140094

# Appendix U

# Screening Level Ecological Risk Assessment Report

# FINAL SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT REPORT

**Raritan Bay Slag Superfund Site**
**Old Bridge and Sayreville, New Jersey**
USACE Contract No. W912DQ-08-D-0018
Task Order No. 018

**December 13, 2011**

CDM

R2-0006577

# Contents

**Acronyms and Abbreviations** ..... **v**

**Executive Summary** ..... **ES-1**

**Section 1 Introduction** ..... **1-1**
1.1 Objectives ..... 1-1
1.2 Report Organization ..... 1-2

**Section 2 Problem Formulation** ..... **2-1**
2.1 Environmental Setting ..... 2-1
2.1.1 Site Location and Description ..... 2-1
2.1.2 Site History ..... 2-1
2.1.3 Site Geology and Hydrogeology ..... 2-2
2.1.3.1 Site Geology ..... 2-2
2.1.3.2 Site Hydrogeology ..... 2-2
2.1.4 Habitat and Biota ..... 2-3
2.1.4.1 Vegetative Species ..... 2-3
2.1.4.2 Wildlife Observed ..... 2-5
2.1.5 Threatened, Endangered Species/Sensitive Environments ..... 2-6
2.1.5.1 Federally-Listed Species ..... 2-6
2.1.5.2 State-Listed Species ..... 2-7
2.2 Conceptual Site Model ..... 2-7
2.2.1 Sources of Contamination ..... 2-7
2.2.2 Exposure Pathways ..... 2-7
2.3 Assessment Endpoints ..... 2-9
2.4 Risk Questions ..... 2-10
2.5 Measurement Endpoints ..... 2-11
2.6 Previous Ecological Risk Assessment Conducted for Area 1 ..... 2-14
2.7 Data Used in the Screening Level Ecological Risk Assessment ..... 2-15
2.7.1 Area 9 ..... 2-17
2.7.1.1 Surface Soil ..... 2-17
2.7.1.2 Sediment ..... 2-18
2.7.1.3 Surface Water ..... 2-18
2.7.2 Area 8 ..... 2-19
2.7.2.1 Sediment ..... 2-20
2.7.2.2 Surface Water ..... 2-20

**Section 3 Exposure Assessment** ..... **3-1**
3.1 Potentially Affected Receptors/Exposure Scenarios ..... 3-1
3.2 Food Chain Exposure Models ..... 3-2
3.3 Life History and Exposure Profiles of Model Receptors ..... 3-2
3.3.1 Belted Kingfisher ..... 3-3
3.3.1.1 Life History ..... 3-3
3.3.1.2 Exposure Profile ..... 3-3
3.3.2 Mink ..... 3-4
3.3.2.1 Life History ..... 3-4
3.3.2.2 Exposure Profile ..... 3-4

3.3.3 American Robin....3-5
3.3.3.1 Life History....3-5
3.3.3.2 Exposure Profile....3-6
3.3.4 Short-tailed Shrew....3-6
3.3.4.1 Life History....3-6
3.3.4.2 Exposure Profile....3-7
3.3.5 American Kestrel....3-7
3.3.5.1 Life History....3-7
3.3.5.2 Exposure Profile....3-8
3.3.6 Red Fox....3-8
3.3.6.1 Life History....3-8
3.3.6.2 Exposure Profile....3-9
3.3.7 Northern Bobwhite....3-9
3.3.7.1 Life History....3-9
3.3.7.2 Exposure Profile....3-10
3.3.8 Eastern Cottontail....3-10
3.3.8.1 Life History....3-10
3.3.8.2 Exposure Profile....3-10
3.3.9 Muskrat....3-11
3.3.9.1 Life History....3-11
3.3.9.2 Exposure Profile....3-11

**Section 4 Effects Assessment....4-1**
4.1 Literature-Based Effects Data....4-1
4.1.1 Ecological Screening Values....4-1
4.1.2 Wildlife Toxicity Reference Values....4-2

**Section 5 Risk Characterization....5-1**
5.1 Risk Characterization Methods....5-1
5.1.1 Direct Contact....5-1
5.1.2 Food Chain Exposure Models....5-1
5.2 Identification of Chemicals of Potential Concern....5-2
5.2.1 Direct Contact....5-3
5.2.1.1 Area 9....5-3
5.2.1.2 Area 8....5-4
5.2.2 Food Chain Exposure Model Risks....5-4
5.2.2.1 Belter Kingfisher....5-4
5.2.2.2 Mink....5-5
5.2.2.3 American Robin....5-5
5.2.2.4 Short-tailed Shrew....5-5
5.2.2.5 American Kestrel....5-5
5.2.2.6 Red Fox....5-5
5.2.2.7 Northern Bobwhite....5-6
5.2.2.8 Eastern Cottontail....5-6
5.2.2.9 Muskrat....5-6
5.3 Refinement of Chemicals of Potential Concern....5-6
5.4 Chemicals of Potential Concern Detected in Background Samples....5-7
5.4.1 Soil....5-7
5.4.2 Sediment....5-7

5.4.3 Surface Water ..... 5-8
5.5 Risk Summary ..... 5-8

**Section 6 Uncertainty Assessment ..... 6-1**
6.1 Problem Formulation ..... 6-1
6.2 Exposure Assessment ..... 6-2
6.3 Effects Assessment ..... 6-2
6.4 Risk Characterization ..... 6-3

**Section 7 Summary and Conclusions ..... 7-1**
7.1 Direct Contact ..... 7-1
7.1.1 Assessment Endpoint 1 ..... 7-1
7.1.2 Assessment Endpoint 2 ..... 7-1
7.1.2.1 Area 9 ..... 7-1
7.1.2.2 Area 8 ..... 7-2
7.2 Food Chain Exposure Models ..... 7-2
7.2.1 Assessment Endpoint 3 ..... 7-3
7.2.2 Assessment Endpoint 4 ..... 7-3
7.2.3 Assessment Endpoint 5 ..... 7-3
7.2.4 Assessment Endpoint 6 ..... 7-3
7.2.5 Assessment Endpoint 7 ..... 7-3
7.2.6 Assessment Endpoint 8 ..... 7-4
7.2.7 Assessment Endpoint 9 ..... 7-4
7.2.8 Assessment Endpoint 10 ..... 7-4
7.2.9 Assessment Endpoint 11 ..... 7-4
7.3 Conclusions ..... 7-4

**Section 8 References ..... 8-1**

## List of Tables

2-1 Vegetation Observed
2-2 Wildlife Observed
2-3 Chemicals Detected in Area 9 Soil
2-4 Chemicals Detected in Area 9 Sediment
2-5 Chemicals Detected in Area 9 Surface Water
2-6 Chemicals Detected in Area 8 Sediment
2-7 Chemicals Detected in Area 8 Surface Water
4-1 Avian Toxicity Reference Values
4-2 Mammalian Toxicity Reference Values
5-1 Biota-Sediment Accumulation Factors and Bioaccumulation Factors
5-2 Food Chain Exposure Model Summary – Aquatic Receptors
5-3 Food Chain Exposure Model Summary – Terrestrial Receptors
5-4 Comparison of Maximum Concentrations of Chemicals of Potential Concern Detected in Area 9 Soil to Background Concentrations
5-5 Comparison of Maximum Concentrations of Chemicals of Potential Concern Detected in Area 8 and 9 Sediment to Background Concentrations
5-6 Comparison of Maximum Concentrations of Chemicals of Potential Concern Detected in Area 8 and 9 Surface Water to Background Concentrations

## List of Figures

1-1 Site Location Map
2-1 Conceptual Site Model
2-2 Background Sample Locations
2-3 Area 9 Sample Locations
2-4 Area 8 Sample Locations
3-1 Area 9 Simplified Food Web Model

## Appendices

*Appendix A* *Letter from the United States Environmental Protection Agency and New Jersey Department of Environmental Protection*
*Appendix B* *Fate, Transport, and Toxicity of Chemicals of Potential Concern*
*Appendix C* *Comparison of One Half of the Maximum Reporting Limits for Non-Detected Chemicals to Ecological Screening Levels*
*Appendix D* *Food Chain Exposure Models*

# Acronyms and Abbreviations

| | |
|---|---|
| ATSDR | Agency for Toxic Substances and Disease Registry |
| BAF | bioaccumulation factor |
| BERA | baseline ecological risk assessment |
| BSAF | biota-sediment accumulation factor |
| BW | body weight |
| CDM | CDM Federal Programs Corporation |
| $C_f$ | concentration in food item |
| COPC | chemical of potential concern |
| $C_s$ | concentration in soil/sediment |
| CSM | conceptual site model |
| EcoSSL | ecological soil screening level |
| EPA | United States Environmental Protection Agency |
| ERAGS | Ecological Risk Assessment Guidance for Superfund |
| ERT | Environmental Response Team |
| ESL | ecological screening level |
| FIR | food ingestion rate |
| g/g bw/day | gram per gram of body weight per day |
| ha | hectare |
| HQ | hazard quotient |
| kg/day | kilogram per day |
| km | kilometer |
| LOAEL | lowest-observed-adverse-effect level |
| mg | milligram |
| mg/kg | milligram per kilogram |
| NHP | Natural Heritage Program |
| NJ | New Jersey |
| NJDEP | New Jersey Department of Environmental Protection |
| NOAEL | no-observed-adverse-effect level |
| PAH | polycyclic aromatic hydrocarbon |
| PCB | polychlorinated biphenyl |
| % | percent |
| PRM | Potomac-Raritan-Magothy |
| RCRA | Resource Conservation and Recovery Act |
| RI/FS | remedial investigation/feasibility study |
| SFF | site foraging factor |
| SIR | soil/sediment ingestion rate |
| SLERA | screening level ecological risk assessment |
| SMDP | scientific management decision point |
| SVOC | semi-volatile organic compound |
| TAL | target analyte list |
| TCL | target compound list |
| TRV | toxicity reference value |
| UCL | upper confidence limit |
| USACE | United States Army of Engineers |
| USFWS | United States Fish and Wildlife Service |

| | |
|---|---|
| VOC | volatile organic compound |
| µg/kg | microgram per kilogram |
| µg/L | microgram per liter |

# Executive Summary

Under the United States Army Corps of Engineers (USACE), Kansas City District, Contract No. W912DQ-08-D-0018, Task Order No. 018, CDM Federal Programs Corporation (CDM) was tasked to provide technical services to complete a Remedial Investigation/Feasibility Study (RI/FS) for the Raritan Bay Slag Superfund Site (the site) located in Old Bridge Township and the Borough of Sayreville, Middlesex County, New Jersey (NJ).

The overall purpose of the task order is to evaluate the nature and extent of contamination at the site and to develop and evaluate remedial alternatives, as appropriate. This screening level ecological risk assessment (SLERA), as part of the RI/FS, provides a preliminary evaluation and is intended to conservatively screen data in order to evaluate the potential for ecological risks associated with terrestrial and aquatic environments present within the study area. More specifically, those areas deemed as sources of site contamination.

The objective of this SLERA is to evaluate the potential ecological impact of chemicals at the site. Conservative assumptions are used to identify exposure pathways and, where possible, quantify potential ecological risks. This report is prepared in accordance with the following documents:

- United States Environmental Protection Agency's (EPA's) 1997 *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments*, Interim Final
- EPA's 1998 *Guidelines for Ecological Risk Assessment*

**Site Background**

Slag was placed at the site approximately 40 years ago during the construction of the Area 1 seawall and western jetty. Elevated levels of lead, antimony, arsenic, and copper were identified by the New Jersey Department of Environmental Protection (NJDEP) in the soil along the seawall in 2007 and at the edge of the beach near the western end of the seawall.

EPA collected samples at the site in September 2008 as part of an Integrated Assessment. The sampling included the collection of soil, sediment, water, biological, and waste samples along the seawall in Laurence Harbor, the western jetty at the Cheesequake Creek Inlet, the beaches near these two locations, and the developed portion of the park. Analytical results generated by both EPA and NJDEP indicated that elevated levels of lead and other heavy metals were present in site media in and around both the seawall in Laurence Harbor and the western jetty at the Cheesequake Creek Inlet.

At EPA's request, the New Jersey Department of Health and Senior Services, in cooperation with the Agency for Toxic Substances and Disease Registry, evaluated the analytical data generated from the samples collected at the site. Their findings concluded that, due to the elevated lead levels, a Public Health Hazard exists at the seawall in Laurence Harbor, the beach between the western end of the seawall and the

first jetty, and the western jetty at the Cheesequake Creek Inlet, including the waterfront area immediately west of the inlet.

**Ecological Reconnaissance and Presence of Threatened and Endangered Species**
An ecological reconnaissance was performed for the site which included an identification of site habitats and ecological receptors. In addition, information regarding threatened and endangered species and ecologically sensitive environments that may exist at or in the vicinity of the site was requested from the EPA and the NJDEP Natural Heritage Program (NHP).

Where intact, several habitats are present onsite, including beach, scrub/shrub, tidal marsh, and upland areas; however, a considerable portion of the site is developed and consists of the Old Bridge Waterfront Park. Due to the development of the park, and encroachment of roads and residences, undeveloped land is limited mostly to beaches and Margaret's Creek; however, all parcels have undergone considerable disturbance activities in the past.

The EPA reported that a review of United States Fish and Wildlife Service (USFWS) records indicate that the Indiana bat (*Myotis sodalist*) and swamp pink (*Helonias bullata*) may potentially be present in Old Bridge Township. However, EPA's review concluded that on-site habitats are unsuitable for swamp pink. Indiana bats may utilize larger mature trees in Margaret's Creek (Area 9) during summer months for roosting.

The NJDEP NHP reported that a review of their records indicated that several threatened or special concern species are known to utilize, or occur within ¼ miles of the site. Of the species identified, only osprey (*Pandion haliaetus*) was observed both flying and foraging on site. In addition, remnants of what appeared to be an osprey nest were observed on top of the navigational tower at the end of the Eastern Cheesequake Creek Jetty during Fall 2010 field activities. During field activities conducted in Spring 2011, osprey was observed constructing a nest at this location.

**Areas Evaluated**
Areas evaluated in this SLERA consist of those area characterized by potential sources of contamination; more specifically, Areas 8 and Area 9. Area 1 was evaluated during a separate investigation conducted in 2008 by the EPA/Environmental Response Team. For Areas 8 and 9, risk from exposure to chemicals in sediment, soil, and surface water to ecological receptors was evaluated. Risk from chemicals present in Area 8 soil was not assessed due to a lack of exposure pathways as almost the entire area is paved, and habitat is extremely limited.

**Assessment and Measurement Endpoints**
At total of eleven assessment endpoints were identified and evaluated in this SLERA. They are as follow:

- Assessment Endpoint 1: Survival, growth, and reproduction of terrestrial organisms (including plants and invertebrates) utilizing Area 9

Measurement Endpoint: Evaluate the toxicity of chemicals in soil by comparing maximum-detected concentrations to soil-specific ecological screening levels (ESLs).

- Assessment Endpoint 2: Survival, growth, and reproduction of aquatic organisms (including fish and invertebrates) utilizing Areas 8 and 9

  Measurement Endpoint: Evaluate the toxicity of chemicals in sediment, and surface water by comparing maximum-detected concentrations to sediment- and surface water-specific ESLs.

- Assessment Endpoint 3: Survival, growth, and reproduction of piscivorous birds utilizing Area 9

  Measurement Endpoint: A food chain exposure model is used to estimate daily dietary exposure of the selected receptor species, the belted kingfisher (*Ceryle alcyon*), to chemicals detected in Area 9 sediment. The estimated daily exposure concentrations are then compared with literature-based dietary exposure concentrations that have been associated with adverse effects in birds.

- Assessment Endpoint 4: Survival, growth, and reproduction of piscivorous mammals utilizing Area 9

  Measurement Endpoint: A food chain exposure model is used to estimate daily dietary exposure of the selected receptor species, the mink (*Mustela vison*), to chemicals detected in Area 9 sediment. The estimated daily exposure concentrations are then compared with literature-based dietary exposure concentrations that have been associated with adverse effects in mammals.

- Assessment Endpoint 5: Survival, growth, and reproduction of insectivorous birds utilizing Area 9

  Measurement Endpoint: A food chain exposure model is used to estimate daily dietary exposure of the selected receptor species, the American robin (*Turdus migratorius*), to chemicals detected in Area 9 soil. The estimated daily exposure concentrations are then compared with literature-based dietary exposure concentrations that have been associated with adverse effects in birds.

- Assessment Endpoint 6: Survival, growth, and reproduction of insectivorous mammals utilizing Area 9

  Measurement Endpoint: A food chain exposure model is used to estimate daily dietary exposure of the selected receptor species, the short-tailed shrew (*Blarina brevicauda*), to chemicals detected in Area 9 soil. The estimated daily exposure concentrations are then compared with literature-based dietary exposure concentrations that have been associated with adverse effects in mammals.

- Assessment Endpoint 7: Survival, growth, and reproduction of carnivorous birds utilizing Area 9

Measurement Endpoint: A food chain exposure model is used to estimate daily dietary exposure of the selected receptor species, the American kestrel (*Falco sparverius*), to chemicals detected in Area 9 soil. The estimated daily exposure concentrations are then compared with literature-based dietary exposure concentrations that have been associated with adverse effects in birds.

- Assessment Endpoint 8: Survival, growth, and reproduction of carnivorous mammals utilizing Area 9

  Measurement Endpoint: A food chain exposure model is used to estimate daily dietary exposure of the selected receptor species, the red fox (*Vulpes vulpes*), to chemicals detected in Area 9 soil. The estimated daily exposure concentrations are then compared with literature-based dietary exposure concentrations that have been associated with adverse effects in mammals.

- Assessment Endpoint 9: Survival, growth, and reproduction of terrestrial herbivorous birds utilizing Area 9

  Measurement Endpoint: A food chain exposure model is used to estimate daily dietary exposure of the selected receptor species, the northern bobwhite (*Colinus virginianus*), to chemicals detected in Area 9 soil. The estimated daily exposure concentrations are then compared with literature-based dietary exposure concentrations that have been associated with adverse effects in birds.

- Assessment Endpoint 10: Survival, growth, and reproduction of terrestrial herbivorous mammals utilizing Area 9

  Measurement Endpoint: A food chain exposure model is used to estimate daily dietary exposure of the selected receptor species, the Eastern cottontail (*Sylvilagus floridanus*), to chemicals detected in Area 9 soil. The estimated daily exposure concentrations are then compared with literature-based dietary exposure concentrations that have been associated with adverse effects in mammals.

- Assessment Endpoint 11: Survival, growth, and reproduction of aquatic herbivorous mammals utilizing Area 9

  Measurement Endpoint: A food chain exposure model is used to estimate daily dietary exposure of the selected receptor species, the muskrat (*Ondatra zibethicus*), to chemicals detected in Area 9 sediment. The estimated daily exposure concentrations are then compared with literature-based dietary exposure concentrations that have been associated with adverse effects in mammals.

**Data Used in the Screening Level Ecological Risk Assessment**

The site has been the subject of numerous investigations dating back to 2004. These events included the sampling and analysis of soil, surface water, sediment, and biota. The data from previous studies are supplemented with sampling and analysis results generated as part of the current RI to adequately characterize contamination at the site to support the RI and the SLERA.

For this SLERA, a single maximum value for each medium type evaluated was selected from the whole dataset; however, Areas 8 and 9 were not evaluated collectively, but rather are addressed separately. Thus, maximum values detected in soil, sediment, and surface water for each area will be used in the SLERA.

**Summary of SLERA Results**

Risks were evaluated through a comparison of maximum concentrations of chemicals in site media to their respective ESLs, and through food chain exposure models.

**Risk via Direct Contact**

Assessment endpoints 1 and 2 were addressed through a comparison of site media chemistry results to ESLs. Assessment endpoint 1 focuses on receptors in the terrestrial environment of Area 9, while assessment endpoint 2 evaluated risks to receptors in the aquatic environments of Areas 8 and 9.

For assessment endpoint 1, *Survival, growth, and reproduction of terrestrial organisms (including plants and invertebrates) utilizing Area 9,* risks to ecological receptors may occur from exposure to the following chemicals:

- SVOCs: fluoranthene, and pyrene
- Pesticides/PCBs: 4,4'-DDT, endosulfan II, and Aroclor 1254
- Inorganics: antimony, arsenic, cadmium, chromium, copper, lead, manganese, mercury, selenium, silver, tin, vanadium, and zinc

For assessment endpoint 2, *Survival, growth, and reproduction of aquatic organisms (including fish and invertebrates) utilizing Areas 8 and 9,* risks noted for each area are presented as follow:

Risks to ecological receptors may occur from exposure to Area 9 sediment from the following chemicals:

- SVOCs: acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene
- Pesticides: alpha-chlordane
- Inorganics: antimony, arsenic, barium, cadmium, copper, iron, lead, mercury, nickel, selenium, silver, vanadium, and zinc

Risks to ecological receptors may occur from exposure to Area 9 surface water from the following chemicals:

- SVOCs: benzo(a)anthracene
- Inorganics (total and dissolved): copper, iron, lead, manganese and zinc

Risks to ecological receptors may occur from exposure to Area 8 sediment from the following chemicals:

- Pesticides/polychlorinated biphenyls (PCBs): 4,4′-DDT, endosulfan II, endosulfan sulfate, gamma-chlordane, and Aroclor 1254
- Inorganics: antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, vanadium, and zinc

Risks to ecological receptors may occur from exposure to Area 8 surface water from the following chemicals:

- Inorganics (total and dissolved ): arsenic, copper, iron, lead, manganese, vanadium, and zinc
- Inorganics (dissolved): nickel

**Risks via Food Chain**

Assessment endpoints 3 through 11 were addressed through food chain exposure models using nine receptors representative of avian and mammalian communities assumed to utilize Area 9. Results of the models are as follow:

Assessment endpoint 3, *Survival, growth, and reproduction of piscivorous birds utilizing Area 9*, was addressed through a food chain exposure model using the belted kingfisher. Results of the model indicate risk from exposure to site-related metals copper and lead along with selenium and zinc

Assessment endpoint 4, *Survival, growth, and reproduction of piscivorous mammals utilizing Area 9*, was addressed through a food chain exposure model using the mink. Results of the model indicate risk from exposure to site-related metals arsenic and copper along with selenium.

Results of the model also indicate the potential for risk from exposure to lead and silver.

Assessment endpoint 5, *Survival, growth, and reproduction of insectivorous birds utilizing Area 9*, was addressed through a food chain exposure model using the American robin. Results of the model indicate risk from dietary exposure to site-related metals arsenic, copper, and lead, along with selenium, zinc, alpha-chlordane, Aroclor 1254, 4,4′-DDD, 4,4′-DDE, 4,4′-DDT, endrin, and gamma-chlordane.

Results of the model also indicate the potential for risk from exposure to cadmium, hexavalent chromium, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, fluoranthene, pentachlorophenol, pyrene, endosulfan II, and methoxychlor.

Assessment endpoint 6, *Survival, growth, and reproduction of insectivorous mammals utilizing Area 9*, was addressed through a food chain exposure model using the short-tailed shrew. Results of the model indicate risk from exposure to site-related metals arsenic and lead, along with selenium, pentachlorophenol, alpha-chlordane, Aroclor 1254, endosulfan II, endrin, and gamma-chlordane.

Results of the model also indicate the potential for risk from exposure to copper, silver, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, fluoranthene, pyrene, and methoxychlor.

Assessment endpoint 7, *Survival, growth, and reproduction of carnivorous birds utilizing Area 9*, was addressed through a food chain exposure models using the American kestrel. Results of the model indicate risk from exposure to the site-related metal lead along with Aroclor 1254 and 4,4′-DDT.

Results of the model also indicate the potential for risk from exposure to zinc, 4,4′-DDD and 4,4′-DDE.

Assessment endpoint 8, *Survival, growth, and reproduction of carnivorous mammals utilizing Area 9*, was addressed through a food chain exposure model using the red fox. Results of the model indicate risk from exposure to the site-related metal arsenic, along with selenium and Aroclor 1254.

Results of the model also indicate the potential for risk from exposure to lead and 4,4′-DDT.

Assessment endpoint 9, *Survival, growth, and reproduction of terrestrial herbivorous birds utilizing Area 9*, was addressed through a food chain exposure model using the northern bobwhite. Results of the model indicate risk from exposure to the site-related metal lead. Results of the model also indicate the potential for risk from exposure to 4,4′-DDT.

Assessment endpoint 10, *Survival, growth, and reproduction of terrestrial herbivorous mammals utilizing Area 9*, was addressed through a food chain exposure model using the eastern cottontail. Results of the model indicate risk from exposure to site-related metals arsenic, copper, and lead.

Results of the model also indicate the potential for risk from exposure to silver and Aroclor 1254.

Assessment endpoint 11, *Survival, growth, and reproduction of aquatic herbivorous mammals utilizing Area 9*, was addressed through a food chain exposure model using the muskrat. Results of the model indicate risk from exposure to site-related metals arsenic and copper.

Results of the model also indicate the potential for risk from exposure to lead, selenium, and silver.

**Conclusions**

In conclusion, this SLERA has determined that chemicals present in site media may pose a risk to ecological receptors utilizing Areas 8 and 9 of the site. Risk drivers consist of several groups of chemicals including PAHs, pesticides, Aroclor 1254, and metals.

Risk from exposure to PAHs is mostly limited to receptors in contact with Area 9

sediments; PAHs pose little or no risk to upper trophic levels receptors, or those organisms in contact with Area 9 soil or Area 8 sediment.

Pesticides as a group pose a risk to receptors in contact with Area 9 soil and Area 8 and 9 sediment; however, risks are only limited to a few compounds. Risk from dietary exposure to pesticides in Area 9 soil to insectivorous birds and mammals, and carnivorous birds are also noted. Collectively speaking, the most prominent pesticide risk driver is 4,4′-DDT, both from direct contact exposure in Area 8 sediment and Area 9 soil and from dietary exposure to insectivorous birds and mammals, and carnivorous birds utilizing Area 9. The same trend is noted for Aroclor 1254 where risks are noted from direct contact with Area 8 sediment and Area 9 soil, and from dietary exposure to insectivorous and carnivorous birds and mammals utilizing Area 9.

Several metals were identified as risk drivers mostly through direct contact based on a comparison with media-specific ESLs. Fewer metals pose a risk via food chain exposure; however, results of the models indicate that arsenic and lead are the primary risk drivers to terrestrial receptors, and arsenic, copper, lead, and selenium to aquatic receptors via dietary exposure. All metals retained as COPCs were detected at higher concentrations than what was found in background samples regardless of media. These metals include antimony, arsenic, chromium, copper, and lead as well as others such as barium, cadmium, manganese, nickel, and zinc.

# Section 1
# Introduction

Under the United States Army Corps of Engineers (USACE), Kansas City District, Contract No. W912DQ-08-D-0018, Task Order No. 018, CDM Federal Programs Corporation (CDM) has been tasked to provide technical services to complete a Remedial Investigation/Feasibility Study (RI/FS) for the Raritan Bay Slag Superfund Site located in Old Bridge Township and the Borough of Sayreville, Middlesex County, New Jersey (NJ) (Figure 1-1).

The overall purpose of the task order is to evaluate the nature and extent of contamination at the site and to develop and evaluate remedial alternatives, as appropriate. This screening level ecological risk assessment (SLERA), as part of the RI/FS, provides a preliminary evaluation of ecological risks from contaminants to ecological receptors present within the study area. More specifically, site areas characterized by sources of contamination. These areas consist of Area 1 within the Seawall sector, Area 8 within the Jetty Sector, and Area 9 (Margaret's Creek). Risks to ecological receptors within Area 1 were evaluated by the United States Environmental Protection Agency/Environmental Response Team (EPA/ERT) during a 2008 investigation (Section 2.6). Thus, this SLERA focuses only on Areas 8 and 9.

## 1.1 Objectives

The objective of this SLERA is to evaluate the potential for risk at the site. Conservative assumptions are used to identify exposure pathways and, where possible, quantify potential ecological risks. This report is prepared in accordance with the following documents:

- *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments*, *Interim Final* (EPA 1997)
- *Guidelines for Ecological Risk Assessment* (EPA 1998)

The SLERA consists of Steps 1 and 2 of a recommended eight step process for conducting ecological risk assessments at Superfund sites (EPA 1997). Step 1 of the Ecological Risk Assessment Guidance (ERAGS), includes a screening level problem formulation and ecological effects evaluation. Descriptions are developed of:

- Environmental setting
- Chemicals known or suspected to exist at the site and the maximum concentrations present in each medium
- Chemical fate and transport mechanisms that might exist
- Mechanisms of ecotoxicity associated with chemicals and categories of receptors that may be affected
- Potentially complete exposure pathways

In Step 2 of the ERAGS, the screening level preliminary exposure estimate and risk calculations, risk is estimated by comparing maximum documented exposure concentrations with the ecotoxicity screening values identified in Step 1. The process

concludes with a scientific management decision point (SMDP), which determines that:

- Ecological threats are negligible
- Ecological risk assessment should continue to determine whether a risk exists
- There is a potential for adverse ecological effects, and a baseline ecological risk assessment (BERA), incorporating more site-specific information, is needed.

Per EPA's ERAGS (1997), a SMDP will be made by risk managers.

## 1.2 Report Organization

This SLERA is composed of eight sections and four appendices including:

| | |
|---|---|
| Section 1 | Introduction – provides an overview of the objectives and organization of the report. |
| Section 2 | Problem Formulation – presents the environmental setting, sample collection and analysis, conceptual site model (CSM), risk questions, and assessment and measurement endpoints. |
| Section 3 | Exposure Assessment – presents the pathways and media through which receptors may be exposed to site chemicals. |
| Section 4 | Effects Assessment – presents the literature based- and chemical-specific ecological screening levels (ESLs), and toxicity reference values (TRVs) for detected chemicals. |
| Section 5 | Risk Characterization – presents the process for selecting chemicals of potential concern (COPCs) and integrates information from the exposure and effects assessments. |
| Section 6 | Uncertainty Assessment – discusses the uncertainties associated with the assumptions used in this SLERA. |
| Section 7 | Summary and Conclusions – summarizes the significant findings of the SLERA. |
| Section 8 | References – provides a list of references cited. |

Tables and figures are presented at the end of the text. In addition, Appendix A presents letters received from the New Jersey Department of Environmental Protection (NJDEP) Natural Heritage Program (NHP) and EPA regarding the presence of state and federally-listed threatened and endangered species at or in the vicinity of the site. Information on the fate, transport, and toxicity of COPCs is included in Appendix B. Appendix C presents a comparison of non-detected chemicals to their respective ESLs using ½ of their reporting limits. Finally, food chain exposure models of select receptors are presented in Appendix D.

# Section 2
# Problem Formulation

The problem formulation contains a general description of the environmental setting, a summary of sample collection and analysis, a description of the risk questions and conceptual site model.

## 2.1 Environmental Setting

This subsection describes the site location and description, site history, site geology and hydrogeology, ecological habitat and biota, and threatened and endangered species that may occur at or in the vicinity of the site.

### 2.1.1 Site Location and Description

The site is located on the shore of Raritan Bay, within the Laurence Harbor section of Old Bridge Township, NJ (Figure 1-1). A small portion of the northern end of the site, the western jetty at the Cheesequake Creek Inlet, is located in the Borough of Sayreville. The site is bordered to the east and west by residential properties, immediately to the south by State Highway 35 with residential properties beyond the highway, and to the north by Raritan Bay.

The site is approximately 1.5 miles in length and consists of the waterfront area between Margaret's Creek and the area just beyond the western jetty at the Cheesequake Creek Inlet. The portion of the site in Laurence Harbor is part of what is now called the Old Bridge Waterfront Park. The park is made up of walking paths, a playground area, several public beaches, and three jetties, not including the two jetties at the Cheesequake Creek Inlet. The park waterfront is protected by a seawall, which is partially constructed with pieces of slag. The western jetty at the Cheesequake Creek Inlet and the adjoining waterfront area west of the jetty are located in Sayreville, and also contain slag.

### 2.1.2 Site History

The slag was placed at the site approximately 40 years ago during the construction of the Area 1 seawall and western jetty. Elevated levels of lead, antimony, arsenic, and copper were identified by the NJDEP in the soil along the seawall in 2007 and at the edge of the beach near the western end of the seawall.

EPA collected samples at the site in September 2008 as part of an Integrated Assessment. The sampling included the collection of soil, sediment, water, biological, and waste samples along the seawall in Laurence Harbor, the western jetty at the Cheesequake Creek Inlet, the beaches near these two locations, and the developed portion of the park. Analytical results generated by both EPA and NJDEP indicated that significantly elevated levels of lead and other heavy metals were present in site media in and around both the seawall in Laurence Harbor and the western jetty at the Cheesequake Creek Inlet.

