JE JACOBS

US Army Corps of Engineers

Prepared for:

Department of the Army
Nashville District, Corps of Engineers
Nashville, Tennessee

Final Screening Level Ecological Risk Assessment Acid Area 2

Former Plum Brook Ordnance Works
Sandusky, Ohio

Contract DACW62-03-D-0004-0004

February, 2008

Prepared by:

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COMPLETION OF INDEPENDENT TECHNICAL REVIEW

Jacobs Engineering Group, Inc. has completed the Final Screening Level Ecological Risk Assessment, Acid Area 2, 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.

[signature] Geologist/Environmental Scientist 2/15/08

(Signature) (Discipline) (Date)

Independent Technical Review Team Leader and Team Members

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[signature] Risk Assessment 2/15/08

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Jacobs SLERA Report Author

CERTIFICATION OF INDEPENDENT TECHNICAL REVIEW

Significant concerns and the explanation of the resolution are as follows (Describe the major technical concerns, possible impact, and resolution):

Comment: See Appendix D for responses to PBOW team member review comments on the draft report.

Comment: Ensure that comments addressing specific sections or text are applied to all other relevant sections/text within the document.

Comment: Ensure that comments received on the Draft Screening Level Ecological Risk Assessment, Acid Area 3 from Larry Tannenbaum, U.S. Army Center for Health Promotion and Preventative Medicine, Environmental Health Risk Assessment Program, are also applied to the Draft Screening Level Ecological Risk Assessment, Acid Area 2.

Comment:

Comment:

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

Al Hardesty (Signature) — 2/15/08 (Date)

(Project Manager)

Final
Screening Level Ecological Risk Assessment

Acid Area 2

Former Plum Brook Ordnance Works
Sandusky, Ohio

Prepared for:

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
NASHVILLE, TENNESSEE
CONTRACT DACW62-03-D-0004-0004

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amsl	above mean sea level
ARP	assessment receptor profile
BAF	bioaccumulation factor
BCF	bioconcentration factor
BSC	background screening concentration
BTAG	Biotechnical Assistance Group
CELRN	U.S. Army Corps of Engineers, Nashville District
COPEC	chemicals of potential ecological concern
DNAP	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
EPA	U.S. Environmental Protection Agency
EPC	exposure-point concentration
FCM	food chain multiplier
ft	foot/feet
FUDS	Formerly Used Defense Site
H_o	null hypotheses
HQ	hazard quotient
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-day	milligram per kilogram per day
msl	mean sea level
NASA	National Aeronautics and Space Administration
NOAEL	no observed adverse effect level
NWI	National Wetland Inventory

ODNR	Ohio Department of Natural Resources
OEPA	Ohio Environmental Protection Agency
OME	Ontario Ministry of the Environment and Energy
PAH	polycyclic aromatic hydrocarbon
PBOW	Plum Brook Ordnance Works
PCB	polychlorinated biphenyl
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
TRV	toxicity reference value
UCL	upper confidence limit
UCL_{95}	95 percent upper confidence limit
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
VOC	volatile organic compound
WQC	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 2, 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, 2007*), and* is consistent with U.S. Environmental Protection Agency (EPA) 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 2 is located in the northwestern portion of PBOW. Acid Area 2 is an open field with two drainage ditches running west to east. The remains of an old railroad grade with a few railroad ties and loose track are still evident at the site. Former building foundations can be observed on the north side of the site. Acid Area 2 covers approximately 25 acres. The majority of the site is currently covered with tall grass and frequent low shrubs. Small wooded areas have developed throughout the site and tend to be thickest in the western portion. The areas outside of the site boundary are heavily wooded. There are no designated wetlands at Acid Area 2.

Ecological surveys were performed in the Spring and Fall of 2006. The predominant community types observed at Acid Area 2 were Upland Old Fields, Shrub Thickets, Successional Woods, and Lowland Woods. During the ecological survey, Acid Area 2 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 2.

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 streams within and adjacent to the area are intermittent.

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 2. 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 2 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 the Acid Area 2 are stated as "the protection of long-term survival and reproductive capabilities for terrestrial invertebrates, herbivorous mammals, omnivorous mammals, insectivorous mammals and birds, carnivorous birds, benthic invertebrates, omnivorous aquatic mammals, and omnivorous aquatic birds." The corresponding null hypothesis (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 surface water and sediment quality criteria for the protection of aquatic life to surface water and 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.

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 elevated hazards from exposure to PCB-1260, 2,4 dinitrotoluene, aluminum, and lead in soil, based on no observed adverse effect level- (NOAEL) based HQ approaches. Estimated hazards are above 1,000 for some receptors using the NOEL-based approach. However, the estimated HQs that are above 1,000 using the NOAEL-based approach are considered unrealistic and toxicologically impossible.

Potential surface water COPEC impacts to aquatic biota are greatest for aluminum, barium, bis(2 ethylhexyl)phthalate, copper, iron, and manganese. Aquatic receptors are predicted to have potentially elevated hazards from exposure to PCB-1260, lead, thallium, aluminum, and chromium in sediment, based on NOAEL-based HQ approaches. Potential hazards are estimated to be above 100 for the mallard using the NOAEL-based approach. However, given the limited aquatic habitat at the site, the potential for adverse impacts to aquatic biota may be negligible.

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.

Based on 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 solely to address ecological concerns do not appear to be warranted at this time. However, additional study may be warranted to evaluate the uncertainties associated with this SLERA. Although HQs are estimated to be above 100 for the mallard using the NOAEL-based approach, neither remedial action nor further study appear to be warranted for surface water and sediment at the site based on uncertainties associated with estimating COPEC concentrations in aquatic insects and the limited amount and poor quality of aquatic habitat available to support waterfowl.

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 2 to reduce the uncertainty associated with ecological risk estimates.

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 2, 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-0004, Delivery Order #4. 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.

This SLERA was prepared in accordance with the *Baseline Human Health Risk Assessment and Ecological Risk Assessment Work Plans* (Jacobs, 2007*), and* is consistent with U.S. Environmental Protection Agency (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 (including both fish and aquatic macroinvertebrates), 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 streams within and adjacent to the area are intermittent.

Concentrations of chemicals measured in relevant environmental media including soil, surface water, and sediment (Jacobs, 2006) were used to develop the 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 are 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 lack 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, 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.

Across PBOW, the land slopes gently to the north-northeast towards Lake Erie. Elevations range from 675 feet (ft) above mean sea level (amsl) at the southwest edge of the site to 625 ft msl in the northern portion of the property at Bogart Road, resulting in an average slope of approximately 0.3 percent. The Lake Plains region is over 69 percent cropland, 2.7 percent pasture land, and 10.5 percent forest (Ohio Department of Natural Resources [ODNR], 1985). However, since the 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.

Acid Area 2 is located in the northwestern portion of PBOW, south of Patrol Road and west of Campbell Street (Figure 1-2). The Acid Area 2 site is an open field with two drainage ditches running west to east: one on the northern perimeter of the site, and one on the southern perimeter of the site. A storm sewer system was constructed at the site, as evidenced by existing drainage grates, manhole covers, and open holes with brick lining. The remains of an old railroad grade with a few railroad ties and loose track are still evident at the site. Former building foundations can be observed on the north side of the site. A paved service road completes a loop around the perimeter of the site. Acid Area 2 covers approximately 25 acres. The ground surface is relatively flat with minimal slope toward the east and southeast. Elevations at the site range from 639.6 ft amsl near the southeastern portion of the site to 643.8 ft amsl in the western portion. The majority of the site is currently covered with tall grass and frequent low shrubs. Small wooded areas have developed throughout the site and tend to be thickest in the western portion. The areas outside of the site boundary are heavily wooded.

Ecological surveys were performed by Jacobs ecologists and their subcontractor in the Spring and Fall of 2006. 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. Jacobs personnel completed a checklist similar to EPA's checklist for ecological assessment/sampling (EPA, 1997). The information from the checklist was used to complete Section 2 of this report. 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 personnel also used the reconnaissance to evaluate the site for more subtle indications of potential effects from contaminant release.

2.1.2 Surface Water

There are two minor surface water features consisting of drainage ditches on the northern and southern side of the site. Both drainage ditches are shallow and intermittent in nature. Given the nature of the northern surface water drainage, which is poorly defined, shallow and intermittent flow it is likely to support low trophic level aquatic organisms only. The southern surface water drainage feature is larger more well defined, but it is also shallow and intermittent. This drainage will support aquatic organisms and possibly waterfowl during migration in the early Spring when water is present. It is not likely that the either drainage feature supports significant populations of forage fish due to their shallow depths and intermittent nature.

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 2 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, the process used by the USFWS in preparing NWI maps. As discussed in the following section, small wetland areas exist at the site.

2.1.4 Vegetative Communities

The predominant community types observed at Acid Area 2 are Upland Old Fields, Shrub Thickets, Successional Woods, and Lowland 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 2. *Cornus racemosa* (gray dogwood) dominates most of these areas. *Eleagnus umbellata* (autumn olive) is common. Small trees and saplings also are present 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 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.

Lowland Woods. Wetlands at Acid Area 2 are restricted to small swales. *Populus deltoides* (cottonwood) is most common in these areas. *Carex* spp. (sedges) and *Glyceria striata* (fowl manna grass) also are present in some areas.

Each of these habitat types can be expected to support different wildlife species; however, given the close proximity of the habitats to each other, many of the species (discussed in Section 2.1.5) would be expected to spend some amount of time within each community type for foraging, resting, and loafing activities, depending on the season.

During the ecological survey, Acid Area 2 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 at Acid Area 2. A few locations were devoid of vegetation, however, these locations were in disturbed areas where trenches were installed and backfilled during soil sampling. Potential adverse impacts of chemical stressors on plant growth are discussed further in Section 5.1. 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.

2.1.5 Species Inventory

Based on information from ODNR (1995) and information collected during the site reconnaissance, 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, 131 of the common plant species frequently observed at Acid Area 2 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 survey (Table 2-1). Numerous deer tracks were also observed during the site reconnaissance. Other mammals observed included the eastern fox squirrel 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. Seventeen bird species were documented at Acid Area 2 during the ecological survey 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, suggesting that ground nesting birds are being stressed at the facility.

The large deer population that feeds on much of the ground cover at the former PBOW limits the cover available for nesting birds and results in increased predation for these species (ODNR, 1995). Current burning practices used by NASA limit ground cover over the eastern portion of PBOW. However, burning is not conducted in the western portion of the installation where Acid Area 2 is located or near buildings, and there is at least one building located at Acid Area 2. Burning has not been conducted in the Acid Area 2 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 2, 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 survey with the exception of the 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 percent) have been observed at the former PBOW, including turtles and snakes (ODNR, 1995). During the ecological survey, no reptiles were observed at Acid Area 2.

Of the 10 species of amphibians that may be found in the region based on species range maps, nine species (90 percent) have been observed at the former PBOW (ODNR, 1995), including salamanders, toads, and frogs. No amphibians were observed at Acid Area 2 during the ecological survey.

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 2 given the limited surface water habitat.

In addition to the wildlife discussed above, additional species observed during site reconnaissance 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 2.

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, and threatened or endangered birds 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 2 (Peecook, 1998).

Based on the ecological survey conducted by Jacobs, no threatened or endangered species were found in Acid Area 2.

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 6 ft was considered. The 0 to 6 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 data base by including samples collected from a depth interval of 4 to 6 ft; although the shrew may not actually burrow to a depth of 6 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 (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 EPA Method 8330 for nitroaromatics as well as EPA Method 8270B for semivolatile organic compounds (SVOCs). EPA Method 8330 provides concentration values for total DNT, but does not provide isomer-specific data. 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. When multiple analytical results were available for an analyte from more than one method, then the value for the method considered more sensitive to that specific analyte was used in lieu of the value from the less sensitive 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 COPEC, 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) on the mean are usually estimated for each COPEC in each medium of interest. The upper 95 percent confidence limit on the mean is generally referred to as the UCL_{95}.

The EPA statistical software package ProUCL Version 3 was used to compute estimated mean and UCL_{95} concentrations for all data sets containing fewer than 15 percent nondetects. ProUCL Version 3 is inappropriate for data sets containing more than 15 percent nondetects.

For data sets with 15% or more nondetects, a combination of the following procedures was used:

- Most statistical computations were made using a FoxPro based statistical package developed by Jacobs and based on a large number of published guidance manuals.
- Kaplan-Meier computations were confirmed using Minitab Version 14 (commercial statistical software from Minitab Inc.).

Data sets consisting of 5 or more data points were tested for normality and lognormality with the Shapiro-Wilk test. Statistical analysis was performed only on those chemicals identified as COPECs. The UCL_{95} was calculated for a normal distribution as follows (EPA, 1992a):

$$UCL_{95} = \bar{x} + t_{1-a,n-1}\left(\frac{s}{\sqrt{n}}\right) \quad \textbf{Eq. 2.1}$$

where:

UCL_{95} = upper 95th confidence limit on the arithmetic mean concentration (calculated)

$\bar{x}$ = sample arithmetic mean

t_1 = critical value for Student's *t*-test

α= 0.05 (95 percent confidence limit for a one-tailed test)

n = number of samples in the data set

s = sample standard deviation.

The UCL_{95} was calculated for a lognormal distribution as follows (Gilbert, 1987):

$$UCL_{95} = e^{\left(\overline{Y} + 0.5 s_y^2 + \left[H_{0.95} \frac{s_y}{(n-1)^{0.5}} \right]\right)} \quad \textbf{Eq. 2.2}$$

where:

UCL_{95} = 95 percent upper confidence limit on the arithmetic mean (calculated)

$\overline{Y}$ = Σy/n = sample arithmetic mean of the log-transformed data,

s_y = ln x = sample standard deviation of the log-transformed data

n = number of samples in the data set

$H_{0.95}$ = value for computing the one-sided upper 95 percent confidence limit on a lognormal mean from standard statistical tables.

If the data distribution was nonparametric, the UCL_{95} was estimated using three different methods: Kaplan-Meier (Kaplan and Meier, 1958), simple bootstrap with replacement (Helsel, 2005), and rank order based on the binomial distribution.

The Kaplan-Meier method for UCL_{95} calculation has been used for many years in the medical industry and in manufacturing to estimate summary statistics for censored data sets (data sets with nondetect results). The Kaplan-Meier method estimates the survival probability function for the evaluated data set. The survival function is the probability that any given data value will exceed any specific quantile of the data set. The UCL_{95} is computed by integrating the area under the stair-step survival function curve.

The simple bootstrap UCL_{95} is computed by resampling the data set with replacement a large number of times, computing the mean of each resampling, and computing the UCL_{95} from these computed means using the Students-t approach.

The UCL_{95} rank order on the arithmetic mean of the data set was estimated by ranking the data observations from smallest to largest. The arithmetic mean was converted to a percentile by interpolation. The rank order of the data point selected as the UCL_{95} was estimated from the following equation (Gilbert, 1987):

$$u = p(n+1) + Z_{1-\alpha}\sqrt{np(1-p)} \quad \textbf{Eq. 2.3}$$

where:

u = rank order of value selected as UCL_{95}, calculated

p = percentile corresponding to the arithmetic mean

n = number of samples in the data set

α= confidence limit (95 percent)

$Z_{1-\alpha}$ = normal deviate variable.

Analytical data from field duplicates were averaged with original sample results to yield one result for use in the statistical manipulations.

Generally, the detection limit is the lowest concentration of a chemical that can be "seen" above the normal, random noise of an analytical instrument or method. Analytical results are presented as nondetects ("U" qualifier) whenever chemical concentrations in samples do not exceed the reporting limits for the analytical procedures for those samples. To apply the statistical procedures described above, a concentration value must be assigned to nondetects. Generally, nondetects were assumed to be present at one-half the reporting limit (EPA, 1989). However, professional judgment was used in those cases where the detection limit was unusually high.

The UCL_{95} or maximum detected concentration (MDC), whichever was smaller, was selected as the EPC and is understood to represent a conservative estimate of average for use in the 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 percent 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.

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 for lognormal data sets or the 95^{th} 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 volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs), a class of organic compounds that form from natural or anthropogenic combustion of organic matter including fossil fuels, that 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 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 EPA Region 5 Biotechnical Assistance Group (BTAG) Bulletin No. 1 (EPA, 1996a). Chemicals that exceeded the RBSEVs, or for which no RBSEV are 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)(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 (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 (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 2 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 Remedial Investigation (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 bounding Acid Area 2: 15 from the southern drainage ditch and 8 from the northern drainage ditch.

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

- Chemical name,
- Frequency of detection,
- Range of detected concentrations,
- Range of detection limits,
- Arithmetic mean of site concentrations,
- 95th percent UCL on the arithmetic mean,
- Appropriate RBSEV,
- Appropriate BSC, and
- Selection/exclusion of chemical as a COPEC.

Surface Soil. A total of 28 surface soil samples have been collected at Acid Area 2, which includes 15 samples collected during the 1998 Site Investigation (SI) and 13 samples collected during the RI. Contaminants detected include VOCs, nitroaromatics, SVOCs, polychlorinated biphenyls (PCBs), and metals. Specific compounds exceeding the surface soil RBSEVs are identified in Table 2-2.

Subsurface Soil. A total of 35 subsurface soil samples have been collected from 28 locations at Acid Area 2, which includes 15 samples from 15 locations during the 1998 SI and 20 samples from 13 locations during the RI. Sample depths for the 1998 SI ranged from 2 to 10 ft bgs. Depths for the samples were limited to the 3 to 5 ft interval and the 8 to 10 ft interval. Contaminants detected include VOCs, SVOCs, PCBs, and metals. Specific compounds exceeding the RBSEV are identified in Table 2-2.

Surface Water. Contaminants detected in surface water at Acid Area 2 include SVOCs, PAHs, and metals. Specific compounds exceeding the RBSEV for surface water are identified in Table 2-2.

Results for the arsenic, vanadium, and trichloroethene exceedances were J-flagged because the detections were between the reporting limit and the detection limit, indicating that the detections are estimated and the associated numerical values are the approximate concentrations of the respective analytes in the samples. Besides the J-flagged results, trichloroethene was not otherwise detected in surface water samples. The bis(2-ethylhexyl)phthalate concentration exceeding the RBSEV was both J-flagged and was detected in the associated trip blank, and is recognized as a common laboratory artifact.

Sediment. Contaminants detected in sediment at Acid Area 2 include VOCs, SVOCs, PAHs, nitroaromatics, PCBs, and metals. Specific compounds exceeding the RBSEV and retained as COPECs in sediments 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. In order to focus the exposure characterization portion of the SLERA on species or components that are the most likely to be affected given the toxicological and mobility characteristics of the COPECs, and on those COPECs that are most likely to produce greater effects in the on-site ecosystem, the selection process focused on species, groups of species, or functional groups, rather than higher organization levels such as communities or ecosystems. 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 (Section 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 2 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 7 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 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 (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 and 0.01, 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 B).

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 of aquatic organisms within the water bodies and/or wetlands was assumed to occur via direct contact with contaminants in the water column and by 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 (*Anas platyrhynchos*; medium-sized aquatic omnivore).

Aquatic organisms provide some of the prey base for aquatic receptors, represented by the mallard and raccoon. An aquatic 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 2 and 6 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). 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) is available in the literature for comparative and interpretive purposes. In addition, both of the selected species would be 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 (EPA, 1993).

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

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 and the National Environmental Policy Act. Other legislation includes the Endangered Species Act 16 U.S.C. 1531-1544 (1993, as amended) and the Migratory Bird Treaty Act 16 U.S .C. 703-711 (1993, as amended). 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 the Acid Area 2 are stated as "the protection of long-term survival and reproductive capabilities for terrestrial invertebrates, herbivorous mammals, omnivorous mammals, insectivorous mammals and birds, carnivorous birds, benthic invertebrates, omnivorous aquatic mammals, and omnivorous aquatic birds." The corresponding 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 2. 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 conceptual site models 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 invertebrates were used to represent the bottom of the food chain. For terrestrial invertebrates and plants, partitioning coefficients and simple empirical uptake models were employed to estimate COPEC concentrations within tissues (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 B.

All trophic levels may be exposed to COPECs, either by direct exposure to contaminated abiotic media or through ingestion of lower trophic level food items. Primary producers (plants) absorb COPECs as well as nutrients from soil and/or water. Through abiotic processes, COPECs can adsorb to the sediment and detritus particles. When these particles settle and become part of the benthic substrate, they may also become a source of COPECs to benthic communities. Various species of aquatic biota fulfill the role of aquatic herbivorous (feeding on aquatic plants and suspended detritus) and predatory invertebrates (feeding on benthic invertebrate species). The combination of COPEC bioconcentration from water, ingestion of contaminated prey, and generally restricted ranges for aquatic organisms provides ideal conditions for significant bioconcentration of COPECs. For this reason, the mallard was included in the aquatic food web as a top trophic-level omnivore capable of bioaccumulating COPECs. 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 (EPA, 1997).

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 ecological conceptual site models (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 2 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 EPA (1997) 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 surface water, 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. 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:

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

where:

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

C_k = the average COPEC concentration in the k^{th} food type (mg/kg dry weight)

F_k = the fraction of the k^{th} food type that is contaminated

I_k = the ingestion rate of the k^{th} food type (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 (BAFs). Where 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 EPA (1995) were used to assess the possibility of contaminant magnification through site receptors. The FCMs were 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 (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. 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 (EPA, 1996b) as follows:

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

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 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 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. 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 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 EPA (1999b) or based on log K_{ow} relationships developed by Connell and Markwell (1990). Inorganic constituent BAFs were obtained from 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 (e.g., the raccoons' use of surface water in foraging activities).

Tissue concentrations in vertebrate prey species were estimated from the daily intake of the COPECs through the use of transfer factors obtained from 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 storm-water 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 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. 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 *Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities* (EPA, 1999b), *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 LD50 values from data bases 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 EPA (1999b).

4.2 Selection of Toxicity Reference Values

The primary source of TRVs for this SLERA was EPA (1999b). 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) was 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 C, with maximum tolerance levels presented for several essential nutrients.

The equilibrium partitioning approach has been used by the 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 surface water and sediment quality criteria for the protection of aquatic life to surface water and 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

To assess the potential impact of COPEC concentrations in surface soil on terrestrial plant species, the EPCs from Acid Area 2 were compared with available benchmark concentrations developed for the protection of terrestrial plants. 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, based on site reconnaissance performed, no signs of vegetative stress were noted (Section 2.1.4).

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 2 were compared with available benchmark concentrations developed for the protection of aquatic life. As shown in Table 2-2, surface water COPEC concentrations for aluminum, barium, bis(2-ethylhexyl)phthalate, copper, iron, and manganese exceeded the available benchmark for the protection of aquatic life. Lead was retained as a COPEC because there was no benchmark for comparison.

As shown in Table 2-2, 43 constituents were retained as COPECs for sediment, of these, 24 had concentrations exceeding the benchmark. The remaining constituents were retained because benchmarks were not available for comparison. Low frequency of detection for organic compounds reported in sediment samples collected at Acid Area 2 resulted in the maximum measured concentration being used as the EPC (Table 2-2). It is important to note that aquatic habitat is limited at Acid Area 2, and is not a major habitat type.

5.3 Predictive Risk Estimation for Terrestrial and Aquatic Wildlife

Estimates of potential for risks associated with exposure to Acid Area 2 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, or 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 (Tannenbaum, 2001; Bartell, 1996).

Conservative NOAEL-based HQs of ten or greater for terrestrial receptors at Acid Area 2 were:

- Deer mouse
  - PCB-1260: HQ = 4E+05
  - 2,4-dinitrotoluene: HQ = 2E+02
  - Aluminum: HQ = 6E+02
  - Lead: HQ = 3E+01
  - PCB-1254: HQ = 3E+01

- Short-tailed shrew
  - PCB-1260: HQ = 3E+05
  - Aluminum: HQ = 2E+02
  - PCB-1254: HQ = 4E+01
  - 2,4-dinitrotoluene: HQ = 1E+01

- Marsh wren
  - PCB-1260: HQ = 2E+05
  - Aluminum: HQ = 1E+02
  - PCB-1254: HQ = 3E+01

- Raccoon
  - PCB-1254: HQ = 1E+05
  - Aluminum: HQ = 4E+03
  - PCB-1260: HQ = 4E+03
  - Lead: HQ = 5E+02
  - Thallium: HQ = 9E+02
  - Benzo(a)anthracene: HQ = 4E+01
  - Benzo(a)pyrene: HQ = 3E+01
  - Chrysene: HQ = 4E+01

- Eastern cottontail
  - PCB-1260: HQ = 2E+05
  - Aluminum: HQ = 4E+02
  - 2,4-dinitrotoluene: HQ = 1E+02
  - Lead: HQ = 2E+01
  - PCB-1254: HQ = 1E+01

- White-tailed deer
  - PCB-1260: HQ = 1E+03

- Red-tailed hawk
  - PCB-1260: HQ = 2E+03

COPECs from soil, rather than surface water, were risk drivers for all of the evaluated terrestrial receptors. Important routes of exposure were invertebrate and plant intake. Only terrestrial hazards were estimated for the raccoon because of the limited extent of aquatic habitat at the site.

Conservative NOAEL-based HQs of ten or greater for aquatic receptors at Acid Area 2 were:

- Mallard duck
    - PCB-1260: HQ = 7E+02
    - Lead: HQ = 1E+02
    - Thallium: HQ = 8E+01
    - Aluminum: HQ = 3E+01
    - Chromium: HQ = 3E+01

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 was 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. Since assessment criteria were developed based on conservative assumptions, the results of the screening and predictive assessments are on the side of conservatism. This has the effect of maximizing the likelihood of accepting a false positive (Type I error: the rejection of a true Ho) and simultaneously minimizing the likelihood of accepting a true negative (Type II error: the acceptance of a false Ho).

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 (but 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 brief site reconnaissance.

The uncertainty analysis lists some 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 (EPA, 1992b). 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. Assuming that COPECs are 100 percent bioavailable likely overestimates the potential for adverse effects. The duration since the contaminant release affects bioavailability as the contaminant becomes 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 that that experienced in the wild by the receptors.

Use of the HQ method to estimate risks to populations or communities. Many of the HQs presented in this SLERA are unrealistically high and toxicologically impossible. Estimated HQs greater than 1000 should be considered suspect.

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 2, 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. Furthermore, the sampling appears to be sufficient to show that the contamination is largely limited to the soil, with the exception of PCB-1260 in two sediment samples at Acid Area 2. Specifically, the data show that surface water is not a medium of concern. There appears to be little uncertainty regarding the media affected by chemical releases at Acid Area 2.

Two sediment samples (AA2-SWSD-19 and AA2-SWSD-20) at Acid Area 2 had elevated concentrations of PCB-1260 at 15,000 and 18,000 ug/kg, respectively, approximately 5 times higher than the next highest detection. The sample locations are upgradient (AA2-SWSD-19) and downgradient (AA2-SWSD-20) of the former process building 706. No explanation is immediately apparent for the high concentrations of PCB-1260. Its occurrence may be a result of the composition of the sediment (i.e., sediment composed of fine-grained particles or with a high organic carbon content will act as traps for organic compounds). However, the concentrations of PAHs in these samples do not appear to be similarly elevated.

The sampling and analytical data are sufficient to identify PCB-1254 as the major contaminant in soil. Metals and PAHs were also identified. PCB-1254 was consistently detected in samples collected from 0.5 to 1.5 ft bgs, but not in samples collected from 0 to 1 ft bgs. Analyses were not performed for pesticides and herbicides, or for dioxins/dibenzofurans. Pesticides and herbicides may have been used to control insects and to discourage overgrowth of weeds. These classes of compounds, however, are commonly identified in agricultural and formerly agricultural areas, and lack of analysis for these chemicals is not considered to impart significant uncertainty to the assessment. Dioxins/dibenzofurans are commonly associated with incineration, but their formation generally requires a source of chlorine such as chlorinated solvents. There is no record or other reason to believe that chlorinated organics were present when the former buildings were demolished and burned; therefore, lack of analysis for the dioxins/dibenzofurans is not viewed as a significant source of uncertainty.

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 not performed for this SLERA. The MDCs for arsenic and iron in surface soil and aluminum, arsenic, iron, and manganese in subsurface soil were lower than their respective background criteria. The MDC for aluminum exceeded its background criterion, which was based on the maximum concentration detected in background samples. The EPC for aluminum was well below its background criterion. Detected concentrations of thallium in surface and subsurface soil exceeded its background criterion. Concentrations of lead detected in surface and subsurface soil, and sediment were 150-, 14-, and 30-times greater than background.

