductive capabilities for omnivorous mammals.	Raccoon (*Procyon lotor*) Ingestion of terrestrial plants, invertebrates, small mammals, water, and incidental soil. Deer mouse (*Peromyscus maniculatus*) Ingestion of terrestrial invertebrates, plants, water, and incidental soil.	Comparison of total daily dose to species-specific toxicity endpoint values.
Protection of long-term survival and reproductive capabilities for carnivorous birds.	Red-tailed hawk (*Buteo jamacencis*) Ingestion of small mammals, birds, water, incidental soil.	Comparison of total daily dose to species-specific toxicity endpoint values.
Protection of long-term survival and reproductive capabilities for small insectivorous mammals	Short-tailed shrew (*Blarnia brevicauda*) Ingestion of terrestrial invertebrates, water, and incidental soil.	Comparison of total daily dose to species-specific toxicity endpoint values.
Protection of long-term survival and reproductive capabilities for insectivorous birds.	March wren (*Cistorthorus palustris*) Ingestion of terrestrial invertebrates, water, and incidental soil.	Comparison of total daily dose to species-specific toxicity endpoint values.
Protection of long-term survival and reproductive capabilities for benthic invertebrates.	benthic invertebrates Ingestion of sediment and direct exposure to surface water.	Comparison of sediment concentrations to sediment critical effects values.
Protection of long-term survival and reproductive capabilities for aquatic invertebrates (crustaceans).	Aquatic invertebrates Direct exposure to water	Comparison of surface water concentrations to aquatic critical effects values.
Protection of long-term survival and reproductive capabilities for semi-aquatic omnivorous mammals.	Raccoon (*Procyon lotor*) Ingestion of aquatic invertebrates, water and incidental sediment	Comparison of total daily dose to species-specific toxicity endpoint values.
Protection of long-term survival and reproductive capabilities for aquatic birds	Mallard (*Anas platyrhynchos*) Ingestion of aquatic and benthic invertebrates, water, and incidental sediment.	Comparison of total daily dose to species-specific toxicity endpoint values.

Table 3-1. Species-Specific Exposure Parameters, Plum Brook Ordnance Works, Sandusky, Ohio

Species	Parameter	Value	Units	Source
Short-tailed shrew	Home range factor[1]	1	unitless	calculated value
Blarina brevicauda	Diet: Plants	0	percent	EPA 1993
	Invertebrates	100	percent	EPA 1993
	Vertebrates (fish)	0	percent	EPA 1993
	Sediment	10.4	percent	EPA 1993
	Ingestion Rate: Food	0.0022	kg/day (dry wt.)	EPA 1993
	Water	0.0023	L/day	EPA 1993
	Body weight	0.015	kg	EPA 1993
	Exposure duration	12	months	EPA 1993
	Home range (ha)	0.39	ha	EPA 1993
White-tailed deer	Home range factor[1]	.02/.03	unitless	calculated value
Odocoileus virginianus	Diet: Plants	100	percent	EPA 1993
	Invertebrates	0	percent	EPA 1993
	Vertebrates (fish)	0	percent	EPA 1993
	Soil	2	percent	EPA 1993
	Ingestion Rate: Food	2	kg/day (dry wt.)	EPA 1993
	Water	4	L/day	EPA 1993
	Body weight	61	g (wet wt.)	Gottschang, 1981
	Exposure duration	12	months	EPA 1993
	Home range (ha)	518	ha	Gottschang, 1981
Marsh wren	Home range factor[1]	1	unitless	calculated value
Cistothorus palustris	Diet: Plants	0	percent	EPA 1993
	Invertebrates	100	percent	EPA 1993
	Vertebrates (fish)	0	percent	EPA 1993
	Soil	2	percent	EPA 1993
	Ingestion Rate: Food	0.0029	g/day (wet wt.)	EPA 1993
	Water	0.0027	L/day	EPA 1993
	Body weight	0.01	g (wet wt.)	EPA 1993
	Exposure duration	4	months	EPA 1993
	Home range (ha)	0.054	ha	EPA 1993
Deer Mouse	Home range factor[1]	1	unitless	calculated value
Peromyscus maniculatus	Diet: Plants	61	percent	EPA 1993
	Invertebrates	39	percent	EPA 1993
	Vertebrates (fish)	0	percent	EPA 1993
	Soil	2	percent	EPA 1993
	Ingestion Rate: Food	0.0028	g/day (wet wt.)	EPA 1993
	Water	0.0022	L/day	EPA 1993
	Body weight	0.0148	g (wet wt.)	EPA 1993
	Exposure duration	12	months	EPA 1993
	Home range (ha)	0.062	ha	EPA 1993
Eastern Cottontail	Home range factor[1]	1	unitless	calculated value
Sylvilagus floridanus	Diet: Plants	100	percent	EPA 1993
	Invertebrates	0	percent	EPA 1993
	Vertebrates	0	percent	EPA 1993
	Soil	6.3	percent	EPA 1993
	Ingestion Rate: Food	0.096	kg/day (dry wt.)	EPA 1993
	Water	0.11	L/day	EPA 1993
	Body weight	1.132	g (wet wt.)	EPA 1993
	Exposure duration	12	months	EPA 1993
	Home range (ha)	3.1	ha	EPA 1993

Table 3-1. Species-Specific Exposure Parameters, Plum Brook Ordnance Works, Sandusky, Ohio

Species	Parameter	Value	Units	Source
Red-Tailed Hawk	Home range factor[1]	.01/.02	unitless	calculated value
Buteo jamaicensis	Diet: Plants	0	percent	EPA 1993
	Invertebrates	0	percent	EPA 1993
	Vertebrates (mammals)	100	percent	EPA 1993
	Soil	2	percent	EPA 1993
	Ingestion Rate: Food	0.057	kg/day (dry wt.)	EPA 1993
	Water	0.057	L/day	EPA 1993
	Body weight	0.957	kg	EPA 1993
	Exposure duration	12	months	EPA 1993
	Home range (ha)	842	ha	EPA 1993
Raccoon	Home range factor[1]	.06/.1	unitless	calculated value
Procyon lotor	Diet: Plants	42	percent	EPA 1993
	Invertebrates	51	percent	EPA 1993
	Vertebrates	5	percent	EPA 1993
	Sediment	9.4	percent	EPA 1993
	Ingestion Rate: Food	0.26	kg/day (dry wt.)	EPA 1993
	Water	0.43	L/day	EPA 1993
	Body weight	5.1	kg	EPA 1993
	Exposure duration	8	months	EPA 1993
	Home range (ha)	156	ha	EPA 1993
Mallard Duck	Home range factor[1]	.02/.03	unitless	calculated value
Anas platyrhynchos	Diet: Plants	62.5	percent	EPA 1993
	Invertebrates	37.5	percent	EPA 1993
	Vertebrates (fish)	0	percent	EPA 1993
	Sediment	2	percent	EPA 1993
	Ingestion Rate: Food	0.063	kg/day (dry wt.)	EPA 1993
	Water	0.064	L/day	EPA 1993
	Body weight	1.13	kg (wet wt.)	EPA 1993
	Exposure duration	7	months	EPA 1993
	Home range (ha)	580	ha	EPA 1993

Notes:

[1]Home range factors are based on an estimated affected area of 10.1 and 16.2 hectares for AA2 and AA3, respectively. If the home range of the species was less than the affected area of the habitat, the home range factor was set at 1.0. If the home range of the species was greater than the affected area of the habitat, the home range factor was calculated by dividing the affected area by the home range.

kg = kilograms
g/day = grams per day
ha = hectares
L/day = liters per day
NA = not available
wt. = weight

Table 3-2. Bioconcentration Factors for Chemicals of Potential Ecological Concern, Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Octanol-Water Partition Coefficient (log K_{ow})[1]	Soil to Invertebrates (mg/kg wet tissue/mg/kg dry soil)[2]	Water to Invertebrates (mg/kg wet tissue/mg dissolved COPEC/L)[3]	Sediment to Invertebrates (mg/kg wet tissue/mg/kg dry sediment)[4]	Water to Fish (mg/kg wet tissue/mg dissolved COPEC/L)[5]	Soil/Sediment to Plants (mg/kg dry tissue/mg/kg dry soil or sediment)[6]	Water to Plants (mg/kg wet tissue/mg dissolved COPEC/L)[7]
Inorganics							
Aluminum	NA	0.22	4,066	0.90	2.70	0.004	833
Antimony	NA	0.22	7.00	0.90	40.0	0.200	1,475
Arsenic	NA	0.11	73.0	0.90	114	0.036	293
Barium	NA	0.22	200	0.90	633	0.150	260
Beryllium	NA	0.22	45.00	0.90	62.0	0.010	141
Cadmium	NA	0.96	3,461	3.40	907	0.364	782
Chromium	NA	0.01	3,000	0.39	19.00	0.008	4,406
Cobalt	NA	0.22	4,066	0.90	40.00	0.350	
Copper	NA	0.04	3,718	0.30	710	0.400	541
Iron	NA	0.22	4,066	0.90		0.001	
Lead	NA	0.03	5,059	0.63	0.09	0.045	1,706
Manganese	NA	0.32	4,066	0.90	35.00	0.050	
Mercury	NA	0.04	20,184	0.07	3,530	0.038	24,762
Nickel	NA	0.02	28.00	0.90	78.00	0.032	61.0
Selenium	NA	0.22	1,262	0.90	129	0.016	1,845
Silver	NA	0.22	1,262	0.90	129	0.400	1,845
Thallium	NA	0.22	15,000	0.90	10,000	0.004	15,000
Vanadium	NA	0.22	4,066	0.90	633	0.003	
Zinc	NA	0.56	4,578	0.57	2,059	1.2E-12	2,175
Cyanide	NA	1.12	4,066	0.90	14.00		22.0
VOCs							
1,1,1-Trichloroethane	2.49	7.82	7.82	7.82	30.2	1.409	7.82
Acetone	-0.222	0.05	0.05	0.05	0.10	52.0	0.05
Benzene	2.13	3.97	3.97	3.97	14.2	2.274	3.97
Carbon Disulfide	2.24	4.88	4.88	4.88	17.9	1.965	4.88
Ethylbenzene	3.15	27.2	27.2	27.2	120	0.585	27.2
Methyl Acetate	-0.09	0.06	0.06	0.06	0.14	43.7	0.06
Toluene	2.73	12.3	12.3	12.3	49.9	1.023	12.3
Xylenes, Total	3.15	27.2	27.2	27.2	120	0.585	27.2
Dioxins							
2,3,7,8-TCDD TEQ		1.59				0.006	
SVOCs							
1,3,5-Trinitrobenzene	1.18	0.66	13.0	58.0	21.04	8.053	2507
2-Butanone (Methyl ethyl ketone)	0.29	0.12	13.0	58.0	21.04	26.3	2507
2,4-Dinitrotoluene	1.996	3.08	13.0	58.0	21.04	2.718	2507
2,6-Dinitrotoluene		2.50	13.0	58.0	21.04	3.150	2507
2,4,6-Trinitrotoluene	2.25	4.97	13.0	58.0	21.04	1.939	2507
2-Methylnaphthalene	3.9	112	112	112	579	0.216	112
3-nitrotoluene	2.45	7.25	7.25	7.25	27.77	1.486	7.25
2-Methylphenol (o-Cresol)	1.95	2.83	2.83	2.83	9.74	2.890	2.83
4-Methylphenol (p-Cresol)	1.963	2.90	2.90	2.90	9.54	2.840	2.90
4-Methyl-2-pentanone (Methyl isobutyl ketone)	1.19	0.67	0.67	0.67		7.947	0.67
Acenaphthene	3.92	116	116	116	604	0.210	116
Acenaphthylene	3.5	52.5	52.5	52.5	251	0.367	52.5
Acetophenone	1.58	1.41	1.41	1.41	4.49	4.729	1.41
Anthracene	4.55	381	381	381	2,262	0.091	381
Benzaldehyde	1.48	1.16	1.16	1.16	3.64	5.402	1.16
Benzo(a)anthracene	5.679	0.03	12,299	1.45	500	0.020	5,258
Benzo(a)pyrene	6.129	0.07	4,697	1.59	500	0.011	5,258
Benzo(b)fluoranthene	6.202	0.07	4,697	1.61	500	0.010	5,258
Benzo(g,h,i)perylene	6.7	0.07	4,697	1.61	500	0.005	5,258
Benzo(k)fluoranthene	6.2	0.08	13,225	1.61	500	0.010	5,258

Table 3-2. Bioconcentration Factors for Chemicals of Potential Ecological Concern, Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Octanol-Water Partition Coefficient (log K_{ow})[1]	Soil to Invertebrates (mg/kg wet tissue/mg/kg dry soil)[2]	Water to Invertebrates (mg/kg wet tissue/mg dissolved COPEC/L)[3]	Sediment to Invertebrates (mg/kg wet tissue/mg/kg dry sediment)[4]	Water to Fish (mg/kg wet tissue/mg dissolved COPEC/L)[5]	Soil/Sediment to Plants (mg/kg dry tissue/mg/kg dry soil or sediment)[6]	Water to Plants (mg/kg wet tissue/mg dissolved COPEC/L)[7]
SVOCs (continued)							
Benzoic acid	1.87	2.43	2.43	2.43	8.24	3.215	2.43
Benzyl butyl phthalate	4.84	658	658	658	4,153	0.062	658
bis(2-ethylhexyl)phthalate	5.205	1,309	318	1,309	70.00	0.038	9,931
Carbazole	3.59	62.3	62.3	62.3	303	0.326	62.3
Chrysene	5.739	0.04	980	1.38	500	0.019	5,258
Cyclohexane	3.44	46.9	46.9	46.9	221	0.398	46.9
Dibenzofuran	4.2	197	197	197	1,086	0.145	197
Dibenz(a,h)anthracene	6.547	0.07	710	1.61	500	0.006	5,258
Di-n-butylphthalate	4.13	172	172	172	938	0.159	172
Fluoranthene	4.95	809	809	809	5,230	0.053	809
Fluorene	4.21	200	200	200	1,109	0.143	200
HMX	0.59	0.22	0.22	0.22	0.56	17.7	0.22
Indeno(1,2,3-cd)pyrene	6.915	0.08	4,697	1.61	500	0.004	5,258
methylcyclohexane	3.61	64.7	64.7	64.7	316	0.317	64.7
n-nitroso-di-n-propylamine	1.36	0.93	0.93	0.93	2.83	6.338	0.93
Naphthalene	3.3	36.0	36.0	36.0	165	0.479	36.0
PCB-1254 (Aroclor 1254)	6.207	1.13	5,538	0.53	230,394	0.010	476,829
PCB-1260 (Aroclor 1260)	6.91	1.13	5,538	0.53	230,394	0.004	476,829
Phenanthrene	4.57	395	395	395	2,359	0.088	395
Phenol	1.46	1.12	1.12	1.12	3.49	5.548	1.12
Pyrene	5.11	1,094	1,094	1,094	7,313	0.043	1,094
RDX	0.87	0.37	0.37	0.37	1.01	12.2	0.37

NA = not applicable

Ref. = references

1. Values taken from Karickhoff and Long 1995, except for acetone and bis(2-ethylhexyl)phthalate whose values were obtained from EPA 1995a. Octanol-water partition coefficients for inorganics do not exist and therefore are not presented.
2. Value taken from EPA 1999c, Appendix C, Table C-1 or calculated using recommended equations.
3. Value taken from EPA 1999c, Appendix C, Table C-3 or calculated using recommended equations.
4. Value taken from EPA 1999c, Appendix C, Table C-6 or calculated using recommended equations.
5. Value taken from EPA 1999c, Appendix C, Table C-5 or calculated using recommended equations.
6. Value taken from EPA 1999c, Appendix C, Table C-2 or calculated using recommended equations.
7. Value taken from EPA 1999c, Appendix C, Table C-4 or calculated using recommended equations.