At EPA's request, the New Jersey Department of Health and Senior Services, in cooperation with the Agency for Toxic Substances and Disease Registry (ATSDR),

evaluated the analytical data generated from the samples collected at the site. Their findings concluded that, due to the elevated lead levels, a Public Health Hazard exists at the seawall in Laurence Harbor, the beach between the western end of the seawall and the first jetty, and the western jetty at the Cheesequake Creek Inlet, including the waterfront area immediately west of the inlet. As a result, EPA restricted access to these areas (by installing fences and posting signs) and provided public outreach to inform residents of the potential health hazards that may exist in these areas.

## 2.1.3 Site Geology and Hydrogeology

This section provides a brief summary of the lithologic and hydrogeologic characteristics of the site and immediate area. A more detailed description of site geology and hydrogeology can be found in the RI report.

### 2.1.3.1 Site Geology

The site is underlain primarily by Quaternary age beach deposits which are up to 15 feet thick. Off shore, the site is underlain by Quaternary age estuarine deposits consisting of organic clay and silt, peat, and sand and gravel. These same estuarine deposits underlie Cheesequake Creek, Margaret's Creek and their associated wetlands. In the vicinity of the site the estuarine deposits are at least 50 feet thick underlying Cheesequake Creek where regional mapping shows that the top of the Cretaceous age Magothy Formation is at an elevation of 50 feet below mean sea level. Developed areas, where houses and business are located, are underlain by weathered coastal plain sediments consisting of sand, silt, and clay, or Upper Terrace Deposits which consist of sand, gravel, and minor silt and are up to 20 feet thick. The surficial deposits described above are underlain by the Cretaceous-age Magothy Formation.

The Magothy Formation is extensive in outcrop and in the subsurface throughout the Coastal Plain of New Jersey. On a regional basis, the formations are part of a major Coastal Plain aquifer system known as the Potomac-Raritan-Magothy (PRM). The PRM system consists of lower, middle, and upper aquifers that are separated by confining units. Only the middle and upper aquifers and their intervening confining unit are present in Middlesex County. In the vicinity of the site, the Magothy Formation is underlain by bedrock at a depth of about 500 feet below ground surface.

### 2.1.3.2 Site Hydrogeology

The site is bordered to the south by the predominantly saline wetlands associated with Cheesequake Creek and Margaret's Creek. Regionally, groundwater flow in the Magothy Formation would be expected to be from the west to the east and to discharge into Raritan Bay. Shallow groundwater flow in the surficial Quaternary age deposits is expected to be predominantly toward the nearest surface water body which might be a creek, a wetland, or the bay. Close to the site, groundwater would be expected to flow toward the bay. There should also be an upward vertical gradient close to the bay as groundwater discharges to the bay. Groundwater levels in the surficial deposits should be influenced by tidal fluctuations in Raritan Bay, Cheesequake Creek, and Margaret's Creek. The influence should be greatest close to the bay and creeks and should dissipate with distance.

### 2.1.4 Habitat and Biota

Site habitats were identified based on a site walkthrough conducted on October 28 and November 3, 2010. Supplemental observations were also documented during sampling events conducted prior to, and after the above mentioned dates. Information regarding site habitats and biota observed are discussed in this section. In addition, dominant vegetative species, and wildlife observed are presented in Tables 2-1 and 2-2, respectively.

The site is located on the south shore of Raritan Bay, and is bordered to the north by the bay and to the east, west and south by residential and light commercial properties. State Highway 35 is located immediately south of these properties (Figure 1-1). The site is approximately 1.5 miles in length and consists of the waterfront area between Margaret's Creek and the area just beyond the western jetty at the Cheesequake Creek Inlet. A considerable portion of the site is developed and consists of the Old Bridge Waterfront Park. The park includes walking paths, a playground area, public beaches, and three jetties, not including the two jetties at the Cheesequake Creek Inlet. The park waterfront is protected by a seawall, which is partially constructed with pieces of slag. The western jetty at the Cheesequake Creek Inlet and the adjoining waterfront area west of the jetty also contain slag. Due to the development of the park, and encroachment of roads and residences, undeveloped land is limited mostly to beaches and Margaret's Creek; however, all parcels have undergone considerable disturbance activities in the past.

#### 2.1.4.1 Vegetative Species

Vegetative species observed at the seawall sector, jetty sector, and Margret's Creek during the site visit are discussed below.

**Seawall Sector:** The Seawall Sector is comprised of Areas 1 through 6, and extends from the Eastern Cheesequake Creek Jetty to the end of the seawall which defines the eastern boundary of Area 1. In general, the most prominent habitats found within the Seawall Sector are scrub/shrub and beach habitat, the former of which includes the berm (intertidal zone), face (slope moving downward from the crest), crest, and dunes. Within the western portion of Area 6 between Cheesequake Creek and a police substation lies a parcel of scrub/shrub habitat dominated by false indigo (*Amorpha fruticosa*), northern bayberry (*Myrica pensylvanica*), groundsel bush (*Baccharis halimifolia*) and wax myrtle (*Myrica cerifera*) intermixed with sweet everlasting (*Gnaphalium obtusifolium*) and grasses such as broomsedge (*Andropogon virginicus*) and switch grass (*Panicum virgatum*). Trees are sporadic and consist primarily of staghorn sumac (*Rhus typhina*); other tree species include eastern cottonwood (*Populus deltoides*), and red cedar (*Juniperus virginiana*).

Remaining scrub/shrub habitats found within the Seawall Sector are limited south of beach dunes and end abruptly at roads or residential properties. In most areas, the defining line between scrub/shrub and beach habitat is a paved walking trail, or boardwalk. The eastern extent of all scrub/shrub habitat ends at Areas 3 and 4 which consists of the Old Bridge Waterfront Park recreational playground, and maintained areas of turf comprised of grass and weed species such as buckhorn plantain (*Plantago*

*lanceolata*), yellow wood sorrel (*Oxalis stricta*), purslane (*Portulaca oleracea*), dandelion (*Taraxacum officinale*), white clover (*Trifolium repens*), and common chickweed (*Stellaria media*).

Within portions of the site parallel to Shoreline Circle Road, scrub/shrub habitats begin to transition into upland habitats which end upon reaching the road. Sporadic trees such as catalpa (*Catalpa speciosa*), cherry (*Prunus* spp.), and black locust (*Robinia pseudoacacia*) are present along with saplings of several tree species such as sweetgum (*Liquidambar styraciflua*), sycamore (*Plantanus occidentalis*), and red maple (*Acer rubrum*). These areas are subjected to extensive pruning as evidenced by the amount of tree saplings and the presence of discarded woody material.

Beach habitats within the Seawall Sector, in general, are sparsely vegetated. The exception is Area 5. When compared to others within the Seawall Sector, Area 5 is characterized by a more diverse and abundant vegetative community along the crest, dunes, and to a limited extent, along the face outside the influence of tides and moderate storm surge. Species indicative of beach habitats such as switch grass, seaside goldenrod (*Solidago sempervirens*), broomsedge, and sandbur (*Cenchrus longispinus*) dominate the area along with sea lavender (*Limonium carolinianum*), hairy bushclover (*Lespedeza hirta*), saltwort (*Salsola kali*), and common cocklebur (*Xanthium strumarium*).

At the top of a newly constructed seawall within Area 6 are dunes dominated by well established monotypic stands of American beachgrass (*Ammophila breviligulata*). Recently planted plugs of beachgrass are found within areas undergoing dune restoration. Small to moderate stands of cordgrass (*Spartina* spp.) are present within the intertidal zones of Areas 5, 2, and 1. The largest stands are present within Area 1 where approximately 70 percent (%) of the shoreline is paralleled by cordgrass.

**Jetty Sector:** The Jetty Sector is comprised of Areas 7, 8, and 11 and extends from the west side of the Eastern Cheesequake Creek Jetty to the western boundary of the site; Area 7 consists of the Cheesequake Creek inlet from the north side of the Highway 35 Bridge to approximately 500 feet into Raritan Bay north of the Eastern and Western Cheesequake Creek Jetties.

Habitats within Areas 8 and 11 are severely disturbed and degraded. This is most prominent in Area 8. In general, viable terrestrial habitat within Area 8 is lacking due to the placement of slag, fill material, and asphalt as the majority of the area is covered by impervious surfaces. Miscellaneous debris and refuse is littered throughout the area. The most predominant species present is Japanese knotweed (*Polygonum cuspidatum*); however, within and along former building foundations staghorn sumac is also abundant. Other species include those typically found in disturbed waste areas such as common mullein (*Verbascum thapsus*), pokeweed (*Phytolacca americana*), and Queen Annes lace (*Daucus carota*). Small stands of cordgrass are present on both sides of the Western Jetty and within the intertidal zone immediately west of the jetty within a small parcel of beach habitat.

In general, habitats within Area 11 can be characterized as beach and scrub/shrub. Moderate stands of cordgrass are present within the intertidal zone of the beach berm; however, moving inland along the beach face vegetation is sparse. Outside the influence of moderate storm surge, groundsel bush dominates the area. Similar to Area 8, miscellaneous debris and refuse is littered throughout the area.

**Margaret's Creek:** Margaret's Creek is primarily characterized by four habitat types, beach, marsh, scrub/shrub, and upland forest; however, marsh habitat is most dominant. The entire area has been subjected to intrusive activities such as the placement and excavation of soil, disposal of miscellaneous debris, and littering. Two large marsh communities are present within Margaret's Creek and are divided via access road, but are hydraulically connected via culvert. Common reed (*Phragmites australis*) dominates both marshes. Similar as to what was observed in Areas 6 and 11, beach habitat transitions into scrub/shrub habitat and goes from a landscape dominated by seaside golden rod and gasses such as switch grass, to shrubby vegetation such as groundsel bush, bayberry, and staghorn sumac.

Forest habitat in Margaret's Creek can be defined as a disturbed mixed oak community comprised of various oak and hardwood tree species such as pin (*Quercus palustris*), post (*Quercus stellata*), black jack (*Quercus marilandica*), and swamp chestnut (*Quercus michauxii*) oaks, red maple, sweetgum, and black gum (*Nyssa sylvatica*). The size of trees, and presence of pioneer species such as gray birch (*Betula populifolia*) indicate a relatively young forest community. Understory consists of saplings of the above mentioned species along with arrowwood (*Viburnum dentatum*) and sweet pepper bush (*Clethra alnifolia*). Forest habitats are limited to raised earth areas west of the access road that intersects the marsh, and upland areas along the eastern and western edges of the marsh and along Highway 35.

### 2.1.4.2 Wildlife Observed

Collectively speaking, the site plays host to an abundance of wildlife. Several species of birds were observed within or immediately adjacent to all site areas. The most common types of birds encountered were wading birds, gulls and waterfowl and consisted of species such as double-crested cormorant (*Phalacrocorax auritus*), ring-billed gull (*Larus delawarensis*), great black-backed gull (*Larus marinus*), herring gull (*Larus argentatus*), and brant (*Branta bernicla*). Within the marshes of Margaret's Creek great egret (*Ardea alba*), mallard (*Anas platyrhynchos*), and bufflehead (*Bucephala albeola*) were observed along with other unidentified waterfowl, and pipers/plovers. In addition, red-tailed hawk (*Buteo jamaicensis*), osprey (*Pandion haliaetus*), and belted kingfisher (*Megaceryle alcyon*) were observed several times within the area of Margaret's Creek and Areas 1 and 2. The latter two species were observed foraging.

Mammals or signs of were observed within several areas on site. Within Margaret's Creek raccoon (*Procyon lotor*) tracks were noted, and at Area 11 white tail (*Odocoileus virginianus*) deer tracks were also observed. Gray squirrel (*Sciurus carolinensis*) and groundhog (*Marmota monax*) were observed within Area 4 and along the seawall at Area 1. When suitable habitat is present, the above mentioned species are expected to occur within other areas of the site along with other mammals including, but not

limited to red fox (*Vulpes vulpes*), and a variety of rodents such as the deer mouse (*Peromyscus maniculatus*), rat (*Rattus norvegicus*), and eastern cottontail (*Sylvilagus floridanus*).

During biota sampling, and other site visits, several marine organisms were observed within open water and inter-tidal areas of Raritan Bay adjacent to the site. Fish observed/caught in Raritan Bay included bluefish (*Pomatomus saltatrix*), striped bass (*Morone saxatilis*), summer flounder (*Paralichthys dentatus*), winter flounder (*Pseudopleuronectes americanus*), tautog (*Tautoga onitis*), bay anchovy (*Anchoa mitchilli*), and Atlantic silverside (*Menidia menidia*). Schools of striped killifish (*Fundulus majalis*) were encountered during high tide wherever cordgrass stands were present. The cordgrass also supported ribbed mussel (*Geukensia demissa*) beds which contained hundreds of individual mussels. Other frequently encountered invertebrates included blue crab (*Callinectes sapidus*), lady crab (*Ovalipes ocellatus*), Atlantic horseshoe crab (*Limulus polyphemus*), blood worm (*Glycera* spp.), common marsh snail (*Melanpus bidentatus*), fan worm (*Sabella* spp.) and long-clawed hermit crab (*Pagurus longicarpus*). Several of these invertebrates were observed on an exposed mud flat along the border of Areas 1 and 2 during low tide.

A less diverse aquatic community, in particular, the lack of marine benthic macroinvertebrates was observed within the outskirts and interior marsh areas of Margaret's Creek. The lack of marine benthic macroinvertebrates and cordgrass observed suggest less saline conditions. This was further supported by water quality readings taken during RI sampling activities where readings indicate less saline conditions when compared to marine environments present in other areas of the site. Thus, the lack of marine benthic macroinvertebrates observed is expected. Forage fish were observed within open water areas adjacent to stands of common reed within the interior marsh, but no positive identification was made. However, it can be assumed that fish observed most likely are a species of killifish (*Fundulus* spp.) such as banded killifish (*Fundulus diaphanous*) or mummichog (*Fundulus heteroclitus*) which can tolerate a range of salinities or freshwater conditions.

## 2.1.5 Threatened, Endangered Species/Sensitive Environments

Information regarding threatened and endangered species and ecologically sensitive environments that may exist at or in the vicinity of the site was requested from the EPA and the NJDEP. Letters received from both agencies are summarized below and presented in Appendix A.

### 2.1.5.1 Federally-Listed Species

The EPA reported that a review of United States Fish and Wildlife Service (USFWS) records indicate that the Indiana bat (*Myotis sodalist*) and swamp pink (*Helonias bullata*) may potentially be present in Old Bridge Township. However, after an in-depth review of on-site habitats it was determined that suitable habitat was not present within the area of the site to support swamp pink. There is potential for Indiana bats to utilize the site during summer months in areas characterized by mature trees. Of the areas investigated on site this would be limited to Margaret's Creek.

#### 2.1.5.2 State-Listed Species

The NJDEP NHP reported that their records indicate the following threatened or special concern species are known to occur at, or utilize the site:

- Black-crowned night heron (*Nycticorax nycticorax*) – Threatened species
- Glossy ibis (*Plegadis falcinellus*) – Special concern species
- Snowy egret (*Egretta thula*) – Special concern species

During several site visits none of the above mentioned species were observed.

As part of NJDEP's record review, areas within ¼ miles of the site are also included in their response. The following threatened or special concern species are known to occur within ¼ miles of the site:

- Eastern box turtle (*Terrapene carolina carolina*) – Special concern species
- Fowler's toad (*Bufo woodhousii fowleri*) – Special concern species
- Northern diamondback terrapin (*Malaclemys terrapin terrapin*) – Special concern species
- Northern parula (*Parula americana*) – Peripheral species
- Osprey (*Pandion haliaetus*) – Threatened species
- Spotted turtle (*Clemmys guttata*) – Special concern species
- Wood thrush (*Hylocichla mustelina*) – Special concern species

On several occasions an osprey was observed flying over and foraging on site. In addition, remnants of what appeared to be an osprey nest were observed on top of the navigational tower at the end of the Eastern Cheesequake Creek Jetty during Fall 2010 field activities. During field activities conducted in Spring 2011, osprey was observed constructing a nest at this location. No other of the above mentioned species were encountered.

## 2.2 Conceptual Site Model

The CSM depicts the fate and transport of chemicals from source(s) to exposure media (surface water, sediment, food, etc) and illustrates the exposure routes for ecological receptors. Development of the CSM includes identification of the sources of contamination, and potential exposure pathways (Figure 2-1).

### 2.2.1 Sources of Contamination

For the purposes of this SLERA, the sources of contamination consists of those areas characterized by the presence of slag material and/or crushed battery casings, more specifically, the Area 1 Seawall, Western Jetty, and an area within Margaret's Creek. Contamination originating from these sources may have, or continues, to migrate to surrounding areas via erosion, weathering, overland flow, and to a lesser extent wind dispersion.

### 2.2.2 Exposure Pathways

An exposure pathway is the means by which chemicals are transported from a source to ecological receptors. The CSM developed for the site (Figure 2-1) depicts the

conceptual flow diagram of chemicals to ecological receptors. Contaminants present in site media may migrate via the following pathways.

- Adsorption to surface soil particles and transport by wind as fugitive dust
- Adsorption to soil particles and transported by erosion, overland sheet flow and surface water
- Exchange between surface water and sediment
- Biological removal (i.e., direct uptake from environmental media, bioaccumulation through ingestion of prey or media, and biomagnifications through the food chain)

Chemicals with strong affinities for soils may be transported as sediment load in surface runoff and surface water flow, or on wind-derived fugitive particulates. Non-volatile chemicals with a lesser affinity for soils may also be transported via wind erosion. The predominant direction of storm water runoff and sheet flow at the site is generally toward the north into Raritan Bay.

Ecological receptors may be exposed to contaminants in soil via direct and/or secondary exposure pathways. Direct exposure pathways include soil ingestion, dermal absorption, and inhalation of contaminants adsorbed to fugitive dust. With the exception of soil invertebrates, exposure via dermal contact is expected to be limited. Mammals and birds are less susceptible to exposure via dermal contact with soils because their fur and feathers prevents skin from coming into direct contact with soil. However, soil ingestion may occur while grooming, preening, burrowing, or consuming plants, or invertebrates present in soil. Direct exposure pathways also include ingestion of contaminated slag material that have flaked off the jetty and seawall, and could be consumed as grit by avian receptors.

Exposure via inhalation of fugitive dust is limited to contaminants present in surface soils at those areas devoid of vegetation. The inherent moisture content of the soil also plays an important role in the amount of fugitive dust generated at a particular site. For these reasons, intake of contaminants via inhalation is expected to be minimal relative to other pathways.

Ecological receptors may be exposed to chemicals in surface water via direct contact. Due to moderate salinity levels measured during RI field activities (approximately 10 to 26 parts per thousand) exposure via ingestion is expected to be limited to aquatic organisms. Exposure via ingestion for mammals and birds utilizing the site is limited to incidental ingestion during foraging as the site does not provide a source of fresh drinking water.

Chemicals present in the sediment may result from erosion or weathering of slag material. Exposure via direct contact may occur, especially for benthic organisms and foraging birds and mammals. It is expected that most ecological receptors utilizing the site inadvertently ingest sediment during foraging.

While chemicals in soils may leach into groundwater, ecological receptors generally will not come into direct contact with chemicals in groundwater since there is no direct

exposure route. However, in areas of groundwater discharge to surface water, it is likely that ecological receptors would come into contact with contaminants present in groundwater.

Secondary exposure pathways involve chemicals that are transferred through different trophic levels of the food chain and may be bioaccumulated. This may include chemicals bioaccumulated from sediment/soil into plant tissues or organisms ingesting soil/sediment. These plants or animals may, in turn, be consumed by animals at higher trophic levels. Chemicals found in sediment and soil may bioaccumulate in food or prey items and then be passed up the food chain to impact organisms at higher trophic levels.

Potential primary exposure pathways for aquatic receptors include ingestion of and direct contact with sediment. Potential secondary exposure pathways for aquatic receptors are limited to incidental ingestion of sediment and ingestion of chemicals which have bioaccumulated into food or prey items.

Potential primary exposure pathways for terrestrial receptors at the site include the ingestion of and direct contact with soil. Potential secondary exposure pathways for terrestrial receptors are limited to incidental ingestion of soils and ingestion of contaminants which have bioaccumulated into food or prey items.

## 2.3 Assessment Endpoints

Assessment endpoints are explicit expressions of an environmental resource that is considered of value, operationally defined by an ecological entity and its attributes (EPA 1997). In SLERAs, assessment endpoints are usually considered to be any adverse effects from site contaminants to any ecological receptors at the site. It is not practical or possible to directly evaluate risks to all the individual components of the ecosystem on site, so assessment endpoints are used to focus on particular components that could be adversely affected by the chemicals associated with the site.

A review of the CSM provided information for the selection of assessment endpoints. Within the study area, terrestrial and aquatic ecosystems are present and have been potentially contaminated due to the presence of slag material and battery casings (Section 2.1.2). Within each ecosystem are a number of biotic communities and habitats which inhabit or forage within these areas. Therefore, the assessment endpoints focused on these groups.

Assessment endpoints evaluated in this SLERA include:

- Assessment Endpoint 1: Survival, growth, and reproduction of terrestrial organisms (including plants and invertebrates) utilizing Area 9
- Assessment Endpoint 2: Survival, growth, and reproduction of aquatic organisms (including fish and invertebrates) utilizing Areas 8 and 9

- Assessment Endpoint 3: Survival, growth, and reproduction of piscivorous birds utilizing Area 9
- Assessment Endpoint 4: Survival, growth, and reproduction of piscivorous mammals utilizing Area 9
- Assessment Endpoint 5: Survival, growth, and reproduction of insectivorous birds utilizing Area 9
- Assessment Endpoint 6: Survival, growth, and reproduction of insectivorous mammals utilizing Area 9
- Assessment Endpoint 7: Survival, growth, and reproduction of carnivorous birds utilizing Area 9
- Assessment Endpoint 8: Survival, growth, and reproduction of carnivorous mammals utilizing Area 9
- Assessment Endpoint 9: Survival, growth, and reproduction of terrestrial herbivorous birds utilizing Area 9
- Assessment Endpoint 10: Survival, growth, and reproduction of terrestrial herbivorous mammals utilizing Area 9
- Assessment Endpoint 11: Survival, growth, and reproduction of aquatic herbivorous mammals utilizing Area 9

## 2.4 Risk Questions

Risk questions summarize important components of the problem formulation phase of the SLERA and are based on the assessment endpoints. Risk questions are directly related to testable hypotheses that can be accepted or rejected using the results of the SLERA. Selected risk questions to be answered in this SLERA include:

- *May ecological receptors be exposed to chemicals present in site soil, sediment and surface water?*
- *Where present, are concentrations of chemicals in Areas 8 and 9 sediment sufficient to cause adverse effects on the survival and/or growth of aquatic organisms (including invertebrates and plants)?*
- *Where present, are concentrations of chemicals in Areas 8 and 9 surface water sufficient to cause adverse effects on the survival and/or growth of aquatic organisms (including invertebrates and plants)?*
- *Where present, are concentrations of chemicals in Area 9 soil sufficient to cause adverse effects on the survival and/or growth of terrestrial organisms (including invertebrates and plants)?*
- *Are dietary exposure levels of chemicals sufficient to cause adverse effects on the growth, survival, and/or reproductive success of piscivorous bird communities utilizing Area 9?*

- *Are dietary exposure levels of chemicals sufficient to cause adverse effects on the growth, survival, and/or reproductive success of piscivorous mammal communities utilizing Area 9?*
- *Are dietary exposure levels of chemicals sufficient to cause adverse effects on the growth, survival, and/or reproductive success of insectivorous bird communities utilizing Area 9?*
- *Are dietary exposure levels of chemicals sufficient to cause adverse effects on the growth, survival, and/or reproductive success of insectivorous mammal communities utilizing Area 9?*
- *Are dietary exposure levels of chemicals sufficient to cause adverse effects on the growth, survival, and/or reproductive success of carnivorous bird communities utilizing Area 9?*
- *Are dietary exposure levels of chemicals sufficient to cause adverse effects on the growth, survival, and/or reproductive success of carnivorous mammal communities utilizing Area 9?*
- *Are dietary exposure levels of chemicals sufficient to cause adverse effects on the growth, survival, and/or reproductive success of terrestrial herbivorous bird communities utilizing Area 9?*
- *Are dietary exposure levels of chemicals sufficient to cause adverse effects on the growth, survival, and/or reproductive success of terrestrial herbivorous mammal communities utilizing Area 9?*
- *Are dietary exposure levels of chemicals sufficient to cause adverse effects on the growth, survival, and/or reproductive success of aquatic herbivorous mammal communities utilizing Area 9?*

## 2.5 Measurement Endpoints

Measurement endpoints are chosen to link the existing site conditions to the goals established by the assessment endpoints and are useful for assessment endpoint evaluation. Measurement endpoints are quantitative expressions of observed or measured biological responses to contamination relevant to selected assessment endpoints. For a SLERA, ESLs are commonly used as measurement endpoints. For this SLERA, measurement endpoints are based on conservative ESLs from sources discussed in Section 4.1.

In addition, detected bioaccumulative chemicals are evaluated through use of food chain exposure models. These models are used to address assessment endpoints regarding the viability of higher trophic level receptors. Chemicals considered to be bioaccumulative are featured in Table 4-2 of *Bioaccumulative Testing and Interpretation for the Purpose of Sediment Quality Assessment, Status and Needs, EPA-823-R-00-001, February 2000.*

For this SLERA, the following assessment endpoints and measurement endpoints, presented below, were selected to evaluate whether site-related chemicals pose a risk to ecological receptors. Risks to upper trophic level receptors are evaluated for Area 9 only as this specific portion of the site is characterized by different habitat types when compared to other areas of the site (Section 2.1.4.1). Risk to upper trophic level receptors utilizing Area 8 would be limited to those utilizing aquatic habitats as all

upland portions of the area are almost entirely covered by asphalt and habitat is extremely limited or severely degraded (Section 2.1.4.1). Due to a lack of an exposure pathway, risks from exposure to chemicals in soil are expected to be minimal or nonexistent. Risk to receptors present in the aquatic habitats of Area 8 is assumed to be similar as those determined during EPA/ERT's investigation (Section 2.6) as both areas are characterized by similar aquatic habitats, presence of source material, elevated concentrations of metals, and proximity to open water. Thus, it is feasible to assume that the same type of organisms, food items, and exposure concentrations found within Area 1 media are similar to those in Area 8, and that the conclusions drawn from EPA/ERT's investigation of Area 1 can be applied to Area 8 receptors**.** Further information regarding the results of EPA/ERT's ecological risk assessment for Area 1 are discussed in Section 2.6.

- Assessment Endpoint 1: Survival, growth, and reproduction of terrestrial organisms (including plants and invertebrates) utilizing Area 9

  Measurement Endpoint: Evaluate the toxicity of chemicals in soil by comparing maximum-detected concentrations to soil-specific ESLs.

- Assessment Endpoint 2: Survival, growth, and reproduction of aquatic organisms (including fish and invertebrates) utilizing Areas 8 and 9

  Measurement Endpoint: Evaluate the toxicity of chemicals in sediment, and surface water by comparing maximum-detected concentrations to sediment- and surface water-specific ESLs.

- Assessment Endpoint 3: Survival, growth, and reproduction of piscivorous birds utilizing Area 9

  Measurement Endpoint: A food chain exposure model is used to estimate daily dietary exposure of the selected receptor species, the belted kingfisher (*Ceryle alcyon*), to chemicals detected in Area 9 sediment. The estimated daily exposure concentrations are then compared with literature-based dietary exposure concentrations that have been associated with adverse effects in birds.

- Assessment Endpoint 4: Survival, growth, and reproduction of piscivorous mammals utilizing Area 9

  Measurement Endpoint: A food chain exposure model is used to estimate daily dietary exposure of the selected receptor species, the mink (*Mustela vison*), to chemicals detected in Area 9 sediment. The estimated daily exposure concentrations are then compared with literature-based dietary exposure concentrations that have been associated with adverse effects in mammals.

- Assessment Endpoint 5: Survival, growth, and reproduction of insectivorous birds utilizing Area 9

Measurement Endpoint: A food chain exposure model is used to estimate daily dietary exposure of the selected receptor species, the American robin (*Turdus migratorius*), to chemicals detected in Area 9 soil. The estimated daily exposure concentrations are then compared with literature-based dietary exposure concentrations that have been associated with adverse effects in birds.

- Assessment Endpoint 6: Survival, growth, and reproduction of insectivorous mammals utilizing Area 9

  Measurement Endpoint: A food chain exposure model is used to estimate daily dietary exposure of the selected receptor species, the short-tailed shrew (*Blarina brevicauda*), to chemicals detected in Area 9 soil. The estimated daily exposure concentrations are then compared with literature-based dietary exposure concentrations that have been associated with adverse effects in mammals.

- Assessment Endpoint 7: Survival, growth, and reproduction of carnivorous birds utilizing Area 9

  Measurement Endpoint: A food chain exposure model is used to estimate daily dietary exposure of the selected receptor species, the American kestrel (*Falco sparverius*), to chemicals detected in Area 9 soil. The estimated daily exposure concentrations are then compared with literature-based dietary exposure concentrations that have been associated with adverse effects in birds.

- Assessment Endpoint 8: Survival, growth, and reproduction of carnivorous mammals utilizing Area 9

  Measurement Endpoint: A food chain exposure model is used to estimate daily dietary exposure of the selected receptor species, the red fox (*Vulpes vulpes*), to chemicals detected in Area 9 soil. The estimated daily exposure concentrations are then compared with literature-based dietary exposure concentrations that have been associated with adverse effects in mammals.

- Assessment Endpoint 9: Survival, growth, and reproduction of terrestrial herbivorous birds utilizing Area 9

  Measurement Endpoint: A food chain exposure model is used to estimate daily dietary exposure of the selected receptor species, the northern bobwhite (*Colinus virginianus*), to chemicals detected in Area 9 soil. The estimated daily exposure concentrations are then compared with literature-based dietary exposure concentrations that have been associated with adverse effects in birds.

- Assessment Endpoint 10: Survival, growth, and reproduction of terrestrial herbivorous mammals utilizing Area 9

  Measurement Endpoint: A food chain exposure model is used to estimate daily dietary exposure of the selected receptor species, the eastern cottontail (*Sylvilagus*

*floridanus*), to chemicals detected in Area 9 soil. The estimated daily exposure concentrations are then compared with literature-based dietary exposure concentrations that have been associated with adverse effects in mammals.

- Assessment Endpoint 11: Survival, growth, and reproduction of aquatic herbivorous mammals utilizing Area 9

  Measurement Endpoint: A food chain exposure model is used to estimate daily dietary exposure of the selected receptor species, the muskrat (*Ondatra zibethicus*), to chemicals detected in Area 9 sediment. The estimated daily exposure concentrations are then compared with literature-based dietary exposure concentrations that have been associated with adverse effects in mammals.

## 2.6 Previous Ecological Risk Assessment Conducted for Area 1

The EPA/ERT conducted a focused ecological risk assessment (ERA) for Area 1 (EPA/ERT 2010a). Site-media consisting of sediment, surface water, pore water, killifish (*Fundulus spp.*), ribbed mussel, long neck clam (*Mya arenaria*), hard clam (*Mercenaria mercenaria*), and the macro algae sea lettuce (*Ulva spp.*) were collected in support of the ERA, and a separate investigation characterizing contaminated site media. All samples were analyzed for metals.

Four assessment endpoints were identified and addressed in the EPA/ERT ERA and are as follow:

- *Assessment Endpoint 1: Survival, Growth, and Reproduction of the Intertidal Invertebrate Community.* This was evaluated through a comparison of surface water, pore water, and sediment chemistry results to ESLs

- *Assessment Endpoint 2: Fecundity and Early-Life Stage Development of the Horseshoe Crab.* This was evaluated through a comparison of surface water, pore water, and sediment chemistry results to ESLs

- *Assessment Endpoint 3: Survival, Growth, and Reproduction of Invertivorous Shore Birds*. This was evaluated via a food chain exposure model using the semipalmated plover (*Charadrius semipalmatus*) which included the results of the chemical analysis of site-specific clam and mussel tissue.

- *Assessment Endpoint 4: Survival, Growth, and Reproduction of Herbivorous Waterfowl*. This was evaluated via a food chain exposure model using the Canada goose (*Branta canadensis*) which included the results of the chemical analysis of site-specific sea lettuce tissue.

Results of the Area 1 ERA indicated risks to the intertidal invertebrate community, and fecundity and early-life stage development of the horseshoe crab from exposure to arsenic and lead in sediment, arsenic, manganese, and lead in pore water, and arsenic, copper, and lead in surface water based on a comparison with chronic ESLs. Risks

from exposure to arsenic in pore water, and copper and lead in surface water were also noted based on a comparison to acute ESLs.

Risks to invertivorous birds were noted based on the semipalmated plover model. Results of the model indicated risk from exposure to arsenic and lead in sediment based on the 95% upper confidence limit (UCL) sediment concentration and maximum food intake exposures. Models run using more representative exposure assumptions using mean sediment and mean food intake exposures, indicated risk from exposure to lead.