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:

   - Surface Soil
     - 2,4-dinitrotoluene: Indeterminate confidence – 93% nondetects
     - Aluminum: High confidence – non nondetects, good fit to gamma distribution

- Benzo(a)anthracene: Moderate confidence – non-parametric, 50% nondetects
- Benzo(a)pyrene: Indeterminate confidence – non-parametric, 50% nondetects, computed UCL only slightly higher than some nondetect detection limits
- Chrysene: Indeterminate confidence – non-parametric, 50% nondetects, UCL calculations unstable
- Lead: High confidence – no nondetects (ProUCL – 99% Chebyshev (mean, sd))
- Naphthalene: Indeterminate confidence – non-parametric, elevated detection limits, 86% nondetetcts
- PCB-1254: Indeterminate confidence – elevated detection limits for nondetects, 61% nondetects
- PCB-1260: Moderate confidence – non-parametric, 25% nondetects
- Thallium: Indeterminate confidence – elevated detection limits for nondetects, 57% nondetects

- Sediment
  - 2,4-dinitrotoluene: Indeterminate confidence – elevated detection limits for nondetects, 83% nondetects
  - Aluminum: High confidence – no nondetects, (ProUCL – normal distribution)
  - Lead: Moderate confidence – parametric UCL is approximately twice the non-parametric UCL, however both exceed the screening criteria by significant amounts (ProUCL – 99% Chebyshev [mean,sd])
  - Mercury: High confidence – no non-detects, non-parametric (Kaplan-Meier)
  - Thallium: Indeterminate confidence – non-parametric, 87% nondetects, UCL calculations unstable
  - PCB-1254: Indeterminate confidence – 96% nondetects
  - PCB-1260: High confidence – 4% nondetects, (ProUCL – 95% Chebyshev [MVUE])
  - Benzo(a)anthracene: Moderate confidence – non-parametric, 17% nondetects (Kaplan-Meier)
  - Benzo(a)pyrene: Indeterminate confidence – non-parametric, 39% nondetects, UCL calculations unstable
  - Chrysene: Indeterminate confidence – non-parametric, 17% nondetects, UCL calculations unstable
- Surface Water
  - 2,4-dinitrotoluene: Not computed – no detections
  - Aluminum: Moderate confidence – non-parametric, 43% nondetects, (Kaplan-Meier)
  - Benzo(a)anthracene: Not computed – no detections
  - Benzo(a)pyrene: Not computed – no detections
  - Chrysene: Not computed – no detections
  - Lead: Low confidence – non-parametric, 87% nondetects, (Kaplan-Meier)

- Mercury: Not computed – no detections
- PCB-1254: Not computed – no detections
- PCB-1260: Not computed – no detections
- Thallium: Not computed – no detections

3. 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.

4. 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 EPA guidance (1992a), 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 surface water and sediment were used as source-term concentrations due to the limited number of samples; an additional sampling effort could potentially reduce the hazard estimate. Also, there are significant uncertainties associated with estimating COPEC concentrations in macroinvertebrates.

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 2 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 elevated hazards from exposure to PCB-1260, 2,4-dinitrotoluene, aluminum, and lead in soil, based on NOAEL-based HQ approaches (Section 5.3). Estimated hazards are above 1,000 for some receptors using the NOEL-based approach. However, the estimated HQs that are above 1,000 using the NOAEL-based approach are considered unrealistic and toxicologically impossible.

Potential surface water COPEC impacts to aquatic biota are greatest for aluminum, barium, bis(2-ethylhexyl)phthalate, copper, iron, and manganese (Section 5.2). Aquatic receptors are predicted to have potentially elevated hazards from exposure to PCB-1260, lead, thallium, aluminum, and chromium in sediment, based on NOAEL-based HQ approaches (Section 5.3). Potential hazards are estimated to be above 100 for the mallard using the NOAEL-based approach. However, given the limited aquatic habitat at the site, the potential for adverse impacts to aquatic biota may be negligible.

Based on 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 solely to address ecological concerns do not appear to be warranted at this time. However, additional study may be warranted to evaluate the uncertainties associated with this SLERA. Although HQs are estimated to be above 100 for the mallard using the NOAEL-based approach, neither remedial action nor further study appear to be warranted for surface water and sediment at the site based on uncertainties associated with estimating COPEC concentrations in aquatic insects and the limited amount and poor quality of aquatic habitat available to support waterfowl.

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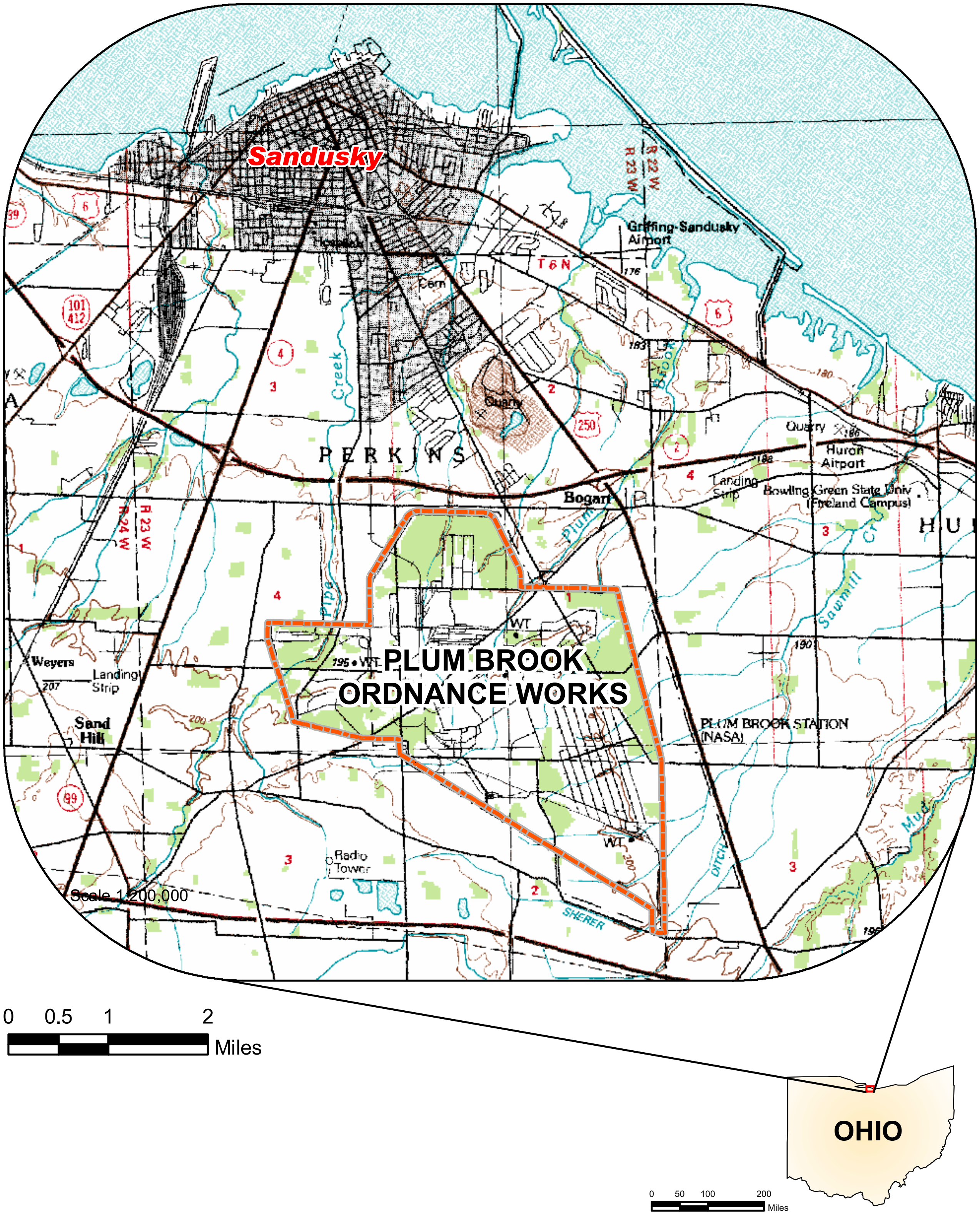


Legend

Plum Brook Ordnance Works Boundary

N

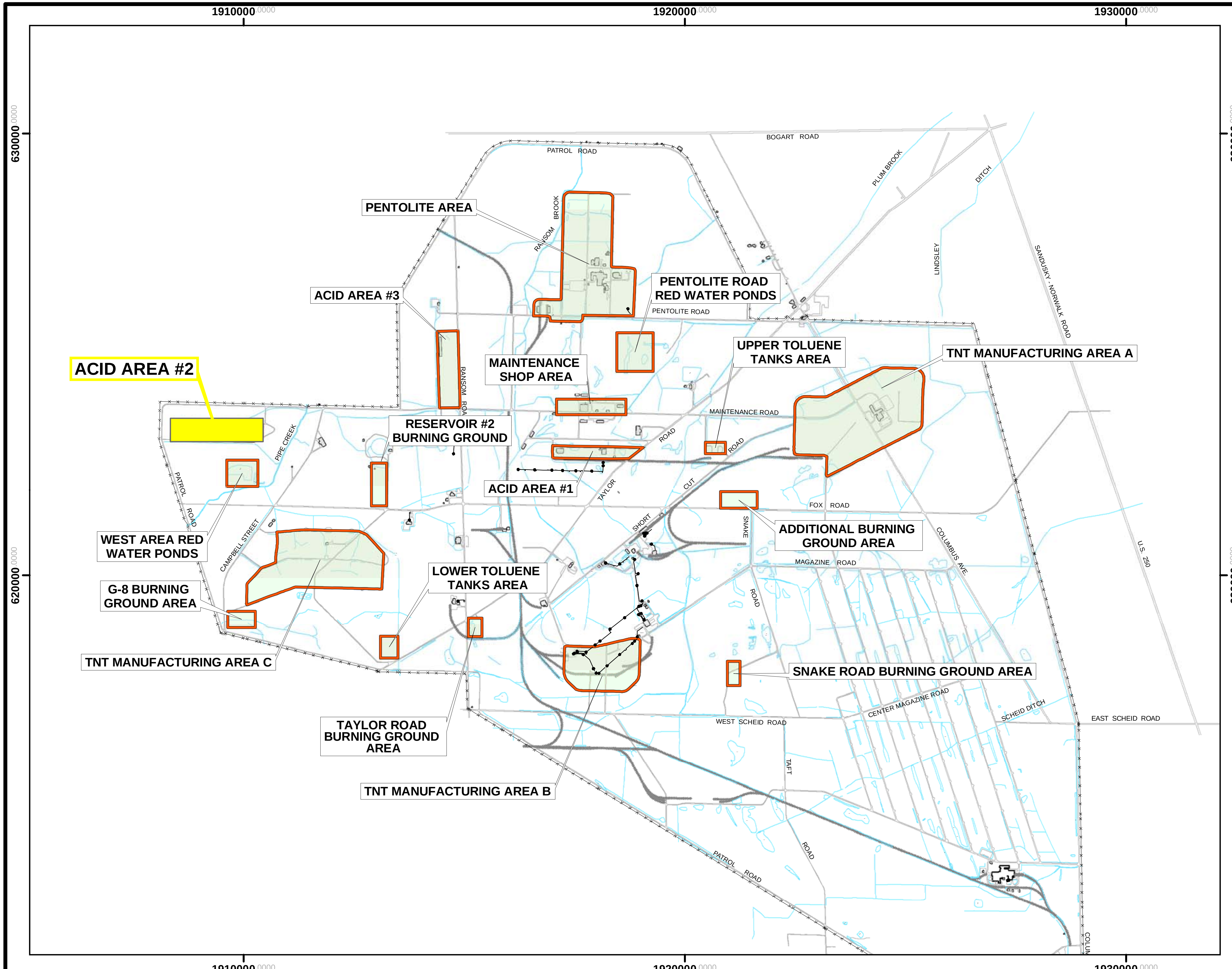
JACOBS

Location Map,
Plum Brook Ordnance Works
Sandusky, Ohio

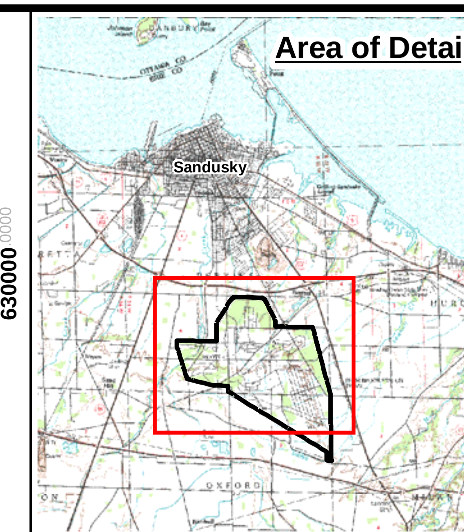
Plumbrook Ordnance Works
Sandusky, Ohio

08/04/06 NZ D:/GIS/Plumbrook/Projects/
Final_AA2_3_RI/ArcGIS/PBOW_Site_Location.mxd

Figure 1-1



Area of Detail



Legend

Area of Concern

Creek, Ditch, Conveyance

N

0 2,000 4,000 Feet

Sources

Data mapped to Ohio State Plane North NAD83, map grid units in feet.

JACOBS

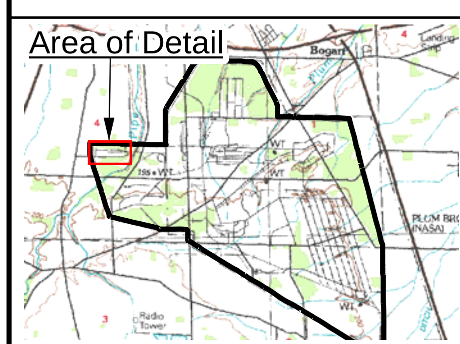
Location Map, Acid Area 2

Plum Brook Ordnance Works
Sandusky, Ohio

07/19/07 JD S:/GIS/Projects/Plumbrook/Projects/Final_AA2_3_RI/ArcGIS/Acid_Area2_LocMap.mxd

Figure 1-2

Area of Detail



Legend

- Upland Old Fields
- Shrub Thickets
- Successional Woods
- Lowland Woods

0 50 100 200
Feet

N

Notes: *Aerial Photography from 2005.*
Data mapped to Ohio State Plane North NAD83, map units are feet.

Habitat Map
Acid Area 2
Plum Brook Ordnance Works
Sandusky, Ohio

09/20/07 JKD S:/GIS/Projects/Plumbrook/Projects/ Screening Level Ecological Risk Assessment/ArcGIS/ AA2_Habitat_Map.mxd

JACOBS

Figure 2-1

Figure 2-2

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

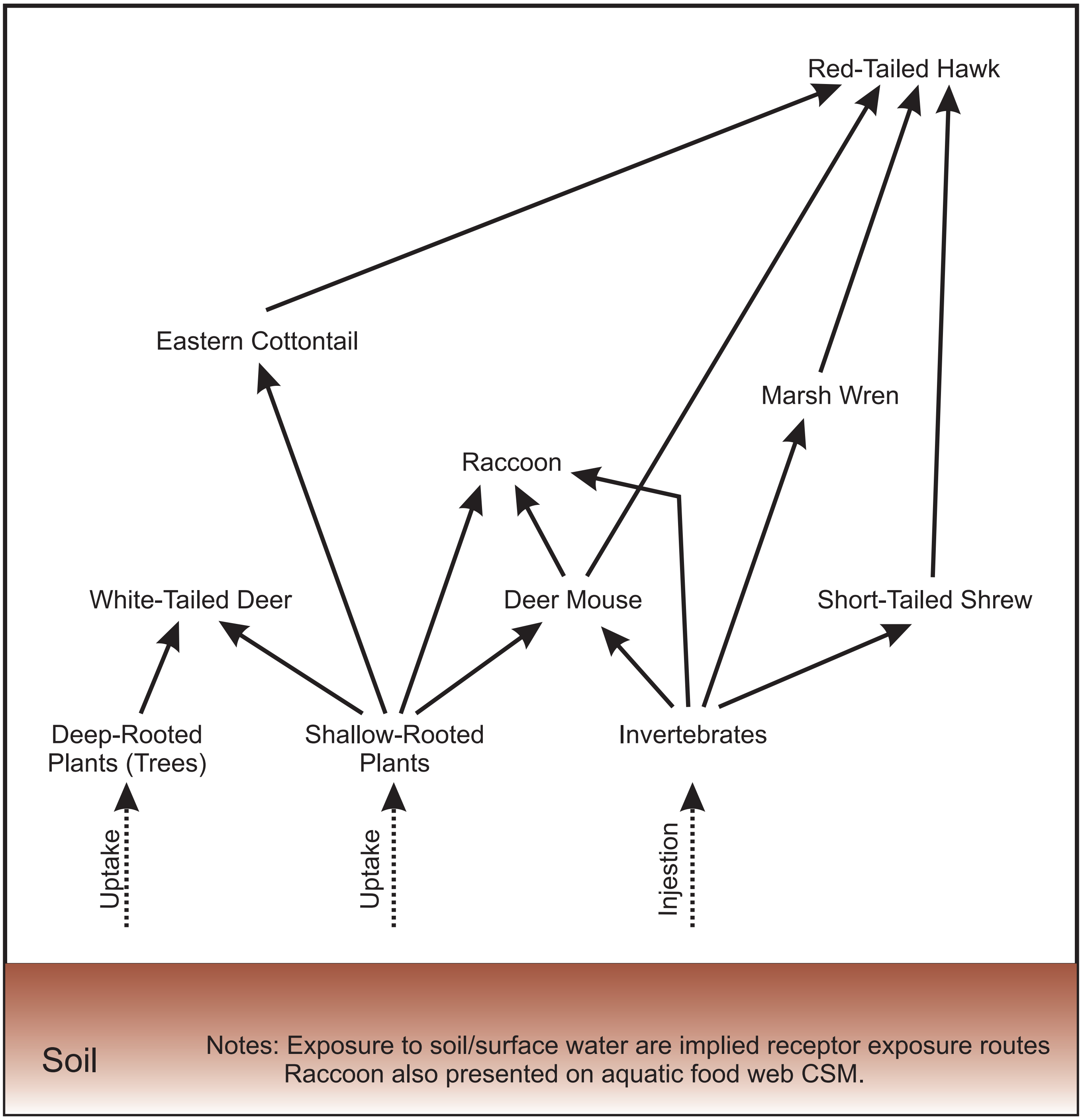
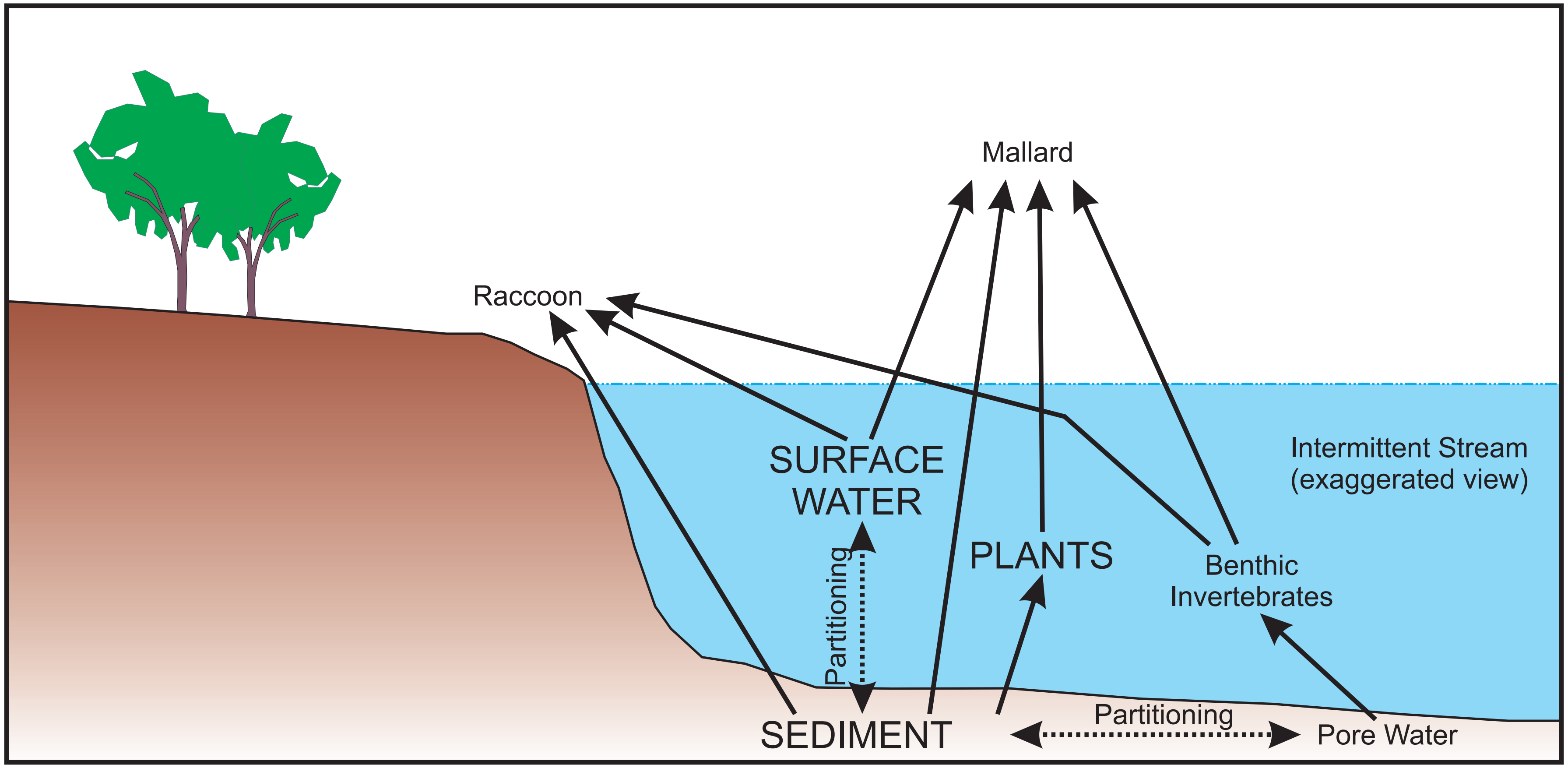
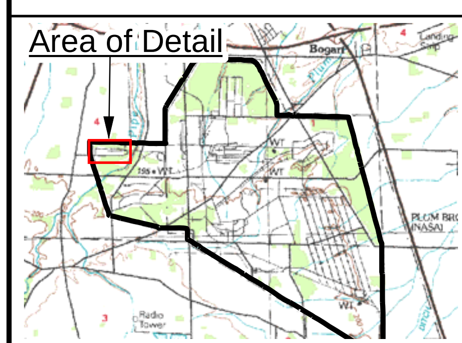


Figure 2-3

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



Notes: Raccoon also presented on terrestrial food web CSM.



Legend

- Storage Tank Areas from Engineering Drawings
- Creek, Ditch, Conveyance
- Buildings
- Railway
- 1998 SI Soil Borings
- 2004 Soil Borings (1 surface sample and 2 subsurface samples)
- 2004 Soil Borings (1 surface sample and 1 subsurface sample)
- Monitoring Wells
- Piezometers
- Surface Water Sediment Sampling Locations

0 50 100 200
Feet

N

Notes: *Aerial Photography from 2005.*
Data mapped to Ohio State Plane North NAD83, map units are feet.

JACOBS

Sampling Locations — Acid Area 2

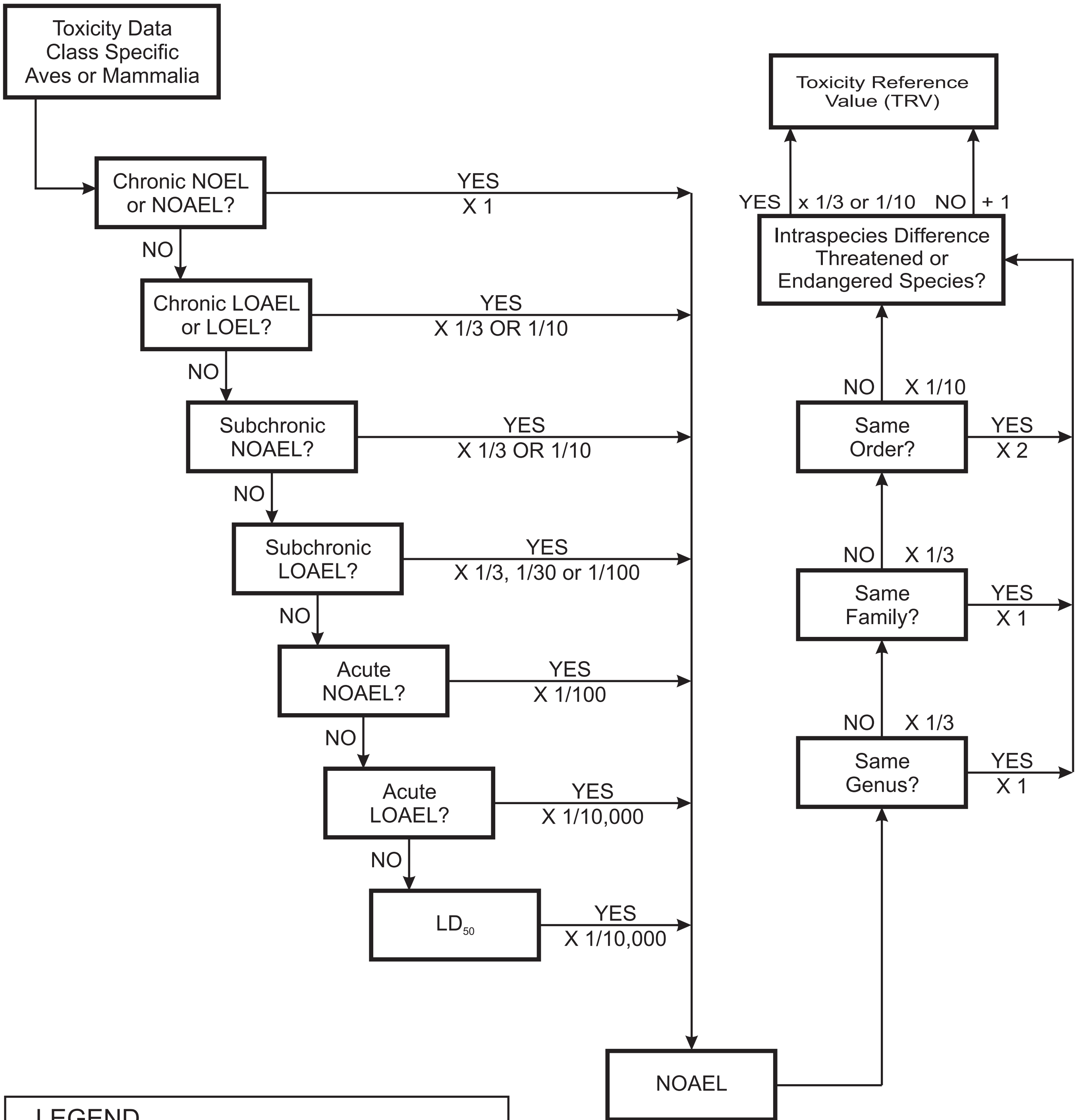
Plum Brook Ordnance Works
Sandusky, Ohio

09/20/07 JKD S:/GIS/Projects/Plumbrook/Projects/Screening Level Ecological Risk Assessment/ArcGIS/AA2_Sampling_Locs.mxd

Figure 2-4

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

TABLE 2-1 Species of Flora and Fauna Observed at Acid Area 2, Plum Brook Ordnance Works, Sandusky, Ohio May 16 and October 4, 2006	
Scientific Name	**Common Name**
FAUNAL SPECIES	
Archilochus colubris	ruby-throated hummingbird
Bombycilla cedrorum	cedar waxing
Buteo swainsoni	swainson's hawk
Cyanocitta cristata	blue jay
Dendroica fusca	blackburnian warbler
Dendroica magnolia	magnolia warbler
Dumetella carolinensis	gray catbird
Hylocichla mustelina	wood thrush
Melospiza melodia	song sparrow
Mniotilta varia	black and white warbler
Cardinalis cardinalis	Northern cardinal
Sialia sialis	Eastern bluebird
Spizella pusilla	field sparrow
Turdus migratorius	American robin
Tyrannus tyrannus	Eastern kingbird
Zenaida macroura	mourning dove
Zonotrichia albicollis	white-throated sparrow
Odocoileus virginianus	white-tailed deer
Procyon lotor	raccoon
Sciurus niger	Eastern fox squirrel
FLORAL SPECIES	
Acer negundo	box elder
Achillea millefolium	yarrow
Agrimonia gryposepala	agrimony
Agrimonia parviflora	small-flowered groovebur
Agrostis alba	redtop
Alliaria petiolata	garlic mustard
Allium vineale	field garlic
Ambrosia artemisiifolia	annual ragweed
Andropogon virginicus	broom sedge
Arisaema triphyllum	jack-in-the-pulpit
Asclepias syriaca	common milkweed