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Table 3-3. Exposure Doses for Short-tailed Shrew (*Blarina brevicauda*) for Exposures at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Conc. Soil mg/kg_{sed} (dry wt)	BCF_{inv} mg/kg wet	IC mg/g_{inv} (wet wt)	P_{inv}	P_{soil}	IR kg_{diet}/day (Dry wt)	II mg/day inv	IS mg/day soil	HRF	EF fraction of year	BW kg	ED mg/kg/day
2,4-Dinitrotoluene	5.07E-01	3.08E+00	1.6E+00	1.00	0.104	0.0022	3.4E-03	1.2E-04	5.00E-01	1.000	0.015	1.2E-01
Antimony	9.50E+00	2.20E-01	2.1E+00	1.00	0.104	0.0022	4.6E-03	2.2E-03	5.00E-01	1.000	0.015	2.3E-01
Beryllium	5.79E-01	2.20E-01	1.3E-01	1.00	0.104	0.0022	2.8E-04	1.3E-04	5.00E-01	1.000	0.015	1.4E-02
Cadmium	8.02E-01	9.60E-01	7.7E-01	1.00	0.104	0.0022	1.7E-03	1.8E-04	5.00E-01	1.000	0.015	6.3E-02
Chromium	1.73E+01	1.00E-02	1.7E-01	1.00	0.104	0.0022	3.8E-04	4.0E-03	5.00E-01	1.000	0.015	1.4E-01
Copper	1.97E+01	4.00E-02	7.9E-01	1.00	0.104	0.0022	1.7E-03	4.5E-03	5.00E-01	1.000	0.015	2.1E-01
Lead	1.83E+02	3.00E-02	5.5E+00	1.00	0.104	0.0022	1.2E-02	4.2E-02	5.00E-01	1.000	0.015	1.8E+00
Mercury	8.73E-02	4.00E-02	3.5E-03	1.00	0.104	0.0022	7.7E-06	2.0E-05	5.00E-01	1.000	0.015	9.2E-04
Nickel	2.00E+01	2.00E-02	4.0E-01	1.00	0.104	0.0022	8.8E-04	4.6E-03	5.00E-01	1.000	0.015	1.8E-01
Vanadium	2.75E+01	2.20E-01	6.1E+00	1.00	0.104	0.0022	1.3E-02	6.3E-03	5.00E-01	1.000	0.015	6.5E-01
PCB-1254 (Aroclor 1254)	1.72E+00	1.13E+00	1.9E+00	1.00	0.104	0.0022	4.3E-03	3.9E-04	5.00E-01	1.000	0.015	1.6E-01
PCB-1260 (Aroclor 1260)	4.91E+00	1.13E+00	5.5E+00	1.00	0.104	0.0022	1.2E-02	1.1E-03	5.00E-01	1.000	0.015	4.4E-01
Naphthalene	7.21E-02	3.60E+01	2.6E+00	1.00	0.104	0.0022	5.7E-03	1.6E-05	5.00E-01	1.000	0.015	1.9E-01

BCF_{inv} = bioconcentration factor for contaminants from sediment into invertebrates (wet wt / dry wt)
BCF_{sed} = bioaccumulation factor for contaminants from sediment into aquatic plants (dry wt)
BW = organism body weight
C = moisture content correction factor (dry weight basis to wet weight basis)
EF = migration factor is the proportion of year in which exposure could occur
g_{diet}/day = grams of dietary intake per day
HRF = home range factor (site area/home range area; estimated to be 0.85)
IC = concentration in invertebrate tissue (SC x BAF_{inv})
II = daily intake concentration from invertebrates (IC x P_{inv} x IR)
IP = daily intake concentration from plant material (PC x P_{plant} x IR)
IR = daily ingestion rate (wet wt)
IS = daily intake concentration from direct sediment ingestion (SC x P_{sed} x IR)
IW = daily intake concentration from direct water ingestion (WC x IRW)
kg = kilograms
mg/day = milligrams per day from food item (inv = invertebrate; plant; sed = sediment)
mg/kg = milligrams per kilogram of food item (inv = invertebrate; plant; sed = sediment)
mg/kg/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter of water
NA = not applicable
ND = contaminant not detected in medium at a concentration above its reporting limit
ED = exposure dose to the omnivore = ([II+IP+IS+IW] x HRF x ED) / BW
P = proportion of ingestion composed of food item (inv = invertebrate; plant; sed = sediment)
PC = concentration in plant material (SC x C x SCF_{sed})
SC_{max} = maximum detected concentration in sediment
WC_{max} = maximum detected concentration in surface water
wt = weight
WI = daily water ingestion rate

Table 3-4. Exposure Doses for White-tailed Deer (*Odocoileus virginianus*) for Exposures at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Conc. Soil mg/kg_{sed} (dry wt)	BCF_{plants} mg/kg (dry wt)	PC mg/g_{plant} (dry wt)	P_{plant}	P_{soil}	IR kg_{diet}/day (Dry wt)	IP mg/day plant	IS mg/day soil	HRF	EF fraction of year	BW kg	ED mg/kg/day
2,4-Dinitrotoluene	5.07E-01	2.72E+00	1.38E+00	1	0.02	2	2.8E+00	2.0E-02	3.90E-04	1.000	61	1.8E-05
Antimony	9.50E+00	2.00E-01	1.90E+00	1	0.02	2	3.8E+00	3.8E-01	3.90E-04	1.000	61	2.7E-05
Beryllium	5.79E-01	1.00E-02	5.79E-03	1	0.02	2	1.2E-02	2.3E-02	3.90E-04	1.000	61	2.2E-07
Cadmium	8.02E-01	3.64E-01	2.92E-01	1	0.02	2	5.8E-01	3.2E-02	3.90E-04	1.000	61	3.9E-06
Chromium	1.73E+01	7.50E-03	1.30E-01	1	0.02	2	2.6E-01	6.9E-01	3.90E-04	1.000	61	6.1E-06
Copper	1.97E+01	4.00E-01	7.88E+00	1	0.02	2	1.6E+01	7.9E-01	3.90E-04	1.000	61	1.1E-04
Lead	1.83E+02	4.50E-02	8.24E+00	1	0.02	2	1.6E+01	7.3E+00	3.90E-04	1.000	61	1.5E-04
Mercury	8.73E-02	3.75E-02	3.27E-03	1	0.02	2	6.5E-03	3.5E-03	3.90E-04	1.000	61	6.4E-08
Nickel	2.00E+01	3.20E-02	6.40E-01	1	0.02	2	1.3E+00	8.0E-01	3.90E-04	1.000	61	1.3E-05
Vanadium	2.75E+01	3.00E-03	8.25E-02	1	0.02	2	1.7E-01	1.1E+00	3.90E-04	1.000	61	8.1E-06
PCB-1254 (Aroclor 1254)	1.72E+00	1.00E-02	1.72E-02	1	0.02	2	3.4E-02	6.9E-02	3.90E-04	1.000	61	6.6E-07
PCB-1260 (Aroclor 1260)	4.91E+00	3.93E-03	1.93E-02	1	0.02	2	3.9E-02	2.0E-01	3.90E-04	1.000	61	1.5E-06
Naphthalene	7.21E-02	4.79E-01	3.46E-02	1	0.02	2	6.9E-02	2.9E-03	3.90E-04	1.000	61	4.6E-07

BCF_{inv} = bioconcentration factor for contaminants from sediment into invertebrates (wet wt / dry wt)
BCF_{sed} = bioaccumulation factor for contaminants from sediment into aquatic plants (dry wt)
BW = organism body weight
C = moisture content correction factor (dry weight basis to wet weight basis)
EF = migration factor is the proportion of year in which exposure could occur
g_{diet}/day = grams of dietary intake per day
HRF = home range factor (site area/home range area; estimated to be 0.85)
IC = concentration in invertebrate tissue (SC x BAF_{inv})
II = daily intake concentration from invertebrates (IC x P_{inv} x IR)
IP = daily intake concentration from plant material (PC x P_{plant} x IR)
IR = daily ingestion rate (wet wt)
IS = daily intake concentration from direct sediment ingestion (SC x P_{sed} x IR)
IW = daily intake concentration from direct water ingestion (WC x IRW)
kg = kilograms
mg/day = milligrams per day from food item (inv = invertebrate; plant; sed = sediment)
mg/kg = milligrams per kilogram of food item (inv = invertebrate; plant; sed = sediment)
mg/kg/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter of water
NA = not applicable
ND = contaminant not detected in medium at a concentration above its reporting limit
ED = exposure dose to the omnivore = ([II+IP+IS+IW] x HRF x ED) / BW
P = proportion of ingestion composed of food item (inv = invertebrate; plant; sed = sediment)
PC = concentration in plant material (SC x C x SCF_{sed})
SC_{max} = maximum detected concentration in sediment
WC_{max} = maximum detected concentration in surface water
wt = weight
WI = daily water ingestion rate

Table 3-5. Exposure Doses for Marsh Wren (*Cistothorus palustris*) for Exposures at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Conc. Soil mg/kg_{sed} (dry wt)	BCF_{inv} mg/kg wet	IC mg/g_{inv} (wet wt)	PC mg/g_{plant} (dry wt)	P_{inv}	P_{soil}	IR kg_{diet}/day (Dry wt)	II mg/day inv	IS mg/day soil	HRF	EF fraction of year	BW kg	ED mg/kg/day
2,4-Dinitrotoluene	5.07E-01	3.08E+00	1.6E+00	0.00E+00	1.00	0.02	0.0029	4.5E-03	2.9E-05	1.00E+00	0.333	0.01	1.5E-01
Antimony	9.50E+00	2.20E-01	2.1E+00	0.00E+00	1.00	0.02	0.0029	6.1E-03	5.5E-04	1.00E+00	0.333	0.01	2.2E-01
Beryllium	5.79E-01	2.20E-01	1.3E-01	0.00E+00	1.00	0.02	0.0029	3.7E-04	3.4E-05	1.00E+00	0.333	0.01	1.3E-02
Cadmium	8.02E-01	9.60E-01	7.7E-01	0.00E+00	1.00	0.02	0.0029	2.2E-03	4.7E-05	1.00E+00	0.333	0.01	7.6E-02
Chromium	1.73E+01	1.00E-02	1.7E-01	0.00E+00	1.00	0.02	0.0029	5.0E-04	1.0E-03	1.00E+00	0.333	0.01	5.0E-02
Copper	1.97E+01	4.00E-02	7.9E-01	0.00E+00	1.00	0.02	0.0029	2.3E-03	1.1E-03	1.00E+00	0.333	0.01	1.1E-01
Lead	1.83E+02	3.00E-02	5.5E+00	0.00E+00	1.00	0.02	0.0029	1.6E-02	1.1E-02	1.00E+00	0.333	0.01	8.8E-01
Mercury	8.73E-02	4.00E-02	3.5E-03	0.00E+00	1.00	0.02	0.0029	1.0E-05	5.1E-06	1.00E+00	0.333	0.01	5.1E-04
Nickel	2.00E+01	2.00E-02	4.0E-01	0.00E+00	1.00	0.02	0.0029	1.2E-03	1.2E-03	1.00E+00	0.333	0.01	7.7E-02
Vanadium	2.75E+01	2.20E-01	6.1E+00	0.00E+00	1.00	0.02	0.0029	1.8E-02	1.6E-03	1.00E+00	0.333	0.01	6.4E-01
PCB-1254 (Aroclor 1254)	1.72E+00	1.13E+00	1.9E+00	0.00E+00	1.00	0.02	0.0029	5.6E-03	1.0E-04	1.00E+00	0.333	0.01	1.9E-01
PCB-1260 (Aroclor 1260)	4.91E+00	1.13E+00	5.5E+00	0.00E+00	1.00	0.02	0.0029	1.6E-02	2.8E-04	1.00E+00	0.333	0.01	5.5E-01
Naphthalene	7.21E-02	3.60E+01	2.6E+00	0.00E+00	1.00	0.02	0.0029	7.5E-03	4.2E-06	1.00E+00	0.333	0.01	2.5E-01

BCF_{inv} = bioconcentration factor for contaminants from sediment into invertebrates (wet wt / dry wt)
BCF_{sed} = bioaccumulation factor for contaminants from sediment into aquatic plants (dry wt)
BW = organism body weight
C = moisture content correction factor (dry weight basis to wet weight basis)
EF = migration factor is the proportion of year in which exposure could occur
g_{diet}/day = grams of dietary intake per day
HRF = home range factor (site area/home range area; estimated to be 0.85)
IC = concentration in invertebrate tissue (SC x BAF_{inv})
II = daily intake concentration from invertebrates (IC x P_{inv} x IR)
IP = daily intake concentration from plant material (PC x P_{plant} x IR)
IR = daily ingestion rate (wet wt)
IS = daily intake concentration from direct sediment ingestion (SC x P_{sed} x IR)
IW = daily intake concentration from direct water ingestion (WC x IRW)
kg = kilograms
mg/day = milligrams per day from food item (inv = invertebrate; plant; sed = sediment)
mg/kg = milligrams per kilogram of food item (inv = invertebrate; plant; sed = sediment)
mg/kg/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter of water
NA = not applicable
ND = contaminant not detected in medium at a concentration above its reporting limit
ED = exposure dose to the omnivore = ([II+IP+IS+IW] x HRF x ED) / BW
P = proportion of ingestion composed of food item (inv = invertebrate; plant; sed = sediment)
PC = concentration in plant material (SC x C x SCF_{sed})
SC_{max} = maximum detected concentration in sediment
WC_{max} = maximum detected concentration in surface water
wt = weight
WI = daily water ingestion rate

Table 3-6. Exposure Doses for Deer Mouse (*Peromyscus maniculatus*) for Exposures at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Conc. Soil mg/kg_{sed} (dry wt)	BCF_{inv} mg/kg wet	IC mg/g_{inv} (wet wt)	BCF_{plants} mg/kg (dry wt)	PC mg/g_{plant} (dry wt)	P_{inv}	P_{plant}	P_{soil}	IR kg_{diet}/day (Dry wt)	II mg/day inv	IP mg/day plant	IS mg/day soil	HRF	EF fraction of year	BW kg	ED mg/kg/day
2,4-Dinitrotoluene	5.07E-01	3.08E+00	1.6E+00	2.72E+00	1.38E+00	0.39	0.61	0.02	0.0028	1.7E-03	2.4E-03	2.8E-05	1.00E+00	1.000	0.0148	2.8E-01
Antimony	9.50E+00	2.20E-01	2.1E+00	2.00E-01	1.90E+00	0.39	0.61	0.02	0.0028	2.3E-03	3.2E-03	5.3E-04	1.00E+00	1.000	0.0148	4.1E-01
Beryllium	5.79E-01	2.20E-01	1.3E-01	1.00E-02	5.79E-03	0.39	0.61	0.02	0.0028	1.4E-04	9.9E-06	3.2E-05	1.00E+00	1.000	0.0148	1.2E-02
Cadmium	8.02E-01	9.60E-01	7.7E-01	3.64E-01	2.92E-01	0.39	0.61	0.02	0.0028	8.4E-04	5.0E-04	4.5E-05	1.00E+00	1.000	0.0148	9.4E-02
Chromium	1.73E+01	1.00E-02	1.7E-01	7.50E-03	1.30E-01	0.39	0.61	0.02	0.0028	1.9E-04	2.2E-04	9.7E-04	1.00E+00	1.000	0.0148	9.3E-02
Copper	1.97E+01	4.00E-02	7.9E-01	4.00E-01	7.88E+00	0.39	0.61	0.02	0.0028	8.6E-04	1.3E-02	1.1E-03	1.00E+00	1.000	0.0148	1.0E+00
Lead	1.83E+02	3.00E-02	5.5E+00	4.50E-02	8.24E+00	0.39	0.61	0.02	0.0028	6.0E-03	1.4E-02	1.0E-02	1.00E+00	1.000	0.0148	2.0E+00
Mercury	8.73E-02	4.00E-02	3.5E-03	3.75E-02	3.27E-03	0.39	0.61	0.02	0.0028	3.8E-06	5.6E-06	4.9E-06	1.00E+00	1.000	0.0148	9.7E-04
Nickel	2.00E+01	2.00E-02	4.0E-01	3.20E-02	6.40E-01	0.39	0.61	0.02	0.0028	4.4E-04	1.1E-03	1.1E-03	1.00E+00	1.000	0.0148	1.8E-01
Vanadium	2.75E+01	2.20E-01	6.1E+00	3.00E-03	8.25E-02	0.39	0.61	0.02	0.0028	6.6E-03	1.4E-04	1.5E-03	1.00E+00	1.000	0.0148	5.6E-01
PCB-1254 (Aroclor 1254)	1.72E+00	1.13E+00	1.9E+00	1.00E-02	1.72E-02	0.39	0.61	0.02	0.0028	2.1E-03	2.9E-05	9.6E-05	1.00E+00	1.000	0.0148	1.5E-01
PCB-1260 (Aroclor 1260)	4.91E+00	1.13E+00	5.5E+00	3.93E-03	1.93E-02	0.39	0.61	0.02	0.0028	6.1E-03	3.3E-05	2.7E-04	1.00E+00	1.000	0.0148	4.3E-01
Naphthalene	7.21E-02	3.60E+01	2.6E+00	4.79E-01	3.46E-02	0.39	0.61	0.02	0.0028	2.8E-03	5.9E-05	4.0E-06	1.00E+00	1.000	0.0148	2.0E-01

BCF_{inv} = bioconcentration factor for contaminants from sediment into invertebrates (wet wt / dry wt)
BCF_{sed} = bioaccumulation factor for contaminants from sediment into aquatic plants (dry wt)
BW = organism body weight
C = moisture content correction factor (dry weight basis to wet weight basis)
EF = migration factor is the proportion of year in which exposure could occur
g_{diet}/day = grams of dietary intake per day
HRF = home range factor (site area/home range area; estimated to be 0.85)
IC = concentration in invertebrate tissue (SC x BAF_{inv})
II = daily intake concentration from invertebrates (IC x P_{inv} x IR)
IP = daily intake concentration from plant material (PC x P_{plant} x IR)
IR = daily ingestion rate (wet wt)
IS = daily intake concentration from direct sediment ingestion (SC x P_{sed} x IR)
IW = daily intake concentration from direct water ingestion (WC x IRW)
kg = kilograms
mg/day = milligrams per day from food item (inv = invertebrate; plant; sed = sediment)
mg/kg = milligrams per kilogram of food item (inv = invertebrate; plant; sed = sediment)
mg/kg/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter of water
NA = not applicable
ND = contaminant not detected in medium at a concentration above its reporting limit
ED = exposure dose to the omnivore = ([II+IP+IS+IW] x HRF x ED) / BW
P = proportion of ingestion composed of food item (inv = invertebrate; plant; sed = sediment)
PC = concentration in plant material (SC x C x SCF_{sed})
SC_{max} = maximum detected concentration in sediment
WC_{max} = maximum detected concentration in surface water
wt = weight
WI = daily water ingestion rate