Finally, risks to herbivorous shorebirds were noted based on the Canada goose model. Results of the model indicated risk from exposure to arsenic, chromium, and lead in sediment based on the most conservative model using the 95% UCL sediment concentrations and maximum food intake. Model calculated risk was not noted following a more representative approach using mean sediment and mean food intake exposures. In addition, as discussed in the previous Section, as Area 8 chemicals, receptors, and exposure pathways are expected to be similar to Area 1, the assessment and measurement endpoints, along with the associated risks to receptors described for Area 1 are applicable to Area 8.

## 2.7 Data Used in the Screening Level Ecological Risk Assessment

The site has been the subject of numerous investigations dating back to 2004. These events included the sampling and analysis of soil, surface water, sediment, and biota. The investigations are listed below.

- Summary Letter Report, Phase I Investigation (Weston 2009a)
- Hazard Ranking System Documentation Record (EPA 2009a)
- Biological Assessment, Ecological Risk Assessment, Report 2 of 2 (EPA/ERT 2010a)
- Chemical Assessment Report: Characterization of Slag/Waste Material Fate and Transport of Contaminants Biomonitoring of Contaminants, Report 1 of 2 (EPA/ERT 2010b)
- Summary Letter Report, Phase II Investigation (Weston 2009b)
- Trip Report: Raritan Bay Sediment Sampling (EPA/ERT 2009)
- Final Beach Sampling Technical Memorandum (CDM 2010a)

These above studies were not designed to fully characterize the nature and extent of contamination at the site or to provide a basis on which remedial action decisions could be made; however, results of these investigations identified arsenic, antimony, copper, chromium, and lead as the primary site-related chemicals. As part of the development of the RI/FS work plan, CDM reviewed the available data and prepared a *Final (Revised) Data Gap Analysis Technical Memorandum* (CDM 2010b). The memorandum identified gaps in the existing data and provided recommendations for field investigation activities to fill the data gaps. The data gap technical memorandum

was used to develop a field investigation program designed to collect data adequate to supplement the existing information and complete the RI, risk assessments, and FS.

Remedial investigation field activities for the site were conducted from June 2010 to December 2010. The RI investigation included sampling and analysis of soil, surface water, sediment, and biota. Samples were analyzed for a variety of organic and inorganic chemicals; however, previous investigations have indicated that metals are the primary site-related chemicals. In addition, organic chemicals, in general, are typically not associated with slag material which is considered the source of contamination at the site. Thus, only a fraction of samples from each medium collected at various portions of the site were analyzed for organic chemicals.

For CDM's RI, data quality objectives were established during project planning to generate data of sufficient quality and quantity to achieve project objectives. Measurement criteria were also established for the data quality indicators, precision, accuracy, representativeness, comparability, and completeness. The overall goal was to generate a complete data set for at least 90% of the samples planned for collection, and 90% valid data from the samples analyzed. The completeness of data set was 97%. Therefore, CDM achieved data completeness and usability established in the Final QAPP (CDM 2010c). Data failing other quality control criteria were appropriately qualified as estimated or non-detect during data validation. All data reported herein are usable as reported with the data validation qualifiers added except for rejected data which is not usable for any purpose.

Data from previous studies are supplemented with sampling and analysis results generated as part of the current RI to adequately characterize contamination at the site to support the RI and the SLERA. Detailed review of the RI approach and findings are provided in the RI report. Samples used in this SLERA are summarized below.

For this SLERA, a single maximum value for each medium type evaluated was selected from the whole dataset; however, Areas 8 and 9 are not evaluated collectively, but rather are addressed separately. Thus, maximum values detected in soil, sediment, and surface water for each area are used in the SLERA. For the purposes of this SLERA, only surface soil and sediment samples are evaluated. Surface soil samples were collected to depths of one foot or six inches below ground surface. The majority of surface sediment samples collected during the RI for use in the SLERA were collected to a depth of six inches from the sediment surface; however, two samples were collected to one foot. Those sediment samples collected by EPA/ERT which are included in the SLERA dataset were collected to a depth of 3 inches. Background soil and sediment samples were collected to depths of 12 inches and 6 inches, respectively. Soil collected from Area 8 is not included in this SLERA as the area is almost entirely covered by asphalt and habitat is extremely limited or severely degraded. Risks to ecological receptors from exposure to contaminants in soil at Area 8 are expected to be minimal or nonexistent.

Background samples were collected as part of the RI investigation (Figure 2-2); the discussion of chemistry results below is limited to Areas 8 and 9. Chemicals detected

in background samples, and those same chemicals retained as COPCs are discussed in Section 5.4.

## 2.7.1 Area 9

Soil, sediment, and surface water were collected from Area 9 (Figure 2-3). The number of samples evaluated in this SLERA by each medium along with a brief summary of analytical results is provided below.

### 2.7.1.1 Surface Soil

Samples were analyzed for target compound list (TCL) volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), target analyte list (TAL) metals including mercury, and hexavalent chromium. In addition, the EPA/ERT dataset also included tin in their list of analytes. Minimum and maximum concentrations of contaminants detected, their frequency of detection, and location of the maximum detected values are presented in Table 2-3.

**VOCs:** A total of 66 samples analyzed for VOCs are evaluated in this SLERA. Six VOCs were detected. Acetone was the most frequently detected compound (14 of 66 samples), followed by methylene chloride in four samples, isopropylbenzene in two samples, and fluorobenzene, and chloroform in one sample.

**SVOCs:** A total of 66 samples analyzed for SVOCs are evaluated in this SLERA. Twenty-eight SVOCs were detected. The most commonly detected SVOCs were the polycyclic aromatic hydrocarbons (PAHs) benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and indeno(1,2,3-cd)pyrene (detected in 53, 47, 56, and 38 samples, respectively).

**Pesticides:** A total of 66 samples analyzed for pesticides are evaluated in this SLERA. Ten pesticides were detected. Alpha-chlordane and gamma-chlordane were detected in 8 and 10 samples, respectively. Remaining pesticides, 4,4'-DDD, 4,4'-DDE, 4,4'-

DDT, dieldrin, endosulfan I and II, endrin and methoxychlor were detected in no more than five samples.

**PCBs**: A total of 66 samples analyzed for PCBs are evaluated in this SLERA. Aroclor 1254 was detected in 11 samples, or 17%, with concentrations ranging from an estimated value of 25 J micrograms per kilogram (µg/kg) to 22,000 µg/kg. Six of the 11 samples had concentrations of 80 µg/kg or less; three samples had concentrations ranging from 150 µg/kg to 350 J µg/kg; the remaining two samples had concentrations of 1,100 µg/kg and 22,000 µg/kg. Aroclor 1260 was detected in two samples at estimated concentrations of 23 J µg/kg and 36 J µg/kg.

**Inorganics:** A total of 110 samples analyzed for TAL metals, 67 for mercury and hexavalent chromium, and five for tin are evaluated in this SLERA. Thallium was the least detected metal (3 of 110 samples). Of the site-related metals, lead was detected in 105 samples at concentrations ranging from an estimated value of 1.7 J milligrams per kilogram (mg/kg) to 10,200 J mg/kg. Arsenic was detected in 106 samples at concentrations ranging from 0.23 mg/kg to 179 mg/kg. Antimony was detected in 37

samples at concentrations ranging from an estimated value of 0.15 J mg/kg to 188 mg/kg. Chromium was detected in all 110 samples at concentrations ranging from an estimated value of 0.96 J mg/kg to 155 mg/kg. Copper was detected in 106 samples at concentrations ranging from an estimated value of 0.46 J mg/kg to 1,170 mg/kg. Iron was also detected in all 110 samples at concentrations ranging from 1,670 mg/kg to 46,800 mg/kg.

#### 2.7.1.2 Sediment

Samples were analyzed for TCL VOCs, SVOCs, pesticides, PCBs, TAL metals including mercury, and hexavalent chromium. In addition, the EPA/ERT dataset also included tin in their list of parameters. Minimum and maximum concentrations of contaminants detected, their frequency of detection, and location of the maximum detected value are presented in Table 2-4.

**VOCs:** A total of 39 samples analyzed for VOCs are evaluated in this SLERA. Four VOCs were detected. Acetone and carbon disulfide were detected in 9 samples. 2-butanone was detected in 3 samples and toluene was detected in 1 sample.

**SVOCs:** A total of 39 samples analyzed for SVOCs are evaluated in this SLERA. Twenty-one SVOCs were detected. The most commonly detected SVOCs were the PAHs benzo(a)anthracene, benzo(a)pyrene, and chrysene; all were detected in 36 samples. These were followed by acenaphthylene and dibenzo(a,h)anthracene detected in 19 samples, and fluoranthene and pyrene detected in 18 samples.

**Pesticides:** A total of 39 samples analyzed for pesticides are evaluated in this SLERA. Four pesticides were detected. Alpha-chlordane was detected in two samples; dieldrin, gamma-chlordane, and methoxychlor were detected once.

**PCBs:** A total of 39 samples analyzed for PCBs are evaluated in this SLERA. Aroclor 1254 was detected in two samples at an estimated concentration of 7.0 J µg/kg and 19 µg/kg. No other PCBs were detected in any sample.

**Inorganics:** A total of 72 samples analyzed for TAL metals, 46 for mercury, and 45 for hexavalent chromium are evaluated in this SLERA. Thallium was the least detected metal (1 of 72 samples). Of the site-related metals, lead was detected in 63 samples at concentrations ranging from 2.9mg/kg to 564 mg/kg. Arsenic was detected in every sample at concentrations ranging from 1.1 mg/kg to 88.9 mg/kg. Antimony was detected in five samples at concentrations ranging from an estimated value of 0.28 J mg/kg to 10.9 mg/kg. Chromium was detected in every sample at concentrations ranging from an estimated value of 1.9 J mg/kg to 59.7 mg/kg. Copper was detected in every sample at concentrations ranging from an estimated value of 1.1 J mg/kg to 1,790 mg/kg. Iron was also detected in all 72 samples at concentrations ranging from 2,960 mg/kg to 89,700 mg/kg.

#### 2.7.1.3 Surface Water

Samples were analyzed for TCL VOCs, SVOCs, pesticides, PCBs, and TAL metals including mercury, and hexavalent chromium. Minimum and maximum

concentrations of contaminants detected, their frequency of detection, and location of the maximum detected value are presented in Table 2-5.

**VOCs:** A total of 18 samples analyzed for VOCs are evaluated in this SLERA. Chloroform was detected in one sample. No other VOCs were detected.

**SVOCs:** A total of 17 samples analyzed for SVOCs are evaluated in this SLERA. Four SVOCs, 3,3'-dichlorobenzidine, benzo(a)anthracene, bis(2-ethylhexyl)phthalate, and pentachlorophenol were each detected once in separate samples. No other SVOCs were detected.

**Pesticides:** A total of 18 samples analyzed for pesticides are evaluated in this SLERA. No pesticides were detected in any sample.

**PCBs:** A total of 18 samples analyzed for PCBs were evaluated in this SLERA. No PCBs were detected in any sample.

**Inorganics:** Surface water samples were analyzed as both total and dissolved fractions. Thirty total and 32 dissolved samples for TAL metals, and 46 for total mercury are evaluated in this SLERA.

For the total metals analysis, the least detected metals were beryllium, cadmium, cobalt, mercury, vanadium. Of the site-related metals, lead was detected in eight samples at concentrations ranging from 2.2 µg/L to 298 µg/L. Arsenic was detected in eight samples at concentration ranging from 0.44 µg/L to 25 µg/L. Antimony was detected in two samples at concentrations of 2.5 J µg/L and 6.3 J µg/L. Chromium was detected in four samples at concentrations ranging from 2.0 J µg/L to 19.8 J µg/L. Copper was detected in seven samples at concentrations ranging from 1.1 J µg/L to 52.5 µg/L. Iron was also detected in 20 samples at concentrations ranging from an estimated value of 418 J µg/L to 74,400 µg/L.

For the dissolved metals analysis, the least detected metals were antimony, beryllium and nickel. Of the site-related metals, lead was detected in two samples at concentrations of 28 µg/L and 282 µg/L. Arsenic was detected in five samples at concentrations ranging from an estimated value of 2.2 J µg/L to 13.6 µg/L. Antimony was detected in one sample at an estimated concentration of 2.8 J µg/L. Chromium was detected in two samples at estimated concentrations of 1.3 J µg/L and 5.4 J µg/L. Copper was detected in seven samples at concentrations ranging from an estimated value of 0.74 J µg/L to 43.5 µg/L. Iron was also detected in 14 samples at concentrations ranging from an estimated value of 14.6 J µg/L to 58,500 µg/L.

### 2.7.2 Area 8

Sediment and surface water were collected from Area 8 (Figure 2-4). The number of samples evaluated in this SLERA by each medium along with a brief summary of analytical results is provided below.

#### 2.7.2.1 Sediment

Samples were analyzed for TCL VOCs, SVOCs, pesticides, PCBs, TAL metals including mercury, and hexavalent chromium. In addition, the EPA/ERT dataset also included tin in their TAL list. Minimum and maximum concentrations of contaminants detected, their frequency of detection, and location of maximum detected values are presented in Table 2-6.

**VOCs:** A total of five samples analyzed for VOCs are evaluated in this SLERA. Carbon disulfide was detected in three samples. No other VOCs were detected in any other sample.

**SVOCs:** A total of five samples analyzed for SVOCs are evaluated in this SLERA. Twenty-six SVOCs were detected. The most commonly detected SVOCs were PAHs consisting of several compounds. The least detected SVOCs were carbazole and butylbenzylphthalate having been detected once.

**Pesticides:** A total of five samples analyzed for pesticides are evaluated in this SLERA. Five pesticides were detected. 4,4′-DDT was detected in two samples; 4,4′-DDE was detected in one sample, and endosulfan II, endosulfan sulfate, and gamma-chlordane were detected once in the same sample.

**PCBs:** A total of five samples analyzed for PCBs are evaluated in this SLERA. Aroclor 1254 was detected in three samples at concentrations ranging from an estimated value of 6.6 J µg/kg to 720 µg/kg. No other PCBs were detected in any other samples.

**Inorganics:** A total of 57 samples analyzed for TAL metals, 44 for mercury, 6 for hexavalent chromium, and 13 for tin are evaluated in this SLERA. In general, most metals were detected in at least 50% of the samples. Of the site-related metals, lead was detected in 53 samples at concentrations ranging from 7.9 mg/kg to 14,200 mg/kg. Arsenic was detected in every sample at concentrations ranging from 3.3 mg/kg to an estimated value of 933 J mg/kg. Antimony was detected in 41 samples at concentrations ranging from an estimated value of 0.77 J mg/kg to 1,720 mg/kg. Chromium was detected in every sample at concentrations ranging from 8.9 mg/kg to 3,500 mg/kg. Copper was detected in every sample at concentrations ranging from 4.4 mg/kg to an estimated value of 969 J mg/kg. Iron was also detected in 55 samples at concentrations ranging from an estimated value of 6,390 J mg/kg to 120,000 mg/kg.

#### 2.7.2.2 Surface Water

Samples were analyzed for TCL VOCs, SVOCs, pesticides, PCBs, and TAL metals including mercury, and hexavalent chromium. Minimum and maximum concentrations of contaminants detected, their frequency of detection, and location of the maximum detected value are presented in Table 2-7.

**VOCs:** A total of two samples analyzed for VOCs are evaluated in this SLERA. Methylene chloride was the only VOC detected in both samples at concentrations of 0.54 µg/L and an estimated concentration of 0.63 J µg/L.

**SVOCs:** A total of two samples analyzed for SVOCs are evaluated in this SLERA. No SVOCs were detected in any sample.

**Pesticides:** A total of two samples analyzed for pesticides are evaluated in this SLERA. No pesticides were detected in any sample.

**PCBs:** A total of two samples analyzed for PCBs are evaluated in this SLERA. No PCBs were detected in any sample.

**Inorganics:** Twelve total and dissolved samples analyzed for TAL metals, seven total and dissolved samples for mercury, and seven total samples for hexavalent chromium are evaluated in this SLERA. Mercury and hexavalent chromium was not detected in any sample. Tin was analyzed in five total and 5 dissolved samples.

For the total metals analysis, most metals were only detected in about one third (four samples) of the samples. Of the site-related metals, lead was detected in four samples at estimated concentrations ranging from 6.7 J µg/L to 1,580 J µg/L. Arsenic was detected in five samples at concentrations ranging from an estimated value of 2.7 J µg/L to 70.9 µg/L. Antimony was detected in two samples at 21.1 J µg/L and 53.2 J µg/L. Chromium was detected in one sample at an estimated concentration of 12.5 J µg/L. Copper was detected in two samples at estimated concentrations at 32.4 J µg/L and 154 J µg/L. Iron was also detected in four samples at concentrations ranging from an estimated value of 345 J µg/L to 6,320 J µg/L.

For the dissolved metals analysis, the least detected metals were cadmium, chromium, silver, tin, and vanadium. Of the site-related metals, lead was detected in three samples at estimated concentrations ranging from 5.1 J µg/L to 1,810 J µg/L. Arsenic was detected in five samples at concentrations ranging from an estimated value of 2.5 J µg/L to 79.7 µg/L. Antimony was detected in two samples at an estimated concentration of 27.7 J µg/L and 61.6 µg/L. Chromium was detected in one sample at an estimated concentration of 14.7 J µg/L. Copper was detected in two samples at estimated concentrations of 45.2 J µg/L and 197 J µg/L. Iron was also detected in four samples at concentrations ranging from an estimated value of 348 J µg/L to 7,900 J µg/L.

# Section 3
# Exposure Assessment

The objective of the exposure assessment is to determine the pathways and media through which ecological receptors may be exposed to site chemicals. Exposure scenarios are simplified descriptions of how potential receptors may come in contact with contaminants. Potential exposure pathways are dependent on habitats and receptors present on-site, the extent and magnitude of contamination, and environmental fate and transport of contaminants.

## 3.1 Potentially Affected Receptors/Exposure Scenarios

The aquatic and terrestrial habitats evaluated in this SLERA consist of Areas 8 and 9 of the site. The contamination of these habitats has been determined through previous investigations and review of the data collected in support of the RI. Based on observations made, and habitats present, a number of organisms may inhabit or forage in these area and can potentially be exposed to contaminants present.

The aquatic habitat in the study area consists of Raritan Bay and a large tidal marsh located in Area 9. Benthic and infaunal organisms inhabit the sediment and directly absorb contaminants through dermal contact with sediment particles and interstitial water, as well as through ingestion of contaminated food items and incidental ingestion of sediment. Direct contact with the whole sediment burden incorporates the contaminant fraction adsorbed to the solid phase as well as contaminants dissolved in the liquid interstitial phase.

The soil macroinvertebrate community is in constant association with soil and is therefore potentially exposed to contaminants through direct contact with the soil and soil interstitial water. Additional exposure may result from the ingestion of contaminated food items. Macroinvertebrates may also be indirectly affected by a reduction in ecosystem functions, such as nutrient cycling and energy transfer that are critical to growth and reproduction.

Terrestrial and wetland plant communities may potentially be exposed to contaminants through direct contact with soil, soil pore water, and surface water. Vegetation may also be indirectly affected by a reduction in ecosystem functions, such as nutrient cycling and energy transfer, which are critical to growth and reproduction. The presence of contaminated vegetation not only places plants at risk, but also affects organisms that utilize vegetation for food and habitat.

Mammals may also utilize the areas for food. Such mammals may feed on a variety of food items such as plants, fish, small mammals, or soil macroinvertebrates. Therefore, these mammals may potentially be exposed to contaminants through ingestion of contaminated food items. They may also be exposed through incidental ingestion of contaminated soil or sediment, direct contact with contaminated sediment or soil, or inhalation of contaminated dust.

Other organisms that are known to inhabit the study area include a variety of birds that live in surrounding areas. These birds may be piscivorous and feed on fish, insectivorous and feed on soil macroinvertebrates or other insects, or herbivorous and feed on plants. Therefore, these birds may potentially be exposed to contaminants through ingestion of contaminated food items. They may also be exposed through incidental ingestion of contaminated soil or sediment, direct contact with contaminated sediment or soil, or inhalation of contaminated dust.

Potential complete exposure pathways include direct contact with contaminated media, ingestion of contaminated food items, incidental ingestion of soil or sediment, dermal contact and inhalation. It should be noted that the dermal contact and inhalation pathways of exposure are difficult to evaluate because exposure through these routes is difficult to quantify. In addition, little information is available in the literature on contaminant effects to wildlife species through these pathways. However, these exposure pathways are either indirectly incorporated or are believed to be small when compared to the significance of the ingestion exposure pathways for contaminants which bioaccumulate or biomagnify.

Assessment and measurement endpoints were identified and focused on specific groups of organisms representative of communities potentially utilizing aquatic and terrestrial habitats found on site (Sections 2.3 and 2.5). For the purpose of this SLERA, maximum concentrations of contaminants detected in soil, sediment, and surface water from Area 9 and sediment and surface water from Area 8 serve as exposure point concentrations and are evaluated via direct exposure (assessment endpoints 1 and 2). In addition, risks from contaminants detected in Area 9 sediment and soil are also evaluated via food chain exposure models (assessment endpoints 3 through 11).

## 3.2 Food Chain Exposure Models

Food chain modeling is reserved and most appropriate for evaluating contaminants with the significant potential to bioaccumulate in the diet and adversely affect upper trophic level receptors (i.e., dose-based effects). Receptor species representative of organisms which are likely to be exposed to contaminants because of specific behaviors, patterns of habitat use, or feeding habits were selected for evaluation in this SLERA. The availability of appropriate exposure and toxicity information on which risk calculations were based was also an important consideration. Representative receptor species selected for this SLERA include the belted kingfisher, mink, American robin, short-tailed shrew, American kestrel, red fox, northern bobwhite, eastern cottontail, and muskrat. A simplified food web illustration for representative modeled receptors assumed to utilize Area 9 is depicted on Figure 3-1.

## 3.3 Life History and Exposure Profiles of Model Receptors

Life history and exposure profiles for model receptor species are presented below. For each receptor, a conservative exposure profile was identified. Conservative exposure parameters include the lowest reported regional adult body weight, and highest ingestion rates. Home range, feeding territory and breeding territory size have been

reported in the literature for several species. However, for this SLERA, a site foraging factor of 1.0 was utilized, as the conservative assumption was made that the receptor species spends all of its time, and acquires all of its food from Area 9.

## 3.3.1 Belted Kingfisher

### 3.3.1.1 Life History

The belted kingfisher is a pigeon-sized, territorial bird that is the only kingfisher present throughout most of North America (Bull and Farrand 1977; NGS 1987). Belted kingfishers inhabit rivers, lakes, and estuaries and are often seen patrolling a favorite sheltered section of a waterway for prey (NGS 1987). Food items include primarily shallow water fish, although crayfish, frogs, small snakes, salamanders, insects, crabs, and even mice may be consumed (Bull and Farrand 1977; Landrum *et al.* 1993). It is estimated that a pair of kingfishers with nearly fledged young require approximately 90 fish per day to feed their offspring and themselves (Landrum *et al.* 1993).

Breeding times for this species vary with locale. Unseasonably mild weather may initiate early nesting in the lower United States. The presence of herbaceous cover and good fishing habitat are the basis for the selection of breeding areas and nest sites. Nests consist of streambank or shoreline burrows and vary in length depending upon the soil texture, typically three to seven feet long. Although usually near water, nests have been found up to 1.6 kilometers (km) away from water. A clutch of five to eight eggs are usually laid between early April and mid-June. Incubation lasts for 25 days with nest occupation for an additional 23 days. Young leave the nest after 33 to 38 days. The fledglings remain near the nest and juveniles disperse by mid-summer (Landrum *et al.* 1993; Cassidy 1990).

### 3.3.1.2 Exposure Profile

Conservative exposure pathways are the highest (ingestion rates) or lowest (body weight, home range size) values located in the literature. Adult belted kingfishers weigh from 0.136 kilograms (kg) to 0.158 kg (EPA 1993). The lowest regional value of 0.136 kg was used as a conservative estimate of body weight.

The diet of belted kingfishers is variable and can consist of a variety of prey including fish, crayfish, frogs, small snakes, salamanders, insects, crabs, and even mice (Bull and Farrand 1977; Landrum *et al.* 1993). For this SLERA, the diet of the belted kingfisher was assumed to consist solely of fish. A food ingestion rate of 0.5 grams per gram of body weight per day (g/g bw/day) was found for adult kingfishers (EPA 1993). Using the above body weight a conservative food ingestion rate of 0.068 kilograms per day (kg/day) was calculated. An incidental sediment ingestion rate could not be identified for the belted kingfisher. A soil ingestion rate of 3.3% of the total diet was measured for mallards (Beyer et al. 1994). To evaluate this pathway, the food ingestion rate of 0.068 kg/day was multiplied by the percent soil ingested by the mallard to yield a sediment ingestion rate of 0.00224 kg/day.

## 3.3.2 Mink

### 3.3.2.1 Life History

Mink are distributed over much of boreal North America, southward throughout the eastern United States and in the west to California, New Mexico, and Texas (Jones and Birney 1988). They can be found in virtually any habitat containing permanent water; they are not commonly found in upland areas (Jones and Birney 1988). Although primarily nocturnal, their activity often extends into midday (Hoffmeister 1989).

Dens are always near water, usually either in an old muskrat burrow or constructed by the mink itself (Jones and Birney 1988). Males tend to live in their own burrows that are less elaborate than ones occupied by females (Barbour and Davis 1974). The mink is a constant wanderer, and home ranges tend to be linear since mink often follow a shoreline (Jones and Birney 1988). Mink are solitary and mark their territories by spraying (Merritt 1987).

Seasonal food availability governs the mink dietary composition (Barbour and Davis 1974). Their diets may consist of crayfish, muskrats, frogs, fish, snakes, rodents, rabbits, and plants, among other items (Schwartz and Schwartz 1981; Jones and Birney 1988). Crayfish and muskrats are a major portion of the summer diet in many regions of North America (Barbour and Davis 1974; Merritt 1987; Jones and Birney 1988). Larger preys are killed by being bitten on the neck. Females have a difficult time handling larger prey such as muskrats, and their diet is usually more limited.

The mink has several predators. Great horned owls, foxes, coyotes, bobcats, and dogs are known to prey on mink (Schwartz and Schwartz 1981; Merritt 1987). There have been records of some mink individuals living up to six years, but mink seldom exceed two years of age in the wild (Schwartz and Schwartz 1981).

### 3.3.2.2 Exposure Profile

Conservative exposure pathways are the highest (ingestion rates) or lowest (body weight, home range size) values located in the literature. Adult mink weigh from 0.550 kg to 1.734 kg (EPA 1993). The lowest regional value of 0.974 kg was used as a conservative estimate of body weight.

The diet of mink is governed by seasonal food availability (Barbour and Davis 1974) and may consist of crayfish, muskrats, frogs, fish, snakes, rodents, rabbits, and plants (Schwartz and Schwartz 1981; Jones and Birney 1988). For this SLERA, the diet of the mink was assumed to consist solely of fish. A food ingestion rate of 0.16 g/g bw/day was found for adult mink (EPA 1993). Using the above body weight a conservative food ingestion rate of 0.156 kg/day was calculated. Incidental sediment ingestion is expected to be negligible (Sample and Suter 1994); however, for the purpose of this SLERA a soil ingestion rate (substituting for sediment) of 9.4% as report by Beyer *et al.* (1994) for the raccoon was used as it is assumed that both species exhibited similar foraging habits. To evaluate this pathway the food ingestion rate of 0.156 kg/day was multiplied by the percent soil ingested by the raccoon to yield a sediment ingestion rate of 0.0147 kg/day.

## 3.3.3 American Robin

### 3.3.3.1 Life History

The American robin occurs throughout most of the continental United States and Canada, wintering in the southern half of North America and into Central America (Bull and Farrand 1977; Peterson 1990). Given the increase in open habitat and lawns, the robin's breeding range has expanded in recent times (Collins and Boyajian 1965; Ehrlich et al. 1988). Habitat requirements for breeding robins include access to fresh water, protected nesting sites, and productive foraging areas (Howell 1942; Ehrlich et al. 1988). These requirements are commonly met in moist forests, swamps, open woodlands, and other open areas (Bull and Farrand 1977). Non-breeding robins occupy similar habitats, although proximity to fruit bearing trees is of more importance.

The primary foraging technique for robins is to hop along the ground in search of ground-dwelling invertebrates, although they commonly search for insects and fruit in tree branches as well. The robin's diet during the breeding season consists mainly of invertebrates and some fruit, but fruit is the primary food consumed outside of the breeding season (Hazelton et al. 1984).

The diet of the American robin consists of seasonally variable proportions of invertebrates (e.g., earthworms, snails, beetles, caterpillars, spiders) and fruit (e.g., dogwood, cherry, sumac, holly, hackberries, and juneberries) (Martin et al. 1951; Paszkowski 1982; Wheelwright 1986; Ehrlich et al. 1988). The ratio of percent invertebrates to percent fruit in the diet is reported to change from 94:6 in spring (nesting season) to 34:66 in summer to 4:96 in fall (migratory season) to 7:93 in winter (Wheelwright 1986). Year round, the diet of the robin averages 63% fruits and 37% invertebrates (Martin et al. 1951; Eiserer 1976; Wheelwright 1988). Robin diets are diverse; analysis of the stomach contents of 1900 robins showed that the birds consumed fruit from more than 50 plant genera and invertebrates from over 100 families (Wheelwright 1986).

Robins typically use the same foraging site for many weeks at a time but join a variety of roosts, usually within 2 km of the foraging area (Morrison and Caccamise 1990). During the breeding periods, male robins establish territories, the size of which is determined by population density: smaller territories are found where robin densities are high. Most foraging occurs within these territories; however, if food resources are limited, adult robins will leave temporarily to forage elsewhere. Breeding territories are vigorously defended; robins will attack man, snake or other enemies to defend its territory or nest, except in more remote locations (Howell 1942; Collins and Boyajian 1965). Females lay eggs in nests made of mud, grass, and twigs, built 0.9 to 7.5 meters above the ground in trees, buildings, or shrubs. Eggs are characteristically bright blue, number from 3 to 6, and hatch in 12 to 14 days. Young juveniles leave two weeks after hatching and can live up to ten years in the wild, though most rarely survive past 14 months (Collins and Boyajian 1965; Cassidy 1990).

Predators that feed on adult robins include cats, dogs, owls, and hawks. Crows, jays, grackles, snakes and squirrels are nest predators, attacking both eggs and nestlings. A

robin that survives to adulthood has a life expectancy of 10 years (Eiserer 1976; Wauer 1999).

#### 3.3.3.2 Exposure Profile

Conservative exposure pathways are the highest (ingestion rates) or lowest (body weight) values located in the literature. Adult American robins weigh from 0.055 to 0.103 kg (Eiserer 1976; Clench and Leberman 1978; Hazelton et al. 1984; Skorupa and Hothem 1985; Wheelwright 1986; Wheelwright 1988; Wauer 1999). The lowest regional value of 0.0635 kg (EPA 1993) was used as a conservative estimate of body weight.

The diet of the American robin primarily consists of fruit and invertebrates. Diet varies seasonally, and depends on habitat and time of day (Wheelwright 1988). The year-round diet is comprised of 37% invertebrates and 63% fruits (Martin et al. 1951; Eiserer 1976; Wheelwright 1988). For this SLERA, the diet of the American robin was assumed to consist solely of invertebrates. Food ingestion rates for the American robin range from 0.89 to 1.96 g/g bw/day (EPA 1993). The highest value of 1.96 g/g bw/day was used as a conservative estimate of food ingestion. Using the above body weight a conservative food ingestion rate of 0.124 kg/day was calculated. A soil ingestion rate for the American robin was not located in the literature. As an alternate, a value of 10.4% (Beyer *et al.* 1994) for the American woodcock was used as the diets of the woodcock and robin are similar. To calculate a conservative estimate of soil ingestion in units of kg/day, the soil ingestion rate was multiplied by food ingestion rate, yielding a value of 0.013 kg/day.

### 3.3.4 Short-tailed Shrew

#### 3.3.4.1 Life History

The short-tailed shrew is common throughout the eastern and central portions of the United States (Jones and Birney 1988, Barbour and Davis 1974). It is a large, heavy-bodied, and extremely active shrew (Merritt 1987). It occupies a variety of moist and dry habitats such as marshes, bogs, forest floors with ample decaying matter, brushland, fencerows, weed fields, and pastures (Barbour and Davis 1974; Merritt 1987; Jones and Birney 1988).

Using echolocation and scent-marking, short-tailed shrews rely heavily on their hearing and sense of smell to locate food and move about (Schwartz and Schwartz 1981; Hoffmeister 1989). They are active both day and night, usually throughout the year, although they may undergo a period of torpor during harsh winters (Hoffmeister 1989). They construct elaborate systems of runways and tunnels at or near the ground surface, or use tunnels left by other species such as moles or voles (Merritt 1987). Tunnel systems include caching sites and dedicated latrines (Merritt 1987). Two types of nests are built by short-tailed shrews: breeding and resting. Both are built underground beneath a log, rock, or other cover and have multiple entrances.