TABLE 2-1. Continued	
Scientific Name	**Common Name**
Asclepias verticillata	whorled milkweed
Asparagus officinalis	asparagus
Asplenium platyneuron	ebony spleenwort
Aster cordifolius	heart-leaved aster
Aster lateriflorus	calico aster
Aster novae-angliae	New England aster
Aster pilosus	aster
Aster simplex	aster
Berberis thunbergii	barberry
Blephilia hirsute	wood mint
Boehmeria cylindrica	false nettle
Botrychium virginianum	grape fern
Brassica nigra	yellow rocket
Carex amphibola	sedge
Carex blanda	sedge
Carex davisii	sedge
Carex gracillima	sedge
Carex hirtifolia	sedge
Carex radiata	sedge
Carex tribuloides	sedge
Carya ovata	shagbark hickory
Chrysanthemum leucanthemum	oxeye daisy
Cinna arundinacea	wood reed grass
Circaea lutetiana	southern broad-leaved enchanters nightshade
Cirsium arvense	creeping thistle
Cirsium muticum	swamp thistle
Cornus florida	flowering dogwood
Cornus racemosa	gray dogwood
Crataegus sp.	hawthorn
Cryptotaenia canadensis	honewort
Dactylis glomerata	orchard grass
Daucus carota	queen Anne's lace
Dentaria laciniata	cut-leaved toothwort
Desmodium cuspidatum	tickseed
Dichanthelium clandestinum	witchgrass
Dipsacus sylvestris	teasel
Eleagnus umbellata	autumn olive
Elymus sp.	rye grass

TABLE 2-1. Continued	
Scientific Name	**Common Name**
Equisetum arvense	horsetail
Erigeron philadelphicus	fleabane
Eupatorium rugosum	white snakeroot
Euthamia graminifolia	fragrant flat-topped goldenrod
Fragaria virginiana	strawberry
Fraxinus americana	white ash
Fraxinus pennsylvanica	green ash
Galium aparine	cleavers
Galium circaezans	wild licorice
Geranium maculatum	wild geranium
Geum laciniatum	avens
Glecoma hederacea	ground ivy
Gleditisa triacanthos	honey locust
Glyceria striata	fowl manna grass
Gnathalium obtusifolium	catfoot
Hackelia virginiana	stickseed
Holcus lanatus	velvet grass
Hystrix patula	bottlebrush grass
Juglans nigra	black walnut
Juniperus virginiana	red cedar
Lepidium campestre	field peppergrass
Ligustrum vulgare	privet
Lobelia inflata	Indian tobacco
Lolium perenne	perennial rye grass
Lonicera japonica	Japanese honeysuckle
Lonicera tatarica	tartarian honeysuckle
Lycopus americana	horehound
Lysimachia nummularia	moneywort
Medicago lupulina	black medic
Melilotus sp.	sweet clover
Morus alba	mulberry
Oenothera biennis	evening primrose
Onoclea sensibilis	sensitive fern
Osmorhiza longistylis	sweet cicely
Oxalis europaea	sorrell
Panicum dichotomoflorum	deer tongue grass
Panicum virgatum	switch grass

TABLE 2-1. Continued	
Scientific Name	**Common Name**
Parthenocissus quinquefolia	Virginia creeper
Phleum pratense	timothy
Phryma leptostachya	lopseed
Phytolacca americana	pokeweed
Pilea pumila	clearweed
Plantago lanceolata	English plantain
Plantago major	common plantain
Platanus occidentalis	sycamore
Poa alsodes	bluegrass
Podophyllum peltatum	mayapple
Polygonum virginianum	Virginia knotweed
Populus deltoides	cottonwood
Potentilla norvegica	cinquefoil
Potentilla simplex	old field cinquefoil
Prunella vulgaris	self heal
Prunus serotina	black cherry
Pycnanthemum tenuifolium	mountain mint
Quercus macrocarpa	bur oak
Quercus rubra	red oak
Ranunculus recurvatus	hooked crowfoot
Ribes cynosbati	gooseberry
Rosa multiflora	multiflora rose
Rosa setigera	prairie rose
Rubus allegheniensis	Allegheny blackberry
Rubus flagellaris	dewberry
Rubus occidentalis	black raspberry
Rudbeckia hirta	black-eyed Susan
Sassafras albidum	sassafras
Satureja vulgaris	wild basil
Senecio aureus	golden alexanders
Setaria glauca	bristle grass
Spiranthes cernua	nodding ladies tresses
Solanum nigrum	black nightshade
Taraxacum officinale	dandelion
Tilia americana	basswood
Toxicodendron radicans	poison ivy
Trifolium hybridium	alsike clover
Ulmus americana	American elm

TABLE 2-1. Continued	
Scientific Name	**Common Name**
Ulmus rubra	slippery elm
Verbascum blattaria	moth mullein
Verbena urticifolia	white vervain
Verbesina alternifolia	wingstem
Viola incognita	white violet
Viola papilionacea	blue violet
Vitis riparia	riverbank grape

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

type	Analyte	units	Percent Detects	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	mean	Recommend Distribution	EPC	bkg	Ecological Screening Level	COPEC	COPC
Surface Soil													
HE	2,4-Dinitrotoluene	mg/Kg	7	0.0646 - 0.410	0.044	5.8	0.189	Poisson	5.8			Yes	
HE	2,6-Dinitrotoluene	mg/Kg	2	0.0595 -0.410	0.833	0.833	0.093	Poisson	0.833		32.8		
HE	3-Nitrotoluene	mg/Kg	7	0.1340 - 0.25	0.157	0.157	0.083	Poisson	0.157		NA	Yes	
HE	Nitrobenzene	mg/Kg	2	0.0499 - 0.410	0.158	0.158	0.079	Poisson	0.158		1310		
MET	Aluminum	mg/Kg	100		4230	18400	8658	ProUCL: Approximate Gamma	9518	15500	NA	Yes	Yes
MET	Antimony	mg/Kg	36	0.559 - 7.50	0.717	2.07	1.18	Non Parametric - Indeterminate	1.45	9.3	0.142		
MET	Arsenic	mg/Kg	100		3.38	19.3	6.73	ProUCL: Approximate Gamma	7.62	36.5	5.7		Yes
MET	Barium	mg/Kg	100		18.7	188	64	Lognormal	66.8	826	1.04		
MET	Beryllium	mg/Kg	57	0.580 - 0.620	0.0842	0.86	0.379	Normal - ROS	0.432	1	1.06		
MET	Cadmium	mg/Kg	54	0.570 - 0.620	0.134	1.3	0.459	Non Parametric - Indeterminate	0.689		0.00222	Yes	
MET	Calcium	mg/Kg	100		1040	104000	12300	Non Parametric	18800	52300	NA	Yes	
MET	Chromium	mg/Kg	100		8.39	25.1	14.7	Normal	16.1	29	0.4		
MET	Cobalt	mg/Kg	96	6.10 - 6.10	3.02	11.9	7.74	Normal	8.45	116	0.14		
MET	Copper	mg/Kg	100		3.66	70.4	18.5	Lognormal	18.9	56.2	5.4	Yes	
MET	Iron	mg/Kg	100		10700	36100	18664	ProUCL: Approximate Gamma	20300	234000	NA		Yes
MET	Lead	mg/Kg	100		3.82	7410	316	ProUCL: 99% Chebyshev (Mean, Sd)	2936	48.6	0.0537	Yes	Yes
MET	Magnesium	mg/Kg	100		901	9770	3170	Lognormal	3260	10400	NA		
MET	Manganese	mg/Kg	100		90.7	1010	316	ProUCL: Approximate Gamma	375	3506	NA		Yes
MET	Mercury	mg/Kg	61	0.038 - 0.041	0.0152	0.429	0.0679	Non Parametric - Indeterminate	0.276	0.1	0.00051	Yes	
MET	Nickel	mg/Kg	100		7.35	25.9	16.9	Normal	18.5	55.1	13.6		
MET	Potassium	mg/Kg	89	586. - 618.	274	1850	862	Normal - ROS	979	3390	NA		
MET	Selenium	mg/Kg	32	0.610 - 6.00	0.59	1.87	0.719	Non Parametric - Indeterminate	0.96	2	0.0276		
MET	Silver	mg/Kg	18	0.0801 - 1.20	0.0933	0.389	0.175	Non Parametric - Kaplan-Meier	0.389	11.1	2		
MET	Sodium	mg/Kg	46	573. - 622.	32	101	52.3	Non Parametric - Kaplan-Meier	52.5		NA	Yes	
MET	Thallium	mg/Kg	43	1.1 - 12.	2.07	5.24	2.25	Non Parametric - Indeterminate	5.24	1.3	0.0569	Yes	Yes
MET	Vanadium	mg/Kg	100		17.3	35.3	22.9	ProUCL: Approximate Gamma	24.2	40.9	1.59		Yes
MET	Zinc	mg/Kg	100		19.7	372	98.9	Non Parametric	121	322	6.62	Yes	
PCB	PCB-1254	ug/Kg	39	18.1 - 7300.	16.7	16000	1995	Non Parametric - Indeterminate	16000		371	Yes	Yes
PCB	PCB-1260	ug/Kg	75	5.07 - 41.	45	31400	4274	Non Parametric	4290		371	Yes	Yes

Table 2-2 Continued.

type	Analyte	units	Percent Detects	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	mean	Recommend Distribution	EPC	BKG	eco_screen	COPEC	COPCs
SVO	2-Methylnaphthalene	ug/Kg	21	26.0 - 410.	60	646	114	Non Parametric - Indeterminate	646		3240		
SVO	3,3-Dichlorobenzidine	ug/Kg	5	666. - 2000.	140	140	140	Poisson	140		646		
SVO	Acenaphthene	ug/Kg	14	11.5 - 410.	112	805	177	Non Parametric - Indeterminate	805		20000		
SVO	Acenaphthylene	ug/Kg	32	39.2 - 410.	60.3	265	114	Non Parametric - Indeterminate	265		682000		
SVO	Anthracene	ug/Kg	36	28.5 - 410.	45	2070	274	Non Parametric - Indeterminate	2070		1480000		
SVO	Benzaldehyde	ug/Kg	100		95.9	95.9	95.9	One Sample	95.9		NA	Yes	
SVO	Benzo(a)anthracene	ug/Kg	50	20.6 - 410	45	8500	700	Non Parametric	8500		5210	Yes	Yes
SVO	Benzo(a)pyrene	ug/Kg	50	27.9 - 410	45	7300	621	Non Parametric - Indeterminate	7300		1520	Yes	Yes
SVO	Benzo(b)fluoranthene	ug/Kg	46	26.6 - 410	71	9700	688	Non Parametric - Indeterminate	9700		59800		Yes
SVO	Benzo(g,h,i)perylene	ug/Kg	46	25.3 - 410.	41	1900	303	Non Parametric - Indeterminate	1900		119000		
SVO	Benzo(k)fluoranthene	ug/Kg	50	30.2 - 410	53	6300	536	Non Parametric	538		148000		Yes
SVO	Biphenyl (Diphenyl)	ug/Kg	100		72.1	72.1	72.1	One Sample	72.1		60000		
SVO	bis(2-Ethylhexyl)phthalate	ug/Kg	18	329. - 410.	39	55	46.2	Non Parametric - Indeterminate	55		925		
SVO	Carbazole	ug/Kg	18	43.3 - 410.	89.3	1500	265	Non Parametric - Indeterminate	1500		NA	Yes	
SVO	Chrysene	ug/Kg	50	16.3 - 410.	52	8300	735	Non Parametric - Indeterminate	8300		4730	Yes	
SVO	Dibenz(a,h)anthracene	ug/Kg	32	21.2 - 410	53	1280	222	Non Parametric - Indeterminate	1280		18400		Yes
SVO	Dibenzofuran	ug/Kg	7	242. - 410.	190	518	183	Poisson	518		NA	Yes	
SVO	Di-n-butylphthalate	ug/Kg	14	380. - 467.	615	9230	948	Non Parametric - Indeterminate	9230		150	Yes	
SVO	Fluoranthene	ug/Kg	54	17.7 - 410.	66.7	17000	1450	Non Parametric - Indeterminate	17000		122000		
SVO	Fluorene	ug/Kg	14	9.65 - 410.	149	1000	240	Non Parametric - Indeterminate	1000		122000		
SVO	Indeno(1,2,3-cd)pyrene	ug/Kg	46	26.6 - 410	38	4540	479	Non Parametric	482		109000		Yes
SVO	Naphthalene	ug/Kg	14	9.45 - 410.	66.2	326	152	Non Parametric - Indeterminate	326		99.4	Yes	
SVO	Phenanthrene	ug/Kg	39	19.9 - 410.	47	7100	735	Non Parametric - Indeterminate	7100		45700		
SVO	Pyrene	ug/Kg	50	15.3 - 410.	58	15000	1010	Non Parametric - Kaplan-Meier	1013		78500		
VOC	2-Butanone (Methyl ethyl ketone)	ug/Kg	32	1.17 - 240	4.39	20.9	8.49	Non Parametric - Indeterminate	8.78		89600		
VOC	4-Methyl-2-pentanone (Methyl isobutyl ketone)	ug/Kg	4	0.963 - 240	4.83	4.83	123	Poisson	4.83		443000		
VOC	Acetone	ug/Kg	36	1.63 - 25.0	13	8600	510	Non Parametric - Indeterminate	8600		2500	Yes	
VOC	Benzene	ug/Kg	18	0.884 - 60.0	2.02	6.52	2.58	Non Parametric - Kaplan-Meier	2.99		255		
VOC	Carbon Disulfide	ug/Kg	25	1.46 - 60.0	5.13	29.1	7.39	Non Parametric - Indeterminate	29.1		94.1		
VOC	Cyclohexane	ug/Kg	62	1.68 - 2.04	2.06	11.6	4.2	Normal	5.99		NA	Yes	
VOC	Ethylbenzene	ug/Kg	18	0.673 - 60.0	1.05	2.9	1.72	Non Parametric - Kaplan-Meier	2.09		5160		
VOC	Methylcyclohexane	ug/Kg	62	0.785 - 0.95	2.15	12	5.35	Lognormal - ROS	6.07		NA	Yes	
VOC	Methylene Chloride	ug/Kg	14	0.960 - 29.0	2.2	29	2.65	Non Parametric - Kaplan-Meier	4.14		4050		
VOC	Toluene	ug/Kg	21	0.793 - 60.0	1.8	13.6	3.72	Non Parametric - Kaplan-Meier	5.69		5450		
VOC	Xylenes, Total	ug/Kg	25	1.13 - 60.0	1.94	7.8	3.29	Non Parametric - Kaplan-Meier	4.79		10000		

Table 2-2 Continued.

type	Analyte	units	Percent Detects	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	mean	Recommend Distribution	EPC	BKG	eco_screen	COPEC	COPCs
Subsurface Soil													
MET	Aluminum	mg/Kg	100		3720	14200	10347	ProUCL: Normal	10939	15500	NA		Yes
MET	Antimony	mg/Kg	29	0.595 - 7.70	0.753	1.67	1.23	Non Parametric - Indeterminate	1.5	9.3	0.142		
MET	Arsenic	mg/Kg	97	0.641	0.808	16.5	8.11	ProUCL: Approximate Gamma	9.14	36.5	5.7		Yes
MET	Barium	mg/Kg	100		22.7	111	66.2	Non Parametric	68.6	826	1.04		
MET	Beryllium	mg/Kg	74	0.600 - 0.640	0.179	0.8	0.476	Normal - ROS	0.488	1	1.06		
MET	Cadmium	mg/Kg	60	0.610 - 0.640	0.23	0.782	0.397	Non Parametric - Indeterminate	0.583		0.00222	Yes	
MET	Calcium	mg/Kg	100	0.0000 - 0.0000	3330	63000		NOT normal	63000			Yes	
MET	Chromium	mg/Kg	100		6.82	31	17.2	ProUCL: Normal	17.8	29	0.4	Yes	Yes
MET	Cobalt	mg/Kg	100		4.58	17.3	10.4	Normal	11.2	116	0.14		
MET	Copper	mg/Kg	100		13.9	31.3	21.5	Normal	22.7	56.2	5.4		
MET	Iron	mg/Kg	100		14100	41800	23826	ProUCL: Approximate Gamma	24500	234000	NA		Yes
MET	Lead	mg/Kg	100		7.9	113	15.6	ProUCL: 95% Chebyshev (Mean, Sd)	31.4	48.6	0.0537	Yes	Yes
MET	Magnesium	mg/Kg	100	0.0000 - 0.0000	2290	22000		NOT normal	22000			Yes	
MET	Manganese	mg/Kg	100		138	1270	431	ProUCL: Approximate Gamma	505	3506	NA		Yes
MET	Mercury	mg/Kg	43	0.0046 - 0.0420	0.0087	0.274	0.0275	Non Parametric - Kaplan-Meier	0.254	0.1	0.00051	Yes	
MET	Nickel	mg/Kg	100		12.4	39.2	25.2	Normal	26.7	55.1	13.6		
MET	Potassium	mg/Kg	100		664	2890	1650	Normal	1820	3390	NA		
MET	Selenium	mg/Kg	6	0.600 - 6.35	1.12	1.5	1.14	Poisson	1.5	2	0.0276		
MET	Silver	mg/Kg	31	0.0756 - 1.30	0.101	0.359	0.229	Non Parametric - Kaplan-Meier	0.359	11.1	2		
MET	Sodium	mg/Kg	57	596.0000 - 644.0000	37.8	172		?NOT normal	172			Yes	
MET	Thallium	mg/Kg	40	0.911 - 1.30	1.27	18.2	2.33	Non Parametric - Indeterminate	18.2	1.3	0.0569	Yes	Yes
MET	Vanadium	mg/Kg	100		12.9	34.7	26	ProUCL: Normal	27.2	40.9	1.59		Yes
MET	Zinc	mg/Kg	100		35.9	304	77.9	Non Parametric	88.8	322	6.62		
PCB	PCB-1254	ug/Kg	20	17.0 - 945	30	333	62.7	Non Parametric - Indeterminate	333			Yes	Yes
PCB	PCB-1260	ug/Kg	40	5.02 - 5.60	13.4	2560	184	Non Parametric - Indeterminate	2560			Yes	Yes

Table 2-2 Continued.

type	Analyte	units	Percent Detects	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	mean	Recommend Distribution	EPC	BKG	eco_screen	COPEC	COPCs
SVO	2-Methylnaphthalene	ug/Kg	6	25.7000 - 420.0000	65.7	89.9		Poisson	89.9		3240		
SVO	Acenaphthene	ug/Kg	3	11.3000 - 420.0000	323	323		Poisson	323		20000		
SVO	Acenaphthylene	ug/Kg	3	35.9000 - 420.0000	597	597		Poisson	597		682000		
SVO	Anthracene	ug/Kg	9	26.2000 - 420.0000	57	1980		Poisson	1980		1480000		
SVO	Benzo(a)anthracene	ug/Kg	9	18.9 - 420	110	3400	197	Poisson	3400		5210		Yes
SVO	Benzo(a)pyrene	ug/Kg	9	25.6 - 420	110	3050	187	Poisson	3050		1520	Yes	Yes
SVO	Benzo(b)fluoranthene	ug/Kg	9	24.4 - 420	95	2410	167	Poisson	2410		59800		Yes
SVO	Benzo(g,h,i)perylene	ug/Kg	9	23.2 - 420.	37	1990	210	Poisson	1990		119000		
SVO	Benzo(k)fluoranthene	ug/Kg	9	27.7000 - 420.0000	120	2360		Poisson	2360		148000		
SVO	Benzyl butyl phthalate	ug/Kg	3	127.0000 - 420.0000	385	385		Poisson	385		NA		
SVO	bis(2-Ethylhexyl)phthalate	ug/Kg	17	325.0000 - 420.0000	41	428		NON PARAMETRIC	428		925		
SVO	Carbazole	ug/Kg	6	42.7000 - 420.0000	87.3	540		Poisson	540		NA	Yes	
SVO	Chrysene	ug/Kg	9	15.0000 - 420.0000	120	3480		Poisson	3480		4730		
SVO	Dibenz(a,h)anthracene	ug/Kg	6	19.5 - 420	148	1280	134	Poisson	1280		18400		Yes
SVO	Di-n-butylphthalate	ug/Kg	6	390. - 511.	47	916	71.8	Poisson	916		150	Yes	
SVO	Fluoranthene	ug/Kg	9	16.2000 - 420.0000	210	9020		Poisson	9020		122000		
SVO	Fluorene	ug/Kg	6	9.5300 - 420.0000	69.6	469		Poisson	469		122000		
SVO	Indeno(1,2,3-cd)pyrene	ug/Kg	9	24.4 - 420	45	4220	222	Poisson	4220		109000		Yes
SVO	Naphthalene	ug/Kg	3	9.32 - 420.	103	103	93.4	Poisson	103		99.4		
SVO	Phenanthrene	ug/Kg	9	18.2 - 420.	71	4300	205	Poisson	4300		45700		
SVO	Pyrene	ug/Kg	9	14.1000 - 420.0000	170	4510		Poisson	4510		78500		
VOC	Acetone	ug/Kg	26	1.50 - 25.0	18	5000	395	Non Parametric - Indeterminate	5000		2500	Yes	
VOC	2-Butanone (Methyl ethyl ketone)	ug/Kg	3	1.0300 - 250.0000	4.08	4.08		Poisson	4.08		89600		
VOC	Benzene	ug/Kg	37	0.7880 - 63.0000	1.6	6.89		NON PARAMETRIC	6.89		255		
VOC	Carbon Disulfide	ug/Kg	3	1.2900 - 63.0000	11.6	11.6		Poisson	11.6		94.1		
VOC	Cyclohexane	ug/Kg	70	1.4900 - 1.8700	1.87	24.5		?NOT normal	24.5		NA	Yes	
VOC	Ethylbenzene	ug/Kg	29	0.6000 - 63.0000	0.678	3.27		NON PARAMETRIC	3.27		5160		
VOC	Methylcyclohexane	ug/Kg	70	0.6940 - 0.8710	2.78	20.6		?NOT normal	20.6		NA	Yes	
VOC	Methylene Chloride	ug/Kg	11	0.8870 - 12.0000	2.3	20		NON PARAMETRIC	20		4050		
VOC	Toluene	ug/Kg	46	0.7070 - 63.0000	1.4	15.7		NON PARAMETRIC	15.7		5450		
VOC	Xylenes, Total	ug/Kg	43	1.0100 - 63.0000	1.39	10.4		NON PARAMETRIC	10.4		10000		

Table 2-2 Continued.

type	Analyte	units	Percent Detects	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	mean	Recommend Distribution	EPC	BKG	eco_screen	COPEC	COPCs
Surface Water													
MET	Aluminum	ug/L	57	100	109	7670	592	Non Parametric - Kaplan-Meier	634		87	Yes	Yes
MET	Arsenic	ug/L	4	3	3.2	3.2	1.57	Poisson	3.2		148		
MET	Barium	ug/L	100		32.4	60.3	34.7	Non Parametric	36.6		4	Yes	
MET	Calcium	ug/L	100		47800	263000	111000	Non Parametric	125000		NA	Yes	
MET	Chromium	ug/L	4	2.00 - 2.00	8.2	8.2	1.31	Poisson	8.2		42		
MET	Copper	ug/L	9	4.00 - 4.00	7.3	7.4	2.47	Poisson	7.4		1.58	Yes	
MET	Iron	ug/L	96	30	56.2	8250	987	Non Parametric - Kaplan-Meier	989		1,000	Yes	Yes
MET	Lead	ug/L	13	1.5	2.9	26.3	2.06	Non Parametric	3.9			Yes	Yes
MET	Magnesium	ug/L	100		12400	28900	21600	Non Parametric	22600		NA	Yes	
MET	Manganese	ug/L	100		3.3	227	43.5	ProUCL: Approximate Gamma	59.5		120	Yes	Yes
MET	Nickel	ug/L	4	3.00 - 3.00	9	9	1.83	Poisson	9		28.9		
MET	Potassium	ug/L	100		1100	4880	2040	Non Parametric	2280		NA	Yes	
MET	Sodium	ug/L	100		2440	5810	3970	Normal	4200		NA	Yes	
MET	Vanadium	ug/L	4	3	15.4	15.4	2.1	Poisson	15.4		19		
MET	Zinc	ug/L	22	5.00 - 5.00	5.3	36.7	8.72	Non Parametric - Kaplan-Meier	9.13		59		
SVO	bis(2-Ethylhexyl)phthalate	ug/L	70	1.0 - 1.4	1.7	5	1.81	Non Parametric	2.55		0.12	Yes	Yes
SVO	Naphthalene	ug/L	52	0.520 - 1.10	0.026	0.044	0.0345	Non Parametric - Indeterminate	0.044		13		
VOC	Trichloroethene	ug/L	4	0.20 - 0.28	0.3	0.3	0.142	Poisson	0.3		47		

Table 2-2 Continued.

type	Analyte	units	Percent Detects	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	mean	Recommend Distribution	EPC	BKG	eco_screen	COPEC	COPCs
Sediment													
GC2	Cyanide	mg/Kg	60	0.17 - 0.21	0.2	0.74	0.352	Lognormal - ROS	0.378		0.0001	Yes	
HE	1,3,5-Trinitrobenzene	mg/Kg	13	0.0306 - 0.100	0.14	0.14		NON PARAMETRIC	0.14			Yes	
HE	1,3-Dinitrobenzene	mg/Kg	4	0.0297 - 0.100	0.0552	0.0552	0.055	Poisson	0.0552		8.61		
HE	2,4,6-Trinitrotoluene	mg/Kg	13	0.0411 - 0.100	0.094	0.77	0.146	Non Parametric - Indeterminate	0.77			Yes	
HE	2,4-Dinitrotoluene	mg/Kg	17	0.0681 - 0.210	0.148	0.72	0.255	Non Parametric - Indeterminate	0.72		14.4		
HE	2-Nitrotoluene	mg/Kg	4	0.103 - 0.197	0.13	0.13	0.13	Poisson	0.13				
HE	4-Nitrotoluene	mg/Kg	4	0.074 - 0.102	0.096	0.096		Poisson	0.096				
HE	HMX	mg/Kg	13	0.0276 - 0.100	0.16	0.53	0.211	Non Parametric - Indeterminate	0.53			Yes	
HE	RDX	mg/Kg	4	0.0354 - 0.100	0.1	0.1	0.1	Poisson	0.1				
HE	Tetryl	mg/Kg	4	0.074 - 0.100	0.134	0.134		Poisson	0.134				
MET	Aluminum	mg/Kg	100		2490	16000	9523	ProUCL: Normal	10755			Yes	Yes
MET	Antimony	mg/Kg	9	0.79 - 4.30	0.847	1.07	0.959	Poisson	1.07	9.3	NA		
MET	Arsenic	mg/Kg	100		2.64	13	6.42	ProUCL: Normal	7.55	36.5	6		Yes
MET	Barium	mg/Kg	100		39.7	111	70.1	Normal	76.4	826	NA		
MET	Beryllium	mg/Kg	96	0.2800 - 0.2800	0.28	1.1		NORMAL	1.1			Yes	
MET	Cadmium	mg/Kg	57	0.2600 - 0.3700	0.33	0.98		?NOT normal	0.98			Yes	
MET	Calcium	mg/Kg	100		1780	31200	8540	Lognormal	8850	52300	NA		
MET	Chromium	mg/Kg	100		3.5	30.4	15.5	ProUCL: Normal	17.5	29	26	Yes	Yes
MET	Cobalt	mg/Kg	96	1.40 - 1.40	4.1	13.1	7.24	Normal	8.12	116	50		
MET	Copper	mg/Kg	100		5.9	53.5	21.7	Lognormal	23.2	56.2	16		
MET	Iron	mg/Kg	100		5810	31800	19144	ProUCL: Normal	21585	234000	20000		Yes
MET	Lead	mg/Kg	100		19.6	1460	140	ProUCL: 99% CHebyshev (Mean, Sd)	776	48.6	31	Yes	Yes
MET	Magnesium	mg/Kg	100		486	8550	3170	Non Parametric	3600	10400	NA		
MET	Manganese	mg/Kg	100		58.6	406	172	ProUCL: Normal	203	3506	460		Yes
MET	Mercury	mg/Kg	100		0.049	1.1	0.17	Non Parametric - Kaplan-Meier	0.23	0.1	0.174	Yes	
MET	Nickel	mg/Kg	100		2.8	44.2	20.6	Normal	23.4	55.1	16		
MET	Potassium	mg/Kg	100		573	1790	1130	Normal	1790	3390	NA		
MET	Selenium	mg/Kg	43	0.7800 - 1.3900	1	3.72		NON PARAMETRIC	3.72			Yes	
MET	Silver	mg/Kg	13	0.116 - 0.430	0.177	0.32	0.232	Non Parametric - Kaplan-Meier	0.32	11.1	0.5		
MET	Sodium	mg/Kg	13	260.0000 - 427.0000	50.4	59		NON PARAMETRIC	59			Yes	
MET	Thallium	mg/Kg	13	0.32 - 0.53	4.02	4.73	0.75	Non Parametric - Indeterminate	4.73			Yes	Yes
MET	Vanadium	mg/Kg	100		5.7	32.2	21.7	ProUCL: Normal	24.1	40.9	NA		Yes
MET	Zinc	mg/Kg	100		8.6	244	84.3	Non Parametric - Kaplan-Meier	90.2	322	120		
PCB	PCB-1254	ug/Kg	4	5.40 - 46.4	1520	1520	71.5	Poisson	1520		60		
PCB	PCB-1260	ug/Kg	96	26.9	39	18000	1520	ProUCL: 95% Chebyshev (MVUE)	5780		5	Yes	Yes