Table 3-7. Exposure Doses for Eastern Cottontail (*Sylvilagus floridanus*) for Exposures at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Conc. Soil mg/kg$_{sed}$ (dry wt)	BCF$_{plants}$ mg/kg (dry wt)	PC mg/g$_{plant}$ (dry wt)	P$_{plant}$	P$_{soil}$	IR kg$_{diet}$/day (Dry wt)	IP mg/day plant	IS mg/day soil	HRF	EF fraction of year	BW kg	ED mg/kg/day
2,4-Dinitrotoluene	5.07E-01	2.72E+00	1.38E+00	1	0.063	0.096	1.3E-01	3.1E-03	6.50E-02	1.000	1.132	7.8E-03
Antimony	9.50E+00	2.00E-01	1.90E+00	1	0.063	0.096	1.8E-01	5.7E-02	6.50E-02	1.000	1.132	1.4E-02
Beryllium	5.79E-01	1.00E-02	5.79E-03	1	0.063	0.096	5.6E-04	3.5E-03	6.50E-02	1.000	1.132	2.3E-04
Cadmium	8.02E-01	3.64E-01	2.92E-01	1	0.063	0.096	2.8E-02	4.9E-03	6.50E-02	1.000	1.132	1.9E-03
Chromium	1.73E+01	7.50E-03	1.30E-01	1	0.063	0.096	1.2E-02	1.0E-01	6.50E-02	1.000	1.132	6.7E-03
Copper	1.97E+01	4.00E-01	7.88E+00	1	0.063	0.096	7.6E-01	1.2E-01	6.50E-02	1.000	1.132	5.0E-02
Lead	1.83E+02	4.50E-02	8.24E+00	1	0.063	0.096	7.9E-01	1.1E+00	6.50E-02	1.000	1.132	1.1E-01
Mercury	8.73E-02	3.75E-02	3.27E-03	1	0.063	0.096	3.1E-04	5.3E-04	6.50E-02	1.000	1.132	4.8E-05
Nickel	2.00E+01	3.20E-02	6.40E-01	1	0.063	0.096	6.1E-02	1.2E-01	6.50E-02	1.000	1.132	1.0E-02
Vanadium	2.75E+01	3.00E-03	8.25E-02	1	0.063	0.096	7.9E-03	1.7E-01	6.50E-02	1.000	1.132	1.0E-02
PCB-1254 (Aroclor 1254)	1.72E+00	1.00E-02	1.72E-02	1	0.063	0.096	1.7E-03	1.0E-02	6.50E-02	1.000	1.132	6.9E-04
PCB-1260 (Aroclor 1260)	4.91E+00	3.93E-03	1.93E-02	1	0.063	0.096	1.9E-03	3.0E-02	6.50E-02	1.000	1.132	1.8E-03
Naphthalene	7.21E-02	4.79E-01	3.46E-02	1	0.063	0.096	3.3E-03	4.4E-04	6.50E-02	1.000	1.132	2.2E-04

BCF_{inv} = bioconcentration factor for contaminants from sediment into invertebrates (wet wt / dry wt)

BCF_{sed} = bioaccumulation factor for contaminants from sediment into aquatic plants (dry wt)

BW = organism body weight

C = moisture content correction factor (dry weight basis to wet weight basis)

EF = migration factor is the proportion of year in which exposure could occur

g_{diet}/day = grams of dietary intake per day

HRF = home range factor (site area/home range area; estimated to be 0.85)

IC = concentration in invertebrate tissue (SC x BAF_{inv})

II = daily intake concentration from invertebrates (IC x P_{inv} x IR)

IP = daily intake concentration from plant material (PC x P_{plant} x IR)

IR = daily ingestion rate (wet wt)

IS = daily intake concentration from direct sediment ingestion (SC x P_{sed} x IR)

IW = daily intake concentration from direct water ingestion (WC x IRW)

kg = kilograms

mg/day = milligrams per day from food item (inv = invertebrate; plant; sed = sediment)

mg/kg = milligrams per kilogram of food item (inv = invertebrate; plant; sed = sediment)

mg/kg/day = milligrams per kilogram body weight per day

mg/L = milligrams per liter of water

NA = not applicable

ND = contaminant not detected in medium at a concentration above its reporting limit

ED = exposure dose to the omnivore = ([II+IP+IS+IW] x HRF x ED) / BW

P = proportion of ingestion composed of food item (inv = invertebrate; plant; sed = sediment)

PC = concentration in plant material (SC x C x SCF_{sed})

SC_{max} = maximum detected concentration in sediment

WC_{max} = maximum detected concentration in surface water

wt = weight

WI = daily water ingestion rate

Table 3-8. Exposure Doses for Red-tailed Hawk (*Buteo jamaicensis*) for Exposures at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Conc. Soil mg/kg_{sed} (dry wt)	BCF_{inv} mg/kg wet	IC mg/g_{inv} (wet wt)	BCF_{plants} mg/kg (dry wt)	VC mg/g_{vert} (dry wt)	Pvert	P_{soil}	IR kg_{diet}/day (Dry wt)	WI L/day	IV mg/day inv	IS mg/day soil	HRF	EF fraction of year	BW kg	ED mg/kg/day
2,4-Dinitrotoluene	5.07E-01	3.08E+00	1.6E+00	2.72E+00	2.94E+00	1.00	0.02	0.057	5.7E-02	1.7E-01	5.8E-04	2.40E-04	1.000	0.957	4.2E-05
Antimony	9.50E+00	2.20E-01	2.1E+00	2.00E-01	3.99E+00	1.00	0.02	0.057	5.7E-02	2.3E-01	1.1E-02	2.40E-04	1.000	0.957	6.0E-05
Beryllium	5.79E-01	2.20E-01	1.3E-01	1.00E-02	1.33E-01	1.00	0.02	0.057	5.7E-02	7.6E-03	6.6E-04	2.40E-04	1.000	0.957	2.1E-06
Cadmium	8.02E-01	9.60E-01	7.7E-01	3.64E-01	1.06E+00	1.00	0.02	0.057	5.7E-02	6.1E-02	9.1E-04	2.40E-04	1.000	0.957	1.5E-05
Chromium	1.73E+01	1.00E-02	1.7E-01	7.50E-03	3.03E-01	1.00	0.02	0.057	5.7E-02	1.7E-02	2.0E-02	2.40E-04	1.000	0.957	9.3E-06
Copper	1.97E+01	4.00E-02	7.9E-01	4.00E-01	8.67E+00	1.00	0.02	0.057	5.7E-02	4.9E-01	2.2E-02	2.40E-04	1.000	0.957	1.3E-04
Lead	1.83E+02	3.00E-02	5.5E+00	4.50E-02	1.37E+01	1.00	0.02	0.057	5.7E-02	7.8E-01	2.1E-01	2.40E-04	1.000	0.957	2.5E-04
Mercury	8.73E-02	4.00E-02	3.5E-03	3.75E-02	6.77E-03	1.00	0.02	0.057	5.7E-02	3.9E-04	1.0E-04	2.40E-04	1.000	0.957	1.2E-07
Nickel	2.00E+01	2.00E-02	4.0E-01	3.20E-02	1.04E+00	1.00	0.02	0.057	5.7E-02	5.9E-02	2.3E-02	2.40E-04	1.000	0.957	2.1E-05
Vanadium	2.75E+01	2.20E-01	6.1E+00	3.00E-03	6.13E+00	1.00	0.02	0.057	5.7E-02	3.5E-01	3.1E-02	2.40E-04	1.000	0.957	9.6E-05
PCB-1254 (Aroclor 1254)	1.72E+00	1.13E+00	1.9E+00	1.00E-02	1.96E+00	1.00	0.02	0.057	5.7E-02	1.1E-01	2.0E-03	2.40E-04	1.000	0.957	2.9E-05
PCB-1260 (Aroclor 1260)	4.91E+00	1.13E+00	5.5E+00	3.93E-03	5.57E+00	1.00	0.02	0.057	5.7E-02	3.2E-01	5.6E-03	2.40E-04	1.000	0.957	8.1E-05
Naphthalene	7.21E-02	3.60E+01	2.6E+00	4.79E-01	2.63E+00	1.00	0.02	0.057	5.7E-02	1.5E-01	8.2E-05	2.40E-04	1.000	0.957	3.8E-05

BCF_{inv} = bioconcentration factor for contaminants from sediment into invertebrates (wet wt / dry wt)
BCF_{sed} = bioaccumulation factor for contaminants from sediment into aquatic plants (dry wt)
BW = organism body weight
C = moisture content correction factor (dry weight basis to wet weight basis)
EF = migration factor is the proportion of year in which exposure could occur
g_{diet}/day = grams of dietary intake per day
HRF = home range factor (site area/home range area; estimated to be 0.85)
IC = concentration in invertebrate tissue (SC x BAF_{inv})
II = daily intake concentration from invertebrates (IC x P_{inv} x IR)
IP = daily intake concentration from plant material (PC x P_{plant} x IR)
IR = daily ingestion rate (wet wt)
IS = daily intake concentration from direct sediment ingestion (SC x P_{sed} x IR)
IW = daily intake concentration from direct water ingestion (WC x IRW)
kg = kilograms
mg/day = milligrams per day from food item (inv = invertebrate; plant; sed = sediment)
mg/kg = milligrams per kilogram of food item (inv = invertebrate; plant; sed = sediment)
mg/kg/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter of water
NA = not applicable
ND = contaminant not detected in medium at a concentration above its reporting limit
ED = exposure dose to the omnivore = ([II+IP+IS+IW] x HRF x ED) / BW
P = proportion of ingestion composed of food item (inv = invertebrate; plant; sed = sediment)
PC = concentration in plant material (SC x C x SCF_{sed})
SC_{max} = maximum detected concentration in sediment
WC_{max} = maximum detected concentration in surface water
wt = weight
WI = daily water ingestion rate

Table 3-9. Exposure Doses for Raccoon (*Procyon lotor*) for Exposures at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Conc. Sediment mg/kg$_{sed}$ (dry wt)	BCF_{inv} mg/kg wet	IC mg/g$_{inv}$ (wet wt)	BCF_{plants} mg/kg (dry wt)	VC mg/g$_{vert}$ (dry wt)	PC mg/g$_{plant}$ (dry wt)	P_{vert}	P_{inv}	P_{plant}	P_{sed}	IR kg$_{diet}$/day (Dry wt)	WI L/day	II mg/day inv	IV mg/day vert	IP mg/day plant	IS mg/day soil	IW mg/day water	HRF	EF fraction of year	BW kg	ED mg/kg/day
Acetone	1.16E-01	4.70E-02	5.5E-03	5.20E+01	2.45E+00	6.04E+00	0.05	0.51	0.42	0.094	0.26	4.3E-01	7.2E-04	3.2E-01	6.6E-01	2.8E-03	0.0E+00	1.29E-03	0.667	5.1	1.7E-04
PCB-1254 (Aroclor 1254)	4.88E-01	1.13E+00	5.5E-01	1.00E-02	6.34E-01	4.88E-03	0.05	0.51	0.42	0.094	0.26	4.3E-01	7.3E-02	8.4E-02	5.3E-04	1.2E-02	0.0E+00	6.00E-02	0.667	5.1	1.3E-03
PCB-1260 (Aroclor 1260)	8.07E-01	1.13E+00	9.1E-01	3.93E-03	1.03E+00	3.17E-03	0.05	0.51	0.42	0.094	0.26	4.3E-01	1.2E-01	1.4E-01	3.5E-04	2.0E-02	0.0E+00	6.00E-02	0.667	5.1	2.2E-03
2-Methylnaphthalene	2.80E-01	1.12E+02	3.1E+01	2.16E-01	3.52E+03	6.04E-02	0.05	0.51	0.42	0.094	0.26	4.3E-01	4.1E+00	4.7E+02	6.6E-03	6.8E-03	0.0E+00	6.00E-02	0.667	5.1	3.7E+00
4-Methylphenol (p-Cresol)	2.70E-01	2.90E+00	7.8E-01	2.84E+00	1.05E+01	7.67E-01	0.05	0.51	0.42	0.094	0.26	4.3E-01	1.0E-01	1.4E+00	8.4E-02	6.6E-03	0.0E+00	6.00E-02	0.667	5.1	1.2E-02
Anthracene	4.55E-02	3.81E+02	1.7E+01	9.08E-02	6.62E+03	4.13E-03	0.05	0.51	0.42	0.094	0.26	4.3E-01	2.3E+00	8.8E+02	4.5E-04	1.1E-03	0.0E+00	6.00E-02	0.667	5.1	6.9E+00
Benzo(a)anthracene	1.94E-01	3.00E-02	5.8E-03	2.02E-02	7.81E-04	3.92E-03	0.05	0.51	0.42	0.094	0.26	4.3E-01	7.7E-04	1.0E-04	4.3E-04	4.7E-03	0.0E+00	6.00E-02	0.667	5.1	4.7E-05
Benzo(a)pyrene	1.52E-01	7.00E-02	1.1E-02	1.11E-02	1.52E-03	1.69E-03	0.05	0.51	0.42	0.094	0.26	4.3E-01	1.4E-03	2.0E-04	1.8E-04	3.7E-03	0.0E+00	6.00E-02	0.667	5.1	4.3E-05
Benzo(b)fluoranthene	2.31E-01	7.00E-02	1.6E-02	1.01E-02	1.84E-03	2.33E-03	0.05	0.51	0.42	0.094	0.26	4.3E-01	2.1E-03	2.4E-04	2.5E-04	5.6E-03	0.0E+00	6.00E-02	0.667	5.1	6.5E-05
Benzo(g,h,i)perylene	1.80E-01	7.00E-02	1.3E-02	5.19E-03	1.25E-03	9.35E-04	0.05	0.51	0.42	0.094	0.26	4.3E-01	1.7E-03	1.7E-04	1.0E-04	4.4E-03	0.0E+00	6.00E-02	0.667	5.1	5.0E-05
Benzo(k)fluoranthene	2.14E-01	8.00E-02	1.7E-02	1.01E-02	2.18E-03	2.16E-03	0.05	0.51	0.42	0.094	0.26	4.3E-01	2.3E-03	2.9E-04	2.4E-04	5.2E-03	0.0E+00	6.00E-02	0.667	5.1	6.3E-05
Carbon Disulfide	1.01E-02	4.88E+00	4.9E-02	1.96E+00	9.83E+00	1.98E-02	0.05	0.51	0.42	0.094	0.26	4.3E-01	6.5E-03	1.3E+00	2.2E-03	2.5E-04	0.0E+00	1.29E-03	0.667	5.1	2.2E-04
Chrysene	2.27E-01	4.00E-02	9.1E-03	1.87E-02	1.11E-03	4.24E-03	0.05	0.51	0.42	0.094	0.26	4.3E-01	1.2E-03	1.5E-04	4.6E-04	5.5E-03	0.0E+00	6.00E-02	0.667	5.1	5.8E-05
Fluoranthene	3.33E-01	8.09E+02	2.7E+02	5.33E-02	2.18E+05	1.78E-02	0.05	0.51	0.42	0.094	0.26	4.3E-01	3.6E+01	2.9E+04	1.9E-03	8.1E-03	0.0E+00	1.29E-03	0.667	5.1	4.9E+00
Indeno(1,2,3-cd)pyrene	2.76E-01	8.00E-02	2.2E-02	3.90E-03	2.08E-03	1.08E-03	0.05	0.51	0.42	0.094	0.26	4.3E-01	2.9E-03	2.8E-04	1.2E-04	6.7E-03	0.0E+00	1.29E-03	0.667	5.1	1.7E-06
Phenanthrene	1.45E-01	3.95E+02	5.7E+01	8.84E-02	2.27E+04	1.28E-02	0.05	0.51	0.42	0.094	0.26	4.3E-01	7.6E+00	3.0E+03	1.4E-03	3.5E-03	0.0E+00	1.29E-03	0.667	5.1	5.1E-01
Pyrene	2.96E-01	1.09E+03	3.2E+02	4.31E-02	3.54E+05	1.28E-02	0.05	0.51	0.42	0.094	0.26	4.3E-01	4.3E+01	4.7E+04	1.4E-03	7.2E-03	0.0E+00	1.29E-03	0.667	5.1	7.9E+00
Chromium	1.96E+01	1.00E-02	2.0E-01	7.50E-03	2.04E-03	1.47E-01	0.05	0.51	0.42	0.094	0.26	4.3E-01	2.6E-02	2.7E-04	1.6E-02	4.8E-01	0.0E+00	6.00E-02	0.667	5.1	4.1E-03
Lead	3.89E+01	3.00E-02	1.2E+00	4.50E-02	3.64E-02	1.75E+00	0.05	0.51	0.42	0.094	0.26	4.3E-01	1.5E-01	4.8E-03	1.9E-01	9.5E-01	0.0E+00	6.00E-02	0.667	5.1	1.0E-02
Mercury	1.63E+00	4.00E-02	6.5E-02	3.75E-02	4.11E-03	6.11E-02	0.05	0.51	0.42	0.094	0.26	4.3E-01	8.6E-03	5.4E-04	6.7E-03	4.0E-02	0.0E+00	6.00E-02	0.667	5.1	4.4E-04
Nickel	7.40E+01	2.00E-02	1.5E+00	3.20E-02	3.02E-02	2.37E+00	0.05	0.51	0.42	0.094	0.26	4.3E-01	2.0E-01	4.0E-03	2.6E-01	1.8E+00	0.0E+00	6.00E-02	0.667	5.1	1.8E-02

BCF_{inv} = bioconcentration factor for contaminants from sediment into invertebrates (wet wt / dry wt)
BCF_{sed} = bioaccumulation factor for contaminants from sediment into aquatic plants (dry wt)
BW = organism body weight
C = moisture content correction factor (dry weight basis to wet weight basis)
EF = migration factor is the proportion of year in which exposure could occur
g_{diet}/day = grams of dietary intake per day
HRF = home range factor (site area/home range area; estimated to be 0.85)
IC = concentration in invertebrate tissue (SC x BAF_{inv})
II = daily intake concentration from invertebrates (IC x P_{inv} x IR)
IP = daily intake concentration from plant material (PC x P_{plant} x IR)
IR = daily ingestion rate (wet wt)
IS = daily intake concentration from direct sediment ingestion (SC x P_{sed} x IR)
IW = daily intake concentration from direct water ingestion (WC x IRW)
kg = kilograms
mg/day = milligrams per day from food item (inv = invertebrate; plant; sed = sediment)
mg/kg = milligrams per kilogram of food item (inv = invertebrate; plant; sed = sediment)
mg/kg/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter of water
NA = not applicable
ND = contaminant not detected in medium at a concentration above its reporting limit
ED = exposure dose to the omnivore = ([II+IP+IS+IW] x HRF x ED) / BW
P = proportion of ingestion composed of food item (inv = invertebrate; plant; sed = sediment)
PC = concentration in plant material (SC x C x SCF_{sed})
SC_{max} = maximum detected concentration in sediment
WC_{max} = maximum detected concentration in surface water
wt = weight
WI = daily water ingestion rate