Although short-tailed shrews strongly prefer to eat animal matter, they are opportunistic omnivores and will voraciously consume whatever food items are available, including earthworms, slugs, snails, arthropods, fungi, roots, fruits, seeds, snakes, salamanders, small mammals, and young birds (Barbour and Davis 1974; Jones

and Birney 1988; Schwartz and Schwartz 1981). Plant matter is generally consumed to a greater extent in winter, and in some regions may constitute up to 25 % of the diet (Schwartz and Schwartz 1981; Hamilton 1930; Barbour and Davis 1974).

Natural predators of the short-tailed shrew include snakes, owls, hawks, shrikes, opossums, raccoons, foxes, coyotes, weasels, bobcats, skunks, and domestic cats, although many of these predators do not consume the shrew (or at least all of the shrew) because of its distasteful musk glands (Barbour and Davis 1974; Merritt 1987; Schwartz and Schwartz 1981). The life expectancy of a short-tailed shrew in the wild is approximately one to two years (Schwartz and Schwartz 1981; Merritt 1987).

#### 3.3.4.2 Exposure Profile

Conservative exposure pathways are the highest (ingestion rates) or lowest (body weight, home range size) values located in the literature. Adult short-tailed shrews weigh from 0.015 kg to 0.019 kg (EPA 1993). The lowest value of 0.015 kg (EPA 1993) was used as a conservative estimate of body weight.

Short-tailed shrews prefer to eat animal matter; however, they are opportunistic omnivores and will consume whatever food items are available, including earthworms, slugs, snails, arthropods, fungi, roots, fruits, seeds, snakes, salamanders, small mammals, and young birds (Barbour and Davis 1974; Jones and Birney 1988; Schwartz and Schwartz 1981). For this SLERA the diet of the short-tailed shrew was assumed to consist solely of invertebrates. A food ingestion rate of 0.62 g/g bw/day was found for adult shot-tailed shrews (EPA 1993). Using the above body weight a conservative food ingestion rate of 0.0093 kg/day was calculated. Connor (1993) reported soil ingestion by the short-tailed shrew to be 5.2% of the diet. To calculate a conservative rate of soil ingestion, this value was multiplied by the conservative food ingestion rate, yielding a value of 0.00048 kg/day.

### 3.3.5 American Kestrel

#### 3.3.5.1 Life History

The American kestrel, once called the sparrow hawk, is the smallest falcon in North America, and very common in the midwestern U.S. It is a jay-sized bird, 9 to 10 inches long with 21 inch wingspan.

The wide distribution of the American kestrel is exemplified in their breeding range, which extends north to Alaska and south into central Mexico. They breed locally in Central America and are distributed widely in South America. Most of the Canadian and northern U.S. kestrels migrate south in the winter; however, some males may stay year round. The American kestrel can be found in many different habitats including parks, suburbs, open fields, forest edges, alpine zones, and deserts (The Raptor Center 2011).

Kestrels are often seen hunting in open country and along roadways, typically hovering over one spot (Delaware Valley Raptor Center 2011). Kestrels also utilize perches for hunting and their health is dependent upon prey availability. When biomass of insects such as grasshoppers are low (winter into early spring), kestrels will

feed primarily on rodents and small birds. During the summer, kestrels will feed on insects, mainly grasshoppers, both in the air and from the ground (Roest 1957).

The kestrel does not have a long life expectancy. In the wild, the average life span is a little over one year. However, in captivity, ages of over 10 years have been recorded. Kestrels may fall prey to accidents and other raptors but its primary enemy is man (Delaware Valley Raptor Center 2011).

#### 3.3.5.2 Exposure Profile

Conservative exposure pathways are the highest (ingestion rates) or lowest (body weight, home range size) values located in the literature. Adult American kestrels weigh from 0.103 kg to 0.138 kg (EPA 1993). The lowest value of 0.103 kg (EPA 1993) was used as a conservative estimate of body weight.

American kestrels feed on a variety of prey including insects, reptiles, small mammals, and birds (EPA 1993). However, for this SLERA, the diet of the American kestrel was assumed to consist solely of small mammals. Food ingestion rates for the American kestrel range from 0.29 to 0.31 g/g bw/day (EPA 1993). The highest value of 0.31 g/g bw/day was used as a conservative estimate of food ingestion. Using the above body weight a conservative food ingestion rate of 0.032 kg/day was calculated. A soil ingestion rate for the American kestrel, or other appropriate surrogate species was not located in the literature as based on raptor feeding habits ingestion of soil is expected to be negligible (Sample and Suter 1994). However, because prey species may contain soil in their gastro-intestinal tracts, or soil adhering to fur or feathers, a soil ingestion rate of 1% is assumed for this SLERA. To calculate a conservative estimate of soil ingestion in unit of kg/day, the soil ingestion rate was multiplied by food ingestion rate, yielding a value of 0.00032 kg/day.

### 3.3.6 Red Fox

#### 3.3.6.1 Life History

The red fox is found throughout Canada and Alaska, and throughout most of the contiguous United States. Red foxes can live close to human habitat without being noticed due to their alertness and keen senses of smell, sight, and hearing. Red fox inhabit open meadows, ditch banks, field and wood edges, fencerows, stream and lake borders, and farmlands (Hoffmeister 1989; Jones and Birney 1988; Merritt 1987). With the exception of the breeding season, red fox have no permanent home, but sleep on the ground (Schwartz and Schwartz 1981). A den, usually modified from an existing woodchuck or fox den, is dug during the breeding season and exceptionally cold winters (Barbour and Davis 1974). These scent-marked dens have multiple rooms, entrances, and trails leading to and from hunting areas (Schwartz and Schwartz 1981). In addition to their dens, both males and females will defend their scent-marked hunting territory from intruders (Jones and Birney 1988).

The red fox is primarily an opportunistic carnivore, consuming food items such as rabbits, opossums, muskrats, skunks, rodents, birds, eggs, carrion, invertebrates, snakes, and frogs (Barbour and Davis 1974; Merritt 1987). Some vegetable matter such as fruits and nuts are also consumed when in season (Jones and Birney 1988). During

times of abundant food supply, the red fox will bury surplus food to return to for consumption at a later time (Schwartz and Schwartz 1981).

Natural predators of the red fox are few but include large hawks and owls, and possibly coyotes (Merritt 1987; Schwartz and Schwartz 1981). Red fox may live from six to ten years in the wild (Schwartz and Schwartz 1981).

#### 3.3.6.2 Exposure Profile

Conservative exposure pathways are the highest (ingestion rates) or lowest (body weight, home range size) values located in the literature. Adult red fox weigh from 3.94 kg to 5.25 kg (EPA 1993). The lowest value of 3.94 kg (EPA 1993) was used as a conservative estimate of body weight.

In general, red fox are primarily opportunistic carnivores, consuming a variety of food items such as small mammals, birds, eggs, carrion, invertebrates, snakes, and frogs (Barbour and Davis 1974; Merritt 1987). Some vegetable matter such as fruits and nuts are also consumed when in season (Jones and Birney 1988). For this SLERA, the diet of the red fox was assumed to consist solely of small mammals. Food ingestion rates for the red fox range from 0.069 to 0.14 g/g bw/day (EPA 1993). The highest value of 0.14 g/g bw/day was used as a conservative estimate of food ingestion. Using the above body weight a conservative food ingestion rate of 0.552 kg/day was calculated. Beyer *et al*. (1994) reported soil ingestion by the red fox to be 2.8% of the diet. To calculate a conservative rate of soil ingestion, this value was multiplied by the conservative food ingestion rate, yielding a value of 0.015 kg/day.

### 3.3.7 Northern Bobwhite

#### 3.3.7.1 Life History

The northern bobwhite is the most widespread North American quail; however, over the past few decades, populations have been declining. The species ranges from southeastern Wyoming, east to southern Minnesota, and across to southern Maine, south through the central and eastern U.S. to eastern New Mexico in the west and Florida in the east (EPA 1993).

Northern bobwhite are an average size quail, and like most other gallinaceous birds are poor fliers that seldom leave the ground and do not migrate. During the breeding season this species of quail prefer to nest in grasslands, idle fields, and pastures, within shaded areas characterized by open herbaceous cover, and growing vegetation. Foraging occurs in areas with open vegetation, some bare ground, and limited litter. During winter months, bobwhite quail require wooded cover with understory (EPA 1993).

Bobwhite forage during the day on the ground or in areas of light litter. Weed seeds, woody plants, and grasses comprise the majority of an adult bobwhite's diet year round; however, during the spring and summer, invertebrates may make up to 10% to 25% of their diet (EPA 1993).

Bobwhites attempt to rear one or two broods per year. Predation is the primary cause of nest loss. Both adult and juvenile mortality is high. In general, 70% to 85% survive less than one year in the wild (EPA 1993).

#### 3.3.7.2 Exposure Profile

Conservative exposure pathways are the highest (ingestion rates) or lowest (body weight) values located in the literature. Adult northern bobwhites weigh from 0.157 to 0.194 kg (EPA 1993). The lowest value of 0.157 kg (EPA 1993) was used as a conservative estimate of body weight.

Northern bobwhite feed almost entirely on plant material; however, during the spring and summer invertebrates may comprise a portion of their diet (EPA 1993). For this SLERA, the diet of the northern bobwhite was assumed to consist solely of plants. Food ingestion rates for adult northern bobwhite range from 0.067 to 0.093 g/g bw/day (EPA 1993). The highest value of 0.093 g/g bw/day was used as a conservative estimate of food ingestion. Using the above body weight a conservative food ingestion rate of 0.015 kg/day was calculated. A soil ingestion rate for the northern bobwhite was not located in the literature. As an alternate, a value of 9.3% (Beyer *et al*. 1994) for the wild turkey was used as feeding habits for both species are assumed to be similar. To calculate a conservative estimate of soil ingestion in unit of kg/day, the soil ingestion rate was multiplied by food ingestion rate, yielding a value of 0.0014 kg/day.

### 3.3.8 Eastern Cottontail

#### 3.3.8.1 Life History

The eastern cottontail is the most widespread of North American medium-sized rabbits. The range of the eastern cottontail spans from southern Canada to over most of the eastern half of the U.S., and has been introduced to the western U.S. The eastern cottontail occupies a variety of habitats that contain weedy forbs and perennial grasses that also function as escape sites. Eastern cottontails are mainly crepuscular and nocturnal, but they can be active at any time of the day. They are active throughout the year (EPA 1993).

The eastern cottontail's diet consists of a wide variety of herbaceous material such as grasses, clover, and alfalfa. Winter food sources include woody vines, shrubs, and plant parts such as twigs and bark.

Eastern cottontails are short-lived; most do not survive beyond their third year in the wild. Eastern cottontail fall prey to large carnivorous mammals and birds. Adult mortality is high; ranging from approximately 65% to 75% per year. Mortality in juveniles is even higher at approximately 85% to 90% (EPA1993).

#### 3.3.8.2 Exposure Profile

Conservative exposure pathways are the highest (ingestion rates) or lowest (body weight, home range size) values located in the literature. Adult cottontails weigh from 1.132 kg to 1.313 kg (EPA 1993). The lowest value of 1.132 kg (EPA 1993) was used as a conservative estimate of body weight.

A food ingestion rate of 0.237 kg/day for the eastern cottontail was reported by Sample and Suter (1994). A soil ingestion rate for the eastern cottontail was not located. Sample and Suter (1994) reported soil ingestion by the eastern cottontail to be similar to that of the black-tailed jackrabbit consisting of 6.3% of its diet. To calculate a conservative rate of soil ingestion, this value was multiplied by the conservative food ingestion rate, yielding a value of 0.015 kg/day.

## 3.3.9 Muskrat

### 3.3.9.1 Life History

The muskrat is a large, semi-aquatic mammal which virtually lives any place where sufficient food and permanent water is present, including saltwater marshes (Schwartz and Schwartz 1981; Jones and Birney 1988). It can be found throughout most of the U.S., with the exception of Hawaii, Florida, south Texas, and parts of California (Merritt 1987; Schwartz and Schwartz 1981).

Muskrats are primarily nocturnal and are active throughout the year (Merritt 1987). Home ranges vary from 10 to 180 meters' length of shoreline, depending on the size and shape of the water in which the animals live (Merritt 1987), or from 0.0484 hectares (ha) to 0.39 ha (Neal 1968; Proulx and Gilbert 1983). The home of a muskrat consists of a system of burrows dug into a bank and leading to underwater and above water openings, or a conical lodge comprised of a heap of vegetation and mud (Merritt 1987; Jones and Birney 1981). Each home is usually inhabited by several muskrats, most often members of the same family (Davis and Schmidly 1994). On occasion, other animals such as birds, reptiles, and amphibians may utilize these dens and lodges, even when muskrats are present (Schwartz and Schwartz 1981).

Although they may consume meat (including carrion) during times of food scarcity, muskrats are generally herbivorous (Davis and Schmidly 1994; Schwartz and Schwartz 1981). Aquatic vegetation, such as cattails, algae, and sedges, appears to be the favored food item (Davis and Schmidly 1994). Terrestrial vegetation, aquatic invertebrates, fish, frogs, clams, snails, reptiles, young birds, and other muskrats have also been reported to be consumed by muskrats (Jones and Birney 1988; Barbour and Davis 1974; Davis and Schmidly 1994; Schwartz and Schwartz 1981).

The mink is usually the main natural predator of muskrats in most areas (Barbour and Davis 1974; Jones and Birney 1988; Schwartz and Schwartz 1981). Raptors, owls, coyotes, foxes, dogs, cats, raccoons, weasels, large snakes, snapping turtles, and fish also prey on muskrats (Schwartz and Schwartz 1981). Muskrats also carry a heavy parasitic load and as a result may suffer population crashes (Jones and Birney 1988). Only about one-third of young muskrats survive to their first winter (Schwartz and Schwartz 1981). One tagged muskrat was reported to survive for four years in the wild (Schwartz and Schwartz 1981).

### 3.3.9.2 Exposure Profile

Conservative exposure pathways are the highest (ingestion rates) or lowest (body weight, home range size) values located in the literature. Adult muskrat weigh from

0.837 kg to 1.48 kg (EPA 1993). The lowest regional value of 1.35 kg (EPA 1993) was used as a conservative estimate of body weight.

In times of food scarcity muskrats may feed on animal matter, but are generally herbivorous (Davis and Schmidly 1994; Schwartz and Schwartz 1981). Food ingestion rates for the muskrat range from 0.26 to 0.34 g/g bw/day (EPA 1993). The highest value of 0.34 g/g bw/day was used as a conservative estimate of food ingestion. Using the above body weight a conservative food ingestion rate of 0.459 kg/day was calculated. A sediment ingestion rate for the muskrat was not located in the literature. As an alternate, a value of 9.4% (Beyer *et al*. 1994) for the raccoon was used as foraging behavior within a tidal marsh (such as the one in Area 9) is expected to be similar for both species. To calculate a conservative estimate of sediment ingestion in unit of kg/day, the soil ingestion rate was multiplied by food ingestion rate, yielding a value of 0.0431 kg/day.

# Section 4
# Effects Assessment

The effects assessment evaluates the potential for site-related contaminants to cause adverse ecological effects, and establishes a relationship between exposure to a contaminant and the increased likelihood of adverse effects. It also presents the available types and sources of effects data which include media- and chemical-specific ESLs, and dose-based TRVs that serve as conservative effect concentrations.

## 4.1 Literature-Based Effects Data

This section of the SLERA describes the sources and types of effects data selected for use. For this SLERA, effects data are limited to ESLs and dose- based TRVs. This section describes and provides support for the sources and types of effects data (i.e., toxicity data) selected for use in this SLERA.

### 4.1.1 Ecological Screening Values

Medium-specific and chemical-specific ESLs were selected for this SLERA. These values were compared to concentrations of chemicals measured in site media to assess ecological risk. Screening values from the following references were applied in a hierarchical fashion to the maximum site specific chemical concentrations detected in soil, sediment and surface water as follow:

- Soil
  - EPA 2008, 2007a through 2007i, 2006a, 2005a through 2005h, and 2003 a and 2003b. Ecological Soil Screening Levels (EcoSSLs); lowest value used
  - Oak Ridge National Laboratory, Preliminary Remediation Goals for Ecological Endpoints (1997)
  - EPA 2003c. Region 5 Resource Conservation and Recovery Act (RCRA) Ecological Screening Levels

- Sediment
  - New Jersey Department of Environmental Protection (NJDEP), Site Remediation Program. 2009. Ecological Screening Criteria
  - Buchman, M.F. 2008. NOAA Screening Quick Reference Tables. 2008.
  - EPA 2006b. Region 3 Biological Technical Assistance Group (BTAG) Marine Sediment Screening Benchmarks

- Surface Water
  - NJDEP, Site Remediation Program. 2009. Ecological Screening Criteria
  - EPA 2009b. National Recommended Water Quality Criteria
  - EPA 2006. Region 3 BTAG Marine Screening Benchmarks

In this SLERA, NJDEP values were examined first to determine if a screening value was available for a particular compound. If a value was available, it was utilized. If not, values from secondary sources were used in the order they are listed above. If a selected screening level was exceeded, or no screening level was located, contaminants were retained as COPCs.

### 4.1.2 Wildlife Toxicity Reference Values

For contaminants evaluated through food chain exposure models a literature search was conducted to locate TRVs. The values were selected to evaluate potential effects of estimated exposure doses received by select avian and mammalian modeled receptor species. The output of the food chain exposure model is a dose, expressed in milligrams of contaminant per kilogram of body weight per day (mg/kg bw/day) and is compared to a dose-based TRV. An attempt was made to select TRVs derived from test organisms which are closely related on a trophic level, and with respect to prey preferences to the model receptor.

For this SLERA, the lowest-observed-adverse-effect level (LOAEL) and no observed-adverse-effect level (NOAEL) were selected as the TRVs. The primary source for selected NOAEL and LOAEL-based TRVs is Toxicological Benchmarks for Wildlife: 1996 Revision (Sample et al. 1996); however, other sources were also utilized when needed. The TRVs used in the food chain exposure models for this SLERA are presented in Tables 4-1 and 4-2.

# Section 5
# Risk Characterization

The risk characterization integrates information from the exposure and effects assessments and estimates risk to representative ecological receptors. This SLERA relies on the hazard quotient (HQ) approach to evaluate risks.

## 5.1 Risk Characterization Methods

For this SLERA, the potential for risk is evaluated primarily through a comparison of chemical concentrations in site media to their respective ESLs and through food chain exposure models. Both means evaluate risks using the HQ approach as described in the following subsections.

### 5.1.1 Direct Contact

Potential risks to ecological receptors are evaluated using the HQ approach. This process involves comparing the maximum chemical concentrations measured in site media to their respective ESLs. By nature these values are conservative, and in this way avoid the potential for underestimating risk. This method compares the maximum exposure concentration for a specific chemical to their screening benchmark counterpart and is expressed as a ratio per the following formula:

$$\textit{Hazard Quotient} = \frac{\textit{Maximum Detected Concentration of a Chemical}}{\textit{ESL}}$$

If resultant HQs are greater than unity (1.0), risk is implied. A HQ less than one suggests that there is a high degree of confidence that minimal risk exists, and therefore, are considered insignificant. Higher HQs are not necessarily indicative of more severe effects.

### 5.1.2 Food Chain Exposure Models

Chemicals detected in Areas 8 and 9 sediment, and Area 9 soil that are considered bioaccumulative, regardless of frequency of detection, are to be evaluated through food chain exposure models. Contaminants were identified as bioaccumulative, as per Table 4-2 in *Bioaccumulative Testing and Interpretation for the Purpose of Sediment Quality Assessment, Status and Needs, EPA-823-R-00-001, February 2000* (EPA 2000).

For those contaminants evaluated through food chain exposure models the HQ method was also employed. Hazard quotient modeling involves calculating potential risks to target receptors based on life history characteristics of selected receptors, the exposure concentration of the contaminant, and data on the likelihood of toxicological effects associated with the modeled dose. The dose represents the intake rate of a contaminant. For this SLERA, the dose is a function of the daily food ingestion rate for the target receptor being modeled, the amount of contaminant present in soil or sediment and hypothetical prey (e.g., earthworms, fish), and the incidental ingestion of soil or sediment.

For each receptor, the dose was calculated using conservative life history and exposure parameters. These included the lowest reported regional (when available) adult body weight and highest ingestion rates. Home range, feeding territory and breeding territory sizes are reported in the literature for several species. However, for this SLERA, a site foraging factor (SFF) of 1.0 (100% utilization) was used which assumed that each modeled receptor spends all of its time, and acquires all of its food from Area 9.

Site-specific representative prey tissue data were not collected; therefore, use of bioaccumulation factors (BAFs) and sediment to biota bioaccumulation factors (BSAFs) were utilized to estimate concentrations of contaminants in prey species (e.g., fish and invertebrates) of select modeled receptors (Table 5-1). The BAFs and BSAFs were applied to the maximum soil and sediment concentrations to predict the tissue burden at a hypothetical concentration. The resultant BAF and BSAF-based values were then used in conjunction with the sediment or soil data to determine the total dose of which the receptor species will be exposed. Since TRVs are generally reported as wet weight concentrations, sediment or soil concentrations were entered into the models as wet weights. Dose was calculated as follow:

$$\text{Total dose} = \{\sum[(FIR \times C_F) + (SIR \times C_s)] \times SFF\}/BW$$

where:

| | |
|---|---|
| FIR | = food ingestion rate |
| $C_F$ | = BSAF or BAF-based maximum contaminant concentration in prey item |
| SIR | = sediment or soil ingestion rate |
| $C_S$ | = maximum contaminant concentration in sediment or soil |
| SFF | = site foraging factor |
| BW | = body weight |

The resultant dose is then compared to the appropriate TRVs and is expressed as a ratio per the following formula:

$$\textit{Hazard Quotient} = \frac{\textit{Exposure Concentration (i.e., Total Dose)}}{\textit{NOAEL or LOAEL-based TRV}}$$

## 5.2 Identification of Chemicals of Potential Concern

Each of the following subsections presents risks based on direct exposure and food chain exposure. Chemicals with maximum detected concentrations above their respective ESLs, or dosed-based TRVs are identified as COPCs. No benchmarks are available for calcium, magnesium, potassium, and sodium. However, these elements are not considered in the evaluation of risk because they are ubiquitous, occur naturally in high concentrations, are essential nutrients, and are unlikely to pose risk. In addition, tissue concentrations of these elements are regulated by living organisms; even at relatively high levels of exposure, internal concentrations generally do not become sufficiently high to cause toxic effects. Information on the fate, transport, and toxicity of contaminants identified as COPCs can be found in Appendix B.

### 5.2.1 Direct Contact

Chemicals with maximum detected values above their selected ESLs (i.e., HQ > 1.0) are identified as COPCs, as are detected chemicals for which screening-level benchmarks could not be identified unless otherwise noted below. The HQs and identified COPCs, and the rationale for their selection, are presented below (Tables 2-3 through 2-7).

For informational purposes, when reporting limits of non-detected contaminants were greater than their respective screening criteria, these chemicals were evaluated using ½ the maximum reporting limit. Results of this screening exercise are presented in Appendix C.

#### 5.2.1.1 Area 9

Contaminants with maximum concentrations above their respective ESLs (HQs >1.0):

**Soil (Table 2-3)**

- SVOCs: bis(2-ethylhexyl)phthalate, butylbenzylphthalate, fluoranthene, and pyrene
- Pesticides/PCBs: 4,4′-DDT, endosulfan II, and Aroclor 1254
- Inorganics: antimony, arsenic, cadmium, chromium, copper, lead, manganese, mercury, selenium, silver, tin, vanadium, and zinc

**Sediment (Table 2-4)**

- VOCs: carbon disulfide
- SVOCs: acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzo(k)fluoranthene, bis(2-ethylhexyl)phthalate, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene
- Pesticides/PCBs: alpha-chlordane
- Inorganics: antimony, arsenic, barium, cadmium, copper, iron, lead, mercury, nickel, selenium, silver, vanadium, and zinc

**Surface Water (Table 2-5)**

- SVOCs: benzo(a)anthracene
- Inorganics (total and dissolved): copper, iron, lead, manganese and zinc

Chemicals detected with no corresponding ESLs:

**Soil (Table 2-3)**

- VOCs: fluorobenzene and isopropylbenzene
- SVOCs: 1,1′-biphenyl, 2-methylphenol, benzaldehyde, carbazole, and dibenzofuran
- Inorganics: aluminum and iron

**Sediment (Table 2-4)**

- VOCs: acetone and 2-butanone
- Acetophenone and carbazole
- Inorganics: aluminum, beryllium, thallium, and hexavalent chromium

**Surface Water (Table 2-5)**

- Inorganics (total and dissolved): aluminum and antimony

#### 5.2.1.2 Area 8

Contaminants with maximum concentrations above their respective ESLs (HQs >1.0):

**Sediment (Table 2-6)**

- VOCs: carbon disulfide
- Pesticides/PCBs: 4,4′-DDT, endosulfan II, endosulfan sulfate, gamma-chlordane, and Aroclor 1254
- Inorganics: antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, vanadium, and zinc

**Surface Water (Table 2-7)**

- Inorganics (total): arsenic, copper, iron, lead, manganese, vanadium, and zinc
- Inorganics (dissolved): arsenic, copper, iron, lead, manganese, nickel, vanadium, and zinc

Chemicals detected with no corresponding ESLs:

**Sediment (Table 2-6)**

- SVOCs: acetophenone, benzaldehyde, and carbazole
- Inorganics: aluminum, beryllium, tin, and hexavalent chromium

**Surface Water (Table 2-7)**

- Inorganics (total and dissolved): aluminum and antimony

### 5.2.2 Food Chain Exposure Model Risks

The following sections summarize the results of the food chain exposure models for each receptor. Nine species representing avian and mammalian communities are assumed to inhabit Area 9 and accumulate chemical residues through ingestion of prey items and incidental ingestion of soil or sediment. NOAEL-based HQs below 1.0 suggest a lack of risk. LOAEL-based HQs that are greater than 1.0 suggest risk. When NOAEL-based HQs are greater than 1.0, but LOAEL-based HQs are not, this suggests the potential for risk. This potential increases as the dose approaches the LOAEL.

Food chain exposure models were run following the methods in Section 5.1.2 and are presented in Appendix D. Results are summarized in the following subsections and are presented in Tables 5-2 and 5-3.

#### 5.2.2.1 Belter Kingfisher

A food chain exposure model using the belted kingfisher was conducted following the methodology discussed in Section 5.1.2. Results of the model indicate risk from exposure to copper, lead, selenium, and zinc as both NOAEL and LOAEL-based HQs are greater than 1.0 (Table 5-2).

#### 5.2.2.2 Mink

A food chain exposure model using the mink was conducted following the methodology discussed in Section 5.1.2. Results of the model indicate risk from exposure to arsenic, copper, and selenium as both NOAEL and LOAEL-based HQs are greater than 1.0 (Table 5-2).

In addition, the model indicates the potential for risk from exposure to lead and silver as the NOAEL-based HQ is greater than 1.0, but the LOAEL-based value is less than 1.0 (Table 5-2).

#### 5.2.2.3 American Robin

A food chain exposure model using the American robin was conducted following the methodology discussed in Section 5.1.2. Results of the model indicate risk from exposure to arsenic, copper, lead, selenium, zinc, alpha-chlordane, Aroclor 1254, 4,4′-DDD, 4,4′-DDE, 4,4′-DDT, endrin, and gamma-chlordane in soil as both NOAEL and LOAEL-based HQs are greater than 1.0 (Table 5-3).

In addition, the model indicates the potential for risk from exposure to cadmium, hexavalent chromium, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, fluoranthene, pentachlorophenol, pyrene, endosulfan II, and methoxychlor in soil as resultant NOAEL-based HQs are greater than 1.0, but LOAEL-based HQs are less than 1.0 (Table 5-3).

#### 5.2.2.4 Short-tailed Shrew

A food chain exposure model using the short-tailed shrew was conducted following the methodology discussed in Section 5.1.2. Results of the model indicate risk from exposure to arsenic, lead, selenium, pentachlorophenol, alpha-chlordane, Aroclor 1254, endosulfan II, endrin, and gamma-chlordane in soil as both NOAEL and LOAEL-based HQs are greater than 1.0 (Table 5-3).

In addition, the model indicates the potential for risk from exposure to copper, silver, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, fluoranthene, pyrene, and methoxychlor in soil as resultant NOAEL-based HQs are greater than 1.0, but LOAEL-based HQs are less than 1.0 (Table 5-3).

#### 5.2.2.5 American Kestrel

A food chain exposure model using the American kestrel was conducted following the methodology discussed in Section 5.1.2. Results of the model indicate risk from exposure to lead, Aroclor 1254, and 4,4′-DDT in soil as both NOAEL and LOAEL-based HQs are greater than 1.0 (Table 5-3).

In addition, the model indicates the potential for risk from exposure to zinc, 4,4′-DDD and 4,4′-DDE in soil as resultant NOAEL-based HQs are greater than 1.0, but LOAEL-based HQs are less than 1.0 (Table 5-3).

#### 5.2.2.6 Red Fox

A food chain exposure model using the red fox was conducted following the methodology discussed in Section 5.1.2. Results of the model indicate risk from

exposure to arsenic, selenium, and Aroclor 1254 in soil as both NOAEL and LOAEL-based HQs are greater than 1.0 (Table 5-3).

In addition, the model indicates the potential for risk from exposure to lead and 4,4'-DDT in soil as resultant NOAEL-based HQs are greater than 1.0, but LOAEL-based HQs are less than 1.0 (Table 5-3).

#### 5.2.2.7 Northern Bobwhite

A food chain exposure model using the northern bobwhite was conducted following the methodology discussed in Section 5.1.2. Results of the model indicate risk from exposure to lead in soil as both NOAEL and LOAEL-based HQs are greater than 1.0 (Table 5-3).

In addition, the model indicates the potential for risk from exposure to 4,4'-DDT in soil as the resultant NOAEL-based HQ is greater than 1.0, but the LOAEL-based HQ is less than 1.0 (Table 5-3).

#### 5.2.2.8 Eastern Cottontail

A food chain exposure model using the eastern cottontail was conducted following the methodology discussed in Section 5.1.2. Results of the model indicate risk from exposure to arsenic, copper, and lead in soil as both NOAEL and LOAEL-based HQs are greater than 1.0 (Table 5-3).

In addition, the model indicates the potential for risk from exposure to silver and Aroclor 1254 in soil as resultant NOAEL-based HQs are greater than 1.0, but LOAEL-based HQs are less than 1.0 (Table 5-3).

#### 5.2.2.9 Muskrat

A food chain exposure model using the muskrat was conducted following the methodology discussed in Section 5.1.2. Results of the model indicate risk from exposure to arsenic and copper in sediment as both NOAEL and LOAEL-based HQs are greater than 1.0 (Table 5-2).

In addition, the model indicates the potential for risk from exposure to lead, selenium, and silver in sediment as resultant NOAEL-based HQs are greater than 1.0, but LOAEL-based HQs are less than 1.0 (Table 5-2).

## 5.3 Refinement of Chemicals of Potential Concern

Risk from exposure to several chemicals was determined through a comparison of chemicals detected in site media to their respective ESLs, and through food chain exposure models. However, certain chemicals retained as COPCs can be eliminated from further evaluation or discussion as they occur naturally in high concentrations or are normally considered a residue or by-product of analytical techniques.

Concentrations of carbon disulfide in sediment from Areas 8 and 9 were found at levels above its respective ESL. Carbon disulfide occurs ubiquitously in the environment, and is a natural product of anaerobic biodegradation (HSDB 2011). Oceans, in particular, are a major source of carbon disulfide. In addition, coastal and

marshland areas of high biological activity are major contributors to naturally occurring carbon disulfide (ATSDR 1996). Given the nature and characteristics of the study area, elevated concentrations of carbon disulfide are expected to occur naturally. Based on this, carbon disulfide is excluded from further evaluation.

Finally, the chemicals acetone, bis(2-ethylhexyl)phthalate, butylbenzylphthalate, and 2-butanone, were detected in Area 9 sediment and soil at concentrations above or no screening levels were available. In general, these chemicals are viewed as common laboratory contaminants. In addition, they are not considered to be site-related and are eliminated from further evaluation.

## 5.4 Chemicals of Potential Concern Detected in Background Samples

Sediment, surface water, and soil samples representative of background conditions were collected in support of the RI (Section 2.7). For informational purposes, maximum concentrations of COPCs were compared to those same chemicals detected in background samples (Tables 5-4 through 5-6). Results of this comparison are discussed below; however, they are not used to further refine the list of COPCs.

### 5.4.1 Soil

Maximum concentrations of Area 9 soil COPCs were compared to those same chemicals which were detected in background samples (Table 5-4). With the exception of metals, COPCs identified in Area 9 soil, in general, consisted of VOCs and SVOCs that were retained as COPCs due to a lack of ESLs. The exception were the PAHs fluoranthene and pyrene, Aroclor 1254, and the pesticides 4,4′-DDT and endosulfan II where concentrations of these chemicals were above their respective ESLs. Several metals, including antimony, arsenic, chromium, cooper, and lead were also detected above ESLs.