Table 2-2 Continued.

type	Analyte	units	Percent Detects	Range of Detection Limits	Minimum Detected Concentration	Maximum Detected Concentration	mean	Recommend Distribution	EPC	BKG	eco_screen	COPEC	COPCs
SVO	2-Methylnaphthalene	ug/Kg	9	31.4 - 82.0	29	54	41.5	Poisson	54		20.2	Yes	
SVO	2-Methylphenol (o-Cresol)	ug/Kg	4	130. - 282.	362	362	96.3	Poisson	362		55.4		
SVO	3-Methylphenol	ug/Kg	5	130.0000 - 210.0000	150	150		Poisson	150				
SVO	4-Methylphenol (p-Cresol)	ug/Kg	9	100. - 210.	150	212	181	Poisson	212		20.2	Yes	
SVO	Acenaphthene	ug/Kg	4	13.8 - 82.0	39	39	29.2	Poisson	39		6.71		
SVO	Acenaphthylene	ug/Kg	48	53.0 - 82.0	48	251	98.8	Non Parametric - Indeterminate	251		5.87	Yes	
SVO	Acetophenone	ug/Kg	100		95.8	156	131	Normal	156			Yes	
SVO	Anthracene	ug/Kg	43	36.40- 82.0	42	430	123	Non Parametric - Indeterminate	430		57.2	Yes	
SVO	Benzaldehyde	ug/Kg	100		212	329	275	Normal	329			Yes	
SVO	Benzo(a)anthracene	ug/Kg	83	59 - 82	56	2300	302	Non Parametric - Kaplan-Meier	327		108	Yes	Yes
SVO	Benzo(a)pyrene	ug/Kg	61	58 - 82	96	2900	354	Non Parametric - Indeterminate	2900		150	Yes	Yes
SVO	Benzo(b)fluoranthene	ug/Kg	74	59 - 82	67	2900	378	Non Parametric - Indeterminate	2900			Yes	Yes
SVO	Benzo(g,h,i)perylene	ug/Kg	43	31.2 - 82.0	38	1100	193	Non Parametric - Indeterminate	1100		170	Yes	
SVO	Benzo(k)fluoranthene	ug/Kg	74	59.0 - 82.0	57	2200	351	Non Parametric - Indeterminate	2200		240	Yes	
SVO	Benzoic acid	ug/Kg	100		180	1850	676	Lognormal	784			Yes	
SVO	Chrysene	ug/Kg	83	59.0 - 82.0	55	2600	366	Non Parametric - Indeterminate	2600		166	Yes	
SVO	Dibenz(a,h)anthracene	ug/Kg	9	23.8 - 82	100	320	45.3	Poisson	320		33	Yes	Yes
SVO	Di-n-butylphthalate	ug/Kg	4	130.0000 - 535.0000	584	584		Poisson	584				
SVO	Fluoranthene	ug/Kg	91	59.0 - 66.0	43	3900	520	Non Parametric - Indeterminate	3900		423	Yes	
SVO	Fluorene	ug/Kg	4	11.6 - 82.0	120	120	120	Poisson	120		77.4		
SVO	Indeno(1,2,3-cd)pyrene	ug/Kg	48	33.9 - 82	44	1400	163	Non Parametric	242		200	Yes	Yes
SVO	N-Nitroso-di-n-propylamine	ug/Kg	9	104 - 210	166	272	90.2	Poisson	272			Yes	Yes
SVO	Phenanthrene	ug/Kg	61	25.3 - 82.0	45	1800	225	Non Parametric - Indeterminate	1800		204	Yes	
SVO	Phenol	ug/Kg	4	130. - 210.	535	535	535	Poisson	535		49.1		
SVO	Pyrene	ug/Kg	91	59.0 - 66.0	41	4200	490	Non Parametric - Indeterminate	4200		195	Yes	
VOC	2-Butanone (Methyl ethyl ketone)	ug/Kg	78	1.6000 - 2.2000	2.7	22.5		?NORMAL	22.5			Yes	
VOC	4-Methyl-2-pentanone (Methyl isobutyl ketone)	ug/Kg	13	0.6500 - 1.3000	1.71	13.5		NON PARAMETRIC	13.5			Yes	
VOC	Acetone	ug/Kg	96	2.04 - 2.04	7.7	336	83.5	Non Parametric - Indeterminate	336		9.1	Yes	
VOC	Benzene	ug/Kg	22	0.5300 - 1.8100	1.6	2.8		NON PARAMETRIC	2.8			Yes	
VOC	Carbon Disulfide	ug/Kg	9	1.40 - 2.95	2.1	2.8	1.12	Poisson	2.8		0.86	Yes	
VOC	Cyclohexane	ug/Kg	35	0.6100 - 3.4100	0.86	8.8		NON PARAMETRIC	8.8			Yes	
VOC	Ethylbenzene	ug/Kg	9	0.8400 - 1.7000	1.4	2.11		Poisson	2.11			Yes	
VOC	Methyl Acetate	ug/Kg	4	1.8000 - 7.2100	290	290		Poisson	290				
VOC	Methylcyclohexane	ug/Kg	22	0.3400 - 1.5900	5.2	9.8		NON PARAMETRIC	9.8			Yes	
VOC	Toluene	ug/Kg	26	0.9800 - 1.9000	2.3	8.5		NON PARAMETRIC	8.5			Yes	
VOC	Xylenes, Total	ug/Kg	4	0.7800 - 2.3100	5.09	5.09		Poisson	5.09				

mg/kg miligram/kilogram
ug/kg microgram/kilogram
mg/L miligram/Liter
ug/L microgram/Liter
BKG Background Concentration

EPC Exposure Point Concentration - Lesser of the UCL or the maximum detected concentration.
PRG Preliminary Remediation Goal - PRGs based on noncancer effects were multiplied by 0.1.
COPEC Contaminant of Potential EcologicalConcern

Table 2-3
NASA Plum Brook
Sandusky, Ohio
Acid Area 2 Proposed Ecological Assessment and Measurement Endpoints

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

Table 3-1. Continued.

Species	Parameter	Value	Units	Source
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
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 L/day = liters per day
g/day = grams per day NA = not available
ha = hectares 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	4066.00	0.90	2.70	0.004	833
Antimony	NA	0.22	7.00	0.90	40.00	0.200	1475
Arsenic	NA	0.11	73.00	0.90	114.00	0.036	293
Barium	NA	0.22	200.00	0.90	633.00	0.150	260
Beryllium	NA	0.22	45.00	0.90	62.00	0.010	141
Cadmium	NA	0.96	3461.00	3.40	907.00	0.364	782
Chromium	NA	0.01	3000.00	0.39	19.00	0.008	4406
Cobalt	NA	0.22	4066.00	0.90	40.00	0.350	
Copper	NA	0.04	3718.00	0.30	710.00	0.400	541
Iron	NA	0.22	4066.00	0.90		0.001	
Lead	NA	0.03	5059.00	0.63	0.09	0.045	1706
Manganese	NA	0.32	4066.00	0.90	35.00	0.050	
Mercury	NA	0.04	20184.00	0.07	3530.00	0.038	24762
Nickel	NA	0.02	28.00	0.90	78.00	0.032	61
Selenium	NA	0.22	1262.00	0.90	129.00	0.016	1845
Thallium	NA	0.22	15000.00	0.90	10000.00	0.004	15000
Vanadium	NA	0.22	4066.00	0.90	633.00	0.003	
Zinc	NA	0.56	4578.00	0.57	2059.00	1.2E-12	2175
Cyanide	NA	1.12	4066.00	0.90	14.00		22
VOCs							
Acetone	-0.222	0.05	0.05	0.05	0.10	52.037	0.05
Benzene	2.13	3.97	3.97	3.97	14.20	2.274	3.97
Carbon Disulfide	2.24	4.88	4.88	4.88	17.88	1.965	4.88
Ethylbenzene	3.15	27.16	27.16	27.16	120.36	0.585	27.16
Methyl Acetate	-0.09	0.06	0.06	0.06	0.14	43.654	0.06
Toluene	2.73	12.30	12.30	12.30	49.92	1.023	12.30
Xylenes, Total	3.15	27.16	27.16	27.16	120.36	0.585	27.16
SVOCs							
1,3,5-Trinitrobenzene	1.18	0.66	13.00	58.00	21.04	8.053	2507
2-Butanone (Methyl ethyl ketone)	0.29	0.12	13.00	58.00	21.04	26.326	2507
2,4-Dinitrotoluene	1.996	3.08	13.00	58.00	21.04	2.718	2507
2,4,6-Trinitrotoluene	2.25	4.97	13.00	58.00	21.04	1.939	2507
2-Methylnaphthalene	3.9	111.71	111.71	111.71	579.43	0.216	111.71
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	116.01	116.01	116.01	604.22	0.210	116.01
Acenaphthylene	3.5	52.54	52.54	52.54	250.61	0.367	52.54
Acetophenone	1.58	1.41	1.41	1.41	4.49	4.729	1.41
Anthracene	4.55	380.58	380.58	380.58	2262.02	0.091	380.58
Benzaldehyde	1.48	1.16	1.16	1.16	3.64	5.402	1.16
Benzo(a)anthracene	5.679	0.03	12299.00	1.45	500.00	0.020	5258
Benzo(a)pyrene	6.129	0.07	4697.00	1.59	500.00	0.011	5258
Benzo(b)fluoranthene	6.202	0.07	4697.00	1.61	500.00	0.010	5258

Table 3-2. Continued

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]
Benzo(g,h,i)perylene	6.7	21943.20	21943.20	21943.20	204642.62	0.005	21943.20
Benzo(k)fluoranthene	6.2	0.08	13225.00	1.61	500.00	0.010	5258
Benzoic acid	1.87	2.43	2.43	2.43	8.24	3.215	2.43
Benzyl butyl phthalate	4.84	657.60	657.60	657.60	4153.34	0.062	657.60
bis(2-ethylhexyl)phthalate	5.205	1309	318.00	1308.87	70.00	0.038	9931
Carbazole	3.59	62.26	62.26	62.26	302.62	0.326	62.26
Chrysene	5.739	0.04	980.00	1.38	500.00	0.019	5258
Cyclohexane	3.44	46.92	46.92	46.92	221.00	0.398	46.92
Dibenzofuran	4.2	196.70	196.70	196.70	1086.42	0.145	196.70
Dibenz(a,h)anthracene	6.547	0.07	710.00	1.61	500.00	0.006	5258
Di-n-butylphthalate	4.13	172.37	172.37	172.37	938.20	0.159	172.37
Fluoranthene	4.95	809.19	809.19	809.19	5229.94	0.053	809.19
Fluorene	4.21	200.44	200.44	200.44	1109.42	0.143	200.44
HMX	0.59	0.22	0.22	0.22	0.56	17.660	0.22
Indeno(1,2,3-cd)pyrene	6.915	0.08	4697.00	1.61	500.00	0.004	5258
methylcyclohexane	3.61	64.65	64.65	64.65	315.57	0.317	64.65
n-nitroso-di-n-propylamine	1.36	0.93	0.93	0.93	2.83	6.338	0.93
Naphthalene	3.3	36.03	36.03	36.03	164.82	0.479	36.03
PCB-1254	6.207	1.13	5538.00	0.53	230394.00	0.010	476829
PCB-1260	6.91	32605.44	32605.44	32605.44	317757.62	0.004	32605.44
Phenanthrene	4.57	395.21	395.21	395.21	2358.83	0.088	395.21
Phenol	1.46	1.12	1.12	1.12	3.49	5.548	1.12
Pyrene	5.11	1094.18	1094.18	1094.18	7313.02	0.043	1094.18
RDX	0.87	0.37	0.37	0.37	1.01	12.166	0.37

NA = not applicable

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
Maximum Exposure Doses for Short-tailed Shrew (*Blarina brevicauda*) Exposed to Soil, Water, and Contaminated Food at Acid Area 2, Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Conc. Soil	BCF_{inv}	IC	Conc Water	BCF_{plants}	PC	P_{inv}	P_{soil}	IR	WI	II	IS	IW	HRF	ED	BW	OD
	mg/g_{sed} (dry wt)	mg/kg wet	mg/g_{inv} (wet wt)	mg/L	mg/kg (dry wt)	mg/g_{plant} (dry wt)			kg_{diet}/day (Dry wt)	L/day	mg/day inv	mg/day soil	mg/day water		fraction of year	kg	mg/kg/day
2,4-Dinitrotoluene	5.80E+00	3.08E+00	1.8E+01	0.00E+00	5.80E+01	3.36E+02	1.00	0.104	0.0022	2.3E-03	3.9E-02	1.3E-03	0.0E+00	1.00E+00	1.000	0.015	2.7E+00
3-Nitrotoluene	1.57E-01	7.25E+00	1.1E+00	0.00E+00	7.25E+00	1.14E+00	1.00	0.104	0.0022	2.3E-03	2.5E-03	3.6E-05	0.0E+00	1.00E+00	1.000	0.015	1.7E-01
Aluminum	9.52E+03	2.20E-01	2.1E+03	6.34E-01	9.00E-01	8.57E+03	1.00	0.104	0.0022	2.3E-03	4.6E+00	2.2E+00	1.5E-03	1.00E+00	1.000	0.015	4.5E+02
Barium	0.00E+00	2.20E-01	0.0E+00	3.66E-02	9.00E-01	0.00E+00	1.00	0.104	0.0022	2.3E-03	0.0E+00	0.0E+00	8.4E-05	1.00E+00	1.000	0.015	5.6E-03
Cadmium	6.89E-01	9.60E-01	6.6E-01	0.00E+00	3.40E+00	2.34E+00	1.00	0.104	0.0022	2.3E-03	1.5E-03	1.6E-04	0.0E+00	1.00E+00	1.000	0.015	1.1E-01
Copper	1.89E+01	4.00E-02	7.6E-01	7.40E-03	3.00E-01	5.67E+00	1.00	0.104	0.0022	2.3E-03	1.7E-03	4.3E-03	1.7E-05	1.00E+00	1.000	0.015	4.0E-01
Iron	0.00E+00	2.20E-01	0.0E+00	9.89E-01	9.00E-01	0.00E+00	1.00	0.104	0.0022	2.3E-03	0.0E+00	0.0E+00	2.3E-03	1.00E+00	1.000	0.015	1.5E-01
Lead	2.94E+03	3.00E-02	8.8E+01	3.90E-03	6.30E-01	1.85E+03	1.00	0.104	0.0022	2.3E-03	1.9E-01	6.7E-01	9.0E-06	1.00E+00	1.000	0.015	5.8E+01
Manganese	0.00E+00	3.20E-01	0.0E+00	5.95E-02	9.00E-01	0.00E+00	1.00	0.104	0.0022	2.3E-03	0.0E+00	0.0E+00	1.4E-04	1.00E+00	1.000	0.015	9.1E-03
Mercury	2.76E-01	4.00E-02	1.1E-02	0.00E+00	6.80E-02	1.88E-02	1.00	0.104	0.0022	2.3E-03	2.4E-05	6.3E-05	0.0E+00	1.00E+00	1.000	0.015	5.8E-03
Thallium	5.24E+00	2.20E-01	1.2E+00	0.00E+00	9.00E-01	4.72E+00	1.00	0.104	0.0022	2.3E-03	2.5E-03	1.2E-03	0.0E+00	1.00E+00	1.000	0.015	2.5E-01
Zinc	1.21E+02	5.60E-01	6.8E+01	0.00E+00	5.70E-01	6.90E+01	1.00	0.104	0.0022	2.3E-03	1.5E-01	2.8E-02	0.0E+00	1.00E+00	1.000	0.015	1.2E+01
PCB-1254	1.60E+01	1.13E+00	1.8E+01	0.00E+00	5.30E-01	8.48E+00	1.00	0.104	0.0022	2.3E-03	4.0E-02	3.7E-03	0.0E+00	1.00E+00	1.000	0.015	2.9E+00
PCB-1260	4.29E+00	3.26E+04	1.4E+05	0.00E+00	3.26E+04	1.40E+05	1.00	0.104	0.0022	2.3E-03	3.1E+02	9.8E-04	0.0E+00	1.00E+00	1.000	0.015	2.1E+04
Benzaldehyde	9.59E-02	1.16E+00	1.1E-01	0.00E+00	1.16E+00	1.12E-01	1.00	0.104	0.0022	2.3E-03	2.5E-04	2.2E-05	0.0E+00	1.00E+00	1.000	0.015	1.8E-02
Benzo(a)anthracene	8.50E+00	3.00E-02	2.6E-01	0.00E+00	1.45E+00	1.23E+01	1.00	0.104	0.0022	2.3E-03	5.6E-04	1.9E-03	0.0E+00	1.00E+00	1.000	0.015	1.7E-01
Benzo(a)pyrene	7.30E+00	7.00E-02	5.1E-01	0.00E+00	1.59E+00	1.16E+01	1.00	0.104	0.0022	2.3E-03	1.1E-03	1.7E-03	0.0E+00	1.00E+00	1.000	0.015	1.9E-01
bis(2-Ethylhexyl)phthalate	0.00E+00	1.31E+03	0.0E+00	2.55E-03	1.31E+03	0.00E+00	1.00	0.104	0.0022	2.3E-03	0.0E+00	0.0E+00	5.9E-06	1.00E+00	1.000	0.015	3.9E-04
Carbazole	1.50E+00	6.23E+01	9.3E+01	0.00E+00	6.23E+01	9.34E+01	1.00	0.104	0.0022	2.3E-03	2.1E-01	3.4E-04	0.0E+00	1.00E+00	1.000	0.015	1.4E+01
Chrysene	8.30E+00	4.00E-02	3.3E-01	0.00E+00	1.38E+00	1.15E+01	1.00	0.104	0.0022	2.3E-03	7.3E-04	1.9E-03	0.0E+00	1.00E+00	1.000	0.015	1.8E-01
Dibenzofuran	5.18E-01	1.97E+02	1.0E+02	0.00E+00	1.97E+02	1.02E+02	1.00	0.104	0.0022	2.3E-03	2.2E-01	1.2E-04	0.0E+00	1.00E+00	1.000	0.015	1.5E+01
Di-n-butylphthalate	9.23E+00	1.72E+02	1.6E+03	0.00E+00	1.72E+02	1.59E+03	1.00	0.104	0.0022	2.3E-03	3.5E+00	2.1E-03	0.0E+00	1.00E+00	1.000	0.015	2.3E+02
Naphthalene	3.26E-01	3.60E+01	1.2E+01	0.00E+00	3.60E+01	1.17E+01	1.00	0.104	0.0022	2.3E-03	2.6E-02	7.5E-05	0.0E+00	1.00E+00	1.000	0.015	1.7E+00
Acetone	8.60E+00	4.70E-02	4.0E-01	0.00E+00	4.70E-02	4.04E-01	1.00	0.104	0.0022	2.3E-03	8.9E-04	2.0E-03	0.0E+00	1.00E+00	1.000	0.015	1.9E-01
Cyclohexane	5.99E-03	4.69E+01	2.8E-01	0.00E+00	4.69E+01	2.81E-01	1.00	0.104	0.0022	2.3E-03	6.2E-04	1.4E-06	0.0E+00	1.00E+00	1.000	0.015	4.1E-02
Methylcyclohexane	6.07E-03	6.47E+01	3.9E-01	0.00E+00	6.47E+01	3.92E-01	1.00	0.104	0.0022	2.3E-03	8.6E-04	1.4E-06	0.0E+00	1.00E+00	1.000	0.015	5.8E-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)
ED = 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/g = milligrams per gram 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
OD = 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
Maximum Exposure Doses for White-tailed Deer (*Odocoileus virginianus*) Exposed to Soil, Water, and Contaminated Food at Acid Area 2, Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Conc. Soil	BCF_{plant}	IC	Conc Water	BCF_{plants}	PC	P_{plant}	P_{soil}	IR	WI	IP	IS	IW	HRF	ED	BW	OD
	mg/g_{sed} (dry wt)	mg/kg wet	mg/g_{inv} (wet wt)	mg/L	mg/kg (dry wt)	mg/g_{plant} (dry wt)			kg_{diet}/day (Dry wt)	L/day	mg/day plant	mg/day soil	mg/day water		fraction of year	kg	mg/kg/day
2,4-Dinitrotoluene	5.80E+00	2.72E+00	1.6E+01	0.00E+00	5.80E+01	3.36E+02	1	0.02	2	4.0E+00	6.7E+02	2.3E-01	0.0E+00	2.00E-02	1.000	61	2.2E-01
3-Nitrotoluene	1.57E-01	1.49E+00	2.3E-01	0.00E+00	7.25E+00	1.14E+00	1	0.02	2	4.0E+00	2.3E+00	6.3E-03	0.0E+00	2.00E-02	1.000	61	7.5E-04
Aluminum	9.52E+03	4.00E-03	3.8E+01	6.34E-01	9.00E-01	8.57E+03	1	0.02	2	4.0E+00	1.7E+04	3.8E+02	2.5E+00	2.00E-02	1.000	61	5.7E+00
Barium	0.00E+00	1.50E-01	0.0E+00	3.66E-02	9.00E-01	0.00E+00	1	0.02	2	4.0E+00	0.0E+00	0.0E+00	1.5E-01	2.00E-02	1.000	61	4.8E-05
Cadmium	6.89E-01	3.64E-01	2.5E-01	0.00E+00	3.40E+00	2.34E+00	1	0.02	2	4.0E+00	4.7E+00	2.8E-02	0.0E+00	2.00E-02	1.000	61	1.5E-03
Copper	1.89E+01	4.00E-01	7.6E+00	7.40E-03	3.00E-01	5.67E+00	1	0.02	2	4.0E+00	1.1E+01	7.6E-01	3.0E-02	2.00E-02	1.000	61	4.0E-03
Iron	0.00E+00	1.00E-03	0.0E+00	9.89E-01	9.00E-01	0.00E+00	1	0.02	2	4.0E+00	0.0E+00	0.0E+00	4.0E+00	2.00E-02	1.000	61	1.3E-03
Lead	2.94E+03	4.50E-02	1.3E+02	3.90E-03	6.30E-01	1.85E+03	1	0.02	2	4.0E+00	3.7E+03	1.2E+02	1.6E-02	2.00E-02	1.000	61	1.3E+00
Manganese	0.00E+00	5.00E-02	0.0E+00	5.95E-02	9.00E-01	0.00E+00	1	0.02	2	4.0E+00	0.0E+00	0.0E+00	2.4E-01	2.00E-02	1.000	61	7.8E-05
Mercury	2.76E-01	3.75E-02	1.0E-02	0.00E+00	6.80E-02	1.88E-02	1	0.02	2	4.0E+00	3.8E-02	1.1E-02	0.0E+00	2.00E-02	1.000	61	1.6E-05
Thallium	5.24E+00	4.00E-03	2.1E-02	0.00E+00	9.00E-01	4.72E+00	1	0.02	2	4.0E+00	9.4E+00	2.1E-01	0.0E+00	2.00E-02	1.000	61	3.2E-03
Zinc	1.21E+02	1.20E-12	1.5E-10	0.00E+00	5.70E-01	6.90E+01	1	0.02	2	4.0E+00	1.4E+02	4.8E+00	0.0E+00	2.00E-02	1.000	61	4.7E-02
PCB-1254	1.60E+01	1.00E-02	1.6E-01	0.00E+00	5.30E-01	8.48E+00	1	0.02	2	4.0E+00	1.7E+01	6.4E-01	0.0E+00	2.00E-02	1.000	61	5.8E-03
PCB-1260	4.29E+00	3.93E-03	1.7E-02	0.00E+00	3.26E+04	1.40E+05	1	0.02	2	4.0E+00	2.8E+05	1.7E-01	0.0E+00	2.00E-02	1.000	61	9.2E+01
Benzaldehyde	9.59E-02	5.40E+00	5.2E-01	0.00E+00	1.16E+00	1.12E-01	1	0.02	2	4.0E+00	2.2E-01	3.8E-03	0.0E+00	2.00E-02	1.000	61	7.4E-05
Benzo(a)anthracene	8.50E+00	2.02E-02	1.7E-01	0.00E+00	1.45E+00	1.23E+01	1	0.02	2	4.0E+00	2.5E+01	3.4E-01	0.0E+00	2.00E-02	1.000	61	8.2E-03
Benzo(a)pyrene	7.30E+00	1.11E-02	8.1E-02	0.00E+00	1.59E+00	1.16E+01	1	0.02	2	4.0E+00	2.3E+01	2.9E-01	0.0E+00	2.00E-02	1.000	61	7.7E-03
bis(2-Ethylhexyl)phthalate	0.00E+00	3.80E-02	0.0E+00	2.55E-03	1.31E+03	0.00E+00	1	0.02	2	4.0E+00	0.0E+00	0.0E+00	1.0E-02	2.00E-02	1.000	61	3.3E-06
Carbazole	1.50E+00	3.26E-01	4.9E-01	0.00E+00	6.23E+01	9.34E+01	1	0.02	2	4.0E+00	1.9E+02	6.0E-02	0.0E+00	2.00E-02	1.000	61	6.1E-02
Chrysene	8.30E+00	1.87E-02	1.5E-01	0.00E+00	1.38E+00	1.15E+01	1	0.02	2	4.0E+00	2.3E+01	3.3E-01	0.0E+00	2.00E-02	1.000	61	7.6E-03
Dibenzofuran	5.18E-01	1.45E-01	7.5E-02	0.00E+00	1.97E+02	1.02E+02	1	0.02	2	4.0E+00	2.0E+02	2.1E-02	0.0E+00	2.00E-02	1.000	61	6.7E-02
Di-n-butylphthalate	9.23E+00	1.59E-01	1.5E+00	0.00E+00	1.72E+02	1.59E+03	1	0.02	2	4.0E+00	3.2E+03	3.7E-01	0.0E+00	2.00E-02	1.000	61	1.0E+00
Naphthalene	3.26E-01	4.79E-01	1.6E-01	0.00E+00	3.60E+01	1.17E+01	1	0.02	2	4.0E+00	2.3E+01	1.3E-02	0.0E+00	2.00E-02	1.000	61	7.7E-03
Acetone	8.60E+00	5.20E+01	4.5E+02	0.00E+00	4.70E-02	4.04E-01	1	0.02	2	4.0E+00	8.1E-01	3.4E-01	0.0E+00	2.00E-02	1.000	61	3.8E-04
Cyclohexane	5.99E-03	3.98E-01	2.4E-03	0.00E+00	4.69E+01	2.81E-01	1	0.02	2	4.0E+00	5.6E-01	2.4E-04	0.0E+00	2.00E-02	1.000	61	1.8E-04
Methylcyclohexane	6.07E-03	3.17E-01	1.9E-03	0.00E+00	6.47E+01	3.92E-01	1	0.02	2	4.0E+00	7.8E-01	2.4E-04	0.0E+00	2.00E-02	1.000	61	2.6E-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)
ED = 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/g = milligrams per gram 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
OD = 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
Maximum Exposure Doses for Marsh Wren (*Cistothorus palustris*) Exposed to Soil, Water, and Contaminated Food at Acid Area 2, Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Conc. Soil	BCF_{inv}	IC	Conc Water	BCF_{plants}	PC	P_{inv}	P_{soil}	IR	WI	II	IS	IW	HRF	ED	BW	OD
	mg/g_{sed} (dry wt)	mg/kg wet	mg/g_{inv} (wet wt)	mg/L	mg/kg (dry wt)	mg/g_{plant} (dry wt)			kg_{diet}/day (Dry wt)	L/day	mg/day inv	mg/day soil	mg/day water		fraction of year	kg	mg/kg/day
2,4-Dinitrotoluene	5.80E+00	3.08E+00	1.8E+01	0.00E+00	5.80E+01	3.36E+02	1.00	0.02	0.0029	2.7E-03	5.2E-02	3.4E-04	0.0E+00	1.00E+00	0.333	0.01	1.7E+00
3-Nitrotoluene	1.57E-01	7.25E+00	1.1E+00	0.00E+00	7.25E+00	1.14E+00	1.00	0.02	0.0029	2.7E-03	3.3E-03	9.1E-06	0.0E+00	1.00E+00	0.333	0.01	1.1E-01
Aluminum	9.52E+03	2.20E-01	2.1E+03	6.34E-01	9.00E-01	8.57E+03	1.00	0.02	0.0029	2.7E-03	6.1E+00	5.5E-01	1.7E-03	1.00E+00	0.333	0.01	2.2E+02
Barium	0.00E+00	2.20E-01	0.0E+00	3.66E-02	9.00E-01	0.00E+00	1.00	0.02	0.0029	2.7E-03	0.0E+00	0.0E+00	9.9E-05	1.00E+00	0.333	0.01	3.3E-03
Cadmium	6.89E-01	9.60E-01	6.6E-01	0.00E+00	3.40E+00	2.34E+00	1.00	0.02	0.0029	2.7E-03	1.9E-03	4.0E-05	0.0E+00	1.00E+00	0.333	0.01	6.5E-02
Copper	1.89E+01	4.00E-02	7.6E-01	7.40E-03	3.00E-01	5.67E+00	1.00	0.02	0.0029	2.7E-03	2.2E-03	1.1E-03	2.0E-05	1.00E+00	0.333	0.01	1.1E-01
Iron	0.00E+00	2.20E-01	0.0E+00	9.89E-01	9.00E-01	0.00E+00	1.00	0.02	0.0029	2.7E-03	0.0E+00	0.0E+00	2.7E-03	1.00E+00	0.333	0.01	8.9E-02
Lead	2.94E+03	3.00E-02	8.8E+01	3.90E-03	6.30E-01	1.85E+03	1.00	0.02	0.0029	2.7E-03	2.6E-01	1.7E-01	1.1E-05	1.00E+00	0.333	0.01	1.4E+01
Manganese	0.00E+00	3.20E-01	0.0E+00	5.95E-02	9.00E-01	0.00E+00	1.00	0.02	0.0029	2.7E-03	0.0E+00	0.0E+00	1.6E-04	1.00E+00	0.333	0.01	5.4E-03
Mercury	2.76E-01	4.00E-02	1.1E-02	0.00E+00	6.80E-02	1.88E-02	1.00	0.02	0.0029	2.7E-03	3.2E-05	1.6E-05	0.0E+00	1.00E+00	0.333	0.01	1.6E-03
Thallium	5.24E+00	2.20E-01	1.2E+00	0.00E+00	9.00E-01	4.72E+00	1.00	0.02	0.0029	2.7E-03	3.3E-03	3.0E-04	0.0E+00	1.00E+00	0.333	0.01	1.2E-01
Zinc	1.21E+02	5.60E-01	6.8E+01	0.00E+00	5.70E-01	6.90E+01	1.00	0.02	0.0029	2.7E-03	2.0E-01	7.0E-03	0.0E+00	1.00E+00	0.333	0.01	6.8E+00
PCB-1254	1.60E+01	1.13E+00	1.8E+01	0.00E+00	5.30E-01	8.48E+00	1.00	0.02	0.0029	2.7E-03	5.2E-02	9.3E-04	0.0E+00	1.00E+00	0.333	0.01	1.8E+00
PCB-1260	4.29E+00	3.26E+04	1.4E+05	0.00E+00	3.26E+04	1.40E+05	1.00	0.02	0.0029	2.7E-03	4.1E+02	2.5E-04	0.0E+00	1.00E+00	0.333	0.01	1.4E+04
Benzaldehyde	9.59E-02	1.16E+00	1.1E-01	0.00E+00	1.16E+00	1.12E-01	1.00	0.02	0.0029	2.7E-03	3.2E-04	5.6E-06	0.0E+00	1.00E+00	0.333	0.01	1.1E-02
Benzo(a)anthracene	8.50E+00	3.00E-02	2.6E-01	0.00E+00	1.45E+00	1.23E+01	1.00	0.02	0.0029	2.7E-03	7.4E-04	4.9E-04	0.0E+00	1.00E+00	0.333	0.01	4.1E-02
Benzo(a)pyrene	7.30E+00	7.00E-02	5.1E-01	0.00E+00	1.59E+00	1.16E+01	1.00	0.02	0.0029	2.7E-03	1.5E-03	4.2E-04	0.0E+00	1.00E+00	0.333	0.01	6.4E-02
bis(2-Ethylhexyl)phthalate	0.00E+00	1.31E+03	0.0E+00	2.55E-03	1.31E+03	0.00E+00	1.00	0.02	0.0029	2.7E-03	0.0E+00	0.0E+00	6.9E-06	1.00E+00	0.333	0.01	2.3E-04
Carbazole	1.50E+00	6.23E+01	9.3E+01	0.00E+00	6.23E+01	9.34E+01	1.00	0.02	0.0029	2.7E-03	2.7E-01	8.7E-05	0.0E+00	1.00E+00	0.333	0.01	9.0E+00
Chrysene	8.30E+00	4.00E-02	3.3E-01	0.00E+00	1.38E+00	1.15E+01	1.00	0.02	0.0029	2.7E-03	9.6E-04	4.8E-04	0.0E+00	1.00E+00	0.333	0.01	4.8E-02
Dibenzofuran	5.18E-01	1.97E+02	1.0E+02	0.00E+00	1.97E+02	1.02E+02	1.00	0.02	0.0029	2.7E-03	3.0E-01	3.0E-05	0.0E+00	1.00E+00	0.333	0.01	9.9E+00
Di-n-butylphthalate	9.23E+00	1.72E+02	1.6E+03	0.00E+00	1.72E+02	1.59E+03	1.00	0.02	0.0029	2.7E-03	4.6E+00	5.4E-04	0.0E+00	1.00E+00	0.333	0.01	1.5E+02
Naphthalene	3.26E-01	3.60E+01	1.2E+01	0.00E+00	3.60E+01	1.17E+01	1.00	0.02	0.0029	2.7E-03	3.4E-02	1.9E-05	0.0E+00	1.00E+00	0.333	0.01	1.1E+00
Acetone	8.60E+00	4.70E-02	4.0E-01	0.00E+00	4.70E-02	4.04E-01	1.00	0.02	0.0029	2.7E-03	1.2E-03	5.0E-04	0.0E+00	1.00E+00	0.333	0.01	5.6E-02
Cyclohexane	5.99E-03	4.69E+01	2.8E-01	0.00E+00	4.69E+01	2.81E-01	1.00	0.02	0.0029	2.7E-03	8.2E-04	3.5E-07	0.0E+00	1.00E+00	0.333	0.01	2.7E-02
Methylcyclohexane	6.07E-03	6.47E+01	3.9E-01	0.00E+00	6.47E+01	3.92E-01	1.00	0.02	0.0029	2.7E-03	1.1E-03	3.5E-07	0.0E+00	1.00E+00	0.333	0.01	3.8E-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)
ED = 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/g = milligrams per gram 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
OD = 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