Table 3-10. Exposure Doses for Mallard Duck (*Anas platyrhynchos*) for Exposures at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Conc. Sediment mg/kg$_{sed}$ (dry wt)	BCF$_{inv}$ mg/kg wet	IC mg/g$_{inv}$ (wet wt)	Conc Water mg/L	BCF$_{plants}$ mg/kg (dry wt)	PC mg/g$_{plant}$ (dry wt)	P$_{inv}$	P$_{plant}$	P$_{sed}$	IR kg$_{diet}$/day (Dry wt)	WI L/day	II mg/day inv	IP mg/day plant	IS mg/day soil	IW mg/day water	HRF	EF fraction of year	BW kg	ED mg/kg/day
1,1,1-Trichloroethane		1.41E+00	0.0E+00	7.50E-03	1.41E+00	0.00E+00	0.38	0.63	0.02	0.063	6.4E-02	0.0E+00	0.0E+00	0.0E+00	4.8E-04	2.00E-02	0.583	1.13	5.0E-06
Acetone	1.16E-01	5.20E+01	6.0E+00		5.20E+01	6.04E+00	0.38	0.63	0.02	0.063	6.4E-02	1.4E-01	2.4E-01	1.5E-04	0.0E+00	2.00E-02	0.583	1.13	3.9E-03
Carbon Disulfide	1.01E-02	1.96E+00	2.0E-02		1.96E+00	1.98E-02	0.38	0.63	0.02	0.063	6.4E-02	4.7E-04	7.8E-04	1.3E-05	0.0E+00	2.00E-02	0.583	1.13	1.3E-05
2-Methylnaphthalene	2.80E-01	2.16E-01	6.0E-02		2.16E-01	6.04E-02	0.38	0.63	0.02	0.063	6.4E-02	1.4E-03	2.4E-03	3.5E-04	0.0E+00	2.00E-02	0.583	1.13	4.3E-05
4-Methylphenol (p-Cresol)	2.70E-01	2.84E+00	7.7E-01		2.84E+00	7.67E-01	0.38	0.63	0.02	0.063	6.4E-02	1.8E-02	3.0E-02	3.4E-04	0.0E+00	2.00E-02	0.583	1.13	5.0E-04
Anthracene	4.55E-02	9.08E-02	4.1E-03		9.08E-02	4.13E-03	0.38	0.63	0.02	0.063	6.4E-02	9.8E-05	1.6E-04	5.7E-05	0.0E+00	2.00E-02	0.583	1.13	3.3E-06
Benzo(a)anthracene	1.94E-01	2.02E-02	3.9E-03		2.02E-02	3.92E-03	0.38	0.63	0.02	0.063	6.4E-02	9.3E-05	1.5E-04	2.4E-04	0.0E+00	2.00E-02	0.583	1.13	5.1E-06
Benzo(a)pyrene	1.52E-01	1.11E-02	1.7E-03		1.11E-02	1.69E-03	0.38	0.63	0.02	0.063	6.4E-02	4.0E-05	6.6E-05	1.9E-04	0.0E+00	2.00E-02	0.583	1.13	3.1E-06
Benzo(b)fluoranthene	2.31E-01	1.01E-02	2.3E-03		1.01E-02	2.33E-03	0.38	0.63	0.02	0.063	6.4E-02	5.5E-05	9.2E-05	2.9E-04	0.0E+00	2.00E-02	0.583	1.13	4.5E-06
Benzo(g,h,i)perylene	1.80E-01	5.19E-03	9.3E-04		5.19E-03	9.35E-04	0.38	0.63	0.02	0.063	6.4E-02	2.2E-05	3.7E-05	2.3E-04	0.0E+00	2.00E-02	0.583	1.13	2.9E-06
Benzo(k)fluoranthene	2.14E-01	1.01E-02	2.2E-03		1.01E-02	2.16E-03	0.38	0.63	0.02	0.063	6.4E-02	5.1E-05	8.5E-05	2.7E-04	0.0E+00	2.00E-02	0.583	1.13	4.2E-06
Chrysene	2.27E-01	1.87E-02	4.2E-03		1.87E-02	4.24E-03	0.38	0.63	0.02	0.063	6.4E-02	1.0E-04	1.7E-04	2.9E-04	0.0E+00	2.00E-02	0.583	1.13	5.7E-06
Fluoranthene	3.33E-01	5.33E-02	1.8E-02		5.33E-02	1.78E-02	0.38	0.63	0.02	0.063	6.4E-02	4.2E-04	7.0E-04	4.2E-04	0.0E+00	2.00E-02	0.583	1.13	1.6E-05
Indeno(1,2,3-cd)pyrene	2.76E-01	3.90E-03	1.1E-03		3.90E-03	1.08E-03	0.38	0.63	0.02	0.063	6.4E-02	2.5E-05	4.2E-05	3.5E-04	0.0E+00	2.00E-02	0.583	1.13	4.3E-06
Phenanthrene	1.45E-01	8.84E-02	1.3E-02		8.84E-02	1.28E-02	0.38	0.63	0.02	0.063	6.4E-02	3.0E-04	5.0E-04	1.8E-04	0.0E+00	2.00E-02	0.583	1.13	1.0E-05
Pyrene	2.96E-01	4.31E-02	1.3E-02		4.31E-02	1.28E-02	0.38	0.63	0.02	0.063	6.4E-02	3.0E-04	5.0E-04	3.7E-04	0.0E+00	2.00E-02	0.583	1.13	1.2E-05
PCB-1254 (Aroclor 1254)	4.88E-01	1.00E-02	4.9E-03		1.00E-02	4.88E-03	0.38	0.63	0.02	0.063	6.4E-02	1.2E-04	1.9E-04	6.1E-04	0.0E+00	2.00E-02	0.583	1.13	9.5E-06
PCB-1260 (Aroclor 1260)	8.07E-01	3.93E-03	3.2E-03		3.93E-03	3.17E-03	0.38	0.63	0.02	0.063	6.4E-02	7.5E-05	1.2E-04	1.0E-03	0.0E+00	2.00E-02	0.583	1.13	1.3E-05
Aluminum		4.00E-03	0.0E+00	6.54E+00	4.00E-03	0.00E+00	0.38	0.63	0.02	0.063	6.4E-02	0.0E+00	0.0E+00	0.0E+00	4.2E-01	2.00E-02	0.583	1.13	4.3E-03
Barium	9.38E-02	1.50E-01	1.4E-02		1.50E-01	1.41E-02	0.38	0.63	0.02	0.063	6.4E-02	3.3E-04	5.5E-04	1.2E-04	0.0E+00	2.00E-02	0.583	1.13	1.0E-05
Chromium	1.96E+01	7.50E-03	1.5E-01		7.50E-03	1.47E-01	0.38	0.63	0.02	0.063	6.4E-02	3.5E-03	5.8E-03	2.5E-02	0.0E+00	2.00E-02	0.583	1.13	3.5E-04
Copper		4.00E-01	0.0E+00	2.19E-02	4.00E-01	0.00E+00	0.38	0.63	0.02	0.063	6.4E-02	0.0E+00	0.0E+00	0.0E+00	1.4E-03	2.00E-02	0.583	1.13	1.4E-05
Iron		1.00E-03	0.0E+00	1.89E+01	1.00E-03	0.00E+00	0.38	0.63	0.02	0.063	6.4E-02	0.0E+00	0.0E+00	0.0E+00	1.2E+00	2.00E-02	0.583	1.13	1.2E-02
Lead	3.89E+01	4.50E-02	1.8E+00		4.50E-02	1.75E+00	0.38	0.63	0.02	0.063	6.4E-02	4.1E-02	6.9E-02	4.9E-02	0.0E+00	2.00E-02	0.583	1.13	1.6E-03
Manganese		5.00E-02	0.0E+00	3.38E+00	5.00E-02	0.00E+00	0.38	0.63	0.02	0.063	6.4E-02	0.0E+00	0.0E+00	0.0E+00	2.2E-01	2.00E-02	0.583	1.13	2.2E-03
Mercury	1.63E+00	3.75E-02	6.1E-02		3.75E-02	6.11E-02	0.38	0.63	0.02	0.063	6.4E-02	1.4E-03	2.4E-03	2.1E-03	0.0E+00	2.00E-02	0.583	1.13	6.1E-05
Nickel	7.40E+01	3.20E-02	2.4E+00	4.80E-02	3.20E-02	2.37E+00	0.38	0.63	0.02	0.063	6.4E-02	5.6E-02	9.3E-02	9.3E-02	3.1E-03	2.00E-02	0.583	1.13	2.5E-03
Zinc		1.20E-12	0.0E+00	2.79E-02	1.20E-12	0.00E+00	0.38	0.63	0.02	0.063	6.4E-02	0.0E+00	0.0E+00	0.0E+00	1.8E-03	2.00E-02	0.583	1.13	1.8E-05

BCF_{inv} = bioconcentration factor for contaminants from sediment into invertebrates (wet wt / dry wt)
BCF_{sed} = bioaccumulation factor for contaminants from sediment into aquatic plants (dry wt)
BW = organism body weight
C = moisture content correction factor (dry weight basis to wet weight basis)
EF = migration factor is the proportion of year in which exposure could occur
g_{diet}/day = grams of dietary intake per day
HRF = home range factor (site area/home range area; estimated to be 0.85)
IC = concentration in invertebrate tissue (SC x BAF_{inv})
II = daily intake concentration from invertebrates (IC x P_{inv} x IR)
IP = daily intake concentration from plant material (PC x P_{plant} x IR)
IR = daily ingestion rate (wet wt)
IS = daily intake concentration from direct sediment ingestion (SC x P_{sed} x IR)
IW = daily intake concentration from direct water ingestion (WC x IRW)
kg = kilograms
mg/day = milligrams per day from food item (inv = invertebrate; plant; sed = sediment)
mg/gk = milligrams per kilogram of food item (inv = invertebrate; plant; sed = sediment)
mg/kg/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter of water
NA = not applicable
ND = contaminant not detected in medium at a concentration above its reporting limit
ED = exposure dose to the omnivore = ([II+IP+IS+IW] x HRF x ED) / BW
P = proportion of ingestion composed of food item (inv = invertebrate; plant; sed = sediment)
PC = concentration in plant material (SC x C x SCF_{sed})
SC_{max} = maximum detected concentration in sediment
WC_{max} = maximum detected concentration in surface water
wt = weight
WI = daily water ingestion rate

Table 4-1. Toxicity Reference Values,
Plum Brook Ordnance Works, Sandusky, Ohio

		Mammals			Birds			Source	
Method Group	Chemical Name	NOAEL (mg/kg/d)	Test Species	Body Wt. (kg)	NOAEL (mg/kg/d)	Test Species	Body Wt. (kg)	Mammals	Birds
GC2	Cyanide	6.87E+01	rat	0.273	--	--	--	Sample et al. 1996	--
DIO	2,3,7,8-TCDD TEQ	1.00E-06	rat	0.35					
HE	1,3-dinitrobenzene	1.13E-01	rat	0.35	4.20E-01	red-winged black bird	0.077	Talmage et. al (1996)	Talmage et. al (1996)
HE	1,3,5-Trinitrobenzene	--	--	--	--	--	--	--	--
HE	2,4,6-Trinitrotoluene	1.60E+00	rat	0.35	7.00E-01	Bobwhite quail	0.19	Talmage et. al (1996)	Talmage et. al (1996)
HE	2,4-Dinitrotoluene	2.00E-01	beagle dog	11	7.00E-01	Bobwhite quail	0.19	IRIS	2,4,6-TNT as surrogate
HE	2,6-Dinitrotoluene	2.00E-01	beagle dog	11	7.00E-01	Bobwhite quail	0.19	2,4-DNT as surrogate	2,4,6-TNT as surrogate
HE	2-Amino-4,6-Dinitrotoluene	1.39E+01	rat	0.35	7.00E-01	Bobwhite quail	0.19	Shaw	Shaw
HE	2-Nitrotoluene	4.50E+01	rat	0.35	7.00E-01	Bobwhite quail	0.19	Shaw	Shaw
HE	3-Nitrotoluene	4.50E+01	rat	0.35	7.00E-01	Bobwhite quail	0.19	2-nitrotoluene as surrogate Dunnick et. Al, 1994 as summarized by Johnson (2000)	2,4,6-TNT as surrogate
HE	4-Amino-2,6-Dinitrotoluene	9.59E+00	rat	0.35	7.00E-01	Bobwhite quail	0.19	Shaw	Shaw
HE	4-Nitrotoluene	4.50E+01	rat	0.35	7.00E-01	Bobwhite quail	0.19	Shaw	Shaw
HE	HMX	--	--	--	--	--	--	--	--
HE	RDX	7.00E+00	mouse	0.03	--	--	--	Talmage et. al (1996)	--
HE	Tetryl	1.30E+00	rat	0.35	--	--	--	Shaw	Shaw
MET	Aluminum	1.93E+00	mouse	0.03	1.10E+02	ringed dove	0.155	Sample et al. 1996	Sample et al. 1996
MET	Antimony	1.25E+00	mouse	0.03	--	--	--	ORNL TM86r3	--
MET	Arsenic	1.25E+00	mouse	0.03	2.46E+00	Brown-headed cowbird	--	ORNL TM86r3	EPA 1999
MET	Barium	5.10E+00	rat	0.435	2.08E+01	chicks	0.121	Sample et al. 1996	Sample et al. 1996
MET	Beryllium	6.60E-02	rat	0.273	--	--	--	Sample et al. 1996	Sample et al. 1996
MET	Cadmium	1.00E+00	rat	0.303	1.45E+00	mallard duck	1.153	Sample et al. 1996	Sample et al. 1996
MET	Calcium	1.05E+03	rabbit	3.8	2.83E+03	Jap. Quail	0.072	Sample et al. 1996	Sample et al. 1996
MET	Chromium	2.74E+00	rat	0.35	1.00E+00	black duck	1.25	Sample et al. 1996	Sample et al. 1996
MET	Cobalt	1.20E+00	rat	0.35	--	--	--	Sample et al. 1996	Sample et al. 1996
MET	Copper	1.17E+01	mink	1	4.70E+01	chicks	0.534	Sample et al. 1996	Sample et al. 1996
MET	Iron	2.60E+01	rabbit	3.8	5.00E+01	poultry	1.6	Sample et al. 1996	Sample et al. 1996
MET	Lead	8.00E+00	rat	0.35	3.85E+00	Am. Kestrel	0.13	Sample et al. 1996	Sample et al. 1996
MET	Magnesium	1.58E+02	rabbit	3.8	1.50E+02	poultry	1.6	Sample et al. 1996	Sample et al. 1996
MET	Manganese	8.80E+01	rat	0.35	9.77E+02	Jap. Quail	0.072	Sample et al. 1996	Sample et al. 1996
MET	Mercury	1.00E+00	mink	1	4.50E-01	Jap. Quail	0.15	Sample et al. 1996	Sample et al. 1996
MET	Nickel	4.00E+01	rat	0.35	7.74E+01	mallard duck	0.782	Sample et al. 1996	Sample et al. 1996
MET	Potassium	1.60E+03	rabbit	3.8	1.00E+03	poultry	1.6	Sample et al. 1996	Sample et al. 1996
MET	Selenium	2.00E-01	rat	0.35	5.00E-01	mallard duck	1	Sample et al. 1996	Sample et al. 1996
MET	Silver	3.75E-01	rat	0.35	?	mallard duck	1	Sample et al. 1996	Sample et al. 1996
MET	Sodium	1.60E+03	rabbit	3.8	1.00E+03	poultry	1.6	Shaw	Shaw
MET	Thallium	7.40E-02	rat	0.365	3.50E-01	Starling	--	Sample et al. 1996	EPA 1999
MET	Vanadium	2.10E-01	rat	0.26	1.14E+01	Mallard Duck	1.17	ORNL TM86r3	ORNL TM86r3
MET	Zinc	1.60E+02	rat	0.35	1.45E+01	hens	1.935	Sample et al. 1996	Sample et al. 1996
PAH	Acenaphthene	1.00E+00	mouse	0.03	--	--	--	Benzo(a)pyrene as surrogate	--