Fluoranthene, pyrene, and 4,4′-DDT were detected in background samples, but at levels orders of magnitude lower than those found in Area 9 soil. Aroclor 1254 and other VOCs and SVOCs retained as COPCs in Area 9 soil were not detected in background samples. In general, most of the metals retained as COPCs were detected in background samples; however, similar to what is discussed above, levels are orders of magnitude lower. For example, maximum concentrations of antimony, arsenic, copper, chromium, lead, and iron in Area 9 soil are 188 mg/kg, 179 mg/kg, 155 mg/kg, 1,170 mg/kg, 10,200 J mg/kg, and 46,800 mg/kg, respectively. Concentrations of these metals in background samples based on the 95% upper prediction limit (UPL) are 0.2 mg/kg, 3.1 mg/kg, 7.8 mg/kg, 2.2 mg/kg, 5.7 mg/kg, and 1,101 mg/kg, respectively.

### 5.4.2 Sediment

Maximum concentrations of Areas 8 and 9 sediment COPCs were compared to those same chemicals which were detected in background samples (Table 5-5). Several COPCs were identified in sediment collected from Areas 8 and 9, and are comprised mostly of PAHs, pesticides, Aroclor 1254, and metals. All SVOCs retained as COPCs in Area 8 sediment were done so due to a lack of ESLs. Several PAHs (which are part

of the SVOC analysis) were detected, but at levels below ESLs. Opposite, was Area 9 sediment where several PAHs were retained as COPCs because levels were above ESLs. Several of these PAHs were also detected in background samples; however, based on the 95% UPL, levels are considerably lower than those found in Area 9 sediment.

Aroclor 1254 and four pesticides were retained as COPCs for Area 8 sediment. Aroclor 1254 and gamma-chlordane were detected in Area 9 sediment, but at levels below their respective ESLs; 4,4'-DDT in Area 9 sediment was found above its ESL. None of the above pesticides or Aroclor 1254 were detected in background sediment samples.

In general, most of the metals retained as COPCs in Areas 8 and 9 sediments were detected in background samples; however, levels in background samples are considerably lower, and in some cases by one or two orders of magnitude. This is most prominent for site-related metals such as antimony, arsenic, chromium, copper, lead, and iron in Area 8 sediment. For example, maximum concentrations of these metals detected in Area 8 sediment are 1,720 mg/kg, 933 J mg/kg, 3,500 mg/kg, 969 J mg/kg, 14,200 mg/kg, and 120,000 mg/kg, respectively. Concentrations of these metals in background samples based on the 95% UPL are 2 mg/kg, 38.7 mg/kg, 75.1 mg/kg, 176 mg/kg, 181.5 mg/kg, and 37,580 mg/kg, respectively. With the exception of the maximum concentration of chromium which was higher, these same metals were also detected in Area 9 sediment, but at levels lower than those found in Area 8; however, concentrations were still higher than the 95% UPL background concentrations.

### 5.4.3 Surface Water

Maximum concentrations of Areas 8 and 9 surface water COPCs were compared to those same chemicals which were detected in background samples (Table 5-6). Chemicals of potential concern in Area 8 and 9 surface water consist of metals (both total and dissolved fractions). The only exception is the PAH benzo(a)anthracene which was detected in one Area 9 surface water sample at a concentration above its ESL. The only metal that was retained as a COPC in both Area 8 and 9 surface water that was also detected in the background samples was manganese (total). Maximum concentrations detected in Area 8 and 9 were 309 J µg/L and 764 J µg/L, respectively. Total manganese in the background samples based on the 95%UPL was 73.7 µg/L. No other metals (both total and dissolved fractions) retained as COPCs in surface water were detected in background samples.

## 5.5 Risk Summary

This section of the SLERA discusses the potential ecological significance of the estimated risks and provides answers to risk questions identified in Section 2. Ecological significance considers the limitations and uncertainties (see Section 6) with the quantitative HQ risk estimates. An important first step to understand the results of this SLERA is to answer the risk questions initially presented in Section 2, Problem Formulation.

The following risk questions were identified as important to the SLERA. The results of the SLERA are used to respond to these questions and to help form conclusions. The risk questions and associated responses are presented below.

- *May ecological receptors be exposed to chemicals present in site soil, sediment and surface water?*

  Response: Yes. Several chemicals including site-related metals, lead, arsenic, antimony, chromium, copper, and iron were detected in all site media collected from Areas 8 and 9. In addition, other metals, PAHs, pesticides, and PCB Aroclors were also detected (Tables 2-3 through 2-7).

- *Where present, are concentrations of chemicals in Areas 8 and 9 sediment sufficient to cause adverse effects on the survival and/or growth of aquatic organisms (including invertebrates and plants)?*

  Response: Yes. Concentrations of site-related metals antimony, arsenic, chromium, copper, lead, and iron were all above their corresponding ESLs. The only exception was chromium in Area 9 sediment where levels were below its respective ESL. In addition, several other metals and organic chemicals were detected at levels above their ESLs (Tables 2-4 and 2-6).

- *Where present, are concentrations of chemicals in Areas 8 and 9 surface water sufficient to cause adverse effects on the survival and/or growth of aquatic organisms (including invertebrates and plants)?*

  Response: Yes. Concentrations of copper, lead, and iron (total and dissolved) in Area 9 surface water were above their respective ESLs as were concentrations of arsenic, copper, lead, and iron (total and dissolved) detected in Area 8 surface water. Antimony (total and dissolved) was detected in surface water from both Area 8 and 9; however, no surface water ESLs were available for evaluation. In addition, several other metals were detected at levels above their ESLs (Tables 2-5 and 2-7).

- *Where present, are concentrations of chemicals in Area 9 soil sufficient to cause adverse effects on the survival and/or growth of terrestrial organisms (including invertebrates and plants)?*

  Response: Yes. Several metals including antimony, arsenic, chromium, copper, and lead were detected at levels above their respective ESLs. In addition, several other metals, PAHs, pesticides, and PCB Aroclor 1254 were detected at levels above their ESLs (Table 2-3).

- *Are dietary exposure levels of chemicals sufficient to cause adverse effects on the growth, survival, and/or reproductive success of piscivorous bird communities utilizing Area 9?*

  Response: Yes. Results of the belted kingfisher model indicate risk from exposure to site-related metals copper and lead. In addition, risk from exposure to selenium

and zinc was also noted as both NOAEL and LOAEL-based HQs are greater than 1.0 (Table 5-2).

- *Are dietary exposure levels of chemicals sufficient to cause adverse effects on the growth, survival, and/or reproductive success of piscivorous mammal communities utilizing Area 9?*

  Response: Yes. Results of the mink model indicate risk from exposure to site-related metals arsenic and copper. In addition, risk from exposure to selenium was also noted as both NOAEL and LOAEL-based HQs are greater than 1.0 (Table 5-2).

  In addition, the model results indicate the potential for risk from exposure to lead and silver as resultant NOAEL-based HQs are greater than 1.0, but LOAEL-based HQs are less than 1.0 (Table 5-2).

- *Are dietary exposure levels of chemicals sufficient to cause adverse effects on the growth, survival, and/or reproductive success of insectivorous bird communities utilizing Area 9?*

  Response: Yes. Results of the American robin model indicate risk from exposure to site-related metals arsenic, copper, and lead. In addition, risk from exposure to selenium, zinc, alpha-chlordane, Aroclor 1254, 4,4′-DDD, 4,4′-DDE, 4,4′-DDT, endrin, and gamma-chlordane in soil was also noted as both NOAEL and LOAEL-based HQs are greater than 1.0 (Table 5-3).

  In addition, the model results indicate the potential for risk from exposure to cadmium, hexavalent chromium, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, fluoranthene, pentachlorophenol, pyrene, endosulfan II, and methoxychlor in soil as resultant NOAEL-based HQs are greater than 1.0, but LOAEL-based HQs are less than 1.0 (Table 5-3).

- *Are dietary exposure levels of chemicals sufficient to cause adverse effects on the growth, survival, and/or reproductive success of insectivorous mammal communities utilizing Area 9?*

  Response: Yes. Results of the short-tailed shrew model indicate risk from exposure to site-related metals arsenic and lead. In addition, risk from exposure to selenium, pentachlorophenol, alpha-chlordane, Aroclor 1254, endosulfan II, endrin, and gamma-chlordane in soil was also noted as both NOAEL and LOAEL-based HQs are greater than 1.0 (Table 5-3).

  In addition, the model indicates the potential for risk from exposure to copper, silver, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, fluoranthene, pyrene, and methoxychlor in soil as resultant NOAEL-based HQs are greater than 1.0, but LOAEL-based HQs are less than 1.0 (Table 5-3).

- *Are dietary exposure levels of chemicals sufficient to cause adverse effects on the growth, survival, and/or reproductive success of carnivorous bird communities utilizing Area 9?*

Response: Yes. Results of the American kestrel model indicate risk from exposure to the site-related metal lead. Risk from exposure to Aroclor 1254 and 4,4′-DDT in soil was also noted as both NOAEL and LOAEL-based HQs are greater than 1.0 (Table 5-3).

In addition, the model indicates the potential for risk from exposure to zinc, 4,4′-DDD and 4,4′-DDE in soil as resultant NOAEL-based HQs are greater than 1.0, but LOAEL-based HQs are less than 1.0 (Table 5-3).

- *Are dietary exposure levels of chemicals sufficient to cause adverse effects on the growth, survival, and/or reproductive success of carnivorous mammal communities utilizing Area 9?*

  Response: Yes. Results of the red fox model indicate risk from exposure to the site-related metal arsenic. Risk from exposure to selenium and Aroclor 1254 in soil was also noted as both NOAEL and LOAEL-based HQs are greater than 1.0 (Table 5-3).

  In addition, the model indicates the potential for risk from exposure to lead and 4,4′-DDT in soil as resultant NOAEL-based HQs are greater than 1.0, but LOAEL-based HQs are less than 1.0 (Table 5-3).

- *Are dietary exposure levels of chemicals sufficient to cause adverse effects on the growth, survival, and/or reproductive success of terrestrial herbivorous bird communities utilizing Area 9?*

  Response: Yes. Results of the northern bobwhite model indicate risk from exposure to the site-related metal lead in soil as both NOAEL and LOAEL-based HQs are greater than 1.0 (Table 5-3).

  In addition, the model indicates the potential for risk from exposure to 4,4′-DDT in soil as the resultant NOAEL-based HQ is greater than 1.0, but the LOAEL-based HQ is less than 1.0 (Table 5-3).

- *Are dietary exposure levels of chemicals sufficient to cause adverse effects on the growth, survival, and/or reproductive success of terrestrial herbivorous mammal communities utilizing Area 9?*

  Response: Yes. Results of the eastern cottontail model indicate risk from exposure to site-related metals arsenic, copper, and lead in soil as both the NOAEL and LOAEL-based HQs are greater than 1.0 (Table 5-3).

  In addition, the model indicates the potential for risk from exposure to silver and Aroclor 1254 in soil as resultant NOAEL-based HQs are greater than 1.0, but the LOAEL-based HQs are less than 1.0 (Table 5-3).

- *Are dietary exposure levels of chemicals sufficient to cause adverse effects on the growth, survival, and/or reproductive success of aquatic herbivorous mammal communities utilizing Area 9?*

Response: Yes. Results of the muskrat model indicate risk from exposure to site-related metals arsenic and copper in sediment as both the NOAEL and LOAEL-based HQs are greater than 1.0 (Table 5-2).

In addition, the model indicates the potential for risk from exposure to lead, selenium, and silver in sediment as resultant NOAEL-based HQs are greater than 1.0, but LOAEL-based HQs are less than 1.0 (Table 5-2).

# Section 6
# Uncertainty Assessment

The potential risks due to contaminants in site media to ecological communities or populations at the site were evaluated by comparing maximum exposure concentrations to ecological screening values, an approach which provides the lowest level at which harmful effects would be predicted to occur, and through use of food chain exposure models. Inherent in these methods is some degree of uncertainty, introduced during various steps in the evaluation. The sources of this uncertainty are discussed below, as well as whether the assumptions used are likely to over- or under-represent ecological risks from chemicals at the site. In general, because this SLERA used conservative assumptions, risks are likely overestimated.

The main sources of uncertainty include natural variability, error, and insufficient knowledge. Natural variability is an inherent characteristic of ecological systems, their stressors, and their combined behavior in the environment. Biotic and abiotic parameters in these systems may vary to such a degree that the exposure and response of similar assessment endpoints in the same system may differ temporally and spatially. Factors that contribute to temporal and spatial variability include differences in individual organism behavior (within and between species), changes in the weather or ambient temperature, unanticipated interference from other stressors, interactions with other species in the community, differences between microenvironments, and numerous other factors.

## 6.1 Problem Formulation

Sources of uncertainty within the problem formulation phase of the SLERA relate to the selection of assessment endpoints and assumptions within the CSM.

The CSM presents the pathways by which contaminants are released from source areas to expose receptors. However, some exposure pathways are difficult to evaluate or cannot be quantitatively evaluated based on available information. Within this SLERA the inhalation exposure pathway was not addressed. It was assumed this exposure pathway is not significant when compared to contaminant exposure via direct contact and incidental ingestion. This may result in underestimating potential risk.

Target receptors were selected to represent a variety of organisms with similar feeding and behavioral strategies and to assist in the evaluation of measurement endpoints. However, species-specific exposure within similar feeding groups may vary and result in differing risk potential. Target receptors were selected with the intent of optimizing exposure and assuming they spend their entire lives restricted to the area of contamination. The assumption that target receptors spend their entire life at the site or a particular area is highly conservative and most likely over-estimates risk.

## 6.2 Exposure Assessment

All exposure assessments have a degree of uncertainty due to necessary simplifications and assumptions, which must be made as part of the evaluation. Major sources of uncertainty in the exposure assessment are discussed below.

Concentrations used to represent exposure point concentrations and characterizations of the distributions of chemicals can be a source of uncertainty. These issues relate to the adequate characterization of the nature and extent of chemical contamination. It is assumed that sufficient samples have been collected from site media and appropriately analyzed to adequately describe the nature and extent of chemical contamination resulting from the release of site-related chemicals.

When potential levels of uncertainty could adversely affect the results of the assessment, conservative approaches are taken that may result in over-protection of sensitive receptors. Such an approach is prudent where uncertainties are high and is in line with regulatory guidance for conducting SLERAs. For example, maximum detected concentrations of chemicals are used to assess potential risk at the SLERA stage, and this approach likely overestimated the average concentrations to which receptors may be exposed.

In this SLERA, it was assumed that COPCs in environmental media were 100% bioavailable. This is a conservative assumption that will overestimate risk. Bioavailability can be affected by factors including chemical speciation, sorption onto soils or sediment, complexation, aging, competition with environmental ligands, or precipitation in anoxic environments in the presence of sulfides (Chapman *et al.* 2003). Soil and sediment particle size can also influence exposure concentrations and bioavailability; soil/sediment comprised of fine particles will tend to have higher chemical concentrations than coarser textured ones due to the larger surface area and increased number of potential adsorption sites.

## 6.3 Effects Assessment

Uncertainties associated with the effects assessment relate to estimations of ESLs and TRVs, the use of conservative assumptions, and the degree of interaction between site contaminants. The major uncertainty in the effects assessment and potential impact on the SLERA is evaluated in this section.

The applicability of literature-derived data depends upon types of results presented and methods used to arrive at these results. Test endpoints produced by laboratory and field tests may be reported as formally defined toxicological endpoints or as less stringently defined measures of mortality or sublethal effects; variations in format introduce a source of uncertainty when used to derive a single acceptable level value. Thus, seemingly equivalent values may, in fact, be significantly different due to differences in test protocols, test conditions, or responses of individual organisms.

Uncertainties can be introduced by use of unrealistic assumptions in the conceptual model. Conservative assumptions are generally made in light of the uncertainty associated with the risk assessment process. This minimizes the possibility of

concluding that no risk is present when a threat actually does exist (e.g., minimizes false negatives). However, the accuracy with which risk was predicted is not known. The use of conservative assumptions likely overestimates risk.

The recommended dose-based NOAELs and LOAELs presented in Sample *et al*. (1996) for avian and mammalian receptors were derived from an extensive literature review by the authors. These well-accepted values are therefore considered appropriate does-based TRVs for the receptors modeled in this SLERA. The same assumption applies to TRVs from other sources that were reviewed when no values were available in the Sample *et al*. (1996) document.

## 6.4 Risk Characterization

By definition, uncertainties in risk characterization are influenced by uncertainties in exposure assessment and effects assessment. The adequate sampling and analysis of study area soil, sediment, and surface water minimize the uncertainties in the exposure assessment of these media. Descriptions of the magnitude and distribution of chemicals at the site are considered to be generally representative of current conditions. Since only the maximum-detected concentrations are used at this stage of the ecological risk assessment, the resulting HQs probably overestimate risks.

The frequency of a specific chemical detected above its criteria was not taken into consideration as part of the COPC identification process. In several instances, chemicals were retained as COPCs; however, they were often detected in a fraction of the samples and in several cases were only found in one.

Effects data can also contribute to overall uncertainty in risk characterization. Confidence in the ability of selected ESLs to assess ecological risks varies for each data value selected. While all values used in this SLERA are associated with some degree of uncertainty, it is the general trend described by the comparisons between exposure concentrations and effects concentrations, and the overall confidence in such comparisons, that are most important. Available information suggests that the ESLs selected for use in this SLERA are generally similar to others, are commonly accepted, and adequate for estimating risk using conservative assumptions.

This SLERA utilized simplifying assumptions in the food chain models, since it is difficult to mimic a complete diet. Thus, for the purpose of the models, receptor species are assumed to only consume a single food item. This is a conservative approach as all modeled receptors are expected to opportunistically consume a wide range of prey/food items, for example, the American robin. A considerable portion of the American robin's diet consists of fruit, especially outside of the breeding season. The assumption that the American robin's diet is comprised solely of soil invertebrates is a conservative assumption.

Ecological screening levels and TRVs for certain contaminants were not always available. When applicable, surrogate values were used. In general, these values were those published for a specific parent compound, metabolite or isomer. For example,

mammalian TRVs for 4,4′-DDD and 4,4′-DDE could not be located. Instead, the value for 4,4′-DDT was utilized.

Marine sediment and surface water ESLs were not always available. In general, and as recommended by the ESL source document, use of freshwater values were used as an alternate. For example, no marine sediment or freshwater ESLs for cobalt, iron, or manganese were available so freshwater values were utilized. This approach was followed for several chemicals which are identified in Tables 2-4 through 2-7 in footnote "a".

Reporting limits for several contaminants not detected were higher than their respective ESLs. In such cases, conservative assumptions were made to account for these non-detect results by assuming the actual concentrations of those contaminants were one half of the reporting limit. Contaminants evaluated following this approach, and those above their respective ESLs are presented in Appendix C.

Fish, soil invertebrate, small mammal, and plant tissue was not collected in support of this SLERA. Instead, BSAFs and BAFs were used to derive hypothetical tissue burden concentrations. If a specific BSAF or BAF was not located, a default value of "1" was used. Use of these values in the absence of site-specific data is not representative of site conditions and may artificially inflate the concentrations of contaminants in prey species when compared to those found on site. Use of these values in calculating dose introduces more uncertainties into already highly conservative food chain exposure models and may over estimate risk.

Maximum concentrations of chemicals entered into the food chain exposure models were converted to wet weight. For each chemical evaluated, wet weights were calculated using the moisture content of the sample which produced the maximum concentration. No moisture content data was available for the samples which produced the highest concentration of silver in sediment, and cadmium, lead, and silver in soil. As a substitute, the moisture content for these samples was assumed to be equal to the average moisture content for each media. This approach resulted in moisture contents values of 53% and 22.3% that were used to convert to weight wet for sediment and soil, respectively.

Detected concentrations of chemicals may not be indicative of bioavailable concentrations. With the exception of dissolved metals in surface water, all data used in the SLERA were based upon the total concentration of the chemical present, as opposed to the bioavailable fraction. Thus, risk may be overestimated.

Finally, the risk characterization method itself can contribute to uncertainty. Hazard quotients depend on a single value for both exposure concentration and effects concentration. Selecting a single ESL or TRV, only after consulting multiple sources to ensure some degree of consistency, minimizes the uncertainty associated with any single value. Incorporating site observations into final conclusions also reduces the dependence on strict quantitative risk estimates that, in some cases, can be highly uncertain.

# Section 7
# Summary and Conclusions

This section of the SLERA provides a summary of the responses to risk questions presented in Section 2.4 of the Problem Formulation. More specifically, those chemicals which pose a risk based on a particular assessment endpoint. Risks were evaluated through a comparison of maximum concentrations of chemicals in site media to their respective ESLs, and through food chain exposure models.

## 7.1 Direct Contact

Assessment endpoints 1 and 2 were addressed through a comparison of site media chemistry results to ESLs. Assessment endpoint 1 focuses on receptors in the terrestrial environment of Area 9, while assessment endpoint 2 evaluated risks to receptors in the aquatic environments of Areas 8 and 9.

### 7.1.1 Assessment Endpoint 1

Assessment endpoint 1, *Survival, growth, and reproduction of terrestrial organisms (including plants and invertebrates) utilizing Area 9*, was addressed through a comparison of Area 9 soil chemistry results to ESLs. Based on this comparison, risks to ecological receptors may occur from exposure to the following contaminants:

- SVOCs: fluoranthene, and pyrene
- Pesticides/PCBs: 4,4'-DDT, endosulfan II, and Aroclor 1254
- Inorganics: antimony, arsenic, cadmium, chromium, copper, lead, manganese, mercury, selenium, silver, tin, vanadium, and zinc

Due to a lack of ESLs, risk from exposure to fluorobenzene, isopropylbenzene, 1,1'-biphenyl, 2-methylphenol, benzaldehyde, carbazole, dibenzofuran, aluminum, and iron was not evaluated. Risk from exposure to these chemicals is inconclusive.

### 7.1.2 Assessment Endpoint 2

Assessment endpoint 2, *Survival, growth, and reproduction of aquatic organisms(including fish and invertebrates) utilizing Areas 8 and 9*, was addressed through a comparison of Areas 8 and 9 sediment and surface water chemistry results to ESLs. Each area was evaluated separately. A summary of risks noted for each is presented in the following sections.

#### 7.1.2.1 Area 9

**Sediment:** Risks to ecological receptors may occur from exposure to the following contaminants:

- SVOCs: acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene

- Pesticides: alpha-chlordane
- Inorganics: antimony, arsenic, barium, cadmium, copper, iron, lead, mercury, nickel, selenium, silver, vanadium, and zinc

Due to a lack of ESLs, risk from exposure to acetophenone, carbazole, aluminum, beryllium, thallium, and hexavalent chromium was not evaluated. Risk from exposure to these chemicals is inconclusive.

**Surface water:** Risks to ecological receptors may occur from exposure to the following contaminants:

- SVOCs: benzo(a)anthracene
- Inorganics (total and dissolved): copper, iron, lead, manganese and zinc

Due to a lack of ESLs for aluminum and antimony, risk from exposure to these metals was not evaluated and is inconclusive.

#### 7.1.2.2 Area 8

**Sediment:** Risks to ecological receptors may occur from exposure to the following contaminants:

- Pesticides/PCBs: 4,4'-DDT, endosulfan II, endosulfan sulfate, gamma-chlordane, and Aroclor 1254
- Inorganics: antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, vanadium, and zinc

Due to a lack of ESLs, risk from exposure to acetophenone, benzaldehyde, carbazole, aluminum, beryllium, tin, and hexavalent chromium was not evaluated. Risk from exposure to these chemicals is inconclusive.

**Surface water:** Risks to ecological receptors may occur from exposure to the following contaminants:

- Inorganics (total and dissolved): arsenic, copper, iron, lead, manganese, vanadium, and zinc
- Inorganics (dissolved): nickel

Due to a lack of ESLs for aluminum and antimony, risk from exposure to these metals was not evaluated and is inconclusive.

## 7.2 Food Chain Exposure Models

Assessment endpoints 3 through 11 were addressed through food chain exposure models using nine receptors representative of avian and mammalian communities assumed to utilize Area 9. NOAEL-based HQs below 1.0 suggest a lack of risk.

LOAEL-based HQs that are greater than 1.0 suggest risk. When NOAEL-based HQs are greater than 1.0, but LOAEL-based HQs are not, this suggests the potential for risk. This potential increases as the dose approaches the LOAEL. Results of the models are discussed in the following sections.

### 7.2.1 Assessment Endpoint 3

Assessment endpoint 3, *Survival, growth, and reproduction of piscivorous birds utilizing Area 9*, was addressed through a food chain exposure model using the belted kingfisher. Results of the model indicate risk from exposure to site-related metals copper and lead along with selenium and zinc.

### 7.2.2 Assessment Endpoint 4

Assessment endpoint 4, *Survival, growth, and reproduction of piscivorous mammals utilizing Area 9*, was addressed through a food chain exposure model using the mink. Results of the model indicate risk from exposure to site-related metals arsenic and copper along with selenium.

Results of the model also indicate the potential for risk from exposure to lead and silver.

### 7.2.3 Assessment Endpoint 5

Assessment endpoint 5, *Survival, growth, and reproduction of insectivorous birds utilizing Area 9*, was addressed through a food chain exposure model using the American robin. Results of the model indicate risk from dietary exposure to site-related metals arsenic, copper, and lead, along with selenium, zinc, alpha-chlordane, Aroclor 1254, 4,4′-DDD, 4,4′-DDE, 4,4′-DDT, endrin, and gamma-chlordane.

Results of the model also indicate the potential for risk from exposure to cadmium, hexavalent chromium, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, fluoranthene, pentachlorophenol, pyrene, endosulfan II, and methoxychlor.

### 7.2.4 Assessment Endpoint 6

Assessment endpoint 6, *Survival, growth, and reproduction of insectivorous mammals utilizing Area 9*, was addressed through a food chain exposure model using the short-tailed shrew. Results of the model indicate risk from exposure to site-related metals arsenic and lead, along with selenium, pentachlorophenol, alpha-chlordane, Aroclor 1254, endosulfan II, endrin, and gamma-chlordane.

Results of the model also indicate the potential for risk from exposure to copper, silver, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, fluoranthene, pyrene, and methoxychlor.

### 7.2.5 Assessment Endpoint 7

Assessment endpoint 7, *Survival, growth, and reproduction of carnivorous birds utilizing Area 9*, was addressed through a food chain exposure model using the American

kestrel. Results of the model indicate risk from exposure to the site-related metal lead along with Aroclor 1254, and 4,4′-DDT.

Results of the model also indicate the potential for risk from exposure to zinc, 4,4′-DDD and 4,4′-DDE.

### 7.2.6 Assessment Endpoint 8

Assessment endpoint 8, *Survival, growth, and reproduction of carnivorous mammals utilizing Area 9*, was addressed through a food chain exposure model using the red fox. Results of the model indicate risk from exposure to the site-related metal arsenic, along with selenium and Aroclor 1254.

Results of the model also indicate the potential for risk from exposure to lead and 4,4′-DDT.

### 7.2.7 Assessment Endpoint 9

Assessment endpoint 9, *Survival, growth, and reproduction of terrestrial herbivorous birds utilizing Area 9*, was addressed through a food chain exposure model using the northern bobwhite. Results of the model indicate risk from exposure to the site-related metal lead. Results of the model also indicate the potential for risk from exposure to 4,4′-DDT.

### 7.2.8 Assessment Endpoint 10

Assessment endpoint 10, *Survival, growth, and reproduction of terrestrial herbivorous mammals utilizing Area 9*, was addressed through a food chain exposure model using the eastern cottontail. Results of the model indicate risk from exposure to site-related metals arsenic, copper, and lead.

Results of the model also indicate the potential for risk from exposure to silver and Aroclor 1254.

### 7.2.9 Assessment Endpoint 11

Assessment endpoint 11, *Survival, growth, and reproduction of aquatic herbivorous mammals utilizing Area 9*, was addressed through a food chain exposure model using the muskrat. Results of the model indicate risk from exposure to site-related metals arsenic and copper.

Results of the model also indicate the potential for risk from exposure to lead, selenium, and silver.

## 7.3 Conclusions

Results of this SLERA have determined that chemicals detected in all site media evaluated from Areas 8 and 9 are at levels that may cause adverse effects to ecological receptors.

For those receptors in direct contact with Area 9 soil, such as soil invertebrates and plants, risk drivers primarily include several metals (including antimony, arsenic,

cadmium, chromium, copper, and lead), and to a lesser extent based on frequency of detection, Aroclor 1254, PAH compounds fluoranthene and pyrene, and the pesticides 4,4′-DDT and endosulfan II.

Risk drivers for receptors in direct contact with Area 9 sediment consists of metals (including antimony, arsenic, copper, lead, and iron) and to a lesser extent, based on frequency of detection, PAHs and the pesticide alpha-chlordane. Similar to Area 9, noted risk drivers for Area 8 sediments include several metals (including antimony, arsenic, chromium, copper, lead, and iron); however, no PAHs were identified as risk drivers. In addition, Area 8 sediment risk drivers also include several pesticides and Aroclor 1254.

For those receptors in direct contact with Area 9 surface water, primary risk drivers consist of copper, iron, lead, manganese, and zinc (both total and dissolved fractions). The same metals along with arsenic and vanadium (total and dissolved fractions), and dissolved nickel are noted risk drivers in Area 8 surface water.

Risks from dietary exposure to upper trophic level consumers such as birds and mammals were also noted. For aquatic receptors, those exposed to Area 9 sediments while foraging for and feeding on fish or aquatic plants, risks were limited to exposure from metals only. Risks to piscivorous birds were limited to copper, lead, selenium, and zinc; risks to piscivorous mammals were limited to arsenic, copper, and selenium. Risks to aquatic herbivorous mammals are limited to arsenic and copper.

Risks from dietary exposure to avian receptors utilizing Area 8 while foraging for and feeding on aquatic invertebrates and plants are assumed based on the results of EPA/ERT's investigation (Section 2.6). Both food items used in ERT's models, ribbed mussels and sea lettuce, were observed along the western jetty of Area 8 which is comprised of similar source material as observed along the Area 1 seawall. Based on the more conservative model, risks to invertivorous birds and herbivorous shorebirds from exposure to arsenic and lead were noted. Chromium also posed a risk to herbivorous shorebirds.

Risks from dietary exposure to terrestrial receptors, those exposed to Area 9 soil while foraging for and feeding on soil invertebrates, small mammals, and plants, vary based on the feeding guilds each modeled receptor represents. Based on the results of the food chain exposure models, insectivorous birds and mammals are the most prone to risks from chemicals in Area 9 soil when compared to receptors representing other feeding guilds. This is primarily due to higher incidental soil ingestion rates, a result of feeding habits, and consumption of soil invertebrates. Prominent risk drivers to insectivorous birds and mammals in Area 9 soil include arsenic, lead, selenium, Aroclor 1254 and several pesticides; however, between each taxa, birds are at risk from several more pesticides and metals such as copper and zinc.

Risks to carnivorous birds and mammals are expected to be minimal. Collectively speaking, between the American kestrel and red fox models, risks were only noted from exposure to arsenic, lead, selenium, Aroclor 1254 and 4,4′-DDT. Likewise, risk to

herbivorous birds and mammals are also expected to be minimal. Results of the models indicate that herbivorous mammals in Area 9 are at risk from exposure to arsenic, copper, and lead in soil; risk to herbivorous birds is limited to lead. Similar to the results of the insectivorous bird and mammal models, feeding behavior and assumed food items heavily influence risk. However, in the case of carnivores and herbivores the results are opposite as incidental soil ingestion is expected to be minimal, and accumulation of chemicals in food items (small mammals and plant) are expected to be less when compared to soil invertebrates.

In conclusion, this SLERA has determined that chemicals present in site media may pose a risk to ecological receptors utilizing Areas 8 and 9 of the site. Risk drivers consist of several groups of chemicals including PAHs, pesticides, Aroclor 1254, and metals.

Risk from exposure to PAHs is mostly limited to receptors in contact with Area 9 sediments; PAHs pose little or no risk to upper trophic levels receptors, or those organisms in contact with Area 9 soil or Area 8 sediment.

Pesticides as a group pose a risk to receptors in contact with Area 9 soil and Areas 8 and 9 sediment; however, risks are only limited to a few compounds. Risk from dietary exposure to pesticides in Area 9 soil to insectivorous birds and mammals, and carnivorous birds are also noted. Collectively speaking, the most prominent pesticide risk driver is 4,4'-DDT, both from direct contact exposure in Area 8 sediment and Area 9 soil and from dietary exposure to insectivorous birds and mammals, and carnivorous birds utilizing Area 9. The same trend is noted for Aroclor 1254 where risks are noted from direct contact with Area 8 sediment and Area 9 soil, and from dietary exposure to insectivorous and carnivorous birds and mammals utilizing Area 9.