Maximum Exposure Doses for Deer Mouse (*Peromyscus maniculatus*) Exposed to Soil, Water, and Contaminated Food at Acid Area 2, Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Conc. Soil mg/g_{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_{soil}	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	ED fraction of year	BW kg	OD mg/kg/day
2,4-Dinitrotoluene	5.80E+00	3.08E+00	1.8E+01	0.00E+00	5.80E+01	3.36E+02	0.39	0.61	0.02	0.0028	2.2E-03	2.0E-02	5.7E-01	3.2E-04	0.0E+00	1.00E+00	1.000	0.0148	4.0E+01
3-Nitrotoluene	1.57E-01	7.25E+00	1.1E+00	0.00E+00	7.25E+00	1.14E+00	0.39	0.61	0.02	0.0028	2.2E-03	1.2E-03	1.9E-03	8.8E-06	0.0E+00	1.00E+00	1.000	0.0148	2.2E-01
Aluminum	9.52E+03	2.20E-01	2.1E+03	6.34E-01	9.00E-01	8.57E+03	0.39	0.61	0.02	0.0028	2.2E-03	2.3E+00	1.5E+01	5.3E-01	1.4E-03	1.00E+00	1.000	0.0148	1.2E+03
Barium	0.00E+00	2.20E-01	0.0E+00	3.66E-02	9.00E-01	0.00E+00	0.39	0.61	0.02	0.0028	2.2E-03	0.0E+00	0.0E+00	0.0E+00	8.1E-05	1.00E+00	1.000	0.0148	5.4E-03
Cadmium	6.89E-01	9.60E-01	6.6E-01	0.00E+00	3.40E+00	2.34E+00	0.39	0.61	0.02	0.0028	2.2E-03	7.2E-04	4.0E-03	3.9E-05	0.0E+00	1.00E+00	1.000	0.0148	3.2E-01
Copper	1.89E+01	4.00E-02	7.6E-01	7.40E-03	3.00E-01	5.67E+00	0.39	0.61	0.02	0.0028	2.2E-03	8.3E-04	9.7E-03	1.1E-03	1.6E-05	1.00E+00	1.000	0.0148	7.8E-01
Iron	0.00E+00	2.20E-01	0.0E+00	9.89E-01	9.00E-01	0.00E+00	0.39	0.61	0.02	0.0028	2.2E-03	0.0E+00	0.0E+00	0.0E+00	2.2E-03	1.00E+00	1.000	0.0148	1.5E-01
Lead	2.94E+03	3.00E-02	8.8E+01	3.90E-03	6.30E-01	1.85E+03	0.39	0.61	0.02	0.0028	2.2E-03	9.6E-02	3.2E+00	1.6E-01	8.6E-06	1.00E+00	1.000	0.0148	2.3E+02
Manganese	0.00E+00	3.20E-01	0.0E+00	5.95E-02	9.00E-01	0.00E+00	0.39	0.61	0.02	0.0028	2.2E-03	0.0E+00	0.0E+00	0.0E+00	1.3E-04	1.00E+00	1.000	0.0148	8.8E-03
Mercury	2.76E-01	4.00E-02	1.1E-02	0.00E+00	6.80E-02	1.88E-02	0.39	0.61	0.02	0.0028	2.2E-03	1.2E-05	3.2E-05	1.5E-05	0.0E+00	1.00E+00	1.000	0.0148	4.0E-03
Thallium	5.24E+00	2.20E-01	1.2E+00	0.00E+00	9.00E-01	4.72E+00	0.39	0.61	0.02	0.0028	2.2E-03	1.3E-03	8.1E-03	2.9E-04	0.0E+00	1.00E+00	1.000	0.0148	6.5E-01
Zinc	1.21E+02	5.60E-01	6.8E+01	0.00E+00	5.70E-01	6.90E+01	0.39	0.61	0.02	0.0028	2.2E-03	7.4E-02	1.2E-01	6.8E-03	0.0E+00	1.00E+00	1.000	0.0148	1.3E+01
PCB-1254	1.60E+01	1.13E+00	1.8E+01	0.00E+00	5.30E-01	8.48E+00	0.39	0.61	0.02	0.0028	2.2E-03	2.0E-02	1.4E-02	9.0E-04	0.0E+00	1.00E+00	1.000	0.0148	2.4E+00
PCB-1260	4.29E+00	3.26E+04	1.4E+05	0.00E+00	3.26E+04	1.40E+05	0.39	0.61	0.02	0.0028	2.2E-03	1.5E+02	2.4E+02	2.4E-04	0.0E+00	1.00E+00	1.000	0.0148	2.6E+04
Benzaldehyde	9.59E-02	1.16E+00	1.1E-01	0.00E+00	1.16E+00	1.12E-01	0.39	0.61	0.02	0.0028	2.2E-03	1.2E-04	1.9E-04	5.4E-06	0.0E+00	1.00E+00	1.000	0.0148	2.1E-02
Benzo(a)anthracene	8.50E+00	3.00E-02	2.6E-01	0.00E+00	1.45E+00	1.23E+01	0.39	0.61	0.02	0.0028	2.2E-03	2.8E-04	2.1E-02	4.8E-04	0.0E+00	1.00E+00	1.000	0.0148	1.5E+00
Benzo(a)pyrene	7.30E+00	7.00E-02	5.1E-01	0.00E+00	1.59E+00	1.16E+01	0.39	0.61	0.02	0.0028	2.2E-03	5.6E-04	2.0E-02	4.1E-04	0.0E+00	1.00E+00	1.000	0.0148	1.4E+00
bis(2-Ethylhexyl)phthalate	0.00E+00	1.31E+03	0.0E+00	2.55E-03	1.31E+03	0.00E+00	0.39	0.61	0.02	0.0028	2.2E-03	0.0E+00	0.0E+00	0.0E+00	5.6E-06	1.00E+00	1.000	0.0148	3.8E-04
Carbazole	1.50E+00	6.23E+01	9.3E+01	0.00E+00	6.23E+01	9.34E+01	0.39	0.61	0.02	0.0028	2.2E-03	1.0E-01	1.6E-01	8.4E-05	0.0E+00	1.00E+00	1.000	0.0148	1.8E+01
Chrysene	8.30E+00	4.00E-02	3.3E-01	0.00E+00	1.38E+00	1.15E+01	0.39	0.61	0.02	0.0028	2.2E-03	3.6E-04	2.0E-02	4.6E-04	0.0E+00	1.00E+00	1.000	0.0148	1.4E+00
Dibenzofuran	5.18E-01	1.97E+02	1.0E+02	0.00E+00	1.97E+02	1.02E+02	0.39	0.61	0.02	0.0028	2.2E-03	1.1E-01	1.7E-01	2.9E-05	0.0E+00	1.00E+00	1.000	0.0148	1.9E+01
Di-n-butylphthalate	9.23E+00	1.72E+02	1.6E+03	0.00E+00	1.72E+02	1.59E+03	0.39	0.61	0.02	0.0028	2.2E-03	1.7E+00	2.7E+00	5.2E-04	0.0E+00	1.00E+00	1.000	0.0148	3.0E+02
Naphthalene	3.26E-01	3.60E+01	1.2E+01	0.00E+00	3.60E+01	1.17E+01	0.39	0.61	0.02	0.0028	2.2E-03	1.3E-02	2.0E-02	1.8E-05	0.0E+00	1.00E+00	1.000	0.0148	2.2E+00
Acetone	8.60E+00	4.70E-02	4.0E-01	0.00E+00	4.70E-02	4.04E-01	0.39	0.61	0.02	0.0028	2.2E-03	4.4E-04	6.9E-04	4.8E-04	0.0E+00	1.00E+00	1.000	0.0148	1.1E-01
Cyclohexane	5.99E-03	4.69E+01	2.8E-01	0.00E+00	4.69E+01	2.81E-01	0.39	0.61	0.02	0.0028	2.2E-03	3.1E-04	4.8E-04	3.4E-07	0.0E+00	1.00E+00	1.000	0.0148	5.3E-02
Methylcyclohexane	6.07E-03	6.47E+01	3.9E-01	0.00E+00	6.47E+01	3.92E-01	0.39	0.61	0.02	0.0028	2.2E-03	4.3E-04	6.7E-04	3.4E-07	0.0E+00	1.00E+00	1.000	0.0148	7.4E-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)
ED = 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/g = milligrams per gram 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
OD = 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
Maximum Exposure Doses for Eastern Cottontail (*Sylvilagus floridanus*) Exposed to Soil, Water, and Contaminated Food at Acid Area 2, Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Conc. Soil	BCF_{plant}	IC	Conc Water	BCF_{plants}	PC	P_{plant}	P_{soil}	IR	WI	IP	IS	IW	HRF	ED	BW	OD
	mg/g_{sed} (dry wt)	mg/kg wet	mg/g_{inv} (wet wt)	mg/L	mg/kg (dry wt)	mg/g_{plant} (dry wt)			kg_{diet}/day (Dry wt)	L/day	mg/day plant	mg/day soil	mg/day water		fraction of year	kg	mg/kg/day
2,4-Dinitrotoluene	5.80E+00	2.72E+00	1.6E+01	0.00E+00	5.80E+01	3.36E+02	1	0.063	0.096	1.1E-01	3.2E+01	3.5E-02	0.0E+00	1.00E+00	1.000	1.132	2.9E+01
3-Nitrotoluene	1.57E-01	1.49E+00	2.3E-01	0.00E+00	7.25E+00	1.14E+00	1	0.063	0.096	1.1E-01	1.1E-01	9.5E-04	0.0E+00	1.00E+00	1.000	1.132	9.7E-02
Aluminum	9.52E+03	4.00E-03	3.8E+01	6.34E-01	9.00E-01	8.57E+03	1	0.063	0.096	1.1E-01	8.2E+02	5.8E+01	7.0E-02	1.00E+00	1.000	1.132	7.8E+02
Barium	0.00E+00	1.50E-01	0.0E+00	3.66E-02	9.00E-01	0.00E+00	1	0.063	0.096	1.1E-01	0.0E+00	0.0E+00	4.0E-03	1.00E+00	1.000	1.132	3.6E-03
Cadmium	6.89E-01	3.64E-01	2.5E-01	0.00E+00	3.40E+00	2.34E+00	1	0.063	0.096	1.1E-01	2.2E-01	4.2E-03	0.0E+00	1.00E+00	1.000	1.132	2.0E-01
Copper	1.89E+01	4.00E-01	7.6E+00	7.40E-03	3.00E-01	5.67E+00	1	0.063	0.096	1.1E-01	5.4E-01	1.1E-01	8.1E-04	1.00E+00	1.000	1.132	5.8E-01
Iron	0.00E+00	1.00E-03	0.0E+00	9.89E-01	9.00E-01	0.00E+00	1	0.063	0.096	1.1E-01	0.0E+00	0.0E+00	1.1E-01	1.00E+00	1.000	1.132	9.6E-02
Lead	2.94E+03	4.50E-02	1.3E+02	3.90E-03	6.30E-01	1.85E+03	1	0.063	0.096	1.1E-01	1.8E+02	1.8E+01	4.3E-04	1.00E+00	1.000	1.132	1.7E+02
Manganese	0.00E+00	5.00E-02	0.0E+00	5.95E-02	9.00E-01	0.00E+00	1	0.063	0.096	1.1E-01	0.0E+00	0.0E+00	6.5E-03	1.00E+00	1.000	1.132	5.8E-03
Mercury	2.76E-01	3.75E-02	1.0E-02	0.00E+00	6.80E-02	1.88E-02	1	0.063	0.096	1.1E-01	1.8E-03	1.7E-03	0.0E+00	1.00E+00	1.000	1.132	3.1E-03
Thallium	5.24E+00	4.00E-03	2.1E-02	0.00E+00	9.00E-01	4.72E+00	1	0.063	0.096	1.1E-01	4.5E-01	3.2E-02	0.0E+00	1.00E+00	1.000	1.132	4.3E-01
Zinc	1.21E+02	1.20E-12	1.5E-10	0.00E+00	5.70E-01	6.90E+01	1	0.063	0.096	1.1E-01	6.6E+00	7.3E-01	0.0E+00	1.00E+00	1.000	1.132	6.5E+00
PCB-1254	1.60E+01	1.00E-02	1.6E-01	0.00E+00	5.30E-01	8.48E+00	1	0.063	0.096	1.1E-01	8.1E-01	9.7E-02	0.0E+00	1.00E+00	1.000	1.132	8.0E-01
PCB-1260	4.29E+00	3.93E-03	1.7E-02	0.00E+00	3.26E+04	1.40E+05	1	0.063	0.096	1.1E-01	1.3E+04	2.6E-02	0.0E+00	1.00E+00	1.000	1.132	1.2E+04
Benzaldehyde	9.59E-02	5.40E+00	5.2E-01	0.00E+00	1.16E+00	1.12E-01	1	0.063	0.096	1.1E-01	1.1E-02	5.8E-04	0.0E+00	1.00E+00	1.000	1.132	1.0E-02
Benzo(a)anthracene	8.50E+00	2.02E-02	1.7E-01	0.00E+00	1.45E+00	1.23E+01	1	0.063	0.096	1.1E-01	1.2E+00	5.1E-02	0.0E+00	1.00E+00	1.000	1.132	1.1E+00
Benzo(a)pyrene	7.30E+00	1.11E-02	8.1E-02	0.00E+00	1.59E+00	1.16E+01	1	0.063	0.096	1.1E-01	1.1E+00	4.4E-02	0.0E+00	1.00E+00	1.000	1.132	1.0E+00
bis(2-Ethylhexyl)phthalate	0.00E+00	3.80E-02	0.0E+00	2.55E-03	1.31E+03	0.00E+00	1	0.063	0.096	1.1E-01	0.0E+00	0.0E+00	2.8E-04	1.00E+00	1.000	1.132	2.5E-04
Carbazole	1.50E+00	3.26E-01	4.9E-01	0.00E+00	6.23E+01	9.34E+01	1	0.063	0.096	1.1E-01	9.0E+00	9.1E-03	0.0E+00	1.00E+00	1.000	1.132	7.9E+00
Chrysene	8.30E+00	1.87E-02	1.5E-01	0.00E+00	1.38E+00	1.15E+01	1	0.063	0.096	1.1E-01	1.1E+00	5.0E-02	0.0E+00	1.00E+00	1.000	1.132	1.0E+00
Dibenzofuran	5.18E-01	1.45E-01	7.5E-02	0.00E+00	1.97E+02	1.02E+02	1	0.063	0.096	1.1E-01	9.8E+00	3.1E-03	0.0E+00	1.00E+00	1.000	1.132	8.6E+00
Di-n-butylphthalate	9.23E+00	1.59E-01	1.5E+00	0.00E+00	1.72E+02	1.59E+03	1	0.063	0.096	1.1E-01	1.5E+02	5.6E-02	0.0E+00	1.00E+00	1.000	1.132	1.3E+02
Naphthalene	3.26E-01	4.79E-01	1.6E-01	0.00E+00	3.60E+01	1.17E+01	1	0.063	0.096	1.1E-01	1.1E+00	2.0E-03	0.0E+00	1.00E+00	1.000	1.132	1.0E+00
Acetone	8.60E+00	5.20E+01	4.5E+02	0.00E+00	4.70E-02	4.04E-01	1	0.063	0.096	1.1E-01	3.9E-02	5.2E-02	0.0E+00	1.00E+00	1.000	1.132	8.0E-02
Cyclohexane	5.99E-03	3.98E-01	2.4E-03	0.00E+00	4.69E+01	2.81E-01	1	0.063	0.096	1.1E-01	2.7E-02	3.6E-05	0.0E+00	1.00E+00	1.000	1.132	2.4E-02
Methylcyclohexane	6.07E-03	3.17E-01	1.9E-03	0.00E+00	6.47E+01	3.92E-01	1	0.063	0.096	1.1E-01	3.8E-02	3.7E-05	0.0E+00	1.00E+00	1.000	1.132	3.3E-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)
ED = 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/g = milligrams per gram 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
OD = 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
Maximum Exposure Doses for Red-tailed Hawk (*Buteo jamaicensis*) Exposed to Soil, Water, and Contaminated Food at Acid Area 2, Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Conc. Soil	BCF_{inv}	IC	Conc Water	BCF_{plants}	VC	Pvert	P_{soil}	IR	WI	IV	IS	IW	HRF	ED	BW	OD
	mg/g_{sed} (dry wt)	mg/kg wet	mg/g_{inv} (wet wt)	mg/L	mg/kg (dry wt)	mg/g_{vert} (dry wt)			kg_{diet}/day (Dry wt)	L/day	mg/day inv	mg/day soil	mg/day water		fraction of year	kg	mg/kg/day
2,4-Dinitrotoluene	5.80E+00	3.08E+00	1.8E+01	0.00E+00	5.80E+01	3.54E+02	1.00	0.02	0.057	5.7E-02	2.0E+01	6.6E-03	0.0E+00	1.00E-02	1.000	0.957	2.1E-01
3-Nitrotoluene	1.57E-01	7.25E+00	1.1E+00	0.00E+00	7.25E+00	2.28E+00	1.00	0.02	0.057	5.7E-02	1.3E-01	1.8E-04	0.0E+00	1.00E-02	1.000	0.957	1.4E-03
Aluminum	9.52E+03	2.20E-01	2.1E+03	6.34E-01	9.00E-01	1.07E+04	1.00	0.02	0.057	5.7E-02	6.1E+02	1.1E+01	3.6E-02	1.00E-02	1.000	0.957	6.5E+00
Barium	0.00E+00	2.20E-01	0.0E+00	3.66E-02	9.00E-01	0.00E+00	1.00	0.02	0.057	5.7E-02	0.0E+00	0.0E+00	2.1E-03	1.00E-02	1.000	0.957	2.2E-05
Cadmium	6.89E-01	9.60E-01	6.6E-01	0.00E+00	3.40E+00	3.00E+00	1.00	0.02	0.057	5.7E-02	1.7E-01	7.9E-04	0.0E+00	1.00E-02	1.000	0.957	1.8E-03
Copper	1.89E+01	4.00E-02	7.6E-01	7.40E-03	3.00E-01	6.43E+00	1.00	0.02	0.057	5.7E-02	3.7E-01	2.2E-02	4.2E-04	1.00E-02	1.000	0.957	4.1E-03
Iron	0.00E+00	2.20E-01	0.0E+00	9.89E-01	9.00E-01	0.00E+00	1.00	0.02	0.057	5.7E-02	0.0E+00	0.0E+00	5.6E-02	1.00E-02	1.000	0.957	5.9E-04
Lead	2.94E+03	3.00E-02	8.8E+01	3.90E-03	6.30E-01	1.94E+03	1.00	0.02	0.057	5.7E-02	1.1E+02	3.3E+00	2.2E-04	1.00E-02	1.000	0.957	1.2E+00
Manganese	0.00E+00	3.20E-01	0.0E+00	5.95E-02	9.00E-01	0.00E+00	1.00	0.02	0.057	5.7E-02	0.0E+00	0.0E+00	3.4E-03	1.00E-02	1.000	0.957	3.5E-05
Mercury	2.76E-01	4.00E-02	1.1E-02	0.00E+00	6.80E-02	2.98E-02	1.00	0.02	0.057	5.7E-02	1.7E-03	3.1E-04	0.0E+00	1.00E-02	1.000	0.957	2.1E-05
Thallium	5.24E+00	2.20E-01	1.2E+00	0.00E+00	9.00E-01	5.87E+00	1.00	0.02	0.057	5.7E-02	3.3E-01	6.0E-03	0.0E+00	1.00E-02	1.000	0.957	3.6E-03
Zinc	1.21E+02	5.60E-01	6.8E+01	0.00E+00	5.70E-01	1.37E+02	1.00	0.02	0.057	5.7E-02	7.8E+00	1.4E-01	0.0E+00	1.00E-02	1.000	0.957	8.3E-02
PCB-1254	1.60E+01	1.13E+00	1.8E+01	0.00E+00	5.30E-01	2.66E+01	1.00	0.02	0.057	5.7E-02	1.5E+00	1.8E-02	0.0E+00	1.00E-02	1.000	0.957	1.6E-02
PCB-1260	4.29E+00	3.26E+04	1.4E+05	0.00E+00	3.26E+04	2.80E+05	1.00	0.02	0.057	5.7E-02	1.6E+04	4.9E-03	0.0E+00	1.00E-02	1.000	0.957	1.7E+02
Benzaldehyde	9.59E-02	1.16E+00	1.1E-01	0.00E+00	1.16E+00	2.23E-01	1.00	0.02	0.057	5.7E-02	1.3E-02	1.1E-04	0.0E+00	1.00E-02	1.000	0.957	1.3E-04
Benzo(a)anthracene	8.50E+00	3.00E-02	2.6E-01	0.00E+00	1.45E+00	1.26E+01	1.00	0.02	0.057	5.7E-02	7.2E-01	9.7E-03	0.0E+00	1.00E-02	1.000	0.957	7.6E-03
Benzo(a)pyrene	7.30E+00	7.00E-02	5.1E-01	0.00E+00	1.59E+00	1.21E+01	1.00	0.02	0.057	5.7E-02	6.9E-01	8.3E-03	0.0E+00	1.00E-02	1.000	0.957	7.3E-03
bis(2-Ethylhexyl)phthalate	0.00E+00	1.31E+03	0.0E+00	2.55E-03	1.31E+03	0.00E+00	1.00	0.02	0.057	5.7E-02	0.0E+00	0.0E+00	1.5E-04	1.00E-02	1.000	0.957	1.5E-06
Carbazole	1.50E+00	6.23E+01	9.3E+01	0.00E+00	6.23E+01	1.87E+02	1.00	0.02	0.057	5.7E-02	1.1E+01	1.7E-03	0.0E+00	1.00E-02	1.000	0.957	1.1E-01
Chrysene	8.30E+00	4.00E-02	3.3E-01	0.00E+00	1.38E+00	1.18E+01	1.00	0.02	0.057	5.7E-02	6.7E-01	9.5E-03	0.0E+00	1.00E-02	1.000	0.957	7.1E-03
Dibenzofuran	5.18E-01	1.97E+02	1.0E+02	0.00E+00	1.97E+02	2.04E+02	1.00	0.02	0.057	5.7E-02	1.2E+01	5.9E-04	0.0E+00	1.00E-02	1.000	0.957	1.2E-01
Di-n-butylphthalate	9.23E+00	1.72E+02	1.6E+03	0.00E+00	1.72E+02	3.18E+03	1.00	0.02	0.057	5.7E-02	1.8E+02	1.1E-02	0.0E+00	1.00E-02	1.000	0.957	1.9E+00
Naphthalene	3.26E-01	3.60E+01	1.2E+01	0.00E+00	3.60E+01	2.35E+01	1.00	0.02	0.057	5.7E-02	1.3E+00	3.7E-04	0.0E+00	1.00E-02	1.000	0.957	1.4E-02
Acetone	8.60E+00	4.70E-02	4.0E-01	0.00E+00	4.70E-02	8.09E-01	1.00	0.02	0.057	5.7E-02	4.6E-02	9.8E-03	0.0E+00	1.00E-02	1.000	0.957	5.8E-04
Cyclohexane	5.99E-03	4.69E+01	2.8E-01	0.00E+00	4.69E+01	5.62E-01	1.00	0.02	0.057	5.7E-02	3.2E-02	6.8E-06	0.0E+00	1.00E-02	1.000	0.957	3.3E-04
Methylcyclohexane	6.07E-03	6.47E+01	3.9E-01	0.00E+00	6.47E+01	7.85E-01	1.00	0.02	0.057	5.7E-02	4.5E-02	6.9E-06	0.0E+00	1.00E-02	1.000	0.957	4.7E-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)
ED = 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/g = milligrams per gram 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
OD = 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
Maximum Exposure Doses for Racoon (*Procyon lotor*) Exposed to Soil, Water, and Contaminated Food at Acid Area 2, Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Conc. Soil	BCF_{inv}	IC	Conc Water	BCF_{vert}	BCF_{plants}	VC	PC	P_{vert}	P_{inv}	P_{plant}	P_{sed}	IR	WI	II	IV	IP	IS	IW	HRF	ED	BW	OD
	mg/g_{sed} (dry wt)	mg/kg wet	mg/g_{inv} (wet wt)	mg/L	mg/kg (dry wt)	mg/kg (dry wt)	mg/g_{vert} (dry wt)	mg/g_{plant} (dry wt)					kg_{diet}/day (Dry wt)	L/day	mg/day inv	mg/day vert	mg/day plant	mg/day soil	mg/day water		fraction of year	kg	mg/kg/day
2,4-Dinitrotoluene	5.80E+00	5.80E+01	3.4E+02	0.00E+00	2.10E+01	2.51E+03	0.00E+00	1.45E+04	0.05	0.51	0.42	0.094	0.26	4.3E-01	4.5E+01	0.0E+00	1.6E+03	1.4E-01	0.0E+00	6.00E-02	0.667	5.1	1.3E+01
3-Nitrotoluene	1.57E-01	7.25E+00	1.1E+00	0.00E+00	2.78E+01	7.25E+00	0.00E+00	1.14E+00	0.05	0.51	0.42	0.094	0.26	4.3E-01	1.5E-01	0.0E+00	1.2E-01	3.8E-03	0.0E+00	6.00E-02	0.667	5.1	2.2E-03
Aluminum	9.52E+03	9.00E-01	8.6E+03	6.34E-01	2.70E+00	8.33E+02	1.71E+00	7.93E+06	0.05	0.51	0.42	0.094	0.26	4.3E-01	1.1E+03	2.3E-01	8.7E+05	2.3E+02	2.7E-01	6.00E-02	0.667	5.1	6.8E+03
Barium	0.00E+00	9.00E-01	0.0E+00	3.66E-02	6.33E+02	2.60E+02	2.32E+01	0.00E+00	0.05	0.51	0.42	0.094	0.26	4.3E-01	0.0E+00	3.1E+00	0.0E+00	0.0E+00	1.6E-02	6.00E-02	0.667	5.1	2.4E-02
Cadmium	6.89E-01	3.40E+00	2.3E+00	0.00E+00	9.07E+02	7.82E+02	0.00E+00	5.39E+02	0.05	0.51	0.42	0.094	0.26	4.3E-01	3.1E-01	0.0E+00	5.9E+01	1.7E-02	0.0E+00	6.00E-02	0.667	5.1	4.6E-01
Copper	1.89E+01	3.00E-01	5.7E+00	7.40E-03	7.10E+02	5.41E+02	5.25E+00	1.02E+04	0.05	0.51	0.42	0.094	0.26	4.3E-01	7.5E-01	7.0E-01	1.1E+03	4.6E-01	3.2E-03	6.00E-02	0.667	5.1	8.8E+00
Iron	0.00E+00	9.00E-01	0.0E+00	9.89E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.05	0.51	0.42	0.094	0.26	4.3E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.3E-01	6.00E-02	0.667	5.1	3.3E-03
Lead	2.94E+03	6.30E-01	1.8E+03	3.90E-03	9.00E-02	1.71E+03	3.51E-04	5.01E+06	0.05	0.51	0.42	0.094	0.26	4.3E-01	2.5E+02	4.7E-05	5.5E+05	7.2E+01	1.7E-03	6.00E-02	0.667	5.1	4.3E+03
Manganese	0.00E+00	9.00E-01	0.0E+00	5.95E-02	3.50E+01	0.00E+00	2.08E+00	0.00E+00	0.05	0.51	0.42	0.094	0.26	4.3E-01	0.0E+00	2.8E-01	0.0E+00	0.0E+00	2.6E-02	6.00E-02	0.667	5.1	2.4E-03
Mercury	2.76E-01	6.80E-02	1.9E-02	0.00E+00	3.53E+03	2.48E+04	0.00E+00	6.83E+03	0.05	0.51	0.42	0.094	0.26	4.3E-01	2.5E-03	0.0E+00	7.5E+02	6.7E-03	0.0E+00	6.00E-02	0.667	5.1	5.9E+00
Thallium	5.24E+00	9.00E-01	4.7E+00	0.00E+00	1.00E+04	1.50E+04	0.00E+00	7.86E+04	0.05	0.51	0.42	0.094	0.26	4.3E-01	6.3E-01	0.0E+00	8.6E+03	1.3E-01	0.0E+00	6.00E-02	0.667	5.1	6.7E+01
Zinc	1.21E+02	5.70E-01	6.9E+01	0.00E+00	2.06E+03	2.18E+03	0.00E+00	2.63E+05	0.05	0.51	0.42	0.094	0.26	4.3E-01	9.1E+00	0.0E+00	2.9E+04	3.0E+00	0.0E+00	6.00E-02	0.667	5.1	2.3E+02
PCB-1254	1.60E+01	5.30E-01	8.5E+00	0.00E+00	2.30E+05	4.77E+05	0.00E+00	7.63E+06	0.05	0.51	0.42	0.094	0.26	4.3E-01	1.1E+00	0.0E+00	8.3E+05	3.9E-01	0.0E+00	6.00E-02	0.667	5.1	6.5E+03
PCB-1260	4.29E+00	3.26E+04	1.4E+05	0.00E+00	3.18E+05	3.26E+04	0.00E+00	1.40E+05	0.05	0.51	0.42	0.094	0.26	4.3E-01	1.9E+04	0.0E+00	1.5E+04	1.0E-01	0.0E+00	6.00E-02	0.667	5.1	2.7E+02
Benzaldehyde	9.59E-02	1.16E+00	1.1E-01	0.00E+00	3.64E+00	1.16E+00	0.00E+00	1.12E-01	0.05	0.51	0.42	0.094	0.26	4.3E-01	1.5E-02	0.0E+00	1.2E-02	2.3E-03	0.0E+00	6.00E-02	0.667	5.1	2.3E-04
Benzo(a)anthracene	8.50E+00	1.45E+00	1.2E+01	0.00E+00	5.00E+02	5.26E+03	0.00E+00	4.47E+04	0.05	0.51	0.42	0.094	0.26	4.3E-01	1.6E+00	0.0E+00	4.9E+03	2.1E-01	0.0E+00	6.00E-02	0.667	5.1	3.8E+01
Benzo(a)pyrene	7.30E+00	1.59E+00	1.2E+01	0.00E+00	5.00E+02	5.26E+03	0.00E+00	3.84E+04	0.05	0.51	0.42	0.094	0.26	4.3E-01	1.5E+00	0.0E+00	4.2E+03	1.8E-01	0.0E+00	6.00E-02	0.667	5.1	3.3E+01
bis(2-Ethylhexyl)phthalate	0.00E+00	1.31E+03	0.0E+00	2.55E-03	7.00E+01	9.93E+03	1.79E-01	0.00E+00	0.05	0.51	0.42	0.094	0.26	4.3E-01	0.0E+00	2.4E-02	0.0E+00	0.0E+00	1.1E-03	6.00E-02	0.667	5.1	1.9E-04
Carbazole	1.50E+00	6.23E+01	9.3E+01	0.00E+00	3.03E+02	6.23E+01	0.00E+00	9.34E+01	0.05	0.51	0.42	0.094	0.26	4.3E-01	1.2E+01	0.0E+00	1.0E+01	3.7E-02	0.0E+00	6.00E-02	0.667	5.1	1.8E-01
Chrysene	8.30E+00	1.38E+00	1.1E+01	0.00E+00	5.00E+02	5.26E+03	0.00E+00	4.36E+04	0.05	0.51	0.42	0.094	0.26	4.3E-01	1.5E+00	0.0E+00	4.8E+03	2.0E-01	0.0E+00	6.00E-02	0.667	5.1	3.7E+01
Dibenzofuran	5.18E-01	1.97E+02	1.0E+02	0.00E+00	1.09E+03	1.97E+02	0.00E+00	1.02E+02	0.05	0.51	0.42	0.094	0.26	4.3E-01	1.4E+01	0.0E+00	1.1E+01	1.3E-02	0.0E+00	6.00E-02	0.667	5.1	1.9E-01
Di-n-butylphthalate	9.23E+00	1.72E+02	1.6E+03	0.00E+00	9.38E+02	1.72E+02	0.00E+00	1.59E+03	0.05	0.51	0.42	0.094	0.26	4.3E-01	2.1E+02	0.0E+00	1.7E+02	2.3E-01	0.0E+00	6.00E-02	0.667	5.1	3.0E+00
Naphthalene	3.26E-01	3.60E+01	1.2E+01	0.00E+00	1.65E+02	3.60E+01	0.00E+00	1.17E+01	0.05	0.51	0.42	0.094	0.26	4.3E-01	1.6E+00	0.0E+00	1.3E+00	8.0E-03	0.0E+00	6.00E-02	0.667	5.1	2.2E-02
Acetone	8.60E+00	4.70E-02	4.0E-01	0.00E+00	1.03E-01	4.70E-02	0.00E+00	4.04E-01	0.05	0.51	0.42	0.094	0.26	4.3E-01	5.4E-02	0.0E+00	4.4E-02	2.1E-01	0.0E+00	6.00E-02	0.667	5.1	2.4E-03
Cyclohexane	5.99E-03	4.69E+01	2.8E-01	0.00E+00	2.21E+02	4.69E+01	0.00E+00	2.81E-01	0.05	0.51	0.42	0.094	0.26	4.3E-01	3.7E-02	0.0E+00	3.1E-02	1.5E-04	0.0E+00	6.00E-02	0.667	5.1	5.3E-04
Methylcyclohexane	6.07E-03	6.47E+01	3.9E-01	#N/A	3.16E+02	6.47E+01	ND	3.92E-01	0.05	0.51	0.42	0.094	0.26	4.3E-01	5.2E-02	0.0E+00	4.3E-02	1.5E-04	0.0E+00	6.00E-02	0.667	5.1	7.5E-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)
ED = 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 = mg/day = milligr milligrams per day from food item (inv = invertebrate; plant; sed = sediment)
mg/g = mg/g = milligr milligrams per gram of food item (inv = invertebrate; plant; sed = sediment)
mg/kg/day = mg/kg/day = milligr milligrams per kilogram body weight per day
mg/L = mg/L = milligr milligrams per liter of water
NA = NA = not ap not applicable
ND = ND = contar contaminant not detected in medium at a concentration above its reporting limit
OD = OD = expos exposure dose to the omnivore = ([II+IP+IS+IW] x HRF x ED) / BW
P = P = propoı proportion of ingestion composed of food item (inv = invertebrate; plant; sed = sediment)
PC = PC = conce concentration in plant material (SC x C x SCF_{sed})
SC_{max} = SC_{max} = maxim maximum detected concentration in sediment
WC_{max} = WC_{max} = maxim maximum detected concentration in surface water
wt = wt = weigh weight
WI = WI = daily v daily water ingestion rate