Table 4-1. Toxicity Reference Values,
Plum Brook Ordnance Works, Sandusky, Ohio

		Mammals			Birds			Source	
Method Group	Chemical Name	NOAEL (mg/kg/d)	Test Species	Body Wt. (kg)	NOAEL (mg/kg/d)	Test Species	Body Wt. (kg)	Mammals	Birds
PCB	PCB-1254 (Aroclor 1254)	6.80E-02	oldfield mouse	0.014	1.80E-01	ring-necked pheasant	1	Sample et al. 1996	Sample et al. 1996
PCB	PCB-1260 (Aroclor 1260)	6.80E-02	mouse	0.014	1.80E-01	ring-necked pheasant	1	Sample et al. 1996	Sample et al. 1996
SV	2,4,6-Trichlorophenol	--	--	--	--	--	--	--	--
SV	2,4-Dichlorophenol	--	--	--	--	--	--	--	--
SV	2,4-Dinitrophenol	--	--	--	--	--	--	--	--
SV	2-Chloronaphthalene	--	--	--	--	--	--	--	--
SV	2-Chlorophenol	--	--	--	--	--	--	--	--
SV	2-Butanone (Methyl ethyl ketone)	--	--	--	--	--	--	--	--
SV	2-Methylnaphthalene	1.00E+00	mouse	0.03	--	--	--	Benzo(a)pyrene as surrogate	--
SV	2-Methylphenol (o-Cresol)	2.19E+02	mink	1	--	--	--	ORNL TM86r3	--
SV	3,3'-Dichlorobenzidine	--	--	--	--	--	--	--	--
SV	4-Methylphenol (p-Cresol)	2.19E+02	mink	1	--	--	--	Sample et al. 1996	--
SV	4-Methyl-2-pentanone (Methyl isobutyl ketone)	--	--	--	--	--	--	--	--
SV	Acetophenone	--	--	--	--	--	--	--	--
SV	Acenaphthylene	1.00E+00	mouse	0.03	--	--	--	Benzo(a)pyrene as surrogate	--
SV	Anthracene	1.00E+00	mouse	0.03	--	--	--	Benzo(a)pyrene as surrogate	--
SV	Benzaldehyde	1.00E+00	mouse	0.03	--	--	--	Benzo(a)pyrene as surrogate	--
SV	Benzo(a)anthracene	1.00E+00	mouse	0.03	--	--	--	Benzo(a)pyrene as surrogate	--
SV	Benzo(a)pyrene	1.00E+00	mouse	0.03	--	--	--	Sample et al. 1996	--
SV	Benzo(b)fluoranthene	1.00E+00	mouse	0.03	--	--	--	Benzo(a)pyrene as surrogate	--
SV	Benzo(g,h,i)perylene	1.00E+00	mouse	0.03	--	--	--	Benzo(a)pyrene as surrogate	--
SV	Benzo(k)fluoranthene	1.00E+00	mouse	0.03	--	--	--	Benzo(a)pyrene as surrogate	--
SV	Benzoic acid	--	--	--	--	--	--	--	--
SV	Benzyl butyl phthalate	--	--	--	--	--	--	--	--
SV	bis(2-Ethylhexyl)phthalate	1.83E+01	mouse	0.03	1.11E+00	ringed dove	0.155	Sample et al. 1996	Sample et al. 1996
SV	Carbazole	--	--	--	--	--	--	--	--
SV	Chrysene	1.00E+00	mouse	0.03	--	--	--	Benzo(a)pyrene as surrogate	--
SV	Dibenz(a,h)anthracene	1.00E+00	mouse	0.03	--	--	--	Benzo(a)pyrene as surrogate	--
SV	Dibenzofuran	--	--	--	--	--	--	--	--
SV	Di-n-butylphthalate	5.50E+02	mouse	0.03	1.10E-01	ringed dove	0.155	Sample et al. 1996	Sample et al. 1996
SV	Fluoranthene	1.00E+00	mouse	0.03	--	--	--	Benzo(a)pyrene as surrogate	--
SV	Fluorene	1.00E+00	mouse	0.03	--	--	--	Benzo(a)pyrene as surrogate	--
SV	Phenol	1.00E+00	mouse	0.03	--	--	--	Benzo(a)pyrene as surrogate	--
SV	Pyrene	1.00E+00	mouse	0.03	--	--	--	Benzo(a)pyrene as surrogate	--
SV	Hexachlorobenzene	1.60E+00	rat	--	2.25E-01	Coturnix quail	--	Benzo(a)pyrene as surrogate	--
SV	Hexachlorobutadiene	2.00E-01	rat	--	3.19E+00	Jap. Quail	--	Benzo(a)pyrene as surrogate	--
SV	Hexachlorocyclopentadiene	3.80E+00	rat	--	--	--	--	Benzo(a)pyrene as surrogate	--
SV	Indeno(1,2,3-cd)pyrene	1.00E+00	mouse	0.03	--	--	--	Benzo(a)pyrene as surrogate	--
SV	Naphthalene	1.00E+00	mouse	0.03	--	--	--	Benzo(a)pyrene as surrogate	--
SV	Pyrene	1.00E+00	mouse	0.03	--	--	--	Benzo(a)pyrene as surrogate	--
VOC	1,1,1-Trichloroethane	1.00E+03	mouse	0.035	--	--	--	Sample et al. 1996	
VOC	Acetone	1.00E+01	rat	0.35	5.20E+01	Coturnix quail	--	Sample et al. 1996	EPA 1999

Table 4-1. Toxicity Reference Values,
Plum Brook Ordnance Works, Sandusky, Ohio

		Mammals			Birds			Source	
Method Group	Chemical Name	NOAEL (mg/kg/d)	Test Species	Body Wt. (kg)	NOAEL (mg/kg/d)	Test Species	Body Wt. (kg)	Mammals	Birds
VOC	Benzene	--	--	--	--	--	--	--	--
VOC	Carbon Disulfide	--	--	--	--	--	--	--	--
VOC	cis-1,3-Dichloropropene	--	--	--	--	--	--	--	--
VOC	Cyclohexane	--	--	--	--	--	--	--	--
VOC	Ethylbenzene	--	--	--	--	--	--	--	--
VOC	Methyl Acetate	--	--	--	--	--	--	--	--
VOC	Methylcyclohexane	--	--	--	--	--	--	--	--
VOC	Toluene	--	--	--	--	--	--	--	--
VOC	Xylenes, Total	--	--	--	--	--	--	--	--

Table 5-1. Hazard Quotients for Short-tailed Shrew (*Blarina brevicauda*) for Exposures at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Effect Dose (mg/kg/day)	Exposure Dose (mg/kg/day)	HQ[1]
2,4-Dinitrotoluene	2.00E-01	1.18E-01	6E-01
Antimony	1.25E+00	2.26E-01	2E-01
Beryllium	6.60E-02	1.38E-02	2E-01
Cadmium	1.00E+00	6.26E-02	6E-02
Chromium	2.74E+00	1.45E-01	5E-02
Copper	1.17E+01	2.08E-01	2E-02
Lead	8.00E+00	1.80E+00	2E-01
Mercury	1.00E+00	9.22E-04	9E-04
Nickel	4.00E+01	1.82E-01	5E-03
Vanadium	2.10E-01	6.53E-01	**3E+00**
PCB-1254 (Aroclor 1254)	6.80E-02	1.56E-01	**2E+00**
PCB-1260 (Aroclor 1260)	6.80E-02	4.44E-01	**7E+00**
Naphthalene	1.00E+00	1.91E-01	2E-01

Notes:

1-Values with bold and shading indicate an elevated potential for adverse ecological effects.

HQ = COPEC-specific hazard quotient

mg/kg/day = milligrams COPEC per kilogram body weight per day

Table 5-2. Hazard Quotients for White-tailed Deer (*Odocoileus virginianus*) for Exposures at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Effect Dose (mg/kg/day)	Exposure Dose (mg/kg/day)	HQ[1]
2,4-Dinitrotoluene	2.00E-01	1.78E-05	9E-05
Antimony	1.25E+00	2.67E-05	2E-05
Beryllium	6.60E-02	2.22E-07	3E-06
Cadmium	1.00E+00	3.94E-06	4E-06
Chromium	2.74E+00	6.08E-06	2E-06
Copper	1.17E+01	1.06E-04	9E-06
Lead	8.00E+00	1.52E-04	2E-05
Mercury	1.00E+00	6.42E-08	6E-08
Nickel	4.00E+01	1.33E-05	3E-07
Vanadium	2.10E-01	8.09E-06	4E-05
PCB-1254 (Aroclor 1254)	6.80E-02	6.60E-07	1E-05
PCB-1260 (Aroclor 1260)	6.80E-02	1.50E-06	2E-05
Naphthalene	1.00E+00	4.60E-07	5E-07

Notes:

1-Values with bold and shading indicate an elevated potential for adverse ecological effects.

HQ = COPEC-specific hazard quotient

mg/kg/day = milligrams COPEC per kilogram body weight per day

Table 5-3. Hazard Quotients for Marsh Wren (*Cistothorus palustris*) for Exposures at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Effect Dose (mg/kg/day)	Exposure Dose (mg/kg/day)	HQ[1]
2,4-Dinitrotoluene	2.00E-01	1.52E-01	8E-01
Antimony	1.25E+00	2.20E-01	2E-01
Beryllium	6.60E-02	1.34E-02	2E-01
Cadmium	1.00E+00	7.60E-02	8E-02
Chromium	2.74E+00	5.02E-02	2E-02
Copper	1.17E+01	1.14E-01	1E-02
Lead	8.00E+00	8.85E-01	1E-01
Mercury	1.00E+00	5.06E-04	5E-04
Nickel	4.00E+01	7.73E-02	2E-03
Vanadium	2.10E-01	6.38E-01	**3E+00**
PCB-1254 (Aroclor 1254)	6.80E-02	1.91E-01	**3E+00**
PCB-1260 (Aroclor 1260)	6.80E-02	5.46E-01	**8E+00**
Naphthalene	1.00E+00	2.51E-01	3E-01

Notes:

1-Values with bold and shading indicate an elevated potential for adverse ecological effects.

HQ = COPEC-specific hazard quotient

mg/kg/day = milligrams COPEC per kilogram body weight per day

Table 5-4. Hazard Quotients for Deer Mouse (*Peromyscus maniculatus*) for Exposures at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Effect Dose (mg/kg/day)	Exposure Dose (mg/kg/day)	HQ[1]
2,4-Dinitrotoluene	2.00E-01	2.76E-01	**1E+00**
Antimony	1.25E+00	4.09E-01	3E-01
Beryllium	6.60E-02	1.23E-02	2E-01
Cadmium	1.00E+00	9.35E-02	9E-02
Chromium	2.74E+00	9.32E-02	3E-02
Copper	1.17E+01	1.04E+00	9E-02
Lead	8.00E+00	2.05E+00	3E-01
Mercury	1.00E+00	9.66E-04	1E-03
Nickel	4.00E+01	1.79E-01	4E-03
Vanadium	2.10E-01	5.60E-01	**3E+00**
PCB-1254 (Aroclor 1254)	6.80E-02	1.52E-01	**2E+00**
PCB-1260 (Aroclor 1260)	6.80E-02	4.30E-01	**6E+00**
Naphthalene	1.00E+00	1.96E-01	2E-01

Notes:

1-Values with bold and shading indicate an elevated potential for adverse ecological effects.

HQ = COPEC-specific hazard quotient

mg/kg/day = milligrams COPEC per kilogram body weight per day

Table 5-5. Hazard Quotients for Eastern Cottontail (*Sylvilagus floridanus*) for Exposures at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Effect Dose (mg/kg/day)	Exposure Dose (mg/kg/day)	HQ[1]
2,4-Dinitrotoluene	2.00E-01	7.77E-03	4E-02
Antimony	1.25E+00	1.38E-02	1E-02
Beryllium	6.60E-02	2.33E-04	4E-03
Cadmium	1.00E+00	1.89E-03	2E-03
Chromium	2.74E+00	6.72E-03	2E-03
Copper	1.17E+01	5.03E-02	4E-03
Lead	8.00E+00	1.09E-01	1E-02
Mercury	1.00E+00	4.84E-05	5E-05
Nickel	4.00E+01	1.05E-02	3E-04
Vanadium	2.10E-01	1.00E-02	5E-02
PCB-1254 (Aroclor 1254)	6.80E-02	6.92E-04	1E-02
PCB-1260 (Aroclor 1260)	6.80E-02	1.81E-03	3E-02
Naphthalene	1.00E+00	2.16E-04	2E-04

Notes:

1-Values with bold and shading indicate an elevated potential for adverse ecological effects.

HQ = COPEC-specific hazard quotient

mg/kg/day = milligrams COPEC per kilogram body weight per day

Table 5-6. Hazard Quotients for Red-tailed Hawk (*Buteo jamaicensis*) for Exposures at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Effect Dose (mg/kg/day)	Exposure Dose (mg/kg/day)	HQ[1]
2,4-Dinitrotoluene	2.00E-01	4.22E-05	2E-04
Antimony	1.25E+00	5.98E-05	5E-05
Beryllium	6.60E-02	2.07E-06	3E-05
Cadmium	1.00E+00	1.54E-05	2E-05
Chromium	2.74E+00	9.27E-06	3E-06
Copper	1.17E+01	1.30E-04	1E-05
Lead	8.00E+00	2.49E-04	3E-05
Mercury	1.00E+00	1.22E-07	1E-07
Nickel	4.00E+01	2.06E-05	5E-07
Vanadium	2.10E-01	9.55E-05	5E-04
PCB-1254 (Aroclor 1254)	6.80E-02	2.85E-05	4E-04
PCB-1260 (Aroclor 1260)	6.80E-02	8.10E-05	1E-03
Naphthalene	1.00E+00	3.77E-05	4E-05

Notes:

1-Values with bold and shading indicate an elevated potential for adverse ecological effects.

HQ = COPEC-specific hazard quotient

mg/kg/day = milligrams COPEC per kilogram body weight per day

Table 5-7. Hazard Quotients for Raccoon (*Procyon lotor*) for Exposures at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Effect Dose (mg/kg/day)	Exposure Dose (mg/kg/day)	HQ[1]
Acetone	1.00E+01	1.66E-04	2E-05
PCB-1254 (Aroclor 1254)	6.80E-02	1.33E-03	2E-02
PCB-1260 (Aroclor 1260)	6.80E-02	2.18E-03	3E-02
2-Methylnaphthalene	1.00E+00	3.69E+00	**4E+00**
4-Methylphenol (p-Cresol)	2.19E+02	1.24E-02	6E-05
Anthracene	1.00E+00	6.91E+00	**7E+00**
Benzo(a)anthracene	1.00E+00	4.74E-05	5E-05
Benzo(a)pyrene	1.00E+00	4.32E-05	4E-05
Benzo(b)fluoranthene	1.00E+00	6.50E-05	7E-05
Benzo(g,h,i)perylene	1.00E+00	4.97E-05	5E-05
Benzo(k)fluoranthene	1.00E+00	6.29E-05	6E-05
Carbon Disulfide	--	2.21E-04	NA
Chrysene	1.00E+00	5.77E-05	6E-05
Fluoranthene	1.00E+00	4.88E+00	**5E+00**
Indeno(1,2,3-cd)pyrene	1.00E+00	1.70E-06	2E-06
Phenanthrene	1.00E+01	5.08E-01	5E-02
Pyrene	1.00E+00	7.93E+00	**8E+00**
Chromium	2.74E+00	4.09E-03	1E-03
Lead	8.00E+00	1.02E-02	1E-03
Mercury	1.00E+00	4.37E-04	4E-04
Nickel	4.00E+01	1.78E-02	4E-04

Notes:

1-Values with bold and shading indicate an elevated potential for adverse ecological effects.

HQ = COPEC-specific hazard quotient

mg/kg/day = milligrams COPEC per kilogram body weight per day

Table 5-8. Hazard Quotients for Mallard Duck (*Anas platyrhynchos*) for Exposures at Acid Area 1, Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Effect Dose (mg/kg/day)	Exposure Dose (mg/kg/day)	HQ[1]
1,1,1-Trichloroethane	--	4.96E-06	NA
Acetone	5.20E+01	3.93E-03	8E-05
Carbon Disulfide	--	1.30E-05	NA
2-Methylnaphthalene	--	4.29E-05	NA
4-Methylphenol (p-Cresol)	--	5.02E-04	NA
Anthracene	--	3.28E-06	NA
Benzo(a)anthracene	--	5.07E-06	NA
Benzo(a)pyrene	--	3.08E-06	NA
Benzo(b)fluoranthene	--	4.52E-06	NA
Benzo(g,h,i)perylene	--	2.95E-06	NA
Benzo(k)fluoranthene	--	4.19E-06	NA
Chrysene	--	5.71E-06	NA
Fluoranthene	--	1.59E-05	NA
Indeno(1,2,3-cd)pyrene	--	4.29E-06	NA
Phenanthrene	--	1.02E-05	NA
Pyrene	--	1.21E-05	NA
PCB-1254 (Aroclor 1254)	1.80E-01	9.53E-06	5E-05
PCB-1260 (Aroclor 1260)	1.80E-01	1.26E-05	7E-05
Aluminum	1.10E+02	4.32E-03	4E-05
Barium	2.08E+01	1.04E-05	5E-07
Chromium	1.00E+00	3.51E-04	4E-04
Copper	4.70E+01	1.45E-05	3E-07
Iron	5.00E+01	1.25E-02	2E-04
Lead	3.85E+00	1.64E-03	4E-04
Manganese	9.77E+02	2.23E-03	2E-06
Mercury	4.50E-01	6.10E-05	1E-04
Nickel	7.74E+01	2.53E-03	3E-05
Zinc	1.45E+01	1.84E-05	1E-06

Notes:

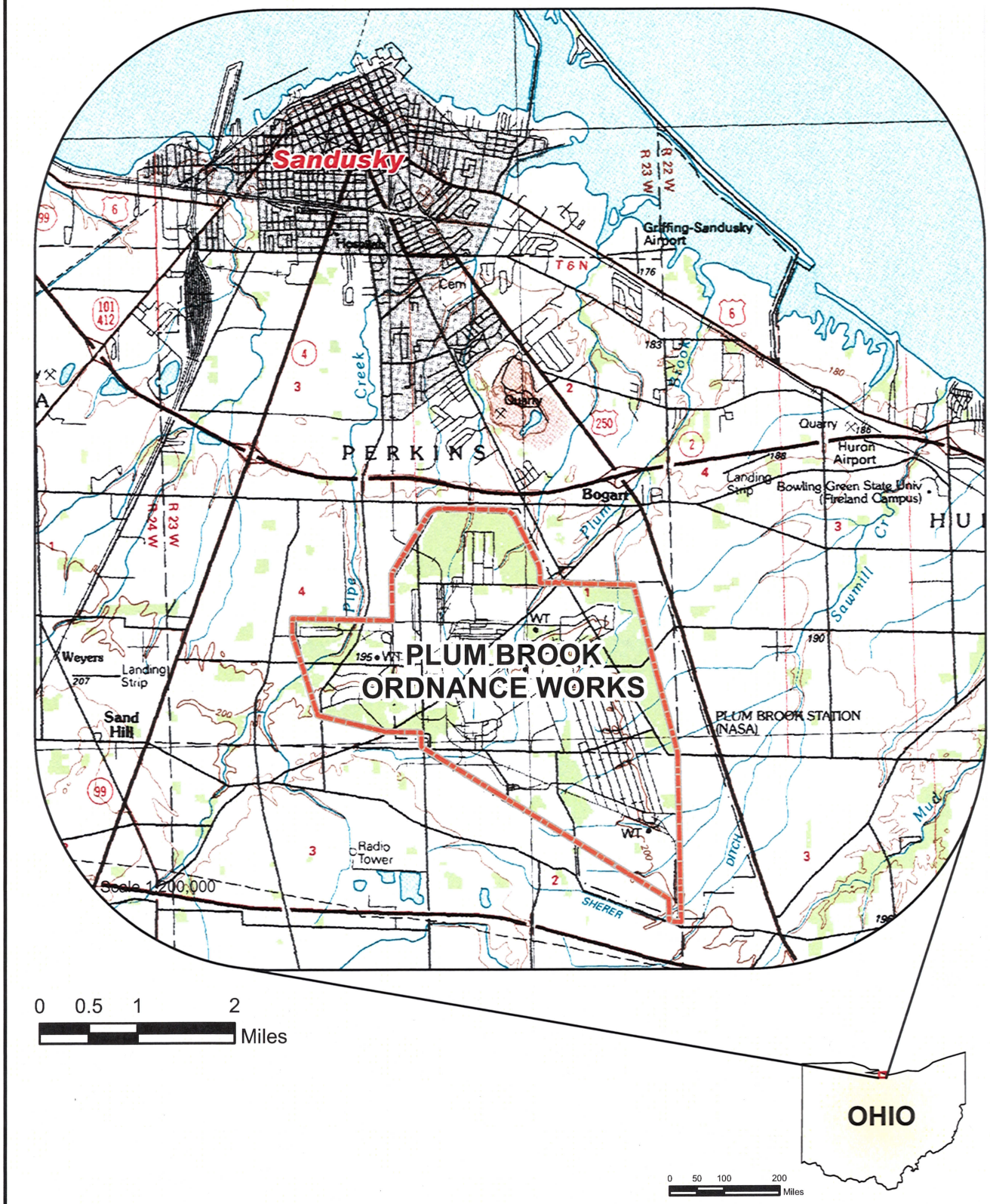
1-Values with bold and shading indicate an elevated potential for adverse ecological effects.