Several metals were identified as risk drivers mostly through direct contact based on a comparison with media-specific ESLs. Fewer metals pose a risk via food chain exposure; however, results of the models indicate that arsenic and lead are the primary risk drivers to terrestrial receptors, and arsenic, copper, lead, and selenium to aquatic receptors via dietary exposure. All metals retained as COPCs were detected at higher concentrations than what was found in background samples regardless of media. These metals include antimony, arsenic, chromium, copper, iron, and lead as well as others such as barium, cadmium, manganese, nickel, and zinc.

# Section 8
# References

Agency for Toxic Substances and Disease Registry (ATSDR). 1996. Toxicological Profile for Carbon Disulfide. U.S. Department of Health and Human Service, Agency for Toxic Substances and Disease Registry, Atlanta, GA.

Barbour, R. W. and W. H. Davis. 1974. Mammals of Kentucky. University Press of Kentucky, Lexington, KY.

Beyer, W. N., E. E. Conner and S. Gerould. 1994. "Estimates of soil ingestion by wildlife." J. Wildl. Manage. 58(2): 375-382.

Buchman, M.F., 2008. NOAA Screening Quick Reference Tables, NOAA OR&R Report 08-1, Seattle, WA, Office of Response and Restoration Division, National Oceanic and Atmospheric Administration.

Bull, J. and J. Farrand, Jr. 1977. The Audubon Society Field Guide to North American Birds, Eastern Region. New York, NY, Alfred A. Knopf, Inc.

Cassidy, J. (ed.). 1990. Book of North American Birds. New York: The Reader's Digest Association, Inc.

CDM Federal Programs Corporation (CDM). 2010a. Final Beach Sampling Technical Memorandum, Raritan Bay Slag Superfund Site, Remedial Investigation/Feasibility Study, Old Bridge/ Sayreville, New Jersey.

CDM. 2010b. Final (Revised) Data Gap Evaluation Technical Memorandum, Raritan Bay Slag Superfund Site, Remedial Investigation/Feasibility Study, Old Bridge/ Sayreville, New Jersey. June.

CDM. 2010c. Final Quality Assurance Project Plan, Remedial Investigation/Feasibility Study, Raritan Bay Slag Superfund Site, Old Bridge/Sayreville, New Jersey. October.

Chapman, P. M., F. Wang, C. R. Janssen, R. R. Goulet, and C. N. Kamunde. 2003. Conducting ecological risk assessments of inorganic metals and metalloids: Current status. Human Ecol. Risk Assess. 9(4): 641-697.

Clench, M. H. and R. C. Leberman. 1978. Weights of 151 species of Pennsylvania birds analyzed by month. Bull. Carnegie Mus. Nat. Hist. 5.

Collins, H. H. J. and N. R. Boyajian. 1965. Familiar Birds of North America. Harper and Row, New York.

Connor, E. E. 1993. Soil ingestion and lead concentration in wildlife species. M.S. Thesis, Virginia Polytechnic Institute, Blacksburg, VA.

Davis, W. B. and D. J. Schmidly. 1994. The Mammals of Texas. Texas Parks and Wildlife.

Delaware Valley Raptor Center. 2011. Raptor Profile: American Kestrel. http://www.dvrconline.org/raptorprof.html#amerkestrel

Efroymson, R.A., G.W. Suter II, B.E. Sample, and D.S. Jones. 1997. Preliminary Remediation Goals for Ecological Endpoints, Prepared for the Department of Energy by Lockheed-Martin Energy Systems, Oak Ridge National Laboratory. ES/ER/TM/-162/R2. August.

Ehrlich, P. R., D. S. Dobkin and D. Wheye. 1988. The Birders Handbook. Simon and Schuster, Fireside, New York.

Eiserer, L. 1976. The American Robin. Nelson-Hall, Chicago, IL.

United States Environmental Protection Agency (EPA). 2009a. Hazardous Ranking System Documentation Record, Raritan Bay Slag. April.

EPA. 2009b. National Recommended Water Quality Criteria. Office of Water. EPA-822-R-02-047.

EPA. 2008. Ecological Soil Screening Levels for Chromium, Revised Interim Final, OSWER Directive 9285.7-66, Office of Solid Waste and Emergency Response. Washington, DC 20460. April.

EPA. 2007a. Ecological Soil Screening Levels for Polycyclic Aromatic Hydrocarbons (PAHs), Interim Final, OSWER Directive 9285.7-78, Office of Solid Waste and Emergency Response. Washington, DC 20460. June.

EPA. 2007b. Ecological Soil Screening Levels for Copper, Revised Interim Final, OSWER Directive 9285.7-68, Office of Solid Waste and Emergency Response. Washington, DC 20460. February.

EPA. 2007c. Ecological Soil Screening Levels for Manganese, Interim Final, OSWER Directive 9285.7-71, Office of Solid Waste and Emergency Response. Washington, DC 20460. April.

EPA. 2007d. Ecological Soil Screening Levels for Nickel, Interim Final, OSWER Directive 9285.7-76, Office of Solid Waste and Emergency Response. Washington, DC 20460. March.

EPA. 2007e. Ecological Soil Screening Levels for Selenium, Interim Final, OSWER Directive 9285.7-72, Office of Solid Waste and Emergency Response. Washington, DC 20460. July.

EPA. 2007f. Ecological Soil Screening Levels for Zinc, Interim Final, OSWER Directive 9285.7-73, Office of Solid Waste and Emergency Response. Washington, DC 20460. June.

EPA. 2007g. Ecological Soil Screening Levels for DDT and Metabolites, Interim Final, OSWER Directive 9285.7-57, Office of Solid Waste and Emergency Response. Washington, DC 20460. April.

EPA. 2007h. Ecological Soil Screening Levels for Dieldrin, Revised Interim Final, OSWER Directive 9285.7-56, Office of Solid Waste and Emergency Response. Washington, DC 20460. April.

EPA. 2007i. Ecological Soil Screening Levels for Pentachlorophenol, Revised Interim Final, OSWER Directive 9285.7-58, Office of Solid Waste and Emergency Response. Washington, DC 20460. April.

EPA. 2006a. Ecological Soil Screening Levels for Silver, Interim Final, OSWER Directive 9285.7-77, Office of Solid Waste and Emergency Response. Washington, DC 20460. September.

EPA. 2006b. EPA Region 3 BTAG Screening Benchmarks, Mid-Atlantic Risk Assessment: Ecological Risk Assessment. http://www.epa.gov/reg3hwmd/risk/eco/index.htm.

EPA. 2005a. Ecological Soil Screening Levels for Antimony, Interim Final, OSWER Directive 9285.7-61, Office of Solid Waste and Emergency Response. Washington, DC 20460. February.

EPA. 2005b. Ecological Soil Screening Levels for Cobalt, Interim Final, OSWER Directive 9285.7-67, Office of Solid Waste and Emergency Response. Washington, DC 20460. March.

EPA. 2005c. Ecological Soil Screening Levels for Vanadium, Interim Final, OSWER Directive 9285.7-75, Office of Solid Waste and Emergency Response. Washington, DC 20460. April.

EPA. 2005d. Ecological Soil Screening Levels for Arsenic, Interim Final, OSWER Directive 9285.7-62, Office of Solid Waste and Emergency Response. Washington, DC 20460. March.

EPA. 2005e. Ecological Soil Screening Levels for Barium, Interim Final, OSWER Directive 9285.7-63, Office of Solid Waste and Emergency Response. Washington, DC 20460. February.

EPA. 2005f. Ecological Soil Screening Levels for Beryllium, Interim Final, OSWER Directive 9285.7-64, Office of Solid Waste and Emergency Response. Washington, DC 20460. February.

EPA. 2005g. Ecological Soil Screening Levels for Cadmium, Interim Final, OSWER Directive 9285.7-65, Office of Solid Waste and Emergency Response. Washington, DC 20460. March.

EPA. 2005h. Ecological Soil Screening Levels for Lead, Interim Final, OSWER Directive 9285.7-70, Office of Solid Waste and Emergency Response. Washington, DC 20460. March.

EPA. 2003a. Ecological Soil Screening Levels for Aluminum, Interim Final, OSWER Directive 9285.7-60, Office of Solid Waste and Emergency Response. Washington, DC 20460. November.

EPA. 2003b. Ecological Soil Screening Levels for Iron, Interim Final, OSWER Directive 9285.7-69, Office of Solid Waste and Emergency Response. Washington, DC 20460. November.

EPA. 2003c. EPA Region 5 Resource Conservation and Recovery Act (RCRA) Ecological Screening Levels. August.

EPA. 2000. Bioaccumulative Testing and Interpretation for the Purpose of Sediment Quality Assessment, Status and Needs, EPA-823-R-00-001.

EPA. 1998. Guidelines for Ecological Risk Assessment. EPA/630-R-95/002F. April.

EPA. 1997. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. EPA 540-R-97-006. June.

EPA. 1993. Wildlife Exposure Factors Handbook, Volume I of II. United States Environmental Protection Agency, Office of Research and Development, Washington, DC. EPA/600/4-93/187a.

EPA/Environmental Response Team (ERT). 2010a. Report 2 of 2 Raritan Bay Slag Site, Old Bridge Township, New Jersey, Biological Assessment, Ecological Risk Assessment. April.

EPA/ERT. 2010b. Chemical Assessment Report: Characterization of Slag/Waste Material Fate and Transport of Contaminants Biomonitoring of Contaminants, Report 1 of 2. Amended April.

EPA/ERT. 2009. Trip Report Phase II, Raritan Bay Sediment Sampling, Laurence Harbor, New Jersey. August.

Hamilton, W. J., Jr. 1930. "The food of Soricidae." Journal of Mammalogy 11: 26-39.

Hazardous Substances Data Bank (HSDB). 2011. National Library of Medicine, online database (http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB)

Hazelton, P. K., R. J. Robel and A. D. Dayton. 1984. "Preferences and influence of paired food items on energy intake of American robins and gray catbirds." Journal of Wildlife Management 48(1): 198-202.

Hoffmeister, D. F. 1989. Mammals of Illinois. Urbana, IL, University of Illinois Press. 348.

Howell, J. C. 1942. "Notes on the nesting habits of the American robin (Turdus migratorius L.)." The American Midland Naturalist 28(3): 529-603.

Jones, J. K. J., Jr. and E. C. Birney. 1988. Handbook of Mammals of the North Central States. Minneapolis, MN: University of Minnesota Press. 346 pp.

Landrum, C.L., T.L. Ashwood, and D.K. Cox. 1993. Belted Kingfishers as Ecological Monitors of Contamination: A Review. Oak Ridge National Laboratory, Environmental Sciences Division, Office of Environmental Restoration and Waste Management, ORNL/M-2533.

Martin, A. C., H. S. Zim and A. L. Nelson. 1951. American Wildlife and Plants. New York, NY, McGraw-Hill Book Co., Inc.

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

Morrison, D. W. and D. F. Caccamise. 1990. "Comparison of roost use by three species of communal roostmates." Condor 92: 405-412.

National Geographic Society (NGS). 1987. Field Guide to the Birds of North America, Second Edition. The National Geographic Society, Washington, D.C.

Neal, T. J. 1968. "A comparison of two muskrat populations." Iowa State J. Sci. 43: 193-210.

New Jersey Department of Environmental Protection. 2009. Ecological Screening Criteria. March. http://www.nj.gov/dep/srp/guidance/ecoscreening/

Paszkowski, C. A. 1982. "Vegetation, ground, and frugivorous foraging of the American robin." Auk 99: 701-709.

Peterson, R. T. 1990. Western Birds. Houghton Mifflin Co., Boston.
Pitts, T. D. 1984. "Description of American robin territories in northwest Tennessee." Migrant 55: 1-6.

Proulx, G. and F. F. Gilbert. 1983. "The ecology of the muskrat Ondatra zibethicus at Luther Marsh, Ontario." Can. Field Naturalist 97: 377-390.

PTI Environmental Services (PTI). 1995. Bioaccumulation factor approach analysis for metals and polar organic compounds. Washington State Department of Ecology. CAOU-03-03. October.

Roest, A. I. 1957. "Notes on the American sparrow hawk." Auk 74(1): 1-19.

Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. Toxicological Benchmarks for Wildlife, Revision, Prepared for the Department of Energy by Lockheed-Martin Energy Systems, Inc., Oak Ridge National Laboratory. ES/ER/TM-86/R3

Sample BE, Suter GW. 1994. Estimating exposure of terrestrial wildlife to contaminants. ES/ER/TM-125. U.S. Department of Energy, Oak Ridge National Laboratory, Oak Ridge, TN.

Schwartz, C. W. and E. R. Schwartz. 1981. The Wild Mammals of Missouri, Revised Edition. Columbia, MO: University of Missouri Press and Missouri Department of Conservation. 356 pp.

Skorupa, J. P. and R. L. Hothem. 1985. "Consumption of commercially-grown grapes by American robins: A field evaluation of laboratory estimates." Journal of Field Ornithology 56(4): 369-378.

The Raptor Center. 2011. American Kestrel. Available at: http:// www.raptor.cvm.umn.edu.

Wauer, R. H. 1999. The American Robin. University of Texas Press, Austin, TX.

Weston Solutions Inc (Weston). 2009a. Summary Letter Report Phase I, Raritan Bay Slag, Old Bridge and Sayreville, New Jersey. January.

Weston. 2009b. Summary Letter Report Phase II, Raritan Bay Slag, Old Bridge and Sayreville, New Jersey. June.

Wheelwright, N. T. 1988. "Seasonal changes in food preferences of American robins in captivity." Auk 105: 374-378.

Wheelwright, N. T. 1986. "The diet of American robins: Analysis of U.S. Biological Survey records." The Auk 103: 710-725.

**Table 2-1**
**Vegetation Observed**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Common Name | Scientific Name | Common Name | Scientific Name |
|---|---|---|---|
| American beachgrass | *Ammophila breviligulata* | Mulitflora rose | *Rosa mulitflora* |
| American holly | *Ilex opaca* | Northern bayberry | *Myrica pensylvanica* |
| Arrowwood | *Viburnum dentatum* | Norway maple | *Acer platanoides* |
| Asiatic bittersweet | *Celastrus orbiculatus* | Osage-orange | *Maclura pomifera* |
| Asiatic dayflower | *Commelina communis* | Pennsylvania smartweed | *Polygonum pensylvanicum* |
| Aster | *Aster* spp. | Pigweed | *Amaranthus* spp. |
| Bedstraw | *Galium* spp. | Pin oak | *Quercus palustris* |
| Black gum | *Nyssa sylvatica* | Poison ivy | *Toxicodendron radicans* |
| Black jack oak | *Quercus marilandica* | Pokeweed | *Phytolacca americana* |
| Black locust | *Robinia pseudoacacia* | Post oak | *Quercus stellata* |
| Black oak | *Quercus velutina* | Princess-tree | *Paulownia tomentosa* |
| Black willow | *Salix nigra* | Prostrate pigweed | *Amaranthus blitoides* |
| Boneset | *Eupatorium perfoliatum* | Purple loosestrife | *Lythrum salicaria* |
| Bradford pear | *Pyrus calleryana* | Purslane | *Portulaca oleracea* |
| Broadleaf plantain | *Plantago major* | Queen Annes lace | *Daucus carota* |
| Broomsedge | *Andropogon virginicus* | Red cedar | *Juniperus virginiana* |
| Buckhorn plantain | *Plantago lanceolata* | Red maple | *Acer rubrum* |
| Buttonbush | *Cephalanthus occidentalis* | Red oak | *Quercus rubra* |
| Catalpa | *Catalpa speciosa* | Red-osier dogwood | *Cornus stolonifera* |
| Cattail | *Typha latifolia* | Saltwort | *Salsola kali* |
| Cherry | *Prunus* spp. | Sandbur | *Cenchrus longispinus* |
| Chestnut oak | *Quercus prinus* | Sassafras | *Sassafras albidum* |
| Chicory | *Cichorium intybus* | Scarlet oak | *Quercus coccinea* |
| Common burdock | *Arctium minus* | Sea lavender | *Limonium carolinianum* |
| Common chickweed | *Stellaria media* | Seaside goldenrod | *Solidago sempervirens* |
| Common cocklebur | *Xanthium strumarium* | Sheep laurel | *Kalmia angustifolia* |
| Common lambsquarters | *Chenopodium album* | Silk tree | *Albizia julibrissin* |
| Common mugwort | *Artemisia vulgaris* | Silver maple | *Acer saccharinum* |
| Common mullein | *Verbascum thapsus* | Smooth crabgrass | *Digitaria ischaemum* |
| Common pokeweed | *Phytolacca americana* | Spotted spurge | *Euphorbia maculata* |
| Common ragweed | *Ambrosia artemisiifolia* | St. John's Wort | *Hypericum perforatum* |
| Common reed | *Phragmites australis* | Staghorn sumac | *Rhus typhina* |
| Common sow thistle | *Sonchus oleraceus* | Swamp chesnut oak | *Quercus michauxii* |
| Cordgrass | *Spartina spp.* | Sweet everlasting | *Gnaphalium obtusifolium* |
| Curly dock | *Rumex crispus* | Sweet fern | *Comptonia peregrina* |

**Table 2-1**
**Vegetation Observed**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Common Name | Scientific Name | Common Name | Scientific Name |
|---|---|---|---|
| Dandelion | *Taraxacum officinale* | Sweetgum | *Liquidambar styraciflua* |
| Eastern cottonwood | *Populus deltoides* | Sweet pepper bush | *Clethra alnifolia* |
| Eveningprimerose | *Oenothera biennis* | Switch grass | *Panicum virgatum* |
| False indigo | *Amorpha fruticosa* | Sycamore | *Plantanus occidentalis* |
| Foxtail grass | *Setaria geniculata* | Tall goldenrod | *Solidago altissima* |
| Goldenrod | *Solidago* spp. | Tickseed sunflower | *Bidens aristosa* |
| Grass-leaved goldenrod | *Euthamia graminifolia* | Tree-of-heaven | *Ailanthus altissima* |
| Gray birch | *Betula populifolia* | Tulip tree | *Liriodendron tulipifera* |
| Ground ivy | *Glechoma hederacea* | Umbrella sedge | *Cyperus strigosus* |
| Groundsel bush | *Baccharis halimifolia* | Vetches | *Vicia* spp. |
| Hairy bushclover | *Lespedeza hirta* | Virginia buttonweed | *Diodia virginiana* |
| Hairy galinsoga | *Galinsoga ciliata* | Virginia creeper | *Parthenocissus quinquefolia* |
| Highbush blueberry | *Vaccinium corymbosum* | Wax myrtle | *Myrica cerifera* |
| Honey locust | *Gleditsia triacanthos* | Weeping willow | *Salix babylonica* |
| Japanese honeysuckle | *Lonicera japonica* | White clover | *Trifolium repens* |
| Japanese knotweed | *Polygonum cuspidatum* | White heath aster | *Aster pilosus* |
| Lowland broomsedge | *Andropogon glomeratus* | White oak | *Quercus alba* |
| Mile-a-minute | *Polygonum perfoliatum* | Wild onion | *Allium vineale* |
| Mountain laurel | *Kalmia latifolia* | Willow | *Salix* spp. |
| Mulberry | *Morus spp.* | Yellow wood sorrel | *Oxalis stricta* |

**Table 2-2**
**Widllife Observed**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Common Name | Scientific Name | Common Name | Scientific Name |
|---|---|---|---|
| American crow | *Corvus brachyrhynchos* | Long-clawed hermit crab | *Pagurus longicarpus* |
| American robin | *Turdus migratorius* | Mallard | *Anas platyrhynchos* |
| American shad | *Alosa sapidissima* | Mocking bird | *Mimus polyglottos* |
| Atlantic horseshoe crab | *Limulus polyphemus* | Mourning dove | *Zenaida macroura* |
| Atlantic silverside | *Menidia menidia* | Mud crab | no positive ID |
| Barnacle | *Balanus spp.* | Northern stargazer | Astroscopus guttatus |
| Bay anchovy | *Anchoa mitchilli* | Osprey | *Pandion haliaetus* |
| Belted kingfisher | *Megaceryle alcyon* | Oyster toadfish | *Opsanus tau* |
| Blood worm | *Glycera* spp. | Pipefish | *Syngnathus* spp. |
| Blue crab | *Callinectes sapidus* | Raccoon | *Procyon lotor* |
| Bluefish | *Pomatomus saltatrix* | Red-tailed hawk | *Buteo jamaicensis* |
| Brant | *Branta bernicla* | Ribbed mussel | *Geukensia demissa* |
| Bufflehead | *Bucephala albeola* | Ring-billed gull | *Larus delawarensis* |
| Canada goose | *Branta canadensis* | Rock dove | *Columba livia* |
| Common marsh snail | *Melanpus bidentatus* | Sea grape | *Molgula* sp. |
| Double-crested cormorant | *Phalacrocorax auritus* | Soft-shell clam | *Mya arenaria* |
| European starling | *Sturnus vulgaris* | Sparrow | *Melospiza* spp. |
| Fan worm | *Sabella* spp. | Spider crab | *Libinia* spp. |
| Garter snake | *Thamnophis sirtalis* | Striped bass | *Morone saxatilis* |
| Gray squirrel | *Sciurus carolinensis* | Striped killifish | *Fundulus majalis* |
| Great black-backed gull | *Larus marinus* | Summer flounder | *Paralichthys dentatus* |
| Great egret | *Ardea alba* | Swan | *Cygnus* spp. |
| Groundhog | *Marmota monax* | Tautog | *Tautoga onitis* |
| Hard clam | *Mercenaria mercenaria* | Warbler | *Dendroica* spp. |
| Herring gull | *Larus argentatus* | White tail deer | *Odocoileus virginianus* |
| Jelly fish | no positive ID | Windowpane flounder | *Scophthalmus aquosus* |
| Lady crab | *Ovalipes ocellatus* | Winter flounder | *Pseudopleuronectes americanus* |

**Table 2-3**
**Chemicals Detected in Area 9 Soil**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | CAS No. | Minimum Concentration Detected | Maximum Concentration Detected | Location of Maximum Concentration | Frequency of Detection | Screening Value | Hazard Quotient | COPC | Rationale |
|---|---|---|---|---|---|---|---|---|---|
| **Volatile Organic Compounds (µg/kg)** | | | | | | | | | |
| Styrene | 100-42-5 | 24 | 130 | A9-45 | 3 / 66 | 300,000 B | 0.0004 | No | BSL |
| Fluorobenzene | 462-06-6 | 10 NJ | 10 NJ | A9-31 | 1 / 66 | NL | NC | Yes | NV |
| Acetone | 67-64-1 | 9.3 | 180 | A9-111 | 14 / 66 | 2,500 C | 0.07 | No | BSL, LC |
| Chloroform | 67-66-3 | 13 | 13 | A9-52 | 1 / 66 | 1,190 C | 0.01 | No | BSL |
| Methylene Chloride | 75-09-2 | 3.3 J | 3.8 J | A9-58 | 4 / 66 | 4,050 C | 0.001 | No | BSL |
| Isopropylbenzene | 98-82-8 | 2.9 J | 11 | A9-45 | 2 / 66 | NL | NC | Yes | NV |
| **Semi-volatile Organic Compounds (µg/kg)** | | | | | | | | | |
| 1,1'-Biphenyl | 92-52-4 | 77 J | 77 J | A9-14 | 1 / 66 | NL | NC | Yes | NV |
| 2-Methylnaphthalene | 91-57-6 | 37 J | 750 | A9-14 | 2 / 66 | 3,240 C | 0.23 | No | BSL |
| 2-Methylphenol | 95-48-7 | 170 J | 170 J | A9-111 | 1 / 66 | NL | NC | Yes | NV |
| Acenaphthene | 83-32-9 | 57 J | 110 J | A9-58 | 2 / 66 | 29,000 Ab | 0.004 | No | BSL |
| Acenaphthylene | 208-96-8 | 39 J | 84 J | A9-42 | 3 / 66 | 29,000 Ab | 0.003 | No | BSL |
| Acetophenone | 98-86-2 | 45 J | 81 J | A9-08 | 5 / 66 | 300,000 C | 0.0003 | No | BSL |
| Anthracene | 120-12-7 | 24 J | 240 J | A9-58 | 5 / 66 | 29,000 Ab | 0.008 | No | BSL |
| Benzaldehyde | 100-52-7 | 25 J | 78 J | A9-52 | 3 / 66 | NL | NC | Yes | NV |
| Benzo(a)anthracene | 56-55-3 | 2.2 J | 740 J | A9-58 | 53 / 66 | 1,100 Ac | 0.67 | No | BSL |
| Benzo(a)pyrene | 50-32-8 | 2 J | 690 J | A9-58 | 47 / 66 | 1,100 Ac | 0.63 | No | BSL |
| Benzo(b)fluoranthene | 205-99-2 | 2.1 J | 1000 J | A9-08 | 56 / 66 | 59,800 C | 0.02 | No | BSL |
| Benzo(g,h,i)perylene | 191-24-2 | 31 J | 540 | A9-58 | 11 / 66 | 1,100 Ac | 0.49 | No | BSL |
| Benzo(k)fluoranthene | 207-08-9 | 41 J | 610 | A9-08 | 9 / 66 | 148,000 C | 0.004 | No | BSL |
| Bis(2-Ethylhexyl) phthalate | 117-81-7 | 23 J | 2000 J | A9-109 | 22 / 66 | 925 C | 2.2 | No | LC |
| Butylbenzylphthalate | 85-68-7 | 76 J | 61000 | A9-111 | 3 / 66 | 239 C | 255 | No | LC |
| Carbazole | 86-74-8 | 75 J | 77 J | A9-42 | 2 / 66 | NL | NC | Yes | NV |
| Chrysene | 218-01-9 | 18 J | 790 J | A9-58 | 22 / 66 | 1,100 Ac | 0.72 | No | BSL |
| Dibenzo(a,h)anthracene | 53-70-3 | 2.3 J | 130 | A9-08 | 21 / 66 | 1,100 Ac | 0.12 | No | BSL |
| Dibenzofuran | 132-64-9 | 35 J | 58 J | A9-58 | 2 / 66 | NL | NC | Yes | NV |
| Di-N-Butylphthalate | 84-74-2 | 30 J | 160 J | A9-25 | 3 / 66 | 200000 B | 0.0008 | No | BSL, LC |
| Di-N-Octyl Phthalate | 117-84-0 | 43 J | 44 J | A9-109 | 2 / 66 | 709000 C | 0.0001 | No | BSL, LC |
| Fluoranthene | 206-44-0 | 28 J | 1200 | A9-42 | 22 / 66 | 1,100 Ac | 1.1 | Yes | ASL |
| Fluorene | 86-73-7 | 91 J | 350 | A9-14 | 2 / 66 | 29,000 Ab | 0.01 | No | BSL |
| Indeno(1,2,3-cd)pyrene | 193-39-5 | 2 J | 380 | A9-58 | 38 / 66 | 1100 Ac | 0.35 | No | BSL |
| Naphthalene | 91-20-3 | 36 J | 920 | A9-14 | 4 / 66 | 29,000 Ab | 0.03 | No | BSL |
| Pentachlorophenol | 87-86-5 | 4.1 J | 12 J | A9-08 | 4 / 66 | 2,100 A | 0.01 | No | BSL |
| Phenanthrene | 85-01-8 | 20 J | 1200 | A9-14 | 13 / 66 | 29,000 Ab | 0.04 | No | BSL |
| Pyrene | 129-00-0 | 24 J | 2100 J | A9-58 | 24 / 66 | 1,100 Ac | 1.9 | Yes | ASL |

**Table 2-3**
**Chemicals Detected in Area 9 Soil**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | CAS No. | Minimum Concentration Detected | Maximum Concentration Detected | Location of Maximum Concentration | Frequency of Detection | Screening Value | | Hazard Quotient | COPC | Rationale |
|---|---|---|---|---|---|---|---|---|---|---|
| **Pesticides/PCBs (µg/kg)** | | | | | | | | | | |
| Alpha-Chlordane | 5103-71-9 | 1.6 NJ | 8.7 J | A9-58 | 8 / 66 | 224 | Cf | 0.04 | No | BSL |
| Aroclor 1254 | 11097-69-1 | 25 J | 22000 | A9-25 | 11 / 66 | 371 | Be | 59 | Yes | ASL |
| Aroclor 1260 | 11096-82-5 | 23 J | 36 J | A9-44 | 2 / 66 | 371 | Be | 0.10 | No | BSL |
| 4,4'-DDD | 72-54-8 | 2.5 JN | 13 NJ | A9-17 | 5 / 66 | 21 | Ad | 0.62 | No | BSL |
| 4,4'-DDE | 72-55-9 | 3.9 NJ | 17 NJ | A9-17 | 5 / 66 | 21 | Ad | 0.81 | No | BSL |
| 4,4'-DDT | 50-29-3 | 12 NJ | 1300 NJ | A9-25 | 5 / 66 | 21 | Ad | 62 | Yes | ASL |
| Dieldrin | 60-57-1 | 1.4 J | 4.7 | A9-42 | 4 / 66 | 4.9 | A | 0.96 | No | BSL |
| Endosulfan I | 959-98-8 | 2.1 NJ | 2.1 NJ | A9-26 | 1 / 66 | 119 | C | 0.02 | No | BSL |
| Endosulfan II | 33213-65-9 | 6.2 | 280 | A9-25 | 3 / 66 | 119 | C | 2.4 | Yes | ASL |
| Endrin | 72-20-8 | 3.0 | 3.0 | A9-42 | 1 / 66 | 10.1 | C | 0.30 | No | BSL |
| Gamma-Chlordane | 5103-74-2 | 1.2 J | 180 NJ | A9-25 | 10 / 66 | 224 | Cf | 0.80 | No | BSL |
| Methoxychlor | 72-43-5 | 19 NJ | 19 NJ | A9-29 | 1 / 66 | 19.9 | C | 0.95 | No | BSL |
| **Inorganic Analytes (mg/kg)** | | | | | | | | | | |
| Aluminum | 7429-90-5 | 149 | 10800 | A9-54 | 110 / 110 | NL | | NC | Yes | NV |
| Antimony | 7440-36-0 | 0.15 J | 188 | A9-109 | 37 / 110 | 0.27 | A | 696 | Yes | ASL |
| Arsenic | 7440-38-2 | 0.23 | 179 | A9-109 | 106 / 110 | 18 | A | 9.9 | Yes | ASL |
| Barium | 7440-39-3 | 0.79 J | 172 | A9-109 | 68 / 110 | 330 | A | 0.52 | No | BSL |
| Beryllium | 7440-41-7 | 0.02 J | 0.81 J | A9-34 | 35 / 110 | 21 | A | 0.04 | No | BSL |
| Cadmium | 7440-43-9 | 0.025 J | 1.7 | S63 | 58 / 110 | 0.36 | A | 4.7 | Yes | ASL |
| Calcium | 7440-70-2 | 22.5 J | 29600 | A9-58 | 68 / 110 | NL | | NC | No | EN |
| Chromium | 7440-47-3 | 0.96 J | 155 | A9-21 | 110 / 110 | 26 | Aa | 6.0 | Yes | ASL |
| Cobalt | 7440-48-4 | 0.14 J | 12.7 | A9-34 | 67 / 110 | 13 | A | 0.98 | No | BSL |
| Copper | 7440-50-8 | 0.46 J | 1170 | A9-21 | 106 / 110 | 28 | A | 42 | Yes | ASL |
| Iron | 7439-89-6 | 1670 | 46800 | A9-55 | 110 / 110 | NL | | NC | Yes | NV |
| Lead | 7439-92-1 | 1.7 J | 10200 J | S63 | 105 / 110 | 11 | A | 927 | Yes | ASL |
| Magnesium | 7439-95-4 | 22.8 J | 4310 | A9-58 | 70 / 110 | NL | | NC | No | EN |
| Manganese | 7439-96-5 | 2.9 J | 368 | A9-37 | 110 / 110 | 220 | A | 1.7 | Yes | ASL |
| Mercury | 7439-97-6 | 0.021 J | 0.47 | A9-109 | 52 / 67 | 0.00051 | B | 922 | Yes | ASL |
| Nickel | 7440-02-0 | 0.074 J | 26.1 | A9-34 | 105 / 110 | 38 | A | 0.69 | No | BSL |
| Potassium | 7440-09-7 | 12.7 J | 3080 | A9-35 | 71 / 110 | NL | | NC | No | EN |
| Selenium | 7782-49-2 | 0.064 J | 8.5 | A9-42 | 37 / 110 | 0.52 | A | 16 | Yes | ASL |
| Silver | 7440-22-4 | 0.19 J | 9.2 J | S167 | 30 / 110 | 4.2 | A | 2.2 | Yes | ASL |
| Sodium | 7440-23-5 | 6.2 J | 2620 | A9-35 | 16 / 110 | NL | | NC | No | EN |
| Thallium | 7440-28-0 | 0.12 J | 0.24 | A9-109 | 3 / 110 | 1 | B | 0.24 | No | BSL |
| Tin | 7440-31-5 | 28.1 | 313 | S63 | 2 / 5 | 50 | B | 6.3 | Yes | ASL |
| Vanadium | 7440-62-2 | 2.1 J | 134 | A9-33 | 108 / 110 | 7.8 | A | 17 | Yes | ASL |