Table 3-10

Maximum Exposure Doses for Mallard Duck (*Anas platyrhynchos*) Exposed to Sediment, Water, and Contaminated Food at Acid Area 2, Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Conc. Sediment	BCF_{inv}	IC	Conc Water	BCF_{plants}	PC	P_{inv}	P_{plant}	P_{sed}	IR	WI	II	IP	IS	IW	HRF	ED	BW	OD
	mg/g_{sed} (dry wt)	mg/kg wet	mg/g_{inv} (wet wt)	mg/L	mg/kg (dry wt)	mg/g_{plant} (dry wt)				kg_{diet}/day (Dry wt)	L/day	mg/day inv	mg/day plant	mg/day soil	mg/day water		fraction of year	kg	mg/kg/day
Cyanide	3.78E-01	9.00E-01	3.4E-01	0.00E+00	2.20E+01	8.32E+00	0.38	0.625	0.02	0.063	6.4E-02	8.0E-03	3.3E-01	4.8E-04	0.0E+00	2.00E-02	0.583	1.13	3.5E-03
1,3,5-Trinitrobenzene	1.40E-01	5.80E+01	8.1E+00	0.00E+00	2.51E+03	3.51E+02	0.38	0.625	0.02	0.063	6.4E-02	1.9E-01	1.4E+01	1.8E-04	0.0E+00	2.00E-02	0.583	1.13	1.4E-01
2,4,6-Trinitrotoluene	7.70E-01	5.80E+01	4.5E+01	0.00E+00	2.51E+03	1.93E+03	0.38	0.625	0.02	0.063	6.4E-02	1.1E+00	7.6E+01	9.7E-04	0.0E+00	2.00E-02	0.583	1.13	8.0E-01
HMX	5.30E-01	2.17E-01	1.2E-01	0.00E+00	2.17E-01	1.15E-01	0.38	0.625	0.02	0.063	6.4E-02	2.7E-03	4.5E-03	6.7E-04	0.0E+00	2.00E-02	0.583	1.13	8.2E-05
Aluminum	1.08E+04	9.00E-01	9.7E+03	6.34E-01	8.33E+02	8.96E+06	0.38	0.625	0.02	0.063	6.4E-02	2.3E+02	3.5E+05	1.4E+01	4.1E-02	2.00E-02	0.583	1.13	3.6E+03
Barium	0.00E+00	9.00E-01	0.0E+00	3.66E-02	2.60E+02	0.00E+00	0.38	0.625	0.02	0.063	6.4E-02	0.0E+00	0.0E+00	0.0E+00	2.3E-03	2.00E-02	0.583	1.13	2.4E-05
Beryllium	1.10E+00	9.00E-01	9.9E-01	0.00E+00	1.41E+02	1.55E+02	0.38	0.625	0.02	0.063	6.4E-02	2.3E-02	6.1E+00	1.4E-03	0.0E+00	2.00E-02	0.583	1.13	6.3E-02
Cadmium	9.80E-01	3.40E+00	3.3E+00	0.00E+00	7.82E+02	7.66E+02	0.38	0.625	0.02	0.063	6.4E-02	7.9E-02	3.0E+01	1.2E-03	0.0E+00	2.00E-02	0.583	1.13	3.1E-01
Chromium	1.75E+01	3.90E-01	6.8E+00	0.00E+00	4.41E+03	7.71E+04	0.38	0.625	0.02	0.063	6.4E-02	1.6E-01	3.0E+03	2.2E-02	0.0E+00	2.00E-02	0.583	1.13	3.1E+01
Copper	0.00E+00	3.00E-01	0.0E+00	7.40E-03	5.41E+02	0.00E+00	0.38	0.625	0.02	0.063	6.4E-02	0.0E+00	0.0E+00	0.0E+00	4.7E-04	2.00E-02	0.583	1.13	4.9E-06
Iron	0.00E+00	9.00E-01	0.0E+00	9.89E-01	0.00E+00	0.00E+00	0.38	0.625	0.02	0.063	6.4E-02	0.0E+00	0.0E+00	0.0E+00	6.3E-02	2.00E-02	0.583	1.13	6.5E-04
Lead	7.76E+02	6.30E-01	4.9E+02	3.90E-03	1.71E+03	1.32E+06	0.38	0.625	0.02	0.063	6.4E-02	1.2E+01	5.2E+04	9.8E-01	2.5E-04	2.00E-02	0.583	1.13	5.4E+02
Manganese	0.00E+00	9.00E-01	0.0E+00	5.95E-02	0.00E+00	0.00E+00	0.38	0.625	0.02	0.063	6.4E-02	0.0E+00	0.0E+00	0.0E+00	3.8E-03	2.00E-02	0.583	1.13	3.9E-05
Mercury	2.30E-01	6.80E-02	1.6E-02	0.00E+00	2.48E+04	5.70E+03	0.38	0.625	0.02	0.063	6.4E-02	3.7E-04	2.2E+02	2.9E-04	0.0E+00	2.00E-02	0.583	1.13	2.3E+00
Selenium	3.72E+00	9.00E-01	3.3E+00	0.00E+00	1.85E+03	6.86E+03	0.38	0.625	0.02	0.063	6.4E-02	7.9E-02	2.7E+02	4.7E-03	0.0E+00	2.00E-02	0.583	1.13	2.8E+00
Thallium	4.73E+00	9.00E-01	4.3E+00	0.00E+00	1.50E+04	7.10E+04	0.38	0.625	0.02	0.063	6.4E-02	1.0E-01	2.8E+03	6.0E-03	0.0E+00	2.00E-02	0.583	1.13	2.9E+01
PCB-1260	5.78E+00	3.26E+04	1.9E+05	0.00E+00	3.26E+04	1.88E+05	0.38	0.625	0.02	0.063	6.4E-02	4.5E+03	7.4E+03	7.3E-03	0.0E+00	2.00E-02	0.583	1.13	1.2E+02
2-Methylnaphthalene	5.40E-02	1.12E+02	6.0E+00	0.00E+00	1.12E+02	6.03E+00	0.38	0.625	0.02	0.063	6.4E-02	1.4E-01	2.4E-01	6.8E-05	0.0E+00	2.00E-02	0.583	1.13	3.9E-03
4-Methylphenol (p-Cresol)	2.12E-01	2.90E+00	6.1E-01	0.00E+00	2.90E+00	6.14E-01	0.38	0.625	0.02	0.063	6.4E-02	1.5E-02	2.4E-02	2.7E-04	0.0E+00	2.00E-02	0.583	1.13	4.0E-04
Acenaphthylene	2.51E-01	5.25E+01	1.3E+01	0.00E+00	5.25E+01	1.32E+01	0.38	0.625	0.02	0.063	6.4E-02	3.1E-01	5.2E-01	3.2E-04	0.0E+00	2.00E-02	0.583	1.13	8.6E-03
Acetophenone	1.56E-01	1.41E+00	2.2E-01	0.00E+00	1.41E+00	2.19E-01	0.38	0.625	0.02	0.063	6.4E-02	5.2E-03	8.6E-03	2.0E-04	0.0E+00	2.00E-02	0.583	1.13	1.4E-04
Anthracene	4.30E-01	3.81E+02	1.6E+02	0.00E+00	3.81E+02	1.64E+02	0.38	0.625	0.02	0.063	6.4E-02	3.9E+00	6.4E+00	5.4E-04	0.0E+00	2.00E-02	0.583	1.13	1.1E-01
Benzaldehyde	3.29E-01	1.16E+00	3.8E-01	0.00E+00	1.16E+00	3.83E-01	0.38	0.625	0.02	0.063	6.4E-02	9.1E-03	1.5E-02	4.1E-04	0.0E+00	2.00E-02	0.583	1.13	2.5E-04
Benzo(a)anthracene	3.27E-01	1.45E+00	4.7E-01	0.00E+00	5.26E+03	1.72E+03	0.38	0.625	0.02	0.063	6.4E-02	1.1E-02	6.8E+01	4.1E-04	0.0E+00	2.00E-02	0.583	1.13	7.0E-01
Benzo(a)pyrene	2.90E+00	1.59E+00	4.6E+00	0.00E+00	5.26E+03	1.52E+04	0.38	0.625	0.02	0.063	6.4E-02	1.1E-01	6.0E+02	3.7E-03	0.0E+00	2.00E-02	0.583	1.13	6.2E+00
Benzo(b)fluoranthene	2.90E+00	1.61E+00	4.7E+00	0.00E+00	5.26E+03	1.52E+04	0.38	0.625	0.02	0.063	6.4E-02	1.1E-01	6.0E+02	3.7E-03	0.0E+00	2.00E-02	0.583	1.13	6.2E+00
Benzo(g,h,i)perylene	1.10E+00	2.19E+04	2.4E+04	0.00E+00	2.19E+04	2.41E+04	0.38	0.625	0.02	0.063	6.4E-02	5.7E+02	9.5E+02	1.4E-03	0.0E+00	2.00E-02	0.583	1.13	1.6E+01
Benzo(k)fluoranthene	2.20E+00	1.61E+00	3.5E+00	0.00E+00	5.26E+03	1.16E+04	0.38	0.625	0.02	0.063	6.4E-02	8.4E-02	4.6E+02	2.8E-03	0.0E+00	2.00E-02	0.583	1.13	4.7E+00
Benzoic acid	7.84E-01	2.43E+00	1.9E+00	0.00E+00	2.43E+00	1.90E+00	0.38	0.625	0.02	0.063	6.4E-02	4.5E-02	7.5E-02	9.9E-04	0.0E+00	2.00E-02	0.583	1.13	1.2E-03
bis(2-Ethylhexyl)phthalate	0.00E+00	1.31E+03	0.0E+00	2.55E-03	9.93E+03	0.00E+00	0.38	0.625	0.02	0.063	6.4E-02	0.0E+00	0.0E+00	0.0E+00	1.6E-04	2.00E-02	0.583	1.13	1.7E-06
Chrysene	2.60E+00	1.38E+00	3.6E+00	0.00E+00	5.26E+03	1.37E+04	0.38	0.625	0.02	0.063	6.4E-02	8.5E-02	5.4E+02	3.3E-03	0.0E+00	2.00E-02	0.583	1.13	5.6E+00
Dibenz(a,h)anthracene	3.20E-01	1.61E+00	5.2E-01	0.00E+00	5.26E+03	1.68E+03	0.38	0.625	0.02	0.063	6.4E-02	1.2E-02	6.6E+01	4.0E-04	0.0E+00	2.00E-02	0.583	1.13	6.8E-01
Fluoranthene	3.90E+00	8.09E+02	3.2E+03	0.00E+00	8.09E+02	3.16E+03	0.38	0.625	0.02	0.063	6.4E-02	7.5E+01	1.2E+02	4.9E-03	0.0E+00	2.00E-02	0.583	1.13	2.1E+00
Indeno(1,2,3-cd)pyrene	2.42E-01	1.61E+00	3.9E-01	0.00E+00	5.26E+03	1.27E+03	0.38	0.625	0.02	0.063	6.4E-02	9.2E-03	5.0E+01	3.0E-04	0.0E+00	2.00E-02	0.583	1.13	5.2E-01
N-Nitroso-di-n-propylamine	2.72E-01	9.29E-01	2.5E-01	0.00E+00	9.29E-01	2.53E-01	0.38	0.625	0.02	0.063	6.4E-02	6.0E-03	9.9E-03	3.4E-04	0.0E+00	2.00E-02	0.583	1.13	1.7E-04
Phenanthrene	1.80E+00	3.95E+02	7.1E+02	0.00E+00	3.95E+02	7.11E+02	0.38	0.625	0.02	0.063	6.4E-02	1.7E+01	2.8E+01	2.3E-03	0.0E+00	2.00E-02	0.583	1.13	4.6E-01
Pyrene	4.20E+00	1.09E+03	4.6E+03	0.00E+00	1.09E+03	4.60E+03	0.38	0.625	0.02	0.063	6.4E-02	1.1E+02	1.8E+02	5.3E-03	0.0E+00	2.00E-02	0.583	1.13	3.0E+00
2-Butanone (Methyl ethyl ketone)	2.25E-02	5.80E+01	1.3E+00	0.00E+00	2.51E+03	5.64E+01	0.38	0.625	0.02	0.063	6.4E-02	3.1E-02	2.2E+00	2.8E-05	0.0E+00	2.00E-02	0.583	1.13	2.3E-02
4-Methyl-2-pentanone (Methyl isobu	1.35E-02	6.74E-01	9.1E-03	0.00E+00	6.74E-01	9.10E-03	0.38	0.625	0.02	0.063	6.4E-02	2.1E-04	3.6E-04	1.7E-05	0.0E+00	2.00E-02	0.583	1.13	6.1E-06
Acetone	3.36E-01	4.70E-02	1.6E-02	0.00E+00	4.70E-02	1.58E-02	0.38	0.625	0.02	0.063	6.4E-02	3.7E-04	6.2E-04	4.2E-04	0.0E+00	2.00E-02	0.583	1.13	1.5E-05
Benzene	2.80E-03	3.97E+00	1.1E-02	0.00E+00	3.97E+00	1.11E-02	0.38	0.625	0.02	0.063	6.4E-02	2.6E-04	4.4E-04	3.5E-06	0.0E+00	2.00E-02	0.583	1.13	7.3E-06
Carbon Disulfide	2.80E-03	4.88E+00	1.4E-02	0.00E+00	4.88E+00	1.37E-02	0.38	0.625	0.02	0.063	6.4E-02	3.2E-04	5.4E-04	3.5E-06	0.0E+00	2.00E-02	0.583	1.13	8.9E-06
Cyclohexane	8.80E-03	4.69E+01	4.1E-01	0.00E+00	4.69E+01	4.13E-01	0.38	0.625	0.02	0.063	6.4E-02	9.8E-03	1.6E-02	1.1E-05	0.0E+00	2.00E-02	0.583	1.13	2.7E-04
Ethylbenzene	2.11E-03	2.72E+01	5.7E-02	0.00E+00	2.72E+01	5.73E-02	0.38	0.625	0.02	0.063	6.4E-02	1.4E-03	2.3E-03	2.7E-06	0.0E+00	2.00E-02	0.583	1.13	3.7E-05
Methylcyclohexane	9.80E-03	6.47E+01	6.3E-01	0.00E+00	6.47E+01	6.34E-01	0.38	0.625	0.02	0.063	6.4E-02	1.5E-02	2.5E-02	1.2E-05	0.0E+00	2.00E-02	0.583	1.13	4.1E-04
Toluene	8.50E-03	1.23E+01	1.0E-01	0.00E+00	1.23E+01	1.05E-01	0.38	0.625	0.02	0.063	6.4E-02	2.5E-03	4.1E-03	1.1E-05	0.0E+00	2.00E-02	0.583	1.13	6.8E-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)
ED = 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/g = milligrams per gram 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
OD = 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 5-1
Hazard Quotients for Short-tailed Shrew (*Blarina brevicauda*) Exposed to Soil, Water, and Contaminated Food at Acid Area 2, Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Effect Dose (mg/kg/day)	Exposure Dose Maximum (mg/kg/day)	HQ[1]
2,4-Dinitrotoluene	2.00E-01	2.71E+00	**1E+01**
3-Nitrotoluene	4.50E+01	1.69E-01	4E-03
Aluminum	1.93E+00	4.52E+02	**2E+02**
Barium	5.10E+00	5.61E-03	1E-03
Cadmium	1.00E+00	1.08E-01	1E-01
Copper	1.17E+01	4.00E-01	3E-02
Iron	2.60E+01	1.52E-01	6E-03
Lead	8.00E+00	5.77E+01	**7E+00**
Manganese	8.80E+01	9.12E-03	1E-04
Mercury	1.00E+00	5.83E-03	6E-03
Thallium	7.40E-02	2.49E-01	**3E+00**
Zinc	1.60E+02	1.18E+01	7E-02
PCB-1254	6.80E-02	2.90E+00	**4E+01**
PCB-1260	6.80E-02	2.05E+04	**3E+05**
Benzaldehyde	1.00E+00	1.78E-02	2E-02
Benzo(a)anthracene	1.00E+00	1.67E-01	2E-01
Benzo(a)pyrene	1.00E+00	1.86E-01	2E-01
bis(2-Ethylhexyl)phthalate	1.83E+01	3.91E-04	2E-05
Carbazole	--	1.37E+01	NA
Chrysene	1.00E+00	1.75E-01	2E-01
Dibenzofuran	--	1.50E+01	NA
Di-n-butylphthalate	5.50E+02	2.33E+02	4E-01
Naphthalene	1.00E+00	1.73E+00	**2E+00**
Acetone	1.00E+01	1.90E-01	2E-02
Cyclohexane	--	4.13E-02	NA
Methylcyclohexane	--	5.77E-02	NA