HQ = COPEC-specific hazard quotient

mg/kg/day = milligrams COPEC per kilogram body weight per day

Figures

FIGURES



Legend

Plum Brook Ordnance Works Boundary

N

JACOBS™

Location Map,
Plum Brook Ordnance Works
Sandusky, Ohio

Plumbrook Ordnance Works
Sandusky, Ohio

11/20/08 JP X:/GIS/Projects/Plumbrook/Projects/AA1_Draft_RI/ArcGIS/PBOW_Site_Location_AA1.mxd

Figure 1-1

Figure 2-2

Simplified Terrestrial Food Web Conceptual Site Model (CSM)
Plum Brook Ordinance Works, Sandusky, Ohio

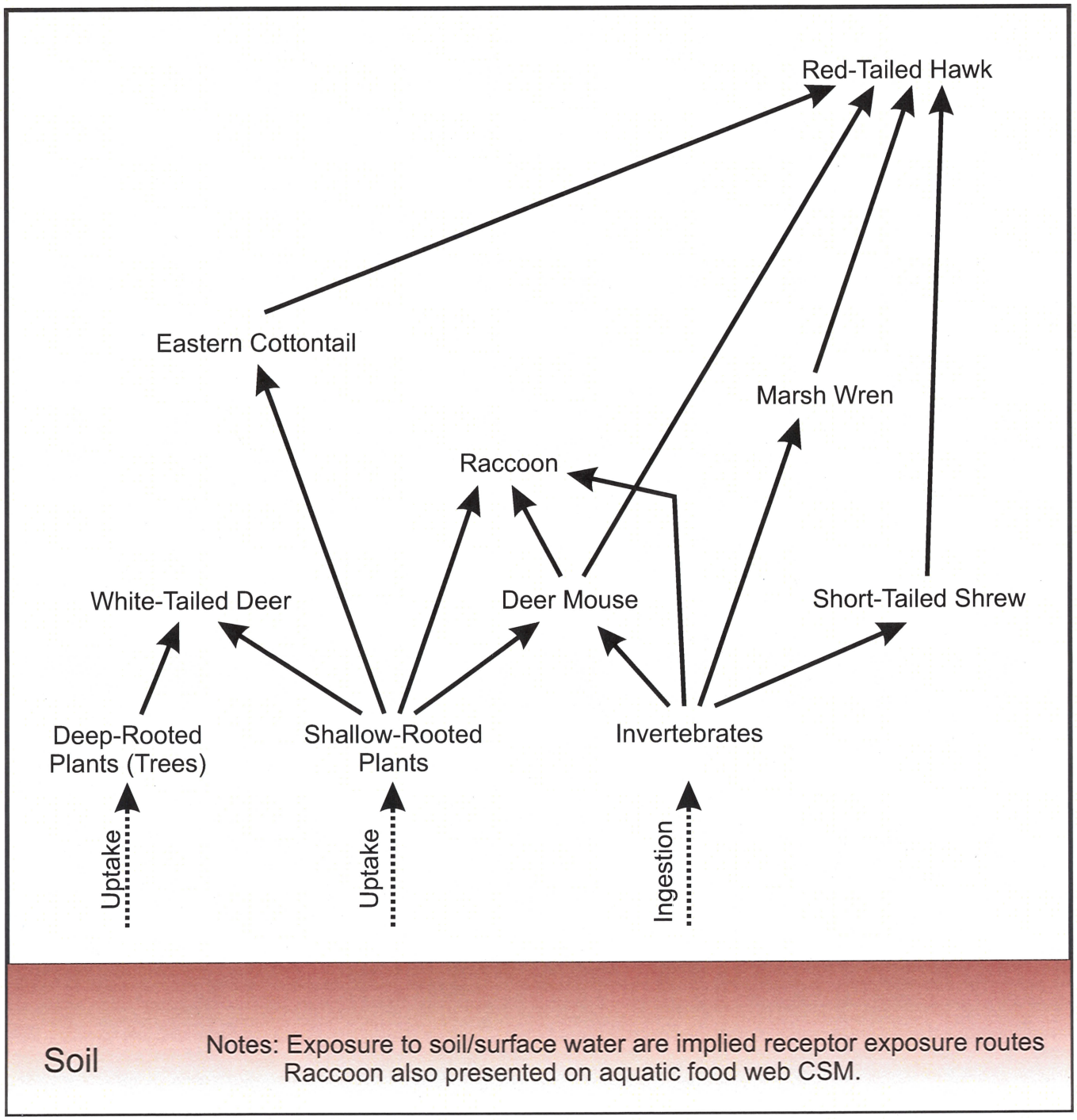
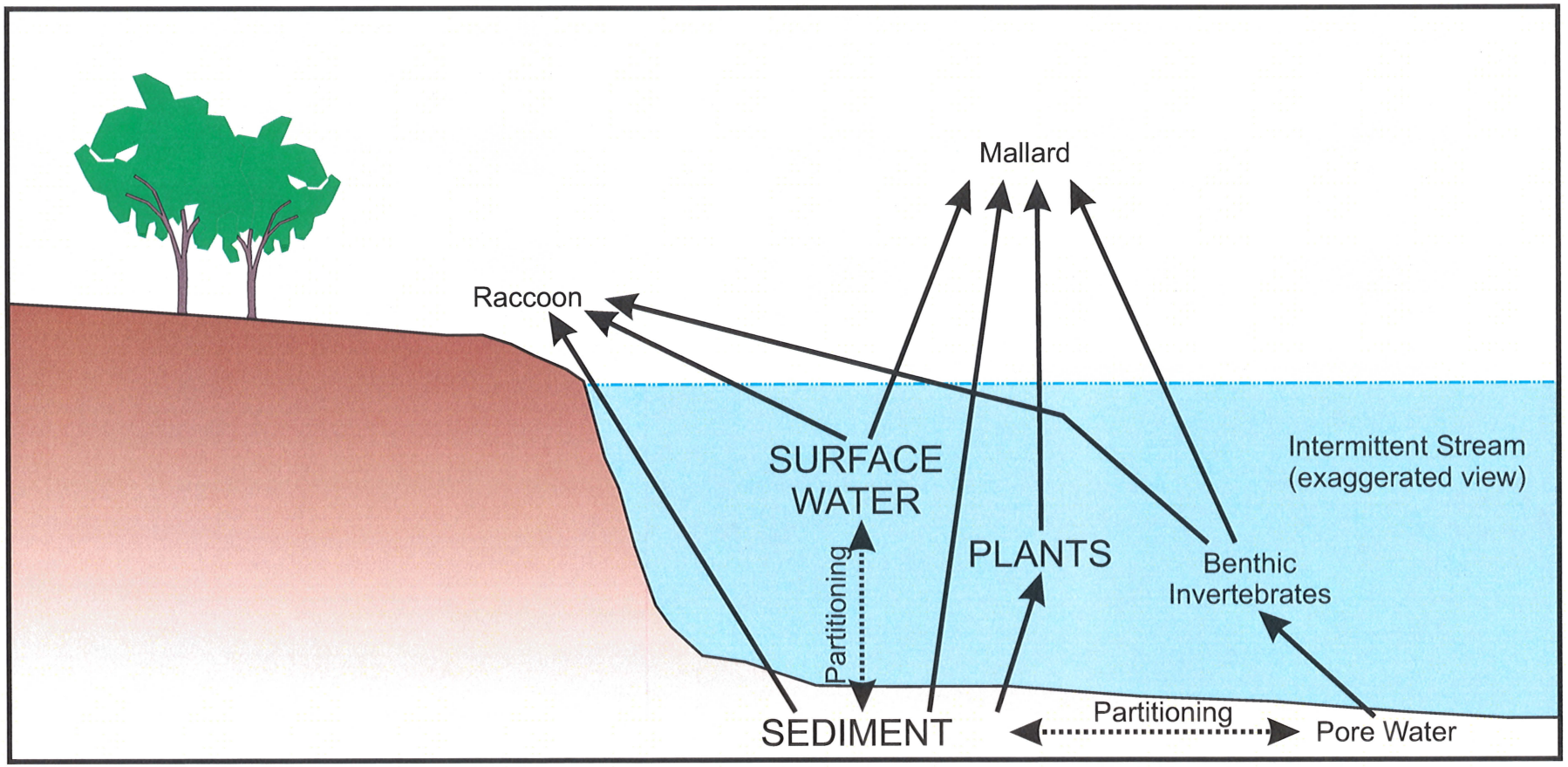


Figure 2-3

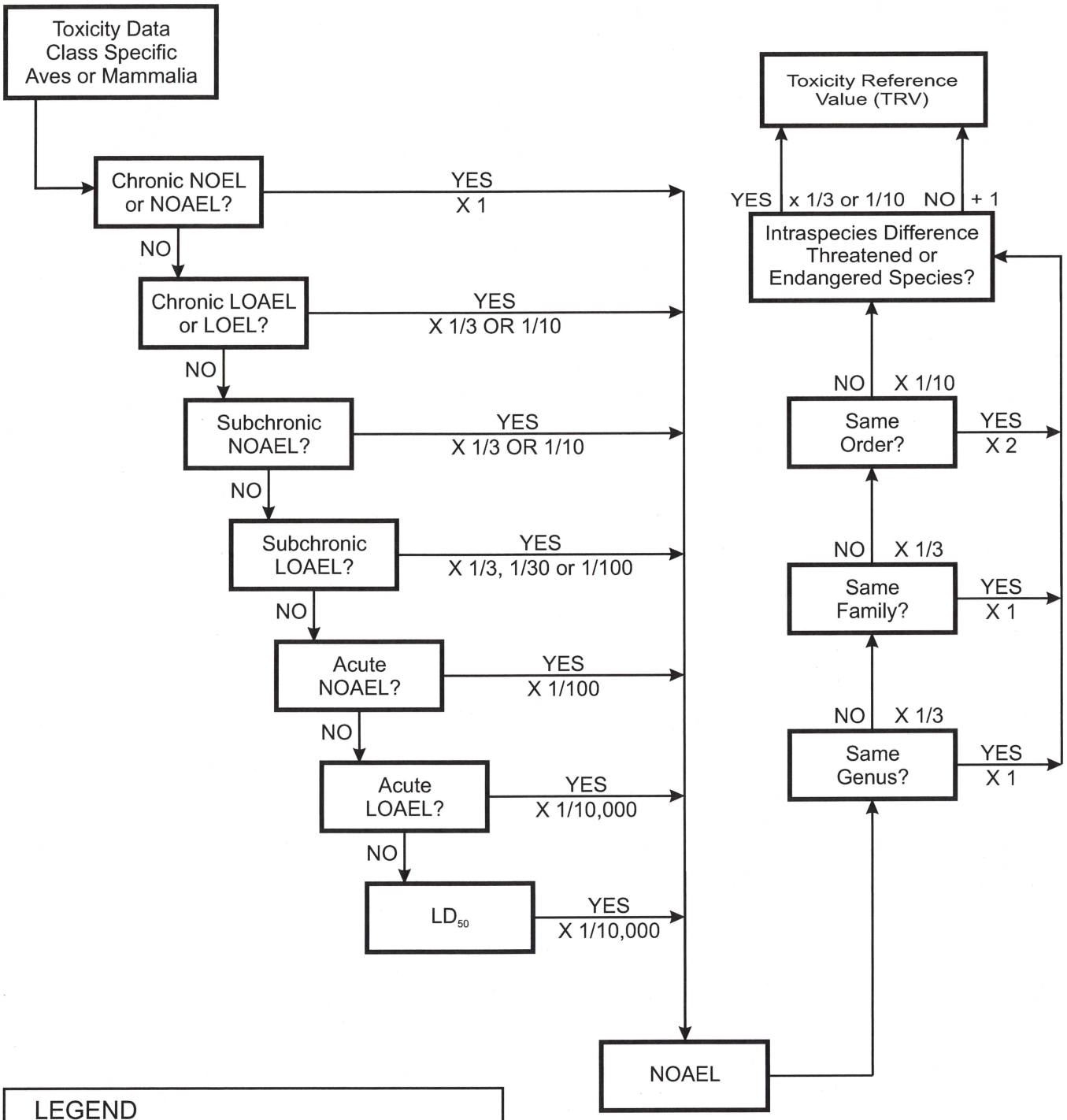
Simplified Aquatic Food Web Conceptual Site Model (CSM)
Plum Brook Ordinance Works, Sandusky, Ohio



Notes: Raccoon also presented on terrestrial food web CSM.

Figure 4-1

Procedural Flow Chart for Deriving Toxicity Reference Values (TRVs)
from Class-Specific Toxicity Data
Plum Brook Ordinance 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 Ohio ERA & ERR Ecological Risk Assessment and Guidance, 2003

APPENDICES

Appendix A

APPENDIX A
ECOLOGICAL SURVEY

NASA Plum Brook
Sandusky, Ohio
Acid Area 1 Plant List
May 14 and October 2, 2008

Scientific Name	Common Name
Acalypha rhomboidea	rhombic three-seeded mercury
Acer negundo	box elder
Acer rubrum	red maple
Achillea millefolium	yarrow
Agalinus tenuifolia	foxglove
Agrimonia parviflora	small-flowered groovebur
Agrostis alba	redtop
Alisma plantago-aquatica	broad-leaved water plantain
Alliaria petiolata	garlic mustard
Andropogon virginicus	broom sedge
Anemone virginiana	thimbleweed
Apocynum cannabinum	dogbane
Asclepias syriaca	common milkweed
Asplenium playtneuron	ebony spleenwort
Aster lateriflorus	calico aster
Aster novae-angliae	New England aster
Aster praealtus	willow-leaf aster
Bidens frondosa	beggar ticks
Boehmeria cylindrica	small-spike false-nettle
Botrychium virginianum	grape fern
Brassica nigra	yellow rocket
Capsella bursa-pastoris	shepherd's purse
Carduus nutans	nodding thistle
Carex blanda	eastern woodland sedge
Carex frankii	Frank's sedge
Carex hirtifolia	sedge
Carex radiata	sedge
Carex tribuloides	broom sedge
Carex vulpinoidea	fox sedge
Chelone glabra	white turtlehead
Circaea lutetiana	southern broad-leaved enchanters nightshade
Cirsium arvense	creeping thistle
Cirsium muticum	swamp thistle
Claytonia virginica	spring beauty
Cornus amomum	silky dogwood
Cornus racemosa	gray dogwood
Crypotaenia canadensis	honewort
Dactylis glomerata	orchard grass

Scientific Name	Common Name
Daucus carota	Queen Anne's lace
Desmodium paniculatum	panicled tick trefoil
Dichanthelium clandestinum	deer-tongue grass
Dipsacus sylvestris	teasel
Eleagnus umbellata	autumn olive
Eleocharis acicularis	needle spike-rush
Elymus riparius	river bank wild rye
Epilobium coloratum	purple-leaved willow herb
Equisetum arvense	field horsetail
Equisetum hyemale	scouring rush
Eragrostis sp.	love grass
Erechtites hieraciifolia	fireweed
Erigeron philadelphicus	common fleabane
Eupatorium album	white thorough-wort
Eupatorium maculatum	Joe pye weed
Eupatorium perfoliatum	boneset
Eupatorium rugosum	white snakeroot
Euphorbia maculata	upright spotted spurge
Euphorbia nutans	eyebane
Euthamia graminifolia	fragrant flat-topped goldenrod
Festuca arundinacea	fescue
Fragaria virginiana	strawberry
Fraxinus pennsylvanica	green ash
Galium aparine	cleavers
Galium asprellum	rough bedstraw
Galium tinctorium	stiff marsh bedstraw
Geum laciniatum	rough avens
Gnathalium obtusifolium	catfoot
Hordeum jubatum	foxtail barley
Hypericum perforatum	St. John's wort
Juncus effusus	soft rush
Juncus torreyi	Torrey's rush
Juniperus virginiana	red cedar
Leersia oryzoides	rice cutgrass
Lemna minor	lesser duckweed
Lepidium campestre	pepper grass
Ligustrum vulgare	privet
Lonicera tatarica	Tartarian honeysuckle
Ludwigia alternifolia	bushy seedbox
Ludwigia palustris	water purslane
Lycopus americana	bugle weed
Lycopus virginicus	Virginia bugle weed
Medicago lupulina	black medick

Scientific Name	Common Name
Melilotus sp.	sweet clover
Mimulus ringens	Allegheny monkey flower
Monarda fistulosa	wild bergamot
Morus alba	Mulberry
Nepeta cataria	catnip
Onoclea sensibilis	sensitive fern
Panicum dichotomiflorum	fall panicgrass
Panicum virgatum	switch grass
Parthenocissus quinquefolia	Virginia creeper
Penstemon digitalis	beard-tongue
Phalaris arundinacea	reed canary grass
Phryma leptostachya	lopseed
Plantago lanceolata	English plantain
Plantago major	common plantain
Poa alsodes	blue grass
Podophyllum peltatum	mayapple
Polygonum cuspidatum	Japanese knotweed
Polygonum pennsylvanicum	Pennsylvania smartweed
Polygonum virginianum	Virginia knotweed
Populus deltoides	cottonwood
Potentilla norvegica	Norwegian cinquefoil
Potentilla simplex	old field cinquefoil
Prunus americana	wild plum
Prunus serotina	black cherry
Pycnanthemum tenuifolium	slender mountain mint
Pyrus coronaria	crabapple
Quercus palustris	pin oak
Ranunculus abortivus	kidney-leaf buttercup
Ranunculus recurvatus	cursed crowfoot
Rosa multiflora	multiflora rose
Rosa setigera	prairie rose
Rubus allegheniensis	Allegheny blackberry
Rubus flagellaris	dewberry
Rubus occidentalis	black raspberry
Rudbeckia hirta	black-eyed Susan
Rumex acetosella	sheep sorrel
Rumex crispus	curly dock
Salix amygdaloides	peachleaf willow
Salix exigua	sandbar willow
Salix nigra	black willow
Sambucus canadensis	common elder
Satureja vulgaris	wild basil

Scientific Name	Common Name
Scirpus atrovirens	green bulrush
Scirpus cyperinus	wool grass
Scirpus validus	soft-stem bulrush
Senecio aureus	golden alexanders
Setaria glauca	yellow bristle grass
Solidago canadensis	Canada goldenrod
Solanum carolinense	horse nettle
Solanum nigrum	black nightshade
Taraxacum officinale	dandelion
Teucrium canadense	American germander
Thelypteris palustris	marsh fern
Toxicodendron radicans	poison ivy
Tragopogon porrifolius	salsify
Trifolium hybridium	alsike clover
Trifolium repens	white clover
Typha angustifolia	narrow-leaf cattail
Typha x glauca	hybrid cattail
Ulmus americana	American elm
Urtica dioicia	stinging nettle
Verbascum blattaria	moth mullein
Verbascum thapsus	woolly mullein
Verbena urticifolia	white vervain
Verbesina alternifolia	wingstem
Vernonia gigantea	ironweed
Vicia sp.	vetch
Viola papilionacea	blue violet
Vitis aestivalis	summer grape
Vitis riparia	riverbank grape

DAVEY
RESOURCE GROUP
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November 17, 2008

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Jon Russ
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Dear Mr. Russ:

Please find enclosed information for the NASA Plum Brook ecological survey. Included are the plant lists for Acid Area 1 and Reservoir No. 2 Burning Ground based on our site visits on May 14 and October 2, 2008. Also enclosed are vegetation community maps for both sites and vegetation community descriptions. The vegetation community maps are approximate due to the poor quality of the aerial photographs.