**Table 2-3**
**Chemicals Detected in Area 9 Soil**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | CAS No. | Minimum Concentration Detected | Maximum Concentration Detected | Location of Maximum Concentration | Frequency of Detection | Screening Value | Hazard Quotient | COPC | Rationale |
|---|---|---|---|---|---|---|---|---|---|
| Zinc | 7440-66-6 | 1.1 | 386 | A9-34 | 90 / 110 | 46 A | 8.4 | Yes | ASL |
| Hexavalent Chromium | 18540-29-9 | 0.3 J | 2.1 J | A9-21 | 28 / 67 | 130 A | 0.02 | No | BSL |

µg/kg - micrograms per kilogram
mg/kg - milligrams per kilogram
ASL - above screening level
BSL - equal to or below screening level
COPC - chemical of potential concern
EN - essential nutrient
J - estimated
NJ - tentatively identified
LC - considered a common laboratory contaminant
NC - no hazard quotient calculated
NL - not listed
NV - chemical detected, but no screening value located
A - EPA Ecological Soil Screening Levels (EcoSSLs). http://www.epa.gov/ecotox/ecossl/
B -Efroymson, R.A., G.W. Suter II, B.E. Sample, and D.S. Jones. 1997. Preliminary Remediation Goals (PRGs) for Ecological Endpoints. Prepared for the U.S. Department of Energy, Office of Environmental Management Contract No. DE-AC05-84OR21401.
C -EPA 2003. EPA Region 5 Resource Conservation and Recovery Act (RCRA) Ecological Screening Levels.
a - value for chromium (trivalent)
b - value for low molecular weight polyaromatic hydrocarbons
c - value for high molecular weight polyaromatic hydrocarbons
d - value for DDT and metabolites
e - value for PCBs
f - value for chlordane

**Table 2-4**
**Chemicals Detected in Area 9 Sediment**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | CAS No. | Minimum Concentration Detected | Maximum Concentration Detected | Location of Maximum Concentration | Frequency of Detection | Screening Value | Hazard Quotient | COPC | Rationale |
|---|---|---|---|---|---|---|---|---|---|
| **Volatile Organic Compounds (µg/kg)** | | | | | | | | | |
| Toluene | 108-88-3 | 31 | 31 | A9-99 | 1 / 39 | 2500 A | 0.01 | No | BSL |
| Acetone | 67-64-1 | 15 J | 180 J | A9-81 | 9 / 39 | NL | NC | No | LC |
| Carbon Disulfide | 75-15-0 | 6.4 | 34 | A9-75 | 9 / 39 | 0.851 Ca | 40 | No | NO |
| 2-Butanone | 78-93-3 | 13 J | 40 | A9-99 | 3 / 39 | NL | NC | No | LC |
| **Semi-volatile Organic Compounds (µg/kg)** | | | | | | | | | |
| 2-Methylnaphthalene | 91-57-6 | 4.1 J | 45 | A9-84 | 6 / 39 | 70 A | 0.64 | No | BSL |
| Acenaphthene | 83-32-9 | 3 J | 64 J | A9-74 | 7 / 39 | 16 A | 4.0 | Yes | ASL |
| Acenaphthylene | 208-96-8 | 3.2 J | 110 J | A9-88 | 19 / 39 | 44 A | 2.5 | Yes | ASL |
| Acetophenone | 98-86-2 | 55 J | 380 J | A9-93 | 6 / 39 | NL | NC | Yes | NV |
| Anthracene | 120-12-7 | 82 J | 95 J | A9-85 | 2 / 39 | 85 A | 1.1 | Yes | ASL |
| Benzo(a)anthracene | 56-55-3 | 5.4 J | 550 J | A9-85 | 36 / 39 | 261 A | 2.1 | Yes | ASL |
| Benzo(a)pyrene | 50-32-8 | 5.9 | 570 J | A9-85 | 36 / 39 | 430 A | 1.3 | Yes | ASL |
| Benzo(b)fluoranthene | 205-99-2 | 32 J | 1000 | A9-85 | 15 / 39 | 1800 A | 0.6 | No | BSL |
| Benzo(g,h,i)perylene | 191-24-2 | 43 J | 480 | A9-85 | 7 / 39 | 170 Aa | 2.8 | Yes | ASL |
| Benzo(k)fluoranthene | 207-08-9 | 31 J | 480 | A9-85 | 8 / 39 | 240 Aa | 2 | Yes | ASL |
| Bis(2-Ethylhexyl) phthalate | 117-81-7 | 98 J | 12000 | A9-104 | 11 / 39 | 182 A | 66 | Yes | ASL |
| Butylbenzylphthalate | 85-68-7 | 100 J | 240 J | A9-83 | 4 / 39 | 16800 C | 0.01 | No | BSL |
| Carbazole | 86-74-8 | 73 J | 73 J | A9-85 | 1 / 39 | NL | NC | Yes | NV |
| Chrysene | 218-01-9 | 5.7 J | 610 J | A9-85 | 36 / 39 | 384 A | 1.6 | Yes | ASL |
| Dibenzo(a,h)anthracene | 53-70-3 | 3.6 J | 76 | A9-85 | 19 / 39 | 63 A | 1.2 | Yes | ASL |
| Fluoranthene | 206-44-0 | 72 J | 1700 | A9-85 | 18 / 39 | 600 A | 2.8 | Yes | ASL |
| Fluorene | 86-73-7 | 2.5 J | 24 J | A9-88 | 9 / 39 | 19 A | 1.3 | Yes | ASL |
| Indeno(1,2,3-cd)pyrene | 193-39-5 | 19 | 430 | A9-85 | 7 / 39 | 200 Aa | 2.2 | Yes | ASL |
| Naphthalene | 91-20-3 | 320 J | 320 J | A9-84 | 1 / 39 | 160 A | 2.0 | Yes | ASL |
| Phenanthrene | 85-01-8 | 33 J | 490 | A9-85 | 6 / 39 | 240 A | 2.0 | Yes | ASL |
| Pyrene | 129-00-0 | 60 J | 1100 | A9-85 | 18 / 39 | 665 A | 1.7 | Yes | ASL |
| **Pesticides/PCBs (µg/kg)** | | | | | | | | | |
| Alpha-Chlordane | 5103-71-9 | 0.76 NJ | 9.2 J | A9-85 | 2 / 39 | 7 A a,c | 1.3 | Yes | ASL |
| Aroclor 1254 | 11097-69-1 | 7.0 J | 19 | A9-84 | 2 / 39 | 60 Aa | 0.32 | No | BSL |
| Dieldrin | 60-57-1 | 2.0 | 2.0 | A9-85 | 1 / 39 | 2 Aa | 1.0 | No | BSL |
| Gamma-Chlordane | 5103-74-2 | 5.7 NJ | 5.7 NJ | A9-85 | 1 / 39 | 7 A a,c | 0.81 | No | BSL |
| Methoxychlor | 72-43-5 | 5.0 J | 5.0 J | A9-106 | 1 / 39 | 29.6 C | 0.17 | No | BSL |

**Table 2-4**
**Chemicals Detected in Area 9 Sediment**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | CAS No. | Minimum Concentration Detected | Maximum Concentration Detected | Location of Maximum Concentration | Frequency of Detection | Screening Value | Hazard Quotient | COPC | Rationale |
|---|---|---|---|---|---|---|---|---|---|
| **Inorganic Analytes (mg/kg)** | | | | | | | | | |
| Aluminum | 7429-90-5 | 178 | 20900 | A9-104 | 72 / 72 | NL | NC | Yes | NV |
| Antimony | 7440-36-0 | 0.28 J | 10.9 | A9-70 | 5 / 72 | 2 Ca | 5.5 | Yes | ASL |
| Arsenic | 7440-38-2 | 1.1 | 88.9 | A9-97 | 72 / 72 | 8.2 A | 11 | Yes | ASL |
| Barium | 7440-39-3 | 1.4 J | 138 | A9-104 | 37 / 72 | 48 A | 2.9 | Yes | ASL |
| Beryllium | 7440-41-7 | 0.034 J | 1.5 J | A9-97 | 30 / 72 | NL | NC | Yes | NV |
| Cadmium | 7440-43-9 | 0.28 J | 3.8 | A9-97 | 24 / 72 | 1.2 A | 3.2 | Yes | ASL |
| Calcium | 7440-70-2 | 95.4 J | 13800 | SED195 | 57 / 72 | NL | NC | No | EN |
| Chromium | 7440-47-3 | 1.9 J | 59.7 | A9-104 | 72 / 72 | 81 A | 0.74 | No | BSL |
| Cobalt | 7440-48-4 | 0.029 J | 12.7 J | A9-74 | 27 / 72 | 50 Ca | 0.25 | No | BSL |
| Copper | 7440-50-8 | 1.1 J | 1790 | A9-97 | 72 / 72 | 34 A | 53 | Yes | ASL |
| Iron | 7439-89-6 | 2960 | 89700 | A9-106 | 72 / 72 | 20000 Ca | 4.5 | Yes | ASL |
| Lead | 7439-92-1 | 2.9 | 564 | A9-97 | 63 / 72 | 47 A | 12 | Yes | ASL |
| Magnesium | 7439-95-4 | 151 J | 7680 | A9-63 | 69 / 72 | NL | NC | No | EN |
| Manganese | 7439-96-5 | 15.7 J | 218 J | A9-74 | 72 / 72 | 460 Ca | 0.47 | No | BSL |
| Mercury | 7439-97-6 | 0.018 J | 2.6 | A9-90 | 45 / 46 | 0.15 A | 17 | Yes | ASL |
| Nickel | 7440-02-0 | 0.39 J | 232 | A9-62 | 69 / 72 | 21 A | 11 | Yes | ASL |
| Potassium | 7440-09-7 | 108 J | 2390 | A9-96 | 43 / 72 | NL | NC | No | EN |
| Selenium | 7782-49-2 | 0.38 J | 6.2 | A9-75 | 24 / 72 | 2.0 Ca | 3.1 | Yes | ASL |
| Silver | 7440-22-4 | 0.24 J | 15.6 J | SED198 | 26 / 72 | 1.0 A | 16 | Yes | ASL |
| Sodium | 7440-23-5 | 356 J | 12400 | A9-90 | 55 / 72 | NL | NC | No | EN |
| Thallium | 7440-28-0 | 2.2 J | 2.2 J | A9-75 | 1 / 72 | NL | NC | Yes | NV |
| Vanadium | 7440-62-2 | 4.5 J | 106 | A9-104 | 71 / 72 | 57 A | 1.9 | Yes | ASL |
| Zinc | 7440-66-6 | 7.2 J | 300 | A9-104 | 72 / 72 | 150 A | 2.0 | Yes | ASL |
| Hexavalent Chromium | 18540-29-9 | 0.41 J | 1.8 | A9-112 | 9 / 45 | NL | NC | Yes | NV |

µg/kg - micrograms per kilogram
mg/kg - milligrams per kilogram
COPC - chemical of potential concern
NC - no hazard quotient calculated
NL - not listed

ASL - above screening level
BSL - equal to or below screening level
EN - essential nutrient
NO - chemical expected to naturally occur given site characteristics
NV - chemical detected, but no screening value located

J - estimated
NJ - tentatively identified
LC - considered a common laboratory contaminant

A - New Jersey Site Remediation Program. 2009. Marine/Estuarine Sediment Screening Guidelines. Effects Range-Low (ER-L) values
C - EPA 2006. EPA Region 3 Biological Technical Assistance Group Marine Sediment Screening Benchmarks,
Mid-Atlantic Risk Assessment: Ecological Risk Assessment, http://www.epa.gov/reg3hwmd/risk/eco/index.htm
a - freshwater value used as directed
c - value for chlordane

**Table 2-5**
**Chemicals Detected in Area 9 Surface Water**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | CAS No. | Minimum Concentration Detected | Maximum Concentration Detected | Location of Maximum Concentration | Frequency of Detection | Screening Value | | Hazard Quotient | COPC | Rationale |
|---|---|---|---|---|---|---|---|---|---|---|
| **Volatile Organic Compounds (µg/L)** | | | | | | | | | | |
| Chloroform | 67-66-3 | 0.46 J | 0.46 J | A9-95 | 1 / 18 | 815 | C | 0.0006 | No | BSL |
| **Semi-volatile Organic Compounds (µg/L)** | | | | | | | | | | |
| 3,3`-Dichlorobenzidine | 91-94-1 | 0.064 | 0.064 | A9-87 | 1 / 17 | 37 | C | 0.0017 | No | BSL |
| Benzo(a)anthracene | 56-55-3 | 0.053 | 0.053 | A9-89 | 1 / 17 | 0.018 | Ca | 2.9 | Yes | ASL |
| Bis(2-Ethylhexyl) phthalate | 117-81-7 | 0.51 J | 0.51 J | A9-93 | 1 / 17 | 16 | Ca | 0.032 | No | BSL, LC |
| Pentachlorophenol | 87-86-5 | 0.52 J | 0.52 J | A9-70 | 1 / 17 | 7.9 | A | 0.0658 | No | BSL |
| **Inorganic Analytes (Total) (µg/L)** | | | | | | | | | | |
| Aluminum | 7429-90-5 | 85.8 | 6030 | SW19 | 8 / 30 | NL | | NC | Yes | NV |
| Antimony | 7440-36-0 | 2.5 J | 6.3 J | SW19 | 2 / 30 | NL | | NC | Yes | NV |
| Arsenic | 7440-38-2 | 0.44 | 25 | SW19 | 8 / 30 | 36 | A* | 0.7 | No | BSL |
| Barium | 7440-39-3 | 14.8 | 21.8 | A9-95 | 2 / 30 | 25000 | C | 0.001 | No | BSL |
| Beryllium | 7440-41-7 | 0.52 J | 0.52 J | A9-95 | 1 / 30 | 0.66 | Ca | 0.79 | No | BSL |
| Cadmium | 7440-43-9 | 0.45 | 0.45 | A9-95 | 1 / 30 | 8.8 | A* | 0.1 | No | BSL |
| Calcium | 7440-70-2 | 348 J | 257000 | A9-70 | 29 / 30 | 116000 | Ca | 2.2 | No | EN |
| Chromium | 7440-47-3 | 2.0 J | 19.8 J | SW41 | 4 / 30 | 57.5 | C | 0.34 | No | BSL |
| Cobalt | 7440-48-4 | 0.93 J | 0.93 J | A9-95 | 1 / 30 | 23 | Ca | 0.04 | No | BSL |
| Copper | 7440-50-8 | 1.1 J | 52.5 | SW19 | 7 / 30 | 3.1 | A* | 17 | Yes | ASL |
| Iron | 7439-89-6 | 418 J | 74400 | SW19 | 20 / 30 | 300 | Ca | 248 | Yes | ASL |
| Lead | 7439-92-1 | 2.2 | 298 | SW19 | 8 / 30 | 24 | A* | 12 | Yes | ASL |
| Magnesium | 7439-95-4 | 5000 | 741000 | A9-70 | 28 / 30 | 82000 | Ca | 9.0 | No | EN |
| Manganese | 7439-96-5 | 13.0 | 764 J | SW19 | 25 / 30 | 120 | Ca | 6.4 | Yes | ASL |
| Mercury | 7439-97-6 | 0.040 J | 0.040 J | A9-91 | 1 / 46 | 0.94 | A* | 0.04 | No | BSL |
| Nickel | 7440-02-0 | 0.51 J | 5.8 J | SW41 | 6 / 30 | 22 | A* | 0.26 | No | BSL |
| Potassium | 7440-09-7 | 2560 | 242000 | A9-70 | 17 / 26 | 53000 | Ca | 4.6 | No | EN |
| Sodium | 7440-23-5 | 170 J | 5780000 | A9-70 | 23 / 26 | 680000 | Ca | 8.5 | No | EN |
| Vanadium | 7440-62-2 | 5.5 | 5.5 | A9-95 | 1 / 30 | 20 | Ca | 0.28 | No | BSL |
| Zinc | 7440-66-6 | 5.4 | 186 | SW19 | 10 / 30 | 81 | A* | 2.3 | Yes | ASL |
| **Inorganic Analytes (Dissolved) (µg/L)** | | | | | | | | | | |
| Aluminum | 7429-90-5 | 33.5 J | 2720 | SW19 | 3 / 32 | NL | | NC | Yes | NV |
| Antimony | 7440-36-0 | 2.8 J | 2.8 J | SW19 | 1 / 32 | NL | | NC | Yes | NV |
| Arsenic | 7440-38-2 | 2.2 J | 13.6 | SW19 | 5 / 32 | 36 | A* | 0.38 | No | BSL |
| Beryllium | 7440-41-7 | 0.35 J | 0.35 J | SW40 | 1 / 32 | 0.66 | Ca | 0.53 | No | BSL |
| Calcium | 7440-70-2 | 20900 J | 286000 | A9-78 | 30 / 32 | 116000 | Ca | 2.5 | No | EN |
| Copper | 7440-50-8 | 0.74 J | 43.5 | SW19 | 7 / 32 | 3.1 | A* | 14 | Yes | ASL |
| Chromium | 7440-47-3 | 1.3 J | 5.4 J | SW19 | 2 / 32 | 57.5 | C | 0.09 | No | BSL |
| Iron | 7439-89-6 | 14.6 J | 58500 | SW19 | 14 / 32 | 300 | Ca | 195 | Yes | ASL |

**Table 2-5**
**Chemicals Detected in Area 9 Surface Water**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | CAS No. | Minimum Concentration Detected | Maximum Concentration Detected | Location of Maximum Concentration | Frequency of Detection | Screening Value | | Hazard Quotient | COPC | Rationale |
|---|---|---|---|---|---|---|---|---|---|---|
| Lead | 7439-92-1 | 28 | 282 | SW19 | 2 / 32 | 24 | A* | 12 | Yes | ASL |
| Magnesium | 7439-95-4 | 32200 J | 845000 | A9-78 | 31 / 32 | 82000 | Ca | 10 | No | EN |
| Manganese | 7439-96-5 | 39.6 J | 693 J | SW19 | 26 / 32 | 120 | Ca | 5.8 | Yes | ASL |
| Nickel | 7440-02-0 | 1.5 J | 1.5 J | SW38 | 1 / 32 | 22 | A* | 0.07 | No | BSL |
| Potassium | 7440-09-7 | 17400 | 284000 | A9-78 | 19 / 28 | 53000 | Ca | 5.4 | No | EN |
| Selenium | 7782-49-2 | 2.3 J | 2.9 J | SW19 | 2 / 32 | 71 | A* | 0.04 | No | BSL |
| Sodium | 7440-23-5 | 78100 | 6780000 | A9-78 | 25 / 28 | 680000 | Ca | NC | No | EN |
| Zinc | 7440-66-6 | 2 J | 151 | SW19 | 5 / 32 | 81 | A* | 1.9 | Yes | ASL |

µg/L - micrograms per liter
ASL - above screening level
BSL - equal to or below screening level
COPC - chemical of potential concern
EN - essential nutrient
J - estimated
LC - considered a common laboratory contaminant
NC - no hazard quotient calculated
NL - not listed
NV - chemical detected, but no screening value located
A -NJDEP 2011. Surface Water Quality Standards, Saline Water Chronic Values, January 2011, downloaded January 24, 2011
C -EPA 2006. EPA Region 3 Biological Technical Assistance Group Marine Screening Benchmarks,
Mid-Atlantic Risk Assessment: Ecological Risk Assessment, http://www.epa.gov/reg3hwmd/risk/eco/index.htm
*-dissolved criteria
a - freshwater value is used as directed by EPA
b - no chronic value available; acute value used

**Table 2-6**
**Chemicals Detected in Area 8 Sediment**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | CAS No. | Minimum Concentration Detected | Maximum Concentration Detected | Location of Maximum Concentration | Frequency of Detection | Screening Value | Hazard Quotient | COPC | Rationale |
|---|---|---|---|---|---|---|---|---|---|
| **Volatile Organic Compounds (µg/kg)** | | | | | | | | | |
| Carbon Disulfide | 75-15-0 | 1.1 J | 5.6 J | C37 | 3 / 5 | 0.851 Ca | 6.6 | No | NO |
| **Semi-volatile Organic Compounds (µg/kg)** | | | | | | | | | |
| 2-Methylnaphthalene | 91-57-6 | 12 J | 17 | A8-05 | 3 / 5 | 70 A | 0.24 | No | BSL |
| 4-Methylphenol | 106-44-5 | 15 J | 17 J | C37 | 2 / 5 | 670 Ca | 0.03 | No | BSL |
| Acenaphthene | 83-32-9 | 6.1 | 12 | A8-01 | 2 / 5 | 16 A | 0.75 | No | BSL |
| Acenaphthylene | 208-96-8 | 7.2 | 19 | A8-05 | 2 / 5 | 44 A | 0.43 | No | BSL |
| Acetophenone | 98-86-2 | 24 J | 60 J | C37 | 3 / 5 | NL | NC | Yes | NV |
| Anthracene | 120-12-7 | 13 J | 47 J | A8-05 | 3 / 5 | 85 A | 0.55 | No | BSL |
| Benzaldehyde | 100-52-7 | 43 J | 67 J | C37 | 3 / 5 | NL | NC | Yes | NV |
| Benzo(a)anthracene | 56-55-3 | 47 | 170 | A8-05 | 4 / 5 | 261 A | 0.65 | No | BSL |
| Benzo(a)pyrene | 50-32-8 | 41 | 130 | A8-05 | 4 / 5 | 430 A | 0.30 | No | BSL |
| Benzo(b)fluoranthene | 205-99-2 | 60 J | 250 | A8-05 | 4 / 5 | 1800 A | 0.14 | No | BSL |
| Benzo(g,h,i)perylene | 191-24-2 | 50 J | 140 J | A8-05 | 3 / 5 | 170 Aa | 0.82 | No | BSL |
| Benzo(k)fluoranthene | 207-08-9 | 21 J | 89 J | A8-05 | 3 / 5 | 240 Aa | 0.37 | No | BSL |
| Bis(2-Ethylhexyl) phthalate | 117-81-7 | 23 J | 90 J | C28 | 4 / 5 | 182 A | 0.49 | No | BSL, LC |
| Butylbenzylphthalate | 85-68-7 | 9.3 J | 9.3 J | C28 | 1 / 5 | 16800 C | 0.001 | No | BSL, LC |
| Carbazole | 86-74-8 | 7.3 J | 7.3 J | C28 | 1 / 5 | NL | NC | Yes | NV |
| Chrysene | 218-01-9 | 59 | 210 | A8-05 | 4 / 5 | 384 A | 0.55 | No | BSL |
| Dibenzo(a,h)anthracene | 53-70-3 | 8.8 | 30 J | A8-05 | 4 / 5 | 63 A | 0.48 | No | BSL |
| Diethylphthalate | 84-66-2 | 6.7 J | 7.6 J | C28 | 2 / 5 | 218 C | 0.03 | No | BSL, LC |
| Di-N-Butylphthalate | 84-74-2 | 9 J | 13 J | C37 | 3 / 5 | 1160 C | 0.01 | No | BSL, LC |
| Fluoranthene | 206-44-0 | 100 J | 400 | A8-05 | 4 / 5 | 600 A | 0.67 | No | BSL |
| Fluorene | 86-73-7 | 7.8 | 12 J | C37 | 4 / 5 | 19 A | 0.63 | No | BSL |
| Indeno(1,2,3-cd)pyrene | 193-39-5 | 56 J | 110 J | A8-05 | 3 / 5 | 200 Aa | 0.55 | No | BSL |
| Naphthalene | 91-20-3 | 18 J | 20 J | C37 | 2 / 5 | 160 A | 0.13 | No | BSL |
| Phenanthrene | 85-01-8 | 42 J | 120 J | A8-05 | 4 / 5 | 240 A | 0.50 | No | BSL |
| Phenol | 108-95-2 | 15 J | 34 J | C37 | 3 / 5 | 420 Ca | 0.08 | No | BSL |
| Pyrene | 129-00-0 | 64 J | 240 J | A8-05 | 4 / 5 | 665 A | 0.36 | No | BSL |
| **Pesticides/PCBs (µg/kg)** | | | | | | | | | |
| Aroclor 1254 | 11097-69-1 | 6.6 J | 720 | A8-05 | 3 / 5 | 60 Aa | 12 | Yes | ASL |
| 4,4'-DDE | 72-55-9 | 0.45 J | 0.45 J | C28 | 1 / 5 | 2.2 A | 0.20 | No | BSL |
| 4,4'-DDT | 50-29-3 | 0.59 J | 96 J | A8-05 | 2 / 5 | 1 A | 96 | Yes | ASL |
| Endosulfan II | 33213-65-9 | 36 | 36 | A8-05 | 1 / 5 | 14 Ca | 2.6 | Yes | ASL |
| Endosulfan Sulfate | 1031-07-8 | 24 NJ | 24 NJ | A8-05 | 1 / 5 | 0.357 C | 67 | Yes | ASL |
| Gamma-Chlordane | 5103-74-2 | 52 NJ | 52 NJ | A8-05 | 1 / 5 | 7 A a,c | 7.4 | Yes | ASL |

**Table 2-6**
**Chemicals Detected in Area 8 Sediment**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | CAS No. | Minimum Concentration Detected | Maximum Concentration Detected | Location of Maximum Concentration | Frequency of Detection | Screening Value | | Hazard Quotient | COPC | Rationale |
|---|---|---|---|---|---|---|---|---|---|---|
| **Inorganic Analytes (mg/kg)** | | | | | | | | | | |
| Aluminum | 7429-90-5 | 1140 | 11000 J | SED54 | 55 / 57 | NL | | NC | Yes | NV |
| Antimony | 7440-36-0 | 0.77 J | 1720 | SED90 | 41 / 57 | 2 | Ca | 860 | Yes | ASL |
| Arsenic | 7440-38-2 | 3.3 | 933 J | SED90 | 56 / 57 | 8.2 | A | 114 | Yes | ASL |
| Barium | 7440-39-3 | 1.8 J | 1090 J | SED90 | 51 / 57 | 48 | A | 23 | Yes | ASL |
| Beryllium | 7440-41-7 | 0.27 J | 0.97 J | C48 | 34 / 57 | NL | | NC | Yes | NV |
| Cadmium | 7440-43-9 | 0.19 J | 22.1 | SED90 | 36 / 57 | 1.2 | A | 18 | Yes | ASL |
| Calcium | 7440-70-2 | 313 J | 48400 | A8-09 | 52 / 57 | NL | | NC | No | EN |
| Chromium | 7440-47-3 | 8.9 | 3500 | SED90 | 57 / 57 | 81 | A | 43 | Yes | ASL |
| Cobalt | 7440-48-4 | 0.77 J | 22.3 | SED90 | 46 / 57 | 50 | Ca | 0.45 | No | BSL |
| Copper | 7440-50-8 | 4.4 | 969 J | SED90 | 56 / 57 | 34 | A | 29 | Yes | ASL |
| Iron | 7439-89-6 | 6390 J | 120000 | SED90 | 55 / 57 | 20000 | Ca | 6.0 | Yes | ASL |
| Lead | 7439-92-1 | 7.9 | 14200 | S60 | 53 / 57 | 47 | A | 302 | Yes | ASL |
| Magnesium | 7439-95-4 | 524 J | 10500 J | SED56 | 54 / 57 | NL | | NC | No | EN |
| Manganese | 7439-96-5 | 21 | 1710 | SED90 | 56 / 57 | 460 | Ca | 3.7 | Yes | ASL |
| Mercury | 7439-97-6 | 0.055 | 1.7 J | C48 | 42 / 44 | 0.15 | A | 11 | Yes | ASL |
| Nickel | 7440-02-0 | 2.6 J | 1500 | SED90 | 56 / 57 | 21 | A | 71 | Yes | ASL |
| Potassium | 7440-09-7 | 188 J | 3870 J | SED56 | 49 / 57 | NL | | NC | No | EN |
| Selenium | 7782-49-2 | 0.13 J | 2.4 J | SED54 | 40 / 57 | 2.0 | Ca | 1.2 | Yes | ASL |
| Silver | 7440-22-4 | 0.2 J | 3.3 J | C48 | 41 / 57 | 1.0 | A | 3.3 | Yes | ASL |
| Sodium | 7440-23-5 | 824 J | 60000 J | SED56 | 55 / 57 | NL | | NC | No | EN |
| Tin | 7440-31-5 | 47.3 | 1480 J | SED90 | 6 / 13 | NL | | NC | Yes | NV |
| Vanadium | 7440-62-2 | 13.7 | 73.4 | SED90 | 57 / 57 | 57 | | 1.3 | Yes | ASL |
| Zinc | 7440-66-6 | 30.2 | 1670 J | S60 | 56 / 57 | 150 | A | 11 | Yes | ASL |
| Hexavalent Chromium | 18540-29-9 | 0.5 J- | 0.98 J- | A8-01 | 4 / 6 | NL | | NC | Yes | NV |

µg/kg - micrograms per kilogram
mg/kg - milligrams per kilogram
COPC - chemical of potential concern
NC - no hazard quotient calculated
NL - not listed

ASL - above screening level
BSL - equal to or below screening level
EN - essential nutrient
NO - chemical expected to naturally occur given site characteristics
NV - chemical detected, but no screening value located

J - estimated
J- - estimated biased low
NJ - tentatively identified
LC - considered a common laboratory contaminant

A - New Jersey Site Remediation Program. 2009. Marine/Estuarine Sediment Screening Guidelines. Effects Range-Low (ER-L) values
C - EPA 2006. EPA Region 3 Biological Technical Assistance Group Marine Sediment Screening Benchmarks,
Mid-Atlantic Risk Assessment: Ecological Risk Assessment, http://www.epa.gov/reg3hwmd/risk/eco/index.htm
a - freshwater value used as directed
c - value for chlordane

**Table 2-7**
**Chemicals Detected in Area 8 Surface Water**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | CAS No. | Minimum Concentration Detected | Maximum Concentration Detected | Location of Maximum Concentration | Frequency of Detection | Screening Value | | Hazard Quotient | COPC | Rationale |
|---|---|---|---|---|---|---|---|---|---|---|
| **Volatile Organic Compounds (µg/L)** | | | | | | | | | | |
| Methylene Chloride | 75-09-2 | 0.54 | 0.63 J | A8-14 | 2 / 2 | 2,560 | C | 0.0002 | No | BSL |
| **Inorganic Analytes (Total) (µg/L)** | | | | | | | | | | |
| Aluminum | 7429-90-5 | 180 J | 12600 J | SW16 | 5 / 12 | NL | | NC | Yes | NV |
| Antimony | 7440-36-0 | 21.1 J | 53.2 J | SW16 | 2 / 12 | NL | | NC | Yes | NV |
| Arsenic | 7440-38-2 | 2.7 J | 70.9 | SW16 | 5 / 12 | 36 | A* | 2.0 | Yes | ASL |
| Barium | 7440-39-3 | 21.4 J | 64.9 J | SW16 | 5 / 12 | 25000 | C | 0.003 | No | BSL |
| Cadmium | 7440-43-9 | 0.34 J | 0.34 J | SW15 | 1 / 12 | 8.8 | A* | 0.04 | No | BSL |
| Calcium | 7440-70-2 | 222000 J | 299000 | A8-14 | 12 / 12 | 116000 | Ca | 2.6 | No | EN |
| Chromium | 7440-47-3 | 12.5 J | 12.5 J | SW15 | 1 / 12 | 57.5 | C | 0.22 | No | BSL |
| Cobalt | 7440-48-4 | 1.1 J | 2.8 J | SW15 | 3 / 12 | 23 | Ca | 0.12 | No | BSL |
| Copper | 7440-50-8 | 32.4 J | 154 J | SW16 | 2 / 12 | 3.1 | A* | 50 | Yes | ASL |
| Iron | 7439-89-6 | 345 J | 6320 J | SW15 | 4 / 12 | 300 | Ca | 21 | Yes | ASL |
| Lead | 7439-92-1 | 6.7 J | 1580 J | SW16 | 4 / 12 | 24 | A* | 66 | Yes | ASL |
| Magnesium | 7439-95-4 | 723000 J | 881000 | A8-14 | 12 / 12 | 82000 | Ca | 11 | No | EN |
| Manganese | 7439-96-5 | 60.3 J | 309 J | SW15 | 4 / 12 | 120 | Ca | 2.6 | Yes | ASL |
| Nickel | 7440-02-0 | 1.4 J | 22.1 J | SW16 | 5 / 12 | 22 | A* | 1.0 | No | BSL |
| Potassium | 7440-09-7 | 233000 J | 298000 | A8-14 | 12 / 12 | 53000 | Ca | 5.6 | No | EN |
| Selenium | 7782-49-2 | 2.4 J | 3.8 J | SW16 | 3 / 12 | 71 | A* | 0.05 | No | BSL |
| Silver | 7440-22-4 | 1.3 J | 1.3 J | SW15 | 2 / 12 | 1.9 | A*b | 0.68 | No | BSL |
| Sodium | 7440-23-5 | 5900000 | 7000000 | A8-14 | 7 / 12 | 680000 | Ca | 10 | No | EN |
| Tin | 7440-31-5 | 27.1 J | 27.1 J | SW16 | 1 / 5 | 73 | Ca | 0.37 | No | BSL |
| Vanadium | 7440-62-2 | 65.2 J | 65.2 J | SW16 | 1 / 12 | 20 | Ca | 3.3 | Yes | ASL |
| Zinc | 7440-66-6 | 67.4 J | 255 J | SW16 | 2 / 12 | 81 | A* | 3.1 | Yes | ASL |
| **Inorganic Analytes (Dissolved) (µg/L)** | | | | | | | | | | |
| Aluminum | 7429-90-5 | 184 J | 15600 J | SW16 | 5 / 12 | NL | | NC | Yes | NV |
| Antimony | 7440-36-0 | 27.7 J | 61.6 | SW16 | 2 / 12 | NL | | NC | Yes | NV |
| Arsenic | 7440-38-2 | 2.5 J | 79.7 | SW16 | 5 / 12 | 36 | A* | 2.2 | Yes | ASL |
| Barium | 7440-39-3 | 21 J | 76.6 J | SW16 | 5 / 12 | 25000 | C | 0.003 | No | BSL |
| Cadmium | 7440-43-9 | 0.35 J | 0.35 J | SW15 | 1 / 12 | 8.8 | A* | 0.04 | No | BSL |
| Calcium | 7440-70-2 | 216000 J | 307000 | A8-09 | 12 / 12 | 116000 | Ca | 2.6 | No | EN |
| Chromium | 7440-47-3 | 14.7 J | 14.7 J | SW15 | 1 / 12 | 57.5 | C | 0.26 | No | BSL |
| Cobalt | 7440-48-4 | 1.1 J | 3.5 J | SW15 | 3 / 12 | 23 | Ca | 0.15 | No | BSL |
| Copper | 7440-50-8 | 45.2 J | 197 J | SW16 | 2 / 12 | 3.1 | A* | 64 | Yes | ASL |
| Iron | 7439-89-6 | 348 J | 7900 J | SW15 | 4 / 12 | 300 | Ca | 26 | Yes | ASL |
| Lead | 7439-92-1 | 5.1 J | 1810 J | SW16 | 3 / 12 | 24 | A* | 75 | Yes | ASL |
| Magnesium | 7439-95-4 | 685000 J | 900000 | A8-09 | 12 / 12 | 82000 | Ca | 11 | No | EN |