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*)
Exposed to Soil, Water, and Contaminated Food at Acid Area 2,
Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Effect Dose (mg/kg/day)	Exposure Dose Maximum (mg/kg/day)	HQ[1]
2,4-Dinitrotoluene	2.00E-01	2.21E-01	**1E+00**
3-Nitrotoluene	4.50E+01	7.49E-04	2E-05
Aluminum	1.93E+00	5.74E+00	**3E+00**
Barium	5.10E+00	4.80E-05	9E-06
Cadmium	1.00E+00	1.55E-03	2E-03
Copper	1.17E+01	3.98E-03	3E-04
Iron	2.60E+01	1.30E-03	5E-05
Lead	8.00E+00	1.25E+00	2E-01
Manganese	8.80E+01	7.80E-05	9E-07
Mercury	1.00E+00	1.59E-05	2E-05
Thallium	7.40E-02	3.16E-03	4E-02
Zinc	1.60E+02	4.68E-02	3E-04
PCB-1254	6.80E-02	5.77E-03	8E-02
PCB-1260	6.80E-02	9.17E+01	**1E+03**
Benzaldehyde	1.00E+00	7.45E-05	7E-05
Benzo(a)anthracene	1.00E+00	8.19E-03	8E-03
Benzo(a)pyrene	1.00E+00	7.71E-03	8E-03
bis(2-Ethylhexyl)phthalate	1.83E+01	3.34E-06	2E-07
Carbazole	--	6.13E-02	NA
Chrysene	1.00E+00	7.62E-03	8E-03
Dibenzofuran	--	6.68E-02	NA
Di-n-butylphthalate	5.50E+02	1.04E+00	2E-03
Naphthalene	1.00E+00	7.71E-03	8E-03
Acetone	1.00E+01	3.78E-04	4E-05
Cyclohexane	--	1.84E-04	NA
Methylcyclohexane	--	2.57E-04	NA

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*) Exposed to Soil, Water, and Contaminated Food at Acid Area 2, Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Effect Dose (mg/kg/day)	Exposure Dose Maximum (mg/kg/day)	HQ[1]
2,4-Dinitrotoluene	2.00E-01	1.74E+00	**9E+00**
3-Nitrotoluene	4.50E+01	1.10E-01	2E-03
Aluminum	1.93E+00	2.21E+02	**1E+02**
Barium	5.10E+00	3.29E-03	6E-04
Cadmium	1.00E+00	6.53E-02	7E-02
Copper	1.17E+01	1.10E-01	9E-03
Iron	2.60E+01	8.90E-02	3E-03
Lead	8.00E+00	1.42E+01	**2E+00**
Manganese	8.80E+01	5.36E-03	6E-05
Mercury	1.00E+00	1.60E-03	2E-03
Thallium	7.40E-02	1.22E-01	**2E+00**
Zinc	1.60E+02	6.78E+00	4E-02
PCB-1254	6.80E-02	1.78E+00	**3E+01**
PCB-1260	6.80E-02	1.35E+04	**2E+05**
Benzaldehyde	1.00E+00	1.10E-02	1E-02
Benzo(a)anthracene	1.00E+00	4.11E-02	4E-02
Benzo(a)pyrene	1.00E+00	6.35E-02	6E-02
bis(2-Ethylhexyl)phthalate	1.83E+01	2.30E-04	1E-05
Carbazole	--	9.03E+00	NA
Chrysene	1.00E+00	4.81E-02	5E-02
Dibenzofuran	--	9.85E+00	NA
Di-n-butylphthalate	5.50E+02	1.54E+02	3E-01
Naphthalene	1.00E+00	1.14E+00	**1E+00**
Acetone	1.00E+01	5.57E-02	6E-03
Cyclohexane	--	2.72E-02	NA
Methylcyclohexane	--	3.79E-02	NA

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*)
Exposed to Soil, Water, and Contaminated Food at Acid Area 2,
Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Effect Dose (mg/kg/day)	Exposure Dose Maximum (mg/kg/day)	HQ[1]
2,4-Dinitrotoluene	2.00E-01	4.02E+01	**2E+02**
3-Nitrotoluene	4.50E+01	2.16E-01	5E-03
Aluminum	1.93E+00	1.18E+03	**6E+02**
Barium	5.10E+00	5.44E-03	1E-03
Cadmium	1.00E+00	3.22E-01	3E-01
Copper	1.17E+01	7.83E-01	7E-02
Iron	2.60E+01	1.47E-01	6E-03
Lead	8.00E+00	2.31E+02	**3E+01**
Manganese	8.80E+01	8.84E-03	1E-04
Mercury	1.00E+00	4.02E-03	4E-03
Thallium	7.40E-02	6.49E-01	**9E+00**
Zinc	1.60E+02	1.34E+01	8E-02
PCB-1254	6.80E-02	2.37E+00	**3E+01**
PCB-1260	6.80E-02	2.65E+04	**4E+05**
Benzaldehyde	1.00E+00	2.15E-02	2E-02
Benzo(a)anthracene	1.00E+00	1.47E+00	**1E+00**
Benzo(a)pyrene	1.00E+00	1.40E+00	**1E+00**
bis(2-Ethylhexyl)phthalate	1.83E+01	3.79E-04	2E-05
Carbazole	--	1.77E+01	NA
Chrysene	1.00E+00	1.38E+00	**1E+00**
Dibenzofuran	--	1.93E+01	NA
Di-n-butylphthalate	5.50E+02	3.01E+02	5E-01
Naphthalene	1.00E+00	2.22E+00	**2E+00**
Acetone	1.00E+01	1.09E-01	1E-02
Cyclohexane	--	5.32E-02	NA
Methylcyclohexane	--	7.43E-02	NA

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*)
Exposed to Soil, Water, and Contaminated Food at Acid Area 2,
Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Effect Dose (mg/kg/day)	Exposure Dose Maximum (mg/kg/day)	HQ[1]
2,4-Dinitrotoluene	2.00E-01	2.86E+01	**1E+02**
3-Nitrotoluene	4.50E+01	9.74E-02	2E-03
Aluminum	1.93E+00	7.77E+02	**4E+02**
Barium	5.10E+00	3.56E-03	7E-04
Cadmium	1.00E+00	2.02E-01	2E-01
Copper	1.17E+01	5.83E-01	5E-02
Iron	2.60E+01	9.61E-02	4E-03
Lead	8.00E+00	1.73E+02	**2E+01**
Manganese	8.80E+01	5.78E-03	7E-05
Mercury	1.00E+00	3.07E-03	3E-03
Thallium	7.40E-02	4.28E-01	**6E+00**
Zinc	1.60E+02	6.50E+00	4E-02
PCB-1254	6.80E-02	8.05E-01	**1E+01**
PCB-1260	6.80E-02	1.19E+04	**2E+05**
Benzaldehyde	1.00E+00	9.98E-03	1E-02
Benzo(a)anthracene	1.00E+00	1.09E+00	**1E+00**
Benzo(a)pyrene	1.00E+00	1.02E+00	**1E+00**
bis(2-Ethylhexyl)phthalate	1.83E+01	2.48E-04	1E-05
Carbazole	--	7.93E+00	NA
Chrysene	1.00E+00	1.02E+00	**1E+00**
Dibenzofuran	--	8.64E+00	NA
Di-n-butylphthalate	5.50E+02	1.35E+02	2E-01
Naphthalene	1.00E+00	9.98E-01	1E+00
Acetone	1.00E+01	8.02E-02	8E-03
Cyclohexane	--	2.39E-02	NA
Methylcyclohexane	--	3.33E-02	NA

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*)
Exposed to Soil, Water, and Contaminated Food at Acid Area 2,
Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Effect Dose (mg/kg/day)	Exposure Dose Maximum (mg/kg/day)	HQ[1]
2,4-Dinitrotoluene	2.00E-01	2.11E-01	**1E+00**
3-Nitrotoluene	4.50E+01	1.36E-03	3E-05
Aluminum	1.93E+00	6.46E+00	**3E+00**
Barium	5.10E+00	2.18E-05	4E-06
Cadmium	1.00E+00	1.80E-03	2E-03
Copper	1.17E+01	4.06E-03	3E-04
Iron	2.60E+01	5.89E-04	2E-05
Lead	8.00E+00	1.19E+00	1E-01
Manganese	8.80E+01	3.54E-05	4E-07
Mercury	1.00E+00	2.10E-05	2E-05
Thallium	7.40E-02	3.56E-03	5E-02
Zinc	1.60E+02	8.29E-02	5E-04
PCB-1254	6.80E-02	1.60E-02	2E-01
PCB-1260	6.80E-02	1.67E+02	**2E+03**
Benzaldehyde	1.00E+00	1.34E-04	1E-04
Benzo(a)anthracene	1.00E+00	7.59E-03	8E-03
Benzo(a)pyrene	1.00E+00	7.30E-03	7E-03
bis(2-Ethylhexyl)phthalate	1.83E+01	1.52E-06	8E-08
Carbazole	--	1.11E-01	NA
Chrysene	1.00E+00	7.12E-03	7E-03
Dibenzofuran	--	1.21E-01	NA
Di-n-butylphthalate	5.50E+02	1.90E+00	3E-03
Naphthalene	1.00E+00	1.40E-02	1E-02
Acetone	1.00E+01	5.84E-04	6E-05
Cyclohexane	--	3.35E-04	NA
Methylcyclohexane	--	4.68E-04	NA

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 Racoon (*Procyon lotor*)
Exposed to Soil, Water, and Contaminated Food at Acid Area 2,
Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Effect Dose (mg/kg/day)	Exposure Dose Maximum (mg/kg/day)	HQ[1]
2,4-Dinitrotoluene	2.00E-01	1.28E+01	**6E+01**
3-Nitrotoluene	4.50E+01	2.19E-03	5E-05
Aluminum	1.93E+00	6.80E+03	**4E+03**
Barium	5.10E+00	2.42E-02	5E-03
Cadmium	1.00E+00	4.64E-01	5E-01
Copper	1.17E+01	8.77E+00	7E-01
Iron	2.60E+01	3.34E-03	1E-04
Lead	8.00E+00	4.29E+03	**5E+02**
Manganese	8.80E+01	2.37E-03	3E-05
Mercury	1.00E+00	5.85E+00	**6E+00**
Thallium	7.40E-02	6.73E+01	**9E+02**
Zinc	1.60E+02	2.25E+02	**1E+00**
PCB-1254	6.80E-02	6.53E+03	**1E+05**
PCB-1260	6.80E-02	2.65E+02	**4E+03**
Benzaldehyde	1.00E+00	2.30E-04	2E-04
Benzo(a)anthracene	1.00E+00	3.83E+01	**4E+01**
Benzo(a)pyrene	1.00E+00	3.29E+01	**3E+01**
bis(2-Ethylhexyl)phthalate	1.83E+01	1.94E-04	1E-05
Carbazole	--	1.77E-01	NA
Chrysene	1.00E+00	3.74E+01	**4E+01**
Dibenzofuran	--	1.93E-01	NA
Di-n-butylphthalate	5.50E+02	3.02E+00	5E-03
Naphthalene	1.00E+00	2.23E-02	2E-02
Acetone	1.00E+01	2.42E-03	2E-04
Cyclohexane	--	5.34E-04	NA
Methylcyclohexane	--	7.45E-04	NA

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*)
Exposed to Sediment, Water, and Contaminated Food at Acid Area 2,
Plum Brook Ordnance Works, Sandusky, Ohio

Contaminant of Potential Ecological Concern (COPEC)	Effect Dose (mg/kg/day)	Exposure Dose Maximum (mg/kg/day)	HQ[1]
Cyanide	--	3.47E-03	NA
1,3,5-Trinitrobenzene	--	1.45E-01	NA
2,4,6-Trinitrotoluene	7.00E-01	7.96E-01	**1E+00**
HMX	--	8.18E-05	NA
Aluminum	1.10E+02	3.64E+03	**3E+01**
Barium	2.08E+01	2.42E-05	1E-06
Beryllium	--	6.33E-02	NA
Cadmium	1.45E+00	3.12E-01	2E-01
Chromium	1.00E+00	3.13E+01	**3E+01**
Copper	4.70E+01	4.89E-06	1E-07
Iron	5.00E+01	6.53E-04	1E-05
Lead	3.85E+00	5.38E+02	**1E+02**
Manganese	9.77E+02	3.93E-05	4E-08
Mercury	4.50E-01	2.32E+00	**5E+00**
Selenium	5.00E-01	2.79E+00	**6E+00**
Thallium	3.50E-01	2.88E+01	**8E+01**
PCB-1260	1.80E-01	1.23E+02	**7E+02**
2-Methylnaphthalene	--	3.92E-03	NA
4-Methylphenol (p-Cresol)	--	4.02E-04	NA
Acenaphthylene	--	8.58E-03	NA
Acetophenone	--	1.45E-04	NA
Anthracene	--	1.06E-01	NA
Benzaldehyde	--	2.53E-04	NA
Benzo(a)anthracene	--	6.99E-01	NA
Benzo(a)pyrene	--	6.20E+00	NA
Benzo(b)fluoranthene	--	6.20E+00	NA
Benzo(g,h,i)perylene	--	1.57E+01	NA
Benzo(k)fluoranthene	--	4.70E+00	NA
Benzoic acid	--	1.25E-03	NA
bis(2-Ethylhexyl)phthalate	1.11E+00	1.68E-06	2E-06
Chrysene	--	5.56E+00	NA
Dibenz(a,h)anthracene	--	6.84E-01	NA
Fluoranthene	--	2.05E+00	NA
Indeno(1,2,3-cd)pyrene	--	5.17E-01	NA
N-Nitroso-di-n-propylamine	#N/A	1.68E-04	NA
Phenanthrene	#N/A	4.63E-01	NA
Pyrene	--	2.99E+00	NA
2-Butanone (Methyl ethyl ketone)	--	2.32E-02	NA
4-Methyl-2-pentanone (Methyl isobutyl keto	--	6.09E-06	NA
Acetone	5.20E+01	1.46E-05	3E-07
Benzene	--	7.26E-06	NA
Carbon Disulfide	--	8.93E-06	NA
Cyclohexane	--	2.69E-04	NA
Ethylbenzene	--	3.73E-05	NA
Methylcyclohexane	--	4.12E-04	NA
Toluene	--	6.81E-05	NA

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

APPENDIX A

ECOLOGICAL SURVEY

DAVEY
RESOURCE GROUP
A Division of The Davey Tree Expert Company

October 4, 2006

Corporate Headquarters
1500 North Mantua Street
P.O. Box 5193
Kent, OH 44240-5193
330•673•5685
Toll Free 1•800•828•8312
FAX: 330•673•0860

Jon Russ
Jacobs Engineering
1527 Cole Boulevard, Building #2
Golden Colorado 80401

Dear Mr. Russ:

Please find enclosed information for the NASA Plum Brook ecological survey. Included are the revised plant lists for Acid Area 2 and Acid Area 3 based on our site visit today.

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
Acid Area 2 Plant List
May 16 and October 4, 2006

Scientific Name	Common Name
Acer negundo	box elder
Achillea millefolium	yarrow
Agrimonia gryposepala	agrimony
Agrimonia parviflora	small-flowered groovebur
Agrostis alba	redtop
Alliaria petiolata	garlic mustard
Allium vineale	field garlic
Ambrosia artemisiifolia	annual ragweed
Andropogon virginicus	broom sedge
Arisaema triphyllum	jack-in-the-pulpit
Asclepias syriaca	common milkweed
Asclepias verticillata	whorled milkweed
Asparagus officinalis	asparagus
Asplenium platyneuron	ebony spleenwort
Aster cordifolius	heart-leaved aster
Aster lateriflorus	calico aster
Aster novae-angliae	New England aster
Aster pilosus	aster
Aster simplex	aster
Berberis thunbergii	barberry
Blephilia hirsute	wood mint
Boehmeria cylindrica	false nettle
Botrychium virginianum	grape fern
Brassica nigra	yellow rocket
Carex amphibola	sedge
Carex blanda	sedge
Carex davisii	sedge
Carex gracillima	sedge
Carex hirtifolia	sedge
Carex radiata	sedge
Carex tribuloides	sedge
Carya ovata	shagbark hickory
Chrysanthemum leucanthemum	oxeye daisy
Cinna arundinacea	wood reed grass
Circaea lutetiana	southern broad-leaved enchanters nightshade
Cirsium arvense	creeping thistle
Cirsium muticum	swamp thistle
Cornus florida	flowering dogwood

Scientific Name	Common Name
Cornus racemosa	gray dogwood
Crataegus sp.	hawthorn
Cryptotaenia canadensis	honewort
Dactylis glomerata	orchard grass
Daucus carota	queen Anne's lace
Dentaria laciniata	cut-leaved toothwort
Desmodium cuspidatum	tickseed
Dichanthelium clandestinum	witchgrass
Dipsacus sylvestris	teasel
Eleagnus umbellata	autumn olive
Elymus sp.	rye grass
Equisetum arvense	horsetail
Erigeron philadelphicus	fleabane
Eupatorium rugosum	white snakeroot
Euthamia graminifolia	fragrant flat-topped goldenrod
Fragaria virginiana	strawberry
Fraxinus americana	white ash
Fraxinus pennsylvanica	green ash
Galium aparine	cleavers
Galium circaezans	wild licorice
Geranium maculatum	wild geranium
Geum laciniatum	avens
Glecoma hederacea	ground ivy
Gleditisa triacanthos	honey locust
Glyceria striata	fowl manna grass
Gnathalium obtusifolium	catfoot
Hackelia virginiana	stickseed
Holcus lanatus	velvet grass
Hystrix patula	bottlebrush grass
Juglans nigra	black walnut
Juniperus virginiana	red cedar
Lepidium campestre	field peppergrass
Ligustrum vulgare	privet
Lobelia inflata	Indian tobacco
Lolium perenne	perennial rye grass
Lonicera japonica	Japanese honeysuckle
Lonicera tatarica	tartarian honeysuckle
Lycopus americana	horehound
Lysimachia nummularia	moneywort
Medicago lupulina	black medic
Melilotus sp.	sweet clover
Morus alba	mulberry
Oenothera biennis	evening primrose

Scientific Name	Common Name
Onoclea sensibilis	sensitive fern
Osmorhiza longistylis	sweet cicely
Oxalis europaea	sorrell
Panicum dichotomoflorum	deer tongue grass
Panicum virgatum	switch grass
Parthenocissus quinquefolia	Virginia creeper
Phleum pratense	timothy
Phryma leptostachya	lopseed
Phytolacca americana	pokeweed
Pilea pumila	clearweed
Plantago lanceolata	English plantain
Plantago major	common plantain
Platanus occidentalis	sycamore
Poa alsodes	bluegrass
Podophyllum peltatum	mayapple
Polygonum virginianum	Virginia knotweed
Populus deltoides	cottonwood
Potentilla norvegica	cinquefoil
Potentilla simplex	old field cinquefoil
Prunella vulgaris	self heal
Prunus serotina	black cherry
Pycnanthemum tenuifolium	mountain mint
Quercus macrocarpa	bur oak
Quercus rubra	red oak
Ranunculus recurvatus	hooked crowfoot
Ribes cynosbati	gooseberry
Rosa multiflora	multiflora rose
Rosa setigera	prairie rose
Rubus allegheniensis	Allegheny blackberry
Rubus flagellaris	dewberry
Rubus occidentalis	black raspberry
Rudbeckia hirta	black-eyed Susan
Sassafras albidum	sassafras
Satureja vulgaris	wild basil
Senecio aureus	golden alexanders
Setaria glauca	bristle grass
Spiranthes cernua	nodding ladies tresses
Solanum nigrum	black nightshade
Taraxacum officinale	dandelion
Tilia americana	basswood

Scientific Name	Common Name
Toxicodendron radicans	poison ivy
Trifolium hybridium	alsike clover
Ulmus americana	American elm
Ulmus rubra	slippery elm
Verbascum blattaria	moth mullein
Verbena urticifolia	white vervain
Verbesina alternifolia	wingstem
Viola incognita	white violet
Viola papilionacea	blue violet
Vitis riparia	riverbank grape

NASA Plum Brook
Sandusky, Ohio
Acid Area 3 Plant List
May 16 and October 4, 2006

Scientific Name	Common Name
Acer negundo	box elder
Acer platanoides	Norway maple
Acer rubrum	red maple
Acer saccharum	sugar maple
Achillea millefolium	yarrow
Actaea pachypoda	white baneberry
Agrimonia gryposepala	agrimony
Agrostis alba	redtop
Alisma plantago-aquatica	water plantain
Alliaria petiolata	garlic mustard
Andropogon virginicus	broom sedge
Anthoxanthum odoratum	sweet vernal grass
Asclepias incarnata	swamp milkweed
Asclepias syriaca	common milkweed
Asparagus officinalis	asparagus
Asplenium platyneuron	ebony spleenwort
Aster cordifolius	heart-leaved aster
Aster lateriflorus	calico aster
Aster simplex	aster
Berberis thunbergii	barberry
Bidens frondosa	beggar ticks
Brassica nigra	yellow rocket
Carex laxiflora	sedge
Carex lurida	sedge
Carex normalis	sedge
Carex tribuloides	sedge
Carya ovata	shagbark hickory
Chara sp.	chara
Chrysanthemum leucanthemum	oxeye daisy
Cichorium intybus	chicory
Cinna arundinacea	wood reed grass
Cirsium arvense	creeping thistle
Cirsium vulgare	bull thistle
Claytonia virginiana	narrow-leaved spring beauty
Cornus racemosa	gray dogwood
Crataegus sp.	hawthorn

Scientific Name	Common Name
Cryptotaenia canadensis	honewort
Dactylis glomerata	orchard grass
Daucus carota	queen Anne's lace
Dentaria laciniata	cut leaved toothwort
Desmodium cuspidatum	tickseed
Dianthus armeria	deptford pink
Dicanthelium clandestinum	witch grass
Dipsacus sylvestris	teasel
Eleagnus umbellata	autumn olive
Eleocharis calva	spike rush
Elymus sp.	wild rye
Equisetum arvense	horsetail
Equisetum hyemale	horsetail
Erigeron philadelphicus	common fleabane
Eupatorium perfoliatum	boneset
Eupatorium rugosum	white snakeroot
Euthamia graminifolia	fragrant flat-topped goldenrod
Festuca sp.	fescue
Galium aparine	cleavers
Galium circaezans	wild licorice
Geum laciniatum	avens
Gleditsia triacanthos	honey locust
Glyceria striata	fowl manna grass
Hydrophyllum virginianum	Virginia waterleaf
Hystrix patula	bottlebrush grass
Juniperus virginiana	red cedar
Leersia virginica	white grass
Lemna minor	lesser duckweed
Lobelia siphilitica	blue lobelia
Lonicera tatarica	tartarian honeysuckle
Ludwigia palustris	water purslane
Lycopus americana	horehound
Matricaria matricarioides	pineapple weed
Medicago lupulina	black medic
Melilotus sp.	sweet clover
Mentha piperita	peppermint
Nepeta cataria	catnip
Onoclea sensibilis	sensitive fern
Osmorhiza longistylis	sweet cicely
Oxalis europaea	sorrell
Panicum dichotomoflorum	deer tongue grass
Panicum virgatum	switch grass

Scientific Name	Common Name
Parthenocissus quinquefolia	Virginia creeper
Penstemon digitalis	beard-tongue
Phleum pratense	timothy
Phryma leptostachya	lopseed
Plantago lanceolata	English plantain
Plantago major	common plantain
Platanus occidentalis	sycamore
Poa sp.	bluegrass
Podophyllum peltatum	mayapple
Polygonum virginianum	Virginia knotweed
Populus deltoides	cottonwood
Potamogeton pectinatus	pondweed
Prunus serotina	black cherry
Pteridium aquilinum	bracken fern
Pycnanthemum teniufolium	mountain mint
Quercus imbricaria	shingle oak
Quercus macrocarpa	bur oak
Quercus palustris	pin oak
Quercus rubra	red oak
Rosa multiflora	multiflora rose
Rosa setigera	prairie rose
Rubus flagellaris	dewberry
Rubus occidentalis	black raspberry
Rudbeckia hirta	black-eyed Susan
Sagittaria latifolia	arrowhead
Salix interior	sandbar willow
Salix nigra	black willow
Scutellaria lateriflora	mad dog skullcap
Senecio aureus	golden alexanders
Setaria glauca	bristle grass
Smilax rotundifolia	greenbriar
Solidago canadensis	Canada goldenrod
Solanum carolinense	horse nettle
Solanum nigrum	black nightshade
Sparganium eurycarpum	bur-reed
Specularia perfoliata	venus looking glass
Spiranthes cernua	nodding ladies tresses
Taraxacum officinale	dandelion
Teucrium canadense	American germander
Toxicodendron radicans	poison ivy
Trifolium hybridum	alsike clover
Trifolium repens	white clover
Typha angustifolia	narrow-leaved cattail

Scientific Name	Common Name
Typha latifolia	broad-leaved cattail
Verbascum blattaria	moth mullein
Verbesina alternifolia	wingstem
Vitis riparia	riverbank grape

NASA Plum Brook
Sandusky Ohio
Plant Community Description

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.

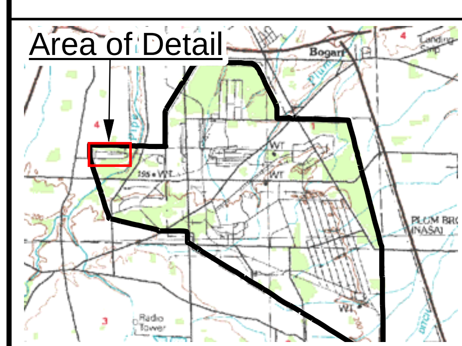
Shrub Thickets. Dense areas of shrub thickets occur in both Acid Areas. *Cornus racemosa* (gray dogwood) dominates most of these areas. *Eleagnus umbellata* (autumn olive) is also common. Small trees and saplings also occur within the shrub thickets.

Successional Woods. Successional woods are comprised of small and moderate sized trees, primarily *Fraxinus pennsylvanica* (green ash), *Acer negundo* (box elder), and *Populus 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.

Upland Woods. A small area of upland woods occurs in the northeast corner of Acid Area 3. This area contains relatively large trees including *Acer saccharum* (sugar maple) and *Tilia americana* (basswood). This area is open with few shrubs and a well developed herbaceous layer.

Lowland Woods. Wetlands on these sites are restricted to small swales. *Populus deltoides* (cottonwood) is most common in these areas. *Carex* spp. (sedges) and *Glyceria striata* (fowl manna grass) also occurs in some areas.

Marshy Drainage Ditch. The drainage ditch along the western edge of Acid Area 2 contains marshy vegetation. *Salix* sp. (willow) is becoming established in these areas too.



Legend

Pink	Upland Old Fields
Blue	Shrub Thickets
Green	Successional Woods
Orange	Lowland Woods

0 50 100 200
Feet

N

Notes: *Aerial Photography from 2005.*
Data mapped to Ohio State Plane North NAD83, map units are feet.