If you have any questions or need additional information, please let me know. This should complete my work on this project.

Sincerely,

Todd Crandall
Natural Resource Consulting

NASA Plum Brook
Sandusky, Ohio
Plant Community Description
Acid Area 1 and Reservoir No. 2 Burning Ground
November, 2008

Upland Old Fields. These areas are dominated by grasses and herbs and have been recently disturbed by mowing and/or brush-hogging. Scattered shrubs, small trees, and groups of shrubs also occur here.

Shrub Thickets. Dense areas of shrub thickets occur in both Acid Area 1 and Reservoir No. 2 Burning Ground. *Cornus racemosa* (gray dogwood) dominates most of these areas. *Eleagnus umbellata* (autumn olive) is also common. Small trees and saplings also occur within the shrub thickets.

Successional Woods. Successional woods are comprised of small and moderate sized trees, primarily *Fraxinus pennsylvanica* (green ash), *Acer negundo* (box elder), and *Populus deltoides* (cottonwood). These areas generally have a moderate to dense shrubby understory. The herbaceous layer is dense in most areas. *Carex* spp. (sedges) dominate most of the understory.

Marsh. Small areas of marsh are found within Acid Area 1. These areas are generally dominated by cattails, with other species such as sedges and bulrushes also occurring. All of these areas were either created by, or influenced by, past disturbances.

Scrub/shrub Wetlands. Several areas of scrub/shrub wetlands are found within Acid Area 1. The drainage ditch along the south side of this site is also a scrub/shrub wetland. These areas contain *Cornus racemosa* (gray dogwood) along with herbaceous species such as sedges and horsetails.

APPENDIX B

APPLICATION OF ESSENTIAL NUTRIENTS IN ECOLOGICAL RISK ASSESSMENT

Appendix B
Application of Essential Nutrients In Ecological Risk Assessment

Introduction

All forms of living matter require inorganic elements, or minerals, for their normal life processes. All animal tissues and feeds contain inorganic or mineral elements in widely varying amounts and proportions. Minerals that are needed in relatively large amounts are referred to as major or macrominerals; those that are needed in very small amounts are referred to as trace minerals or microminerals. These terms represent quantity designations of the amounts required in an animal's diet and their generally low or trace concentrations in tissues. The major minerals are required in concentrations of greater than 100 parts per million (ppm) and are often reported as a percentage of diet, while trace elements are required at less than 100 ppm and are sometimes reported at the parts per billion (ppb) level. Table B-1 presents 24 elements known to be required by at least some animal species (McDowell, 1992).

Table B-1. General Macro and Microminerals

Major or Macrominerals	Trace or Microminerals		
Calcium (Ca)	Arsenic (As)*	Iodine (I)	Nickel (Ni)*
Chlorine (Cl)	Boron (B)*	Iron (Fe)	Selenium (Se)
Magnesium (Mg)	Chromium (Cr)	Lead (Pb)*	Silicon (Si)*
Phosphorus (P)	Cobalt (Co)	Lithium (Li)*	Tin (Sn)*
Potassium(K)	Copper (Cu)	Manganese (Mn)	Vanadium (V)*
Sodium (Na)	Fluorine (F)	Zinc (Zn)	Molybdenum (Mo)
Sulfur (S)			

* These elements have not been shown to be essential for livestock or humans consuming typical diets.

The listing of some of the trace elements as essential is difficult and sometimes tentative, and rests on experiments with one or more species. In these experiments, diets adequate in all nutrients except the mineral in question produced clinical signs that were prevented or overcome by adding that mineral to the diets (McDowell, 1992).

Unlike other nutrients, mineral elements cannot be synthesized by living organisms. Minerals act as: (1) structural components of body organs and tissues, (2) constituents of body fluids and tissues as electrolytes, and (3) catalysts in enzyme and hormone systems. The most obvious function of mineral elements in the body is to provide structural support (skeleton) for the body. Calcium, phosphorus, magnesium, fluoride, and silicon in bones and teeth all contribute to mechanical stability. Birds use calcium to produce eggshells, phosphorus, sulfur, and silicon are found in muscle proteins. Minerals are interrelated and balanced against each other, and most often cannot be considered as single elements with independent and self-sufficient roles in the organized bodily processes. The definite relationship of cadmium and phosphorus in the formation of bones and teeth and the interrelationships of iron, copper, and cobalt (in vitamin B_{12}) in hemoglobin synthesis and red blood cell formation are examples. Sodium, potassium, calcium, phosphorus, and chlorine serve individually and collectively in the body fluids. A number of trace elements (i.e., copper, zinc, and selenium) in addition to certain vitamins (i.e., A, D, E, B_6, and folacin) and other nutrients, are strongly related to adequate immune response (McDowell, 1992).

Mineral Requirements

A series of "safe" dietary levels of potentially toxic elements has been established on the extent to which other elements that affect their absorption and retention are present (McDowell, 1992). Table B-2 presents some of these "safe" dietary levels or mineral requirements for selected species.

Table B-2. Mineral Requirements for Selected Species

Species	Mineral (mg/kg of feed)									
	Ca	Mg	K	Na	Cu	Fe	Mn	P	Se	Zn
Japanese Quail	25,000	500	4,000	1,500	6	100	70	5,000	0.2	50
Rat	5,000	400	3,600	500	5	35	50	4,000	0.10	0.25
Mouse	4,000	500	2,000	---	4.5	25	44	4,000	---	30
Cat	8,000	400	4,000	500	5	80	5	6,000	0.1	50
Mink	6,000	440	3,000	---	6	80	44	5,500	0.1	66

mg/kg – milligrams per kilogram

To determine whether concentrations of these minerals in the environment exceed safe dietary levels, the mineral requirements were converted to dietary doses using the following equation:

$$\text{Dose (mg/kg-day)} = \text{Diet (mg/kg)} \times \text{FI (kg/day)} \times 1 / \text{BW(kg)}$$

where:

Diet (mg/kg) = mineral requirement for each nutrient in milligrams per kilogram
FI (kg/day) = food ingestion rate in kilograms per day
BW(kg) = body weight in kilograms.

Variables for the species are shown in Table B-3.

Table B-3. Food Ingestion and Body Weights

Species	Food Ingestion (FI) (kg/day)	Body Weight (kg)
Japanese Quail	0.017 derived from (FI(kg/day) = $0.0582*BW(kg)^{0.651b}$	0.15[a]
Rat	0.08[a]	0.35[a]
Mouse	0.0055[a]	0.03[a]
Cat	0.24 derived from (FI(kg/day) = $0.0687*BW(kg)^{0.822b}$	4.5 derived from 10 lbs*0.4535923 conversion factor.[c]
Mink	0.137[a]	1.0[a]

[a]Oak Ridge National Laboratory (ORNL), 1996.
[b]U.S . Environmental Protection Agency (EPA), 1993.
[c]IT Corporation, 1999.
BW – body weight
FI – food ingestion rate
kg – kilograms
kg/day – kilograms per day
lbs - pounds

Table B-4 presents the mineral requirements calculated as dietary doses for selected species presented in Table B-3.

Table B-4. Mineral Requirements as a Dietary Dose for Selected Species

Species	Mineral (mg/kg of feed)									
	Ca	Mg	K	Na	Cu	Fe	Mn	P	Se	Zn
Japanese Quail	2,833	56.7	453	170	0.7	11.3	7.9	567	0.02	5.7
Rat	1,143	91.4	823	114	1.1	8	11.4	914	0.02	0.06
Mouse	733	92	367	---	0.8	4.6	8.1	733	---	5.5
Cat	427	21	213	26.7	0.3	4.3	0.3	320	0.01	2.7
Mink	822	60	411	---	0.8	11	6	753	0.01	9

mg/kg – milligrams per kilogram

Maximum Tolerance Levels

Information concerning the toxicity or tolerance of minerals is incomplete. According to available information, the toxic level of most major minerals is about 10 times the recommended level for young, growing livestock. The toxic levels of trace minerals appear to be highly variable, ranging between 10 and 1,500 times the recommended level. The National Research Council publishes maximum tolerance levels for domestic animals. The maximum tolerance level is defined as that dietary level that, when fed for a limited period, will not impair animal performance and should not produce unsafe residues in human food derived from animals. The levels listed in Table B-5 were derived from toxicity data on the designated species. Tolerance levels vary with the species, adaptation, duration of receiving the toxicants, age, physical condition of the animal, and many other factors (McDowell, 1992).

Table B-5. Maximum Tolerance Levels for Domestic Animals

Species	Mineral (mg/kg of feed)									
	Ca	Mg	K	Na	Cu	Fe	Mn	P	Se	Zn
Poultry	40,000[b] 12,000[c]	(3,000)	(20,000)	20,000	300	1,000	2,000	8,000	20,000	1,000
Rabbits	20,000	(3,000)	(30,000)	(30,000)	200	(500)	(400)	10,000	(20,000)	(500)

Source: McDowell, 1992.
The levels in parentheses were derived by interspecific species extrapolation.
[a]Ratio of calcium to phosphorus is important.
[b]Laying hen.
[c]Other poultry.
mg/kg – milligrams per kilogram

Using the same procedure described in Section H.2.0, the maximum tolerance levels were converted into dietary doses to determine whether concentrations of these minerals in the environment exceed safe dietary levels. Variables for the domestic animals are shown in Table B-6.

Table B-6. Food Ingestion and Body Weights for Domestic Animals

Species	Food Ingestion (FI)(kg/day)	Body Weight (kg)
Poultry	0.08 derived from (FI(kg/day) = 0.0582*BW(kg)$^{0.651a}$	1.6 (mean weight of male and female chicken)[b]
Rabbits	0.2 derived from (FI(kg/day) = 0.0687*BW(kg)$^{0.822a}$	3.8[b]

[a] EPA, 1993.
[b] ORNL, 1996.
BW – body weight
FI – food ingestion rate
kg – kilograms
kg/day – kilograms per day

Table B-7 presents the calculated dietary doses for selected species presented in Table B-6.

Table B-7. Maximum Tolerance Level as a Dietary Dose for Domestic Animals

Species	Mineral (mg/kg of feed)									
	Ca	Mg	K	Na	Cu	Fe	Mn	P	Se	Zn
Poultry	600	150	1,000	1,000	15	50	100	400	1,000	50
Rabbits	1,053	158	1,579	1,579	11	26	21	526	1,053	26

mg/kg – milligrams per kilogram

Data Use

Mineral requirements or maximum tolerance levels will be used in ecological risk assessments, as appropriate.

References

IT, 1999. Best professional judgment for cat's (Felis domesticus) body weight being 10 lbs.

Oak Ridge National Laboratory (ORNL), 1996. Toxicological Benchmarks for Wildlife: 1996 Revision, B. E. Sample, D. M. Opresko, G. W. Suter 11. ES/ER/TM-86/R3, June 1996.

U.S. Environmental Protection Agency (EPA), 1993. Wildlife Exposure Factors Handbook, EPA/600/R-93/187a, December.

McDowell, L. R., 1992. Minerals in Animal and Human Nutrition, Academic Press, Inc. San Diego.

Appendix C

APPENDIX C
ASSESSMENT RECEPTOR PROFILES

Appendix C

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, deer 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 shorthaired, 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 (Areas 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 re-mate 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 re-nest 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 interspersed 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 Naturalis***t, 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 under parts 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., 198, ***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 FactorsHandbook***, EPA/600/R-93/187a.

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

Appendix D

APPENDIX D

RESPONSES TO COMMENTS ON THE DRAFT SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT

Comments Received from Beaujon, James S LRN
7 June 2010

Subject: Internal Draft Baseline HHRA Acid Area 1, PBOW

I skimmed through Jacobs' Draft HHRA for PBOW Acid Area 1. RAs not being my forte' I only have a few comments-

Comment 1. Executive Summary and Text: A Figure 1-3 is referenced but there was no Figure 1-3 in the copy I got.

Response: The reference to Figure 1-3 has been deleted

Comment 2. Page 1-3, section 1.3.1, 3rd line: Change "Most of the building" to "Most of the buildings".

Response: The change has been made as noted.

Comment 3. Page 3-2, section 3.1.1, Geology paragraph, 4th line: The number 8 is spelled out while all the other numbers are not.

Response: The change has been per the comment.

Comment 4. Sections 3.1.3.3 and 3.1.3.4: Reference is made to "the burn area", please revise the sections to be applicable to AA1.

Response: The reference has been deleted per the comment.

Subject: Jacobs' Internal Draft Screening Level Eco Risk Assessment

I looked over the subject document and have the following 2 observations:

Comment 1. Page 1-1, end of 2nd paragraph: Change "(CERLN)" to "(CELRN)".

Response: The change has been made as noted.

Comment 2. Page 2-4, Section 2.1.5 and Table 2-1: Table 2-1's title and the text suggest it lists fauna as well as flora but only flora are listed in the Table 2-1 in my copy.

Response: The change has been made as noted.

MCHB-TS-REH

MEMORANDUM FOR District Engineer, US Army Corps of Engineers, Nashville District (CELRN-EC-R-M/Ms. Kathy McClanahan), 110 Ninth Avenue South, Room 682, US Court House Annex, Nashville, TN 37203

SUBJECT: Internal Draft Screening Level Ecological Risk Assessment (SLERA), Acid Area 1, Former Plum Brook Ordnance Works (PBOW), April 2010

1. The US Army Public Health Command (Provisional), formerly the US Army Center for Health Promotion and Preventive Medicine, reviewed the subject document on behalf of the Office of The Surgeon General pursuant to Army Regulation 200-1 (Environmental Protection and Enhancement). We appreciate the opportunity to review this assessment. Our comments and recommendations are enclosed.

2. Although we concur with the subject document's findings, there are several technical challenges to the SLERA. We will be able to concur with the document after the necessary changes, highlighted in our comments, are made. We look forward to providing further technical risk assessment support on this and other Former Plum Brook Ordnance Works projects.

4. The scientist reviewing this document and our point of contact is Mr. Larry Tannenbaum, Environmental Health Risk Assessment Program, DSN 584-5210 or commercial (410) 436-5210.

FOR THE COMMANDER:

Encl

JEFFREY S. KIRKPATRICK
Director, Health Risk Management

CF:
HQDA (DASG-PPM-NC)
USACE (CEHNC-CX-ES)

COMMENTS AND RECOMMENDATIONS

1. Pages ES-2 and ES-3, L. Tannenbaum
   Executive Summary
   Comment: The text is misleading for the reader. Although in theory, risk characterization in an ecological risk assessment (ERA) context intends to "estimate the likelihood, severity, and characteristics of potential adverse effects from environmental stressors at a site", in actuality there is no way to estimate such things. Additionally, hazard quotients (HQs) mentioned here, do not estimate the potential for toxicological effects to occur. Finally, the last paragraph of the executive summary is seemingly inconsistent. If "low hazards" were predicted for aquatic receptors (from exposure to certain chemicals, termed contaminants of potential ecological concern; COPECs), then a list of (certain) COPECs should have been identified. See next comment.
   Recommendation: In the document revision, please modify the text so as not to give the reader the impression that ecological risk can be characterized. Please have the revised text address the inconsistency regarding COPECs discussed in the Comment.

Response: The risk assessment follows the procedures and processes established and accepted with the risk assessment community. Additionally, the risk assessment follows the format of past risk assessments completed at the former Plum Brook Ordnance Works that have been reviewed and accepted by USACE and the regulators. The risk assessment was completed consistent with the procedures identified in the Final Screening Ecological Risk Assessment Work Plan, Acid Area 1, April 2009.

2. Page 1-1, Section 1.0, L. Tannenbaum
   Introduction
   Comment: The text in the fourth paragraph says that the magnitude of the potential for adverse effects (to identified receptors) was estimated. This is incorrect; the crude HQ estimates of variable magnitude (many of which are toxicologically impossible, by the subject document's own admission) do not allow for estimates of magnitude of adverse effect potential. See Comment 8.
   Recommendation: Please modify the text as necessary to address the Comment's concern.

Response: Please see response to Comment 1.

3. Page 2-4, Section 2.1.5, L. Tannenbaum
   Species Inventory
   Comment: The text at the end of the page's last paragraph is not understood. Is the text saying that because there are ground-nesting bird species at PBOW, that such birds are (necessarily) chemically stressed?
   Recommendation: Please provide a clarification and please modify the text as necessary to better state the point being made.

Response: The text referring to ground nesting birds and the potential for them to be chemically stressed has been deleted from the document.

4. Page 2-6, Section 2.1.6, L. Tannenbaum
   Threatened and Endangered Species Information
   Comment: The last listed species on the page of threatened or endangered plants and birds, is a bat (i.e., a mammal).
   Recommendation: In the document revision, please adjust the table and associated text accordingly.

Response: The text has been revised per the comment.

5. Page 2-13, Section 2.2.6, L. Tannenbaum
   Comparison to Risk-Based Screening Ecotoxicity Values
   Comment: We suspect that the U.S. Environmental Protection Agency Region 5 technical group that is mentioned here, is misnamed.
   Recommendation: Please check to see if "Biotechnical Assistance Group" should be "Biological Assistance Group" or "Biological Technical Assistance Group".

Response: BTAG has been revised to Biological Technical Assistance Group per the comment.

6. Pages 2-15 and 2-16, Section 2.4.1, L. Tannenbaum
   Terrestrial Receptors
   Comment: The approach to ecological assessment appears, in part, to have necessarily included a mammal and a bird of each distinct feeding strategy (e.g., herbivory, omnivory). Such is not however, the way that ecological assessments are to be assembled. Sites should be cautiously reviewed for the species they support and that can satisfy established receptor selection criteria. Established ERA guidance does not call for the inclusion of a representative of each feeding strategy for both birds and mammals. Importantly, the subject document, in nevertheless striving to include so many species, has made some inappropriate choices. The deer mouse and the short-tailed shrew are inappropriate selections because sites are not remediated for their protection. Although red-tailed hawk may consume small rodents from the Acid Area 1 site, with the hawk's home range so vastly subsuming Acid Area 1, it is clear that the hawk does not satisfy an essential receptor selection criterion; listed just two paragraphs above the hawk's mention, are two criteria that the hawk violates, namely having a limited home range, and having a high potential abundance and wide distribution at the site. The white-tailed deer for rather obvious reasons is also an inappropriate choice. It is curious that several of the above-named receptors are included when the text acknowledges their relatively huge home ranges and the reality that the species' area use factors are so minimal.
   Recommendation: In the revised document, please ensure that the inappropriate species are removed. Alternatively, the species identified in the comment can be retained provided that new text is supplied indicating why the species are inappropriate

for study (e.g., spatially irrelevance), and noting that assessment outcomes for the species cannot drive cleanup decisions.

Response: The indicator species selected for assessment are based on several factors. None of the assessment results for one species alone will drive cleanup decisions for the site. Cleanup decisions should always be based on weight-of-evidence decision processes. It should be noted that the results of the SLERA conclude that remedial actions are *not* warranted to address ecological concerns at Acid Area 1.

The indicator species used in the SLERA follow the format of past risk assessments completed at the former Plum Brook Ordnance Works that have been reviewed and accepted by USACE and the regulators. Selection of Acid Area 1 indicator species were completed consistent with the procedures identified in the Final Screening Ecological Risk Assessment Work Plan, Acid Area 1, April 2009.

7. Page 3-5, Section 3.1, L. Tannenbaum
   Exposure Analysis
   Comment: It is clearly stated on the first page of the Executive Summary that the ecological survey found no signs of vegetative stress (e.g., stunted growth, poor foliage growth, etc.) at Acid Area 1. This being the case, there was no need to review soil contaminant concentrations, and to consider these within a context of the contaminants posing stresses to the vegetation (by comparing the exposure point concentrations [EPC] against available benchmarks that the subject document recognizes to be poor measures of risk).
   Recommendation: In the document revision, please ensure that all references to the screening of soil EPCs with plant toxicity benchmarks are removed.

Response: Chemical concentrations detected in soil were compared to benchmark values to provide additional evidence that potential impacts to vegetative species are *not* predicted. The comparisons to benchmark values, in conjunction with findings of the ecological survey were used to draw conclusions regarding potential impacts. A weight-of-evidence decision process was used to draw appropriate conclusions.

8. Page 4-1, Section 4.2, L. Tannenbaum
   Selection of Toxicity Reference Values
   Comment: The text's stated primary source of toxicity reference values (TRVs) is that of U.S. Environmental Protection Agency combustion facility guidance. The subject Acid Area 1 site is not a combustion site, however.
   Recommendation: Please provide supporting text here to justify the application of combustion facility risk assessment guidance for the subject site. If such support cannot be furnished, please have the document revision indicate what the new primary source is for TRVs.

Response: The text has been revised to indicate that the primary source of TRVs for completion of the ERA is from Sample et al 1996, not EPAs combustion facility guidance.

9. Page 5-2, Section 5.3. L. Tannenbaum
Predictive Risk Estimation for Terrestrial Wildlife
Comment: The text alludes to a scheme for relative potential-for-adverse ecological effects, as "low potential", "significant potential", etc. There is no empirical evidence to substantiate such a scheme, however. Additionally, even if the HQs spoken of are No Observed Adverse Effect Level-based, values greater than 10 would rightfully be termed unrealistically high and toxicologically impossible, i.e., terminology the subject document itself uses in the uncertainty section (Section 5.4). Also, the Tannenbaum 2001 reference, in addition to not being a peer-reviewed article, is almost assuredly not the reference that was intended. (Note that the identified journal for the 2001 reference and that of the Tannenbaum et al 2003 reference is Human and Ecological Risk Assessment, and not Journal of Human and Ecological Risk Assessment.) See next Comment.
Recommendation: In the revised document, please either remove the references to nominal potential-for-risk equivalencies for HQs of varying magnitude, or supply text acknowledging the absence of substantiation for the designations of potential for risk. Please replace the Tannenbaum 2001 reference here with the following two references, and ensure that these are cited in Section 7.0 (References) as well:
Tannenbaum, L.V., Johnson, M.S., and Bazar, M., 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 (1): 387-401.

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

Response: Application and use of HQs in the SLERA follow the format of past risk assessments completed at the former Plum Brook Ordnance Works that have been reviewed and accepted by USACE and the regulators. The process of predicting risk through HQs was completed consistent with the procedures identified in the Final Screening Ecological Risk Assessment Work Plan, Acid Area 1, April 2009. However, additional text regarding the uncertainty of using HQs to predict risk has been added to the text as noted below.

The text has been revised per the comment and now states "It should also be noted that HQs are not measures of risk, are not population-based statistics, nor are they linearly scaled statistics. The use of HQs to predict risk is questionable and may or may not substantiate risk. Accordingly, an HQ above 1, even exceedingly so, does not necessarily mean that there is even one individual expressing the toxicological effect associated with a given chemical to which it was exposed (Bartell, 1996).

The reference to Tannenbaum 2001 was removed from the section per the comment.

10. Page 5-4, Section 5.4, L. Tannenbaum
Uncertainty Analysis

Comment: The treatment of HQ method ("Use of the HQ method to estimate risk to populations or communities") is incomplete.

Recommendation: In the revised document, please ensure that the text of this two-sentence paragraph is expanded to both name and define a list of some five method limitations. Finally, please have the revised paragraph note prominently that there exists no statistic or metric for expressing ecological "risk".

Response: Uncertainty text presented by the U.S. EPA regarding application and decision making using HQs has been added per the comment as follows: "There are also limitations to the HQ approach that stem from uncertainties in both the numerator (the estimate of dose or exposure and the denominator (the TRV) used to calculate the HQ. For example, TRV values are based on toxicity tests performed under laboratory conditions, which may or may not account for factors that can influence toxicity in the field. Also, some TRVs are based on limited and sometimes internally inconsistent toxicity data, and TRVs may not be available for all receptors of concern at a site. Therefore, some TRVs may be relatively uncertain, especially when extrapolation of findings across different species is required. In addition, estimation of actual exposure levels is often difficult (especially for terrestrial receptors) due to lack of site-specific data on intake rates, home ranges, etc (U.S. EPA

Because of these potential limitations, the HQ approach is best considered to be a screening-level means of evaluation. That is, if an HQ is above a level of concern, this an indication that effects may be occurring, but further studies (e.g., direct observation of exposed receptors) are sometimes needed in order to confirm if this is really the case.

Ohio Environmental Protection Agency

Interoffice Memo

To:	Paul Jayko, **NWDO-DERR**	Date: 25 May 2010
From:	Janusz Z. Byczkowski, DERR, CO	
Subject:	**"Internal Draft Baseline Human Health Risk Assessment", and "Internal Draft Screening Ecological Risk Assessment", Acid Area 1, Former Plum Brook Ordnance Works Sandusky, Ohio,** February 2010. Site: US NASA PLUM BROOK, TAYLOR & COLUMBUS Rds., SANDUSKY, OH 44870; ERIE Cnt.; OHID# 322-0552.	

The following comments and suggestions are regarding two documents: ***"Internal Draft Baseline Human Health Risk Assessment", and "Internal Draft Screening Ecological Risk Assessment", Acid Area 1, Former Plum Brook Ordnance Works Sandusky, Ohio,*** dated April 2010.

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If you have any questions or need further technical support, please give me a call at: 614-644-3070 or e-mail at jbyczkowski@epa.state.oh.us.

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www.epa.ohio.gov

DOCUMENT TITLE: Internal Drafts: "Baseline Human Health Risk Assessment", and "Screening Level Ecological Risk Assessment"

SITE: Acid Area 1, Former Plum Brook Ordnance Works Sandusky, Ohio 44870 **DOCUMENT/DATE:** April 2010

Ohio EPA – Division of Emergency and Remedial Response COMMENTS

REVIEWER: Dr. Janusz Z. Byczkowski, DERR, CO; Tel: 614-644-3070; e-mail: jbyczkowski@epa.state.oh.us.

Review/DATE: 05/25/2010

Comment Number	Sect. Page/ Line#	Cross Ref.	Comment	Recommendation	Response
1.	HHRA S. 1.0 P. 1-1 L# 14 S. 2.1.3 P. 2-3 L# 24 S. 8.0 P. 8-3 L# 25		If you have any questions or need further technical support, please give me a call at: 614-644-3070 or e-mail at jbyczkowski@epa.state.oh.us . This document states that: "*…It is consistent with U.S. Environmental Protection Agency (EPA) and Ohio EPA (OEPA) guidance…*" then it says: "*…RBSCs used in this BHHRA were derived from the U.S. EPA Region 3 RBC tables (U.S. EPA, 2004a)…*" but in References Section it lists: "*…U.S. EPA, 2004a, Region 9 Preliminary Remediation Goals…*" and provides the URL: " http://www.epa.gov/region09/waste/sfund/prg/files/prgtable.pdf " <u>Comment:</u> Text, tables, guidelines and references should be reconciled (*e.g.,* Region 3 *vs.* Region 9). In addition the URL, as written in the example above, does not work anymore. Please note, that according to OEPA-DERR (2009) guidance for toxicity based screen, either a current (as of December 2009) RSL table, or the archived 2004 Region 9 PRG table should be used instead of "*Region 3 RBC tables".*	This document requires quality reading/typo corrections. A few additional specific editorial corrections are recommended before finalizing these documents and releasing to the public: Please reconcile text, tables, references and Internet addresses (URLs). Please apply and refer to current OEPA-DERR guidelines available on Internet at: http://www.epa.ohio.gov/derr/rules/guidance.aspx.	The document will be reviewed for typos and corrections in text and tables. The internet address identified as incorrect will be revised per the comment. In Table 4-1, toxicity values listed as reference doses are based on noncancer endpoints. Toxicity values listed as cancer slope factors are based on cancer endpoints. The text will be revised to indicate that the current RSL tables were used for completion of the risk assessment. The text will be reviewed and revised for consistency throughout. Figure 3-1 has been revised for consistency

Comment Number	Sect. Page/ Line#	Cross Ref.	Comment	Recommendation	Response
			Moreover, despite the claim in the Section 2.1.3 that "*…the noncancer values listed in RBC tables were multiplied by a factor of 0.1 to provide additional protection…*", the values, listed in Table 2-1 as "*Toxicity Screening Level*", are not adjusted. In the Table 4-1, there is no indication which toxicity values are based on cancer and which on noncancer endpoints. While the Section 3.2.2 states that "*…The simple whole-house tap water-to-air model* […] *was used in BHHRA…*", the caption to Figure 3-1 says "*…Although theoretically complete, this pathway in* (sic!) *not quantified as explained in text…*" Also, despite the statement in Section 3.1.3.1 that "*…the BHHRA will qualitatively evaluate potential exposure to perched groundwater…*", there is no such an evaluation described in this document. There are multiple typos throughout this document that should be corrected (e.g., Table 5-1 "*rdnance*"). **Reference:** **OEPA-DERR (2009)** Use of U.S. EPA's Regional Screening Levels as Screening Values in Human Health Risk Assessments. 21 August 2009. On line: http://www.epa.ohio.gov/portals/30/rules/screening.pdf		

Comment Number	Sect. Page/ Line#	Cross Ref.	Comment	Recommendation	Response
2.	S. 2.1.5 P. 2-4 L# 10		This document states: "*…groundwater BSC is either the MDC or the calculated 95 percent upper tolerance limit of the background groundwater data set…*" and then: "*…Background screening was not used to eliminate COPCs…*" <u>Comment:</u> The use of "*MDC*" or the "*95 percent" UTL* as BSCs, is currently not recommended by OEPA-DERR for background screening. If background levels (BSCs) cannot be recalculated from the original data in accordance with OEPA-DERR (2009a) guidance, then either no chemicals detected in Acid Area 1 should be screened based on background level or a detailed explanation should be provided as to why OEPA-DERR (2009a) was not applied. The discussion provided in Section 6.0 does not explain deviation from U.S. EPA and/or OEPA-DERR methodology, and thus, it is insufficient. **Reference:** **OEPA-DERR (2009a)** Use of Background for Remedial Response Sites. 21 August 2009. On line: http://www.epa.ohio.gov/portals/30/rules/bground%20guidance.pdf	Please recalculate BSCs according to OEPA-DERR (2009a) guidance, or explain why the guidance was not used.	It is true, there is no recent background data taken specifically for 2BG. However, there is a metals background data set from 2001, from background locations as agreed upon by the PBOW Team, including USACE and OEPA, that would suffice as the background data set for all PBOW FUDS AOCs to be investigated, including Acid Area 1. During the development of the appropriate background statistic to compare to for PBOW FUDS AOCs, the PBOW Team reviewed many statistics, including arithmetic mean, median, UCLs and UTLs. The OEPA risk assessors Bonnie Buthker, Laurie Moore with the rest of the PBOW team deemed the 95% UTL or the maximum detected background metal concentration, which ever is less, as the appropriate statistic to use during background screening of AOCs' metals, and as documented in the May 2000 PBOW Team Meeting Minutes as consensus for using this method.

3.	SLERA ES P. ES-3 L# 21 also S. 6.0 P. 6-1 L# 22 and L# 28		This document states: "*…Estimated HQs for the terrestrial receptors […] are less than 10 indicating a low potential for adverse effect…*" and then: "*…Estimated HQs for the raccoon are less than 10 indicating a low potential for adverse effect…*" <u>Comment:</u> The OEPA goal for hazard quotient is ≤1. Therefore, HQ ≤ 10 is an order of magnitude above this goal, so it should not be described as "*a low potential*". The potential is ten times too high.	Please delete from these phrases the adjective "*low*".	The following text describing HQs and associated interpretation is provided in Section 5.3 of the SLERA. "The HQs were compared according 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 adverse ecological effects. HQs from 10 up to but less than 100 represent a significant potential that effects could result from greater exposure. HQs greater than 100 represent the highest potential for expected effects (Wentsel, et al., 1996). OEPA considers HQs greater than 1.0 to be potentially significant. It should also be noted that HQs are not measures of risk, are not population-based statistics, nor are they linearly scaled statistics. Accordingly, an HQ above 1, even exceedingly so, does not necessarily mean that there is even one individual expressing the toxicological effect associated with a given chemical to which it was exposed". No change was made to the text.

4.	S. 2.0 P. 2-1 L# 9		This document states: "*…The potential for adverse ecological effects to ecological receptors at the site is minimal or nonexistent due to the lack of potential chemical stressors…*" Comment: Since in ecological risk assessment, the goal of HQ ≤ 1.0 is based on concentration and it represents a threshold below which no significant adverse effect is expected, this is not necessarily the "*lack*" of a chemical stressor which determines "*minimal or nonexistent*" potential for adverse effect. Rather this is their low concentration, This null hypothesis should be rephrased.	Please substitute in this null hypothesis the word "*lack*" with "**low concentration**"	The change has been made as noted.
5.	S. 4.2 P. 4-1 L# 29 Table 4-1		This document states: "*…These factors were used together to derive a final adjusted TRV, also presented in Table 4-1…*" Comment: In the Table 4-1, two columns of values are listed: "*NOAEL*" and "*Body Wt.*" For those not familiar with the methodology, there is no way to understand which column actually represents "*final adjusted*" TRVs.	Please indicate (in the table head or footnote) which column represents **TRV**.	Table 4-1 presents all identified TRVs available in the literature. Appendix B presents the selected TRV used for the risk assessment. The text has been revised accordingly.
6.	S. 5.3 P. 5-2 and 5-3 Tables		The tables provide a column of numbers without explanation of their meaning or dimension.	Please add a table head that saying "**Hazard Quotients**"	Hazard Quotient has been added to the title block per the comment.