JACOBS

Habitat Map
Acid Area 2
Plum Brook Ordnance Works
Sandusky, Ohio

09/20/07 JKD S:/GIS/Projects/Plumbrook/Projects/Screening Level Ecological Risk Assessment/ArcGIS/AA2_Habitat_Map.mxd

Figure A-1

APPENDIX B

ASSESSMENT RECEPTOR PROFILES

Appendix B
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 animals 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 competes 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 occupy nearly every dry land habitat within their 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 (Anas platyrhynchos). The mallard duck is widespread throughout most of the United States and is the most abundant of the United States ducks. It is large, migratory duck with an average body size of 58 centimeters from bill to tail tip. Wintering mallards prefer the natural bottomland 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 yearly, 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 Naturalist***, Vol. 93, pp. 16-27.

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

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

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

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

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

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

References:

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

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

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

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

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

References:

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

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

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

White-tailed Deer (*Odocoileus virginianus*). The white-tailed deer is a member of the Family Cervidae. They are large, even-toed, hoofed mammals with long legs. Their coat is predominantly light brown or chestnut colored, with the 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, soybeans, 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) inhabiting 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 C

APPLICATION OF ESSENTIAL NUTRIENTS IN ECOLOGICAL RISK ASSESSMENT

Appendix C
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 ofthe 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 level. Table C-1 presents 24 elements known to be required by at least some animal species (McDowell, 1992).

Table C-1
General Macro and Microminerals

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

* 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 C-2 presents some of these "safe" dietary levels or mineral requirements for selected species.

Table C-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

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
FI (kg/day) = food ingestion rate
BW(kg/day) = body weight.

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

Table C-3
Food Ingestion and Body Weights

Species	Food Ingestion (FI) (kg/day)	Body Weight (Kg)
Japanese Quail	0.017 derived from (FI(kg/day) = $0.0582 \cdot BW(kg)^{0.651}$[b]	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) = $0.0687 \cdot BW(kg)^{0.822}$[b]	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.

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

Table C-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

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 C-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 C-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.

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 C-6.

Table C-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)$^{0.651}$[a]	1.6 (mean weight of male and femal chicken)[b]
Rabbits	0.2 derived from (FI(kg/day) = 0.0687*BW(kg)$^{0.822}$[a]	3.8[b]

a EPA, 1993.
b ORNL, 1996.

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

Table C-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

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 D

RESPONSES TO COMMENTS ON THE DRAFT SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT

Comments received on the Draft Screening Level Ecological Risk Assessment, Acid Area 3 from Larry Tannenbaum, U.S. Army Center for Health Promotion and Preventative Medicine, Environmental Health Risk Assessment Program, were also applied to the Draft Screening Level Ecological Risk Assessment, Acid Area 2; therefore, these comments and responses are included in this appendix.

OhioEPA

inter-office communication

To:	Paul Jayko, **NWDO-DERR**	Date: 6 December 2007
From:	Janusz Z. Byczkowski, DERR, CO	
Subject:	**Draft Screening Level Ecological Risk Assessment, Acid Area 2, Former Plum Brook Ordnance Works Sandusky, Ohio,** April 2007. Site: US NASA PLUM BROOK, TAYLOR & COLUMBUS Rds., SANDUSKY, OH 44870; ERIE Cnt.; OHID# 322-0552.	

The following memo is about the document: ***"Draft Screening Level Ecological Risk Assessment, Acid Area 2", Former Plum Brook Ordnance Works Sandusky, Ohio,*** dated September, 2007.

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

DOCUMENT TITLE: *Draft* ***Screening Level Ecological Risk Assessment, Acid Area 2***	
SITE: US NASA PLUM BROOK, TAYLOR & COLUMBUS Rds., SANDUSKY, OH 44870; ERIE Cnt.; OHID# 322-0552.	**DOCUMENT/DATE**: Draft /September 2007
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: 12/06/2007	

1. **S 1.0, P 1-1, L# 12**

Comment:

General Remark:

This Document should be revised to include some of the current Ohio EPA – Division of Emergency and Remedial Response (OEPA-DERR) remedial investigation/feasibility study (RI/FS) programmatic guidelines, especially the Ecological Risk Assessment Guidance Document (OEPA-DERR, 2003).

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.

For example, this Document states:
"... *This SLERA was prepared in accordance with the Baseline Human Health Risk Assessment and Ecological Risk Assessment Work Plans (Jacobs 2007)* ..."

However, these plans were accepted by OEPA "...*with condition that their implementation will follow the OEPA – DERR RI/FS programmatic guidelines...*" whereas in this Document none of the OEPA-DERR guidelines is even listed as a reference in the *Section 7.0*. The only place where the OEPA-DERR (2003) guidance has been mentioned is the "*Credit*" at the Figure 1-4.

Reference:

OEPA – DERR (2003) Ecological Risk Assessment Guidance Document. February 2003. On line http://www.epa.state.oh.us/derr/rules/RR-031.pdf.

Recommendation: I suggest a **revision** of the Document: (i) to include OEPA-DERR - RI/FS programmatic recommendations available on-line at: http://www.epa.state.oh.us/derr/rules/guidance.html, and (ii) to follow the suggestions and to resolve the specific issues listed below.

Response: The text has been revised to include citation of the referenced OEPA-DERR guidance and the References in Section 8.0 have been updated.

2. **S 2.2.2, P 2-7, L# 40**

Comment: This Document states: "...*Inclusion of outliers increases the overall conservatism of the risk estimate...*"

Such a generic statement is inappropriate in any science-based risk evaluation as it is simply false. The upper-bound outliers in "background" populations do not "*increase [...] conservatism of risk estimate*", neither do the lower-bound outliers in "exposed" populations. The inclusion of identified outliers in the assessment does increase data variability, and consequently, risk estimate uncertainty.

Moreover, the issue of outliers does not belong in the RI's screening level risk assessment. It should have been addressed in the DQO (U.S. EPA, 2006) and then handled accordingly (e.g., using a Visual Sample Plan, PNL, 2007; ProUCL 4.0, U.S. EPA, 2007; or other appropriate software).

References:

U.S. EPA (2006) Data Quality Assessment: A Reviewer's Guide, EPA QA/G-9R. EPA/240/B-06/002. On line http://www.epa.gov/quality/qs-docs/g9r-final.pdf

PNL (2007) Visual Sample Plan (ver. 5.0). On line http://dqo.pnl.gov/vsp/

U.S. EPA (2007) Statistical Software ProUCL 4.0 for Environmental Applications For Data Sets with and without Nondetect Observations, ProUCL Version 4.0.01. On line http://www.epa.gov/esd/tsc/software.htm.

Recommendation: Please remove this statement from the text and follow the DQO-prescribed methodology – and if needed, revise the DQO.

Response: The referenced text has been deleted from the document.

3. **S 2.2.2, P2-9, L#34**

Comment: This Document states: "...*(EPA, 1989a)...*" There is no "...*1989a*" in the reference list on P. 7-4.

Recommendation: Please remove "*a*" from the quoted reference or append the reference list.

Response: The references/callouts have been corrected.

4. **S 2.2.2, P2-10, L# 2**

Comment: This Document states: "...*elevated detection limits that exceeded the maximum detected concentration (MDC) due to matrix interference or sample dilution may be eliminated from the data set and not used in the estimation of the EPC; however, no data points were eliminated...*"

This statement seems to be cryptic, and possibly, not pertinent to the assessment that actually was performed.

Recommendation: Please rephrase or remove this statement.

Response: The referenced text has been deleted.

5. **S 3.1, P3-3, Eq.3.3**

Comment: This Document states:

"...*K_{OC} = the partition constant relative to organic carbon.*

K_{OW} = the partition constant of octanol relative to water..."

The same K_{OC} variable in the Eq. 3.2 is listed as a "*chemical-specific octanol/water partition coefficient*".

K_{OC} and K_{OW} are typically called "partition coefficients". The usual definitions of these partition coefficients are as follows:

K_{OC} = the soil organic carbon-water partitioning coefficient (it is the ratio of the mass of a chemical that is adsorbed in the soil per unit mass of organic carbon in the soil per the equilibrium chemical concentration in solution).
K_{OW} = the octanol-water partition coefficient (it is the ratio of the concentration of a chemical in octanol and in water at equilibrium and at a specified temperature).

To avoid any confusion, the same symbol or acronym should be consistently used throughout the Document to depict the same variables with the same definition.

Recommendation: Please correct explanations for coefficients used in this equation.

Response: The equations in the document have been reviewed and revised to make the terms and definitions consistent.

6. Table 2-2
Comment: In the rows for "*Sediment*", *PCB-1254* is not flagged as a COPC, despite the max. detected concentration of 1,520 ug/kg, over 25 times higher than screening level of 60 ug/kg.

According to U.S. EPA (1989): "*...infrequently detected chemicals with concentrations that greatly exceeded reference concentrations should not be eliminated...*"

Even though frequency of its detection is low (4%), PCB-1254 cannot be screened out from risk assessment. Given the information provided in the Table 2-2, it is a COPEC in surface and subsurface soil.

Reference:
U.S. EPA (1989) Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part A), Interim Final, EPA/540/1-89/002, December 1989. On-line: http://www.epa.gov/oswer/riskassessment/ragsa/index.htm.

Recommendation: Please flag **PCB-1254** in Sediment as "**COPC**".

Response: Quantitative analysis of this constituent, while appropriate based on the guidance, is not warranted because PCB-1254 was only detected in one sediment sample at the site. Additionally, the PRG was based on residential contact with soil, which likely overestimates potential risk from exposure to sediment.

7. Figure 2-2
Comment: This Document states: "*...Passive Uptade...*", "*...Injestion...*" Likely typos.

Recommendation: Please correct typos.

Response: The typos have been corrected.

Comments of Jim Beaujon Concerning Jacob's *Draft Screening Level Ecological Risk Assessment, Acid Area 2*, Former Plum Brook Ordnance Works, dated September 2007

1. Page v, Acronyms: "formerly used defense site" should be "Formerly Used Defense Sites", note, in addition to upper case change "Sites" is plural. Also, shouldn't "H_o" be identified as "null hypotheses"?

Response: "H_o" has been identified as "null hypotheses" and the acronyms have been corrected.

2. Executive Summary: Please add an Executive Summary.

Response: An Executive Summary has been added to the document.

3. Page 1-1, Section 1.0, 2nd paragraph: Please change appropriate sentences to read- "This work is being conducted for … (DERP)-Formerly Used Defense Sites (FUDS). Investigations at PBOW under DERP-FUDS are being managed by" …

Response: In response to this comment and a similar comment from another reviewer, the text has been revised as follows:

"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 US"ACE Huntington District and technically overseen by the USACE Nashville District (CELRN)."

4. Page 2-1, Section 2.1.1, 1st paragraph, reference to Figure 1-1: Given this is the first reference to Figure 1-1 shouldn't it be relabeled Figure 2-1 and the other figures and references to them relabeled as necessary? Also, Figure 1-2 doesn't appear to be referenced at all in the text. Maybe it should be relabeled Figure 2-2 and also referenced in Section 2.1.1.

Response: Figures 1-1 and 1-2 are now called out in Section 1.0.

5. Page 2-2, 1st full paragraph: Change "Power" to "Powder". Also, the Trojan Powder Company never owned the PBOW property. PBOW was a GOCO, Government-Owned, Contractor Operated, facility. GOCO = A manufacturing plant that is owned by the Government and operated under contract by a non-government, private firm.

Response: The text has been revised as requested.

6. Page 2-3, Section 2.1.4, 2nd paragraph, last line: Change "community types" to "community type".

Response: The text has been revised as requested.

7. Page 2-4, Section 2.1.5, 4th paragraph: Reference is made to a "recent" change in NASA's burning practices, yet the citation is dated 1998. Given the "change" was nearly 10 years ago shouldn't you check with our current NASA contact (Bob Lallier) to confirm that this is still the practice?

Response: In response to this comment, the reference to "Peecook 1998" has been deleted and the first two sentences of the subject paragraph have been replaced with the following text:

The large deer population that feeds on much of the ground cover at the former PBOW limits the cover available for nesting birds and results in increased predation for these species (ODNR, 1995). Current burning practices used by NASA limit ground cover over the eastern portion of PBOW. However, burning is not conducted in the western portion of the installation where Acid Area 2 is located or near buildings, and there is at least one building located at Acid Area 2. Burning has not been conducted in the Acid Area 2 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 2, as any ground cover affected by previous burning would have had ample time to recover.

8. Page 2-6, Section 2.2.1, 2nd line: Change "was been considered" to "was considered".

Response: The text has been revised as requested.

9. Page 2-7, sentence just prior to Section 2.2.2: Relative to the rationale used for DNT data selection, what was the rationale or where was/is it presented?

Response: The rationale for DNT data selection has been added to this section.

10. Page 2-8: Definitions for Equation 2.2 variables: The "s_y" in the equation appears to use a lower case "s" rather than the upper case as used in the definition.

Response: The "S" in the definition has been changed to lower case.

11. Page 2-10, Section 2.2.5, 1st paragraph: Please edit for clarity. The first reference to "derivation of BSCs" (4th line of paragraph) appears to be for groundwater but it isn't clearly stated (e.g. "derivation of groundwater BSCs"). Then in the last sentence "Background values for soil" are mentioned, are these also BSCs?

Response: The text has been revised for clarity. There are BSCs for groundwater and soil. The discussion of groundwater BSCs has been deleted as it doesn't apply to the ecological risk assessment.

12. Page 2-11, Section 2.2.6: Even though the BTAG Bulletin may predate the change, given the EPA's current regional naming system wouldn't it be "Region 5" rather than "Region V"?

Response: The EPA regional naming convention has been changed throughout the document in response to this comment.

13. Tables and Figures appendix: If the tables and figures are to be presented in the same appendix then they should not be segregated within the appendix but should be presented in the order in which they are first referenced in the text. For example, the figures labeled 1-1 and 1-2 are referenced before any tables therefore they should be presented in the appendix ahead of the tables.

Response: The figures and tables are now provided under separate tabs.

14. Tables: Please add page numbers to each table that lacks them, in the form of "Page # of # pages". This would probably work best as a header or footer.

Response: The page numbers have been added as requested.

15. Figures 1-1 and 1-2: See comment #4 above.

Response: Figures 1-1 and 1-2 are now called out in Section 1.0.

16. Figure 1-2: Although not critical to this document you might as well correct the following now. The area marked as Acid Area #1 is incorrect. The correct area is just south of what is marked. Also, consider narrowing the area marked for Acid Area #3. Generally the #3 area is considered to be bounded by Ransom Road on the east and the service road on the west.

Response: The figure has been modified as requested.

16. Figures 2-1, 2-4, and A-1: Please add a North arrow.

Response: North arrows have been added to the figures as requested.

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: Draft Screening Level Ecological Risk Assessment (SLERA), Acid Area 3, Former Plum Brook Ordnance Works (PBOW), Sandusky, OH, September 2007

1. 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 AR 200-1 (Environmental Protection and Enhancement). We appreciate the opportunity to review this risk assessment.

2. Our comments and recommendations are enclosed.

3. We identify a number of technical key issues regarding the conducting of the SLERA and the interpretation of its findings. We cannot concur with the subject document as it presently stands. We look forward to providing further technical risk assessment support on this and other PBOW projects.

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

FOR THE COMMANDER:

Encl

JEFFREY S. KIRKPATRICK
Director, Health Risk Management

CF:
HQDA (DASG-PPM-NC) (wo/encl)
USACE (CENWO-HX-H) (w/encl)

COMMENTS AND RECOMMENDATIONS

1. Page 1-1, Section 1.0, L. Tannenbaum
   Introduction
   Comment: There is an error in the first sentence of the Section's fourth paragraph. A SLERA cannot determine risk, be it adverse or not. A SLERA is firstly, a screening tool only. Additionally, a SLERA is incapable of producing a metric that expresses risk, the probability of a toxicological endpoint coming about. SLERA's deal only with hazard quotients (HQ), which are not expressions of risk. See Comments 7 and 8.
   Recommendation: Please reword the identified sentence. Consider using: "The primary objective of this SLERA is to determine the potential for there to be health effects in certain site-exposed ecological receptors."

Response: The text has been revised to replace references to "ecological risk" with "potential for adverse ecological effects".

2. Page 2-14, Section 2.4.1, L. Tannenbaum
   Terrestrial Receptors
   Comment: Several of the animals selected to serve as "representative assessment receptor species" are inappropriate for the SLERA. The small rodents/insectivores, namely the Deer mouse and the Short-tailed shrew, are inappropriate because site cleanups do not proceed on their behalf. These species do not satisfy the definition of an assessment endpoint, i.e., they are not valued ecological resources that are to be protected.

Response: The assessment receptors were selected to be consistent with previous risk assessments conducted at Plum Brook. Additionally, the receptors were selected as they may serve as surrogates for RTE species, may exhibit marked sensitivity to contaminants (small home range, etc), and are key components of ecosystem structure (for example, serving as prey items for higher trophic level consumers).

Further, if HQs produced for these small mammals *should* exceed unity (1.0), this does not allow for any health assessments to be made for the larger, wider-ranging, and higher trophic level species that may feed on them. Based on HQs, it cannot legitimately be suggested that small rodents are anticipated to be absent at the sites, and also that rodent predators are diminished in population size as a consequence.

Response: Small rodents are not predicted to be absent, but rather, to potentially exhibit adverse effects. Health assessment for predators was performed using BCFs and ingestion rates for prey items.

The White-tailed deer and the Red-tailed hawk are also inappropriate receptors for the subject SLERA effort (despite the claims provided in support of their selection at the start of the page's last paragraph). These species have home ranges so vast, that the subject site occupies a most miniscule portion of the range. Opportunities then for these species to develop toxicological effects are rather nil. Additionally, the site of interest would not contain sufficient species representatives to justify their inclusion in a SLERA.

Response: These receptors were retained to be consistent with other RAs conducted for PBOW.

Recommendation: In the revised document, please remove the species identified in the Comment from the evaluation. If the species are to remain, please have the text in this Section prominently note that the species were evaluated although they do not satisfy essential criteria for the proper selection of site-representative species. A useful reference that demonstrates the spatial irrelevance of mammalian species at contaminated sites is: Tannenbaum, L.V., 2005. Two Simple Algorithms for Refining Mammalian Receptor Selection in Ecological Risk Assessments. Integrated Environmental Assessment and Management, Volume 1(3): 290-298. See next Comment.

3. Page 2-15, Section 2.4.2, L. Tannenbaum
   Aquatic Receptors
   Comment: Potential contaminant-caused effects to macroinvertebrates and phytoplankton (algae) are said to have been assessed using available criteria. Aside from the screening effort for these receptors being very imprecise, aquatic sites are not remediated in order to benefit macroinvertebrates and phytoplankton.

Response: The assessment of potential adverse effects to macroinvertebrates and phytoplankton is truly a screening level assessment wherein the concentrations of COPECs are compared to available benchmarks such as AWQC and sediment benchmarks. The screening serves to evaluate the "health" of the system should it serve as a viable habitat. It is noted throughout the text that the drainages present a limited habitat due to their size and duration of surface water flow.

Additionally, an exceedance of a screening criterion does not allow for extrapolation to the risk of potential effects in higher trophic level aquatic species (i.e., those species that *could* serve as the basis of a position recommending remediation). Thus, applying screening criteria for macroinvertebrates and phytoplankton will not allow for any form of a health assessment for mallards or raccoons, as is suggested in this Section.

Response: Extrapolation to the risk of potential effects on higher trophic level organisms was performed using BCFs and invertebrate ingestion rates.

Also, the word "biological" in the Section's last sentence should be "biologically".

Response: "Biological" has been changed to "biologically" as requested.

Recommendation: In the revised document, please modify the text as needed to address the points made in the Comment.

4. Page 2-16, Section 2.5.1, L. Tannenbaum
   Assessment Endpoints

Comment: The overall premise stated here in support of developing assessment endpoints, and implied also in the text of Section 2.4.1 (page 2-14), is not valid. Acid Area 3 has been contaminated for at least 50 years. With such a vast amount of time having elapsed, it is far too late to be going about characterizing "risk" or even the potential for it (recognizing that ample opportunities have been afforded the site biota to have fully developed and expressed any toxicological outcomes).

Recommendation: Please, at a minimum, have the revised report acknowledge in this Section that realistically, it is too late to be endeavoring to assess potential health effects and impacts. Two applicable references that we recommend be cited and incorporated are: Tannenbaum, L.V., 2003. Can Ecological Receptors Really Be At Risk? Human and Ecological Risk Assessment, Volume 9(1): 5-13, and 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: The time elapsed since the site was active is not relevant given the persistence of the COPECs (e.g., metals, PAHs, PCB). Adaptation to environmental stressors may or may not be beneficial to the receptor or the ecosystem. If, based on the results of the SLERA, the assessment were to proceed to a Baseline Risk Assessment, additional investigation and testing could be performed including such methods as live trapping of small rodents, reptiles, and insects, collection of biological tissues for chemical analysis, toxicity testing, and comparisons to reference ecosystems. One purpose of the SLERA is to evaluate whether the evidence suggests that more in-depth study is necessary or warranted; the text has been revised to state this clearly in Section 5.2.

5. Page 2-17, Section 2.5.1, L. Tannenbaum
   Assessment Endpoints
   Comment: A minor rewording of the Section's last sentence would assist the text.
   Recommendation: Please consider using the following: ". . . bioconcentration may occur in plants and invertebrates, and higher food chain receptors may bioaccumulate . . ." See next two Comments.

Response: The text has been revised as requested.

6. Page 3-1, Section 3.0, L. Tannenbaum
   Exposure Characterization
   Comment: The first two definitions supplied are somewhat problematic. First, the implication from the last sentence of the Section's first paragraph is that the subject SLERA effort is at liberty to define technical terms as it prefers (when it would be best to employ definitions that are employed in the ecological risk assessment field as a matter of convention). Also, the first definition (for the term "bioconcentration") does not at all allude to a higher concentration in an organism's tissue being achieved relative to the surrounding medium. As it presently reads, the definition provided for bioconcentration reflects "biouptake" (only).
   Recommendation: Please revise the text of the Section to a) remove the suggestion that the definitions provided were crafted to meet the needs of the subject SLERA (only), and b) provide conventionally used terminology.

Response: The text has been revised for clarity and consistency using conventional definitions in response to this comment.

7. Pages 5-1 to 5-4, Section 5.3, L. Tannenbaum
   Predictive Risk Estimation for Terrestrial and Aquatic Wildlife
   Comment: The text of the Section's first two sentences should be modified for accuracy. Also, all of the HQs shown on page 5-2 are, as described in the peer-reviewed literature, "unrealistically high and toxicologically impossible." By way of example, Short-tailed shrews at Acid Area 3 are consuming PCB-1260 daily at the rate of 20,000 times the safe dose. Finally, the treatment of uncertainty on pages 5-2 to 5-4 is not as complete as it should be.
   Recommendation: Please consider replacing the identified sentences with: "Estimates of the potential for risk . . . ", and "The potential-for-risk estimation was performed . . ." Please bolster the treatment of uncertainty to acknowledge that the HQs that were generated are meaningless, given their magnitude. Have the text note that had HQs been computed for the reference location (note: a practice that technically should not be conducted), these too would significantly "fail" (i.e., exceed values of 1.00)

Response: The text has been revised as requested.

8. Page 6-1, Section 6.0, L. Tannenbaum
   Summary and Conclusions
   Comment: Each of the last three paragraphs of the Section is extremely problematic, and they stand as the leading cause of our inability to concur with the subject document. The first of the identified paragraphs ignores/overlooks the impossibility of the high magnitude HQs that were computed. It is therefore inappropriate to conclude that "terrestrial receptors are predicted to incur elevated hazards . . . " The second of the identified paragraphs, in addition to having the same claim as its forerunner, is suggesting at the end, that the limited habitat removes the ecological risk concern. If the aquatic habitat is indeed rather limited, the assessment should not have taken hold in the first place. The third identified paragraph (i.e., the Section's last paragraph) is the most problematic; it bases it's conclusion of remedial actions not appearing to be warranted on there being no rare, threatened, or endangered (RTE) species confirmed present at the site. What is the basis for such a statement? Additionally, if there are no such RTE species present, why then was a SLERA effort conducted altogether?
   Recommendation: In concert with the Comment, please consider significantly rethinking the SLERA, and revamping the subject document accordingly.

Response: The summary and conclusions have been expanded upon for clarity and to address the limitations of the overall assessment. It is not agreed that the entire document requires significant rethinking and revamping. The SLERA as presented is consistent with previous assessments conducted at PBOW and follows applicable guidance. The document has been revised to indicate that a decision to perform remedial action to protect ecological receptors should not proceed unless a Baseline Risk Assessment is conducted with more in-depth ecological testing.

MEMORANDUM

TO: LISA Humphreys, USACE PBOW Coordinator, and others

FROM: Julie Weatherington-Rice, Ph.D., RAB TAPP Coordinator

RE: Draft Baseline Human Health Risk Assessment Acid Area 2 & Acid Area 3; Draft Screening Level Ecological Risk Assessment Acid Area 2 & Acid Area 3, Jacobs Engineering Group, September, 2007 (four volumes)

DATE: November 29, 2007

Per our current contractual arrangement with US ACE which require both a technical memorandum for each report and an educational explanation to the RAB, this memorandum constitutes the technical review of the Jacobs September 2007 "Draft Baseline Human Health Risk Assessment Acid Area 2 & Acid Area 3; Draft Screening Level Ecological Risk Assessment Acid Area 2 & Acid Area 3, (four volumes)" documents. Please forward to those who need to read this technical review.

Introduction

These four documents were reviewed together. The comments for the Human Health Risk Assessments and the Ecological Risk Assessments hold for both Acid Areas 2 & 3 unless so noted. In some cases, the explanations and/or supporting information needed for further clarity for some of my technical comments are contained in the educational memorandum. Rather than repeat that supporting information here, if the reviewer needs to understand the source(s) of documentation that support the request and/or comment and/or correction, the reviewer is directed to the educational memorandum which should also be available through Lisa Humphreys if the reviewer is interested.

Draft Screening Level Ecological Risk Assessment Acid Area 2 & Acid Area 3 Specific Comments

10. 3.1 Exposure Analysis – page 3-4 Acid Area 3

The paragraph beginning "The EPA guidance notes that for chemicals for which...." is repeated. The repeated paragraph should be deleted.

Response: The duplicate paragraph has been deleted.

11. 3.1 Exposure Analysis – Soil Exposure Pathway

"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)." Another important variable is the type of vegetation growing at the site. There are extreme variations among plant species as to their ability to extract cations from the soil and their ability to lower local pH by the extraction of acids such as tannic acids. In addition, the root mass of the specific plant will also vary the amount of cation extraction the plant can uptake. Additionally, the microbiological community of the soil has a significant affect on the availability of nutrient (and toxic) plant uptake.

Were all these factors considered in this review? Which plants are included on Table 3-2? Are these plants representative of the physiological behavior of the plant communities found at these two areas? Are all plant communities at Acid Areas 2 & 3 represented in the information gathered for Table 3-2 or does that table represent only some sub-set of the plants at the two locations? If it represents only a subset, is this the most conservative of subsets? For instance, for heavy metal uptake, the Brassicaceae (broccoli/mustard) family is a good surrogate because they have a very high affinity for the uptake of heavy metals.

Response: Published literature values were used, which in some cases were averages for multiple plant groups and soil types or derived by regression equations from existing studies. These values are considered to be conservative in that they likely tend to overestimate uptake and are applicable to a wide range of plant and soil types. Contaminant via uptake into the human food chain generally does not contribute significantly to exposure, the exceptions being PCBs from terrestrial and aquatic food sources and mercury from consumption of fish.

12. 5.3 Predictive Risk Estimation for Terrestrial and Aquatic Wildlife

This comment number is reserved for the educational memorandum.

13. 6.0 Summary

This comment number is reserved for the educational memorandum.

14. Tables 5-1 through 5-8

The column furthest to the right, "HQ max" has some concentrations bolded and backed with a gray screen. The tables do not explain the significance of the bolding and gray screening. That information needs to be added to the notes at the end of each table.

Response: This information has been added as a footnote.

15. Figure 2-2

This figure, found in both reports, has a notation that the uptake of nutrients and contaminants from the soil by Deep-Rooted Plants (Trees) and Shallow-Rooted Plants is a "Passive uptake". Nutrient and contamination uptake by plants is a very active uptake, not a passive uptake. Please correct these figures to represent actual plant physiological processes.

Response: The figures have been modified in response to this comment.

This concludes my technical comments on these Draft Baseline Human Health Risk Assessment Acid Area 2 & Acid Area 3; Draft Screening Level Ecological Risk Assessment Acid Area 2 & Acid Area 3, Jacobs Engineering Group, September, 2007 (four volumes) documents. If you have any questions and/or need further clarification on any point discussed in this memorandum, please feel free to contact me.