**Table 2-7**
**Chemicals Detected in Area 8 Surface Water**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | CAS No. | Minimum Concentration Detected | Maximum Concentration Detected | Location of Maximum Concentration | Frequency of Detection | Screening Value | | Hazard Quotient | COPC | Rationale |
|---|---|---|---|---|---|---|---|---|---|---|
| Manganese | 7439-96-5 | 77.7 J | 330 J | SW15 | 4 / 12 | 120 | Ca | 2.8 | Yes | ASL |
| Nickel | 7440-02-0 | 1.4 J | 26.2 J | SW16 | 4 / 12 | 22 | A* | 1.2 | Yes | ASL |
| Potassium | 7440-09-7 | 237000 J | 297000 | A8-16 | 12 / 12 | 53000 | Ca | 5.6 | No | EN |
| Selenium | 7782-49-2 | 2.3 J | 2.6 J | SW15 | 2 / 12 | 71 | A* | 0.04 | No | BSL |
| Silver | 7440-22-4 | 1.7 J | 1.7 J | SW16 | 1 / 12 | 1.9 | A*b | 0.89 | No | BSL |
| Sodium | 7440-23-5 | 5890000 | 6750000 | A8-16 | 7 / 12 | 680000 | Ca | 9.9 | No | EN |
| Tin | 7440-31-5 | 35.4 J | 35.4 J | SW16 | 1 / 5 | 73 | Ca | 0.48 | No | BSL |
| Vanadium | 7440-62-2 | 63.8 J | 63.8 J | SW16 | 1 / 12 | 20 | Ca | 3.2 | Yes | ASL |
| Zinc | 7440-66-6 | 81.6 J | 363 J | SW16 | 2 / 12 | 81 | A* | 4.5 | Yes | ASL |

µg/L - micrograms per liter
ASL - above screening level
BSL - equal to or below screening level
COPC - chemical of potential concern
EN - essential nutrient
J - estimated
NC - no hazard quotient calculated
NL - not listed
NV - chemical detected, but no screening value located
A -NJDEP 2011. Surface Water Quality Standards, Saline Water Chronic Values, January 2011, downloaded January 24, 2011
C -EPA 2006. EPA Region 3 Biological Technical Assistance Group Marine Screening Benchmarks,
Mid-Atlantic Risk Assessment: Ecological Risk Assessment, http://www.epa.gov/reg3hwmd/risk/eco/index.htm
*-dissolved criteria
a - freshwater value is used as directed by EPA
b - no chronic value available; acute value used

**Table 4-1**
**Avian Toxicity Reference Values**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | Belted Kingfisher | | American Robin | | American Kestrel | | Northern Bobwhite | |
|---|---|---|---|---|---|---|---|---|
| | LOAEL | NOAEL | LOAEL | NOAEL | LOAEL | NOAEL | LOAEL | NOAEL |
| Arsenic | 7.4 a | 2.5 a | 7.4 a | 2.5 a | 7.4 a[1] | 2.5 a[1] | 7.4 a[2] | 2.5 a[2] |
| Cadmium | 20 a | 1.45 a | 20 a | 1.45 a | 20 a[1] | 1.45 a[1] | 20 a[2] | 1.45 a[2] |
| Copper | 61.7 a | 47 a | 61.7 a | 47 a | 61.7 a[1] | 47 a[1] | 61.7 a[2] | 47 a[2] |
| Lead | 11.3 a | 1.13 a | 11.3 a | 1.13 a | 11.3 a[1] | 1.13 a[1] | 11.3 a[2] | 1.13 a[2] |
| Nickel | 107 a | 77.4 a | 107 a | 77.4 a | 107 a[1] | 77.4 a[1] | 107 a[2] | 77.4 a[2] |
| Selenium | 1 a | 0.5 a | 1 a | 0.5 a | 1 a[1] | 0.5 a[1] | 1 a[2] | 0.5 a[2] |
| Silver | 60.5 j | 20.2 j | 60.5 j | 20.2 j | 60.5 j | 20.2 j | 60.5 j | 20.2 j |
| Zinc | 131 a | 14.5 a | 131 a | 14.5 a | 131 a[1] | 14.5 a[1] | 131 a[2] | 14.5 a[2] |
| Hexavalent Chromium | 26.6 l,h | 2.66 l | 26.6 l,h | 2.66 l | 26.6 l,h | 2.66 l | 26.6 l,h | 2.66 l |
| Acenaphthene | 4550 b,c | 445 b,c | 4550 b,c | 445 b,c | 4550 b,c | 445 b,c | 4550 b,c | 445 b,c |
| Acenaphthylene | 4550 b,c | 445 b,c | 4550 b,c | 445 b,c | 4550 b,c | 445 b,c | 4550 b,c | 445 b,c |
| Anthracene | 4550 b,c | 445 b,c | 4550 b,c | 445 b,c | 4550 b,c | 445 b,c | 4550 b,c | 445 b,c |
| Benzo(a)anthracene | 20 b,d | 2 b,d | 20 b,d | 2 b,d | 20 b,d | 2 b,d | 20 b,d | 2 b,d |
| Benzo(a)pyrene | 20 b,d | 2 b,d | 20 b,d | 2 b,d | 20 b,d | 2 b,d | 20 b,d | 2 b,d |
| Benzo(b)fluoranthene | 20 b,d | 2 b,d | 20 b,d | 2 b,d | 20 b,d | 2 b,d | 20 b,d | 2 b,d |
| Benzo(g,h,i)perylene | 20 b,d | 2 b,d | 20 b,d | 2 b,d | 20 b,d | 2 b,d | 20 b,d | 2 b,d |
| Benzo(k)fluoranthene | 20 b,d | 2 b,d | 20 b,d | 2 b,d | 20 b,d | 2 b,d | 20 b,d | 2 b,d |
| Chrysene | 20 b,d | 2 b,d | 20 b,d | 2 b,d | 20 b,d | 2 b,d | 20 b,d | 2 b,d |
| Dibenzo(a,h)anthracene | 20 b,d | 2 b,d | 20 b,d | 2 b,d | 20 b,d | 2 b,d | 20 b,d | 2 b,d |
| Fluoranthene | 20 b,d | 2 b,d | 20 b,d | 2 b,d | 20 b,d | 2 b,d | 20 b,d | 2 b,d |
| Fluorene | 4550 b,c | 445 b,c | 4550 b,c | 445 b,c | 4550 b,c | 445 b,c | 4550 b,c | 445 b,c |
| Indeno(1,2,3-cd)pyrene | 20 b,d | 2 b,d | 20 b,d | 2 b,d | 20 b,d | 2 b,d | 20 b,d | 2 b,d |
| Pentachlorophenol | Not evaluated | | 67.3 k,h | 6.73 k | 67.3 k,h | 6.73 k | 67.3 k,h | 6.73 k |
| Phenanthrene | 4550 b,c | 445 b,c | 4550 b,c | 445 b,c | 4550 b,c | 445 b,c | 4550 b,c | 445 b,c |
| Pyrene | 20 b,d | 2 b,d | 20 b,d | 2 b,d | 20 b,d | 2 b,d | 20 b,d | 2 b,d |
| alpha-Chlordane | 10.7 a,e | 2.1 a,e | 10.7 a,e | 2.1 a,e | 10.7 a[1],e | 2.1 a[1],e | 10.7 a[2],e | 2.1 a[2],e |
| Aroclor-1254 | 1.8 a | 0.18 a | 1.8 a | 0.18 a | 1.8 a[1] | 0.18 a[1] | 1.8 a[2] | 0.18 a[2] |
| Aroclor-1260 | Not evaluated | | 1.8 a,f | 0.18 a,f | 1.8 a[1],f | 0.18 a[1],f | 1.8 a[2],f | 0.18 a[2],f |

**Table 4-1**
**Avian Toxicity Reference Values**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | Belted Kingfisher | | American Robin | | American Kestrel | | Northern Bobwhite | |
|---|---|---|---|---|---|---|---|---|
| | LOAEL | NOAEL | LOAEL | NOAEL | LOAEL | NOAEL | LOAEL | NOAEL |
| 4,4-DDD | Not evaluated | | 0.028 a,g | 0.003 a,g | 0.028 a[1],g | 0.003 a[1],g | 0.028 a[2],g | 0.003 a[2],g |
| 4,4-DDE | Not evaluated | | 0.028 a,g | 0.003 a,g | 0.028 a[1],g | 0.003 a[1],g | 0.028 a[2],g | 0.003 a[2],g |
| 4,4-DDT | Not evaluated | | 0.028 a,g | 0.003 a,g | 0.028 a[1],g | 0.003 a[1],g | 0.028 a[2],g | 0.003 a[2],g |
| Dieldrin | 0.77 a,h | 0.077 a | 0.77 a,h | 0.077 a | 0.77 a[1],h | 0.077 a[1] | 0.77 a[2],h | 0.077 a[2] |
| Endosulfan I | Not evaluated | | 100 a,h,i | 10 a,i | 100 a[1],h,i | 10 a[1],i | 100 a[2],h,i | 10 a[2],i |
| Endosulfan II | Not evaluated | | 100 a,h,i | 10 a,i | 100 a[1],h,i | 10 a[1],i | 100 a[2],h,i | 10 a[2],i |
| Endrin | Not evaluated | | 0.1 a | 0.01 a | 0.1 a[1] | 0.01 a[1] | 0.1 a[2] | 0.01 a[2] |
| gamma-Chlordane | 10.7 a,e | 2.1 a,e | 10.7 a,e | 2.1 a,e | 10.7 a[1],e | 2.1 a[1],e | 10.7 a[2],e | 2.1 a[2],e |
| Methoxyclor | 200 m,h | 20 m | 200 m,h | 20 m | 200 m,h | 20 m | 200 m,h | 20 m |

Notes:

LOAEL - lowest-observed-adverse-effect level

NOAEL - no-observed-adverse-effect level

TRV - toxicity reference value

1 - no TRV for American kestrel located in Sample and Suter (1996); value for red-tailed hawk used

2 - no TRV for northern bobwhite located in Sample and Suter (1996); value for wild turkey used

a - TRVs taken from Sample, B.E., D.M. Opresko and G.W. Suter II. 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. ES/ER/TM-86/R3. Oak Ridge National Laboratoy, Oakridge, TN.

b - TRVs taken from Lockheed-Martin. 2002. Final Report, Atlantic Wood Industries,
Ecological Risk Assessment, Portsmouth, Virginia. EPA Contract 68-C-99-223.

c - value for low molecular weight polyaromatic hydrocarbons (LMWPAHs)

d - value for high molecular weight PAHs

e - value for chlordane

f - value for Aroclor 1254

g - value for DDT and metabolites

h - no LOAEL located; value derived by multiplying the NOAEL by a factor of 10

i - value for endosulfan

j - TRVs taken from EPA. 2005. Ecological Soil Screening Levels (Eco-SSLs) for Silver. Washington, DC. US Environmental Protection Agency

k - TRVs taken from EPA. 2007. Eco-SSLs for Pentachlorophenol. Washington, DC. US Environmental Protection Agency

l - TRV for trivalent chromium from EPA. 2008. Eco-SSLs for Chromium. Washington, DC. US Environmental Protection Agency

m - Derived from LD50 for methoxychlor taken from Methoxychlor Reregistration Eligibility Decision (RED) June 30, 2004 EPA Publication No. EPA 738-R-04-010

Not evaluated - Chemical only detected in soil and is not evaluted using the designated receptor

**Table 4-2**
**Mammalian Toxicity Reference Values**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | Mink | | Short-tailed Shrew | | Red Fox | | Eastern Cottontail | | Muskrat | |
|---|---|---|---|---|---|---|---|---|---|---|
| | LOAEL | NOAEL | LOAEL | NOAEL | LOAEL | NOAEL | LOAEL | NOAEL | LOAEL | NOAEL |
| Arsenic | 0.524 a | 0.052 a | 1.498 a | 0.15 a | 0.36 a | 0.036 a | 0.501 a | 0.05 a | 0.524 a[1] | 0.052 a[1] |
| Cadmium | 7.419 a | 0.742 a | 21.2 a | 2.12 a | 5.094 a | 0.509 a | 7.089 a | 0.709 a | 7.419 a[1] | 0.742 a[1] |
| Copper | 15.4 a | 11.7 a | 44 a | 33.4 a | 10.6 a | 8.0 a | 14.7 a | 11.2 a | 15.4 a[1] | 11.7 a[1] |
| Lead | 61.53 a | 6.15 a | 175.83 a | 17.58 a | 42.25 a | 4.22 a | 58.79 a | 5.88 a | 61.53 a[1] | 6.15 a[1] |
| Nickel | 61.53 a | 30.77 a | 175.83 a | 87.91 a | 42.25 a | 21.12 a | 58.79 a | 29.4 a | 61.53 a[1] | 30.77 a[1] |
| Selenium | 0.254 a | 0.154 a | 0.725 a | 0.44 a | 0.174 a | 0.106 a | 0.243 a | 0.147 a | 0.254 a[1] | 0.154 a[1] |
| Silver | 6.02 b | 0.6 b,c | 6.02 b | 0.6 b,c | 6.02 b | 0.6 b,c | 6.02 b | 0.6 b,c | 6.02 b | 0.6 b,c |
| Zinc | 246.1 a | 123.1 a | 703.3 a | 351.7 a | 169 a | 84.5 a | 235.2 a | 117.6 a | 246.1 a[1] | 123.1 a[1] |
| Hexavalent Chromium | 10.11 a | 2.52 a | 28.88 a | 7.21 a | 6.94 a | 1.73 a | 9.66 a | 2.41 a | 10.11 a[1] | 2.52 a[1] |
| Acenaphthene | 656 e,f,h | 65.6 e,f | 656 e,f,h | 65.6 e,f | 656 e,f,h | 65.6 e,f | 656 e,f,h | 65.6 e,f | 656 e,f,h | 65.6 e,f |
| Acenaphthylene | 656 e,f,h | 65.6 e,f | 656 e,f,h | 65.6 e,f | 656 e,f,h | 65.6 e,f | 656 e,f,h | 65.6 e,f | 656 e,f,h | 65.6 e,f |
| Anthracene | 656 e,f,h | 65.6 e,f | 656 e,f,h | 65.6 e,f | 656 e,f,h | 65.6 e,f | 656 e,f,h | 65.6 e,f | 656 e,f,h | 65.6 e,f |
| Benzo(a)anthracene | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g |
| Benzo(a)pyrene | 4.16 a | 0.42 a | 11.89 a | 1.19 a | 2.86 a | 0.29 a | 3.98 a | 0.4 a | 4.16 a[1] | 0.42 a[1] |
| Benzo(b)fluoranthene | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g |
| Benzo(g,h,i)perylene | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g |
| Benzo(k)fluoranthene | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g |
| Chrysene | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g |
| Dibenzo(a,h)anthracene | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g |
| Fluoranthene | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g |
| Fluorene | 656 e,f,h | 65.6 e,f | 656 e,f,h | 65.6 e,f | 656 e,f,h | 65.6 e,f | 656 e,f,h | 65.6 e,f | 656 e,f,h | 65.6 e,f |
| Indeno(1,2,3-cd)pyrene | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g |
| Pentachlorophenol | Not evaluated | | 5.275 a | 0.527 a | 1.267 a | 0.127 a | 1.764 a | 0.176 a | Not evaluated | |
| Phenanthrene | 656 e,f,h | 65.6 e,f | 656 e,f,h | 65.6 e,f | 656 e,f,h | 65.6 e,f | 656 e,f,h | 65.6 e,f | 656 e,f,h | 65.6 e,f |
| Pyrene | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g | 6.15 e,g,h | 0.615 e,g |
| alpha-Chlordane | 3.8 a,i | 1.9 a,i | 10.9 a,i | 5.5 a,i | 2.6 a,i | 1.3 a,i | 3.7 a,i | 1.8 a,i | 3.8 a[1],i | 1.9 a[1],i |
| Aroclor-1254 | 0.69 a | 0.14 a | 0.668 a | 0.067 a | 0.474 a | 0.096 a | 0.223 a | 0.022 a | 0.69 a[1] | 0.14 a[1] |
| Aroclor-1260 | Not evaluated | | 0.668 a,d | 0.067 a,d | 0.474 a,d | 0.096 a,d | 0.223 a,d | 0.022 a,d | Not evaluated | |
| 4,4-DDD | Not evaluated | | 8.79 a,j | 1.76 a,j | 2.11 a,j | 0.42 a,j | 2.94 a,j | 0.59 a,j | Not evaluated | |
| 4,4-DDE | Not evaluated | | 8.79 a,j | 1.76 a,j | 2.11 a,j | 0.42 a,j | 2.94 a,j | 0.59 a,j | Not evaluated | |
| 4,4-DDT | Not evaluated | | 8.79 a,j | 1.76 a,j | 2.11 a,j | 0.42 a,j | 2.94 a,j | 0.59 a,j | Not evaluated | |
| Dieldrin | 0.154 a | 0.015 a | 0.44 a | 0.044 a | 0.106 a | 0.011 a | 0.147 a | 0.015 a | 0.154 a[1] | 0.015 a[1] |
| Endosulfan I | Not evaluated | | 3.3 a,k,h | 0.33 a,k | 0.8 a,k,h | 0.08 a,k | 1.1 a,k,h | 0.11 a,k | Not evaluated | |
| Endosulfan II | Not evaluated | | 3.3 a,k,h | 0.33 a,k | 0.8 a,k,h | 0.08 a,k | 1.1 a,k,h | 0.11 a,k | Not evaluated | |
| Endrin | Not evaluated | | 1.094 a | 0.109 a | 0.263 a | 0.026 a | 0.366 a | 0.037 a | Not evaluated | |
| gamma-Chlordane | 3.8 a,i | 1.9 a,i | 10.9 a,i | 5.5 a,i | 2.6 a,i | 1.3 a,i | 3.7 a,i | 1.8 a,i | 3.8 a[1],i | 1.9 a[1],i |
| Methoxyclor | 6.2 a | 3.1 a | 17.6 a | 8.8 a | 4.2 a | 2.1 a | 5.9 a | 2.9 a | 6.2 a[1] | 3.1 a[1] |

**Table 4-2**
**Mammalian Toxicity Reference Values**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

Notes:
LOAEL - lowest-observed-adverse-effect level
NOAEL - no-observed-adverse-effect level
TRV - toxicity reference value
1 - no TRV for muskrat located in Sample and Suter (1996); value for mink used
a - TRVs taken from Sample, B.E., D.M. Opresko and G.W. Suter II. 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. ES/ER/TM-86/R3. Oak Ridge National Laboratoy, Oakridge, TN.
b - TRVs taken from EPA. 2005. Ecological Soil Screening Levels (Eco-SSLs) for Silver. Washington, DC. US Environmental Protection Agency
c - no NOAEL located; value derived by dividing the LOAEL by a factor of 10
d - value for Aroclor 1254
e - TRVs taken from EPA. 2007. Eco-SSLs for Poly Aromatic Hydrocarbons (PAHs). Washington, DC. US Environmental Protection Agency
f - value for low molecular weight PAHs
g - value for high molecular weight PAHs
h - no LOAEL located; value derived by multiplying the NOAEL by a factor of 10
i - value for chlordane
j - value for DDT and metabolites
k - value for endosulfan
Not evaluated - Chemical only detected in soil and is not evaluted using the designated receptor

**Table 5-1**
**Biota-Sediment Accumulation Factors and Bioaccumulation Factors**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | Fish Biota-Sediment Accumulation Factor | | Earthworm Bioaccumulation Factor | | Plant Bioaccumulation Factor | | Small Mammal Bioaccumulation Factor | |
|---|---|---|---|---|---|---|---|---|
| Arsenic | 0.12 | n | 0.11 | b | 0.036 | b | 0.48 | c,m |
| Cadmium | 2.0 | n | 0.96 | b | 0.364 | b | 0.32 | c,m |
| Copper | 1.0 | o | 0.04 | b | 0.4 | b | 20.0 | c,m |
| Lead | 0.43 | n | 0.03 | b | 0.045 | b | 57.2 | c,m |
| Nickel | 1.0 | o | 0.02 | b | 0.032 | b | 3.2 | c,m |
| Selenium | 1.0 | o | 0.22 | b | 0.016 | b | 1.4 | c,m |
| Silver | 1.0 | o | 0.22 | b | 0.4 | b | 0.03 | c,m |
| Zinc | 5.0 | n | 0.56 | b | 1.2E-12 | b | 117.7 | c,m |
| Hexavalent Chromium | 1.0 | o | 1.0 | o | 1.0 | o | 1.0 | o |
| Acenaphthene | 0.029 | a | 1.47 | c | 7.3 | c | 0 | c |
| Acenaphthylene | 0.000 | a | 22.9 | c | 1.0 | o | 0 | c |
| Anthracene | 0.008 | a | 2.42 | c | 0.31 | c | 0 | c |
| Benzo(a)anthracene | 0.094 | a | 1.59 | c | 0.0202 | b | 0 | c |
| Benzo(a)pyrene | 0.000 | a | 1.33 | c | 0.00 | b | 0 | c |
| Benzo(b)fluoranthene | 0.002 | a | 2.6 | c | 0.0101 | b | 0 | c |
| Benzo(g,h,i)perylene | 0.070 | a | 2.94 | c | 0.361 | c | 0 | c |
| Benzo(k)fluoranthene | 0.002 | a | 2.60 | c | 0.0101 | b | 0 | c |
| Chrysene | 0.064 | a | 2.29 | c | 0.0187 | b | 0 | c |
| Dibenzo(a,h)anthracene | 0.001 | a | 2.31 | c | 0.0064 | b | 0 | c |
| Fluoranthene | 0.038 | a | 3.04 | c | 0.5 | c | 0 | c |
| Fluorene | 0.526 | a | 9.57 | c | 7.3 | c | 0 | c |
| Indeno(1,2,3-cd)pyrene | 0.076 | a | 2.86 | c | 0.0039 | b | 0 | c |
| Pentachlorophenol | Not evaluated | | 1034 | b | 0.0449 | b | 0.20 | c,m |
| Phenanthrene | 0.018 | a | 1.72 | c | 2.1 | c | 0 | c |
| Pyrene | 0.039 | a | 1.75 | c | 0.72 | c | 0 | c |
| alpha-Chlordane | 0.146 | a | 7,925.7 | b,d | 0.0086 | b,g,h | 1.0 | o |
| Aroclor-1254 | 2.3 | a | 1.13 | b,e | 0.01 | b,e | 1.0 | o |
| Aroclor-1260 | Not evaluated | | 1.13 | b,e | 0.01 | b,e | 1.0 | o |
| 4,4-DDD | Not evaluated | | 1.26 | b,f | 0.00937 | b,f | 4.9 | c,l |
| 4,4-DDE | Not evaluated | | 1.26 | b,f | 0.00937 | b,f | 4.9 | c,l |
| 4,4-DDT | Not evaluated | | 1.26 | b,f | 0.037 | c | 4.9 | c |
| Dieldrin | 1.6 | a | 4.27 | b* | 0.41 | c | 3.8 | c |

**Table 5-1**
**Biota-Sediment Accumulation Factors and Bioaccumulation Factors**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | Fish Biota-Sediment Accumulation Factor | | Earthworm Bioaccumulation Factor | | Plant Bioaccumulation Factor | | Small Mammal Bioaccumulation Factor | |
|---|---|---|---|---|---|---|---|---|
| Endosulfan I | Not evaluated | | 97.9 | b,d | 0.17 | b,g,i | 1.0 | o |
| Endosulfan II | Not evaluated | | 97.9 | b,d | 0.17 | b,g,i | 1.0 | o |
| Endrin | Not evaluated | | 1,296.6 | b,d | 0.046 | b,g | 1.0 | o |
| gamma-Chlordane | 0.49 | a | 7,925.7 | b,d | 0.0086 | b,g,h | 1.0 | o |
| Methoxyclor | 1.8 | j | 1,034 | b,d | 0.045 | b,g | 1.0 | o |

Notes:

a - Whole body value taken from EPA, BSAF Database, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Mid-Continent Ecology Division

b - EPA Region 6 Multimedia Planning and Permitting Division, Office of Solid Waste., August 1999, Screening Level Ecological risk Assessment Protocol: Appendix C: Media to Receptor BCF Values

c - EPA, Guidance for Developing Ecological Soil Screening Levels, Attachment 4-1 Exposure Factors and Bioaccumulation Models for Derivation of Wildlife Eco-SSLs, OSWER Directive 9285.7-55, Februray 2005.

d - BAF calculated using the regression equation: $LogBCF=(0.819*logK_{ow})-1.146$ as per Appendix C in source"b".

* - highest BAF reported for depurated eartworms

e - value for Aroclor 1254

f - value for 4,4'-DDE

g - BAF calculated using the regression equation: $log\ BCF=1.588-0.578 \times log\ K_{ow}$ as per Appendix C in source "b"

h - calculated using the log $K_{ow}$ for chlordane

i - calculated using the log $K_{ow}$ for endosulfan

j - Unknown fish species or tissue type taken from U.S. Navy. 2003. Final Quantico Watershed Study, Quantico Creek Ecological and Assessment. Human Health Risk Screening U.S. Navy Chesapeake Division Naval Facilities Engineering Command. Contract No. N47408-01-D-8207. Project No. G486004

l - value for DDT

m - no BAF values located; values shown are estimated tissue concentrations calculated using the regression equation as presented in source "c"

n - Highest whole body value taken from PTI Environmental Services. 1995. Bioaccumulation Factor Approach Analysis for Metals and Polar Organic Compounds, Final Report submitted to Washington State Department of Ecology. October.

o- default value of "1" used when no BSAF/BAF were located.

Not evaluated - Chemical only detected in soil and is not evaluted using the designated receptor

**Table 5-2**
**Food Chain Exposure Model Summary - Aquatic Receptors**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | Belted Kingfisher | | Mink | | Muskrat | |
|---|---|---|---|---|---|---|
| | LOAEL | NOAEL | LOAEL | NOAEL | LOAEL | NOAEL |
| | Hazard Quotient | Hazard Quotient | Hazard Quotient | Hazard Quotient | Hazard Quotient | Hazard Quotient |
| Arsenic | 0.23 | 0.7 | **1.4** | **14.5** | **1.9** | **19** |
| Cadmium | 0.0479 | 0.66 | 0.10 | 1.0 | 0.02 | 0.2 |
| Copper | **3.7** | **4.9** | **5.1** | **6.6** | **4.8** | **6.4** |
| Lead | **2.9** | **28.7** | 0.19 | **1.9** | 0.1 | **1.1** |
| Nickel | 0.68 | 0.94 | 0.40 | 0.8 | 0.1 | 0.2 |
| Selenium | **2.4** | **4.8** | **3.2** | **5.3** | 0.7 | **1.1** |
| Silver | 0.063 | 0.187 | 0.21 | **2.1** | 0.2 | **2.1** |
| Zinc | **1.5** | **13.3** | 0.255 | 0.51 | 0.01 | 0.02 |
| Hexavalent Chromium | 0.024 | 0.24 | 0.022 | 0.09 | 0.046 | 0.19 |
| Acenaphthene | 0.0000001 | 0.000001 | 0.000001 | 0.00001 | 0.00007 | 0.001 |
| Acenaphthylene | 0.0000001 | 0.000001 | 0.000001 | 0.00001 | 0.000017 | 0.00017 |
| Anthracene | 0.0000002 | 0.000002 | 0.000001 | 0.0000 | 0.00001 | 0.0001 |
| Benzo(a)anthracene | 0.001 | 0.01 | 0.001 | 0.01 | 0.002 | 0.02 |
| Benzo(a)pyrene | 0.0003 | 0.003 | 0.001 | 0.01 | 0.002 | 0.02 |
| Benzo(b)fluoranthene | 0.0005 | 0.005 | 0.001 | 0.01 | 0.003 | 0.03 |
| Benzo(g,h,i)perylene | 0.001 | 0.01 | 0.001 | 0.01 | 0.01 | 0.1 |
| Benzo(k)fluoranthene | 0.0002 | 0.002 | 0.0006 | 0.01 | 0.001 | 0.01 |
| Chrysene | 0.0008 | 0.008 | 0.001 | 0.01 | 0.002 | 0.02 |
| Dibenzo(a,h)anthracene | 0.00003 | 0.0003 | 0.0001 | 0.001 | 0.0002 | 0.002 |
| Fluoranthene | 0.002 | 0.02 | 0.003 | 0.03 | 0.0296 | 0.3 |
| Fluorene | 0.0000004 | 0.00 | 0.000001 | 0.00001 | 0.00003 | 0.0003 |
| Indeno(1,2,3-Cd)Pyrene | 0.0006 | 0.006 | 0.001 | 0.01 | 0.001 | 0.01 |
| Phenanthrene | 0.000001 | 0.00001 | 0.000007 | 0.00007 | 0.0003 | 0.003 |
| Pyrene | 0.001 | 0.0104 | 0.002 | 0.02 | 0.02623 | 0.3 |
| Alpha-Chlordane | 0.00004 | 0.0002 | 0.00005 | 0.0001 | 0.00004 | 0.00009 |
| Aroclor 1254 | 0.007 | 0.1 | 0.006 | 0.03 | 0.0005 | 0.003 |
| Dieldrin | 0.001 | 0.01 | 0.002 | 0.02 | 0.00118 | 0.0121 |
| Gamma-Chlordane | 0.0001 | 0.0004 | 0.0001 | 0.0001 | 0.00003 | 0.0001 |
| Methoxychlor | 0.00001 | 0.0001 | 0.0001 | 0.0003 | 0.00002 | 0.00004 |

Notes:
NOAEL = no observed adverse effect level
LOAEL = lowest observed adverse effect level
Shaded cells indicate hazard quotient greater than one

**Table 5-3**
**Food Chain Exposure Model Summary - Terrestrial Receptors**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | Northern Bobwhite | | Eastern Cottontail | | American Kestrel | | Red Fox | | American Robin | | Short-Tailed Shrew | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LOAEL | NOAEL | LOAEL | NOAEL | LOAEL | NOAEL | LOAEL | NOAEL | LOAEL | NOAEL | LOAEL | NOAEL |
| | Hazard Quotient | Hazard Quotient | Hazard Quotient | Hazard Quotient | Hazard Quotient | Hazard Quotient | Hazard Quotient | Hazard Quotient | Hazard Quotient | Hazard Quotient | Hazard Quotient | Hazard Quotient |
| Arsenic | 0.3 | 0.8 | 6.4 | 64 | 0.08 | 0.2 | 1.8 | 18 | 8.7 | 26 | 10 | 102 |
| Cadmium | 0.003 | 0.04 | 0.02 | 0.2 | 0.005 | 0.07 | 0.01 | 0.1 | 0.1 | 1.9 | 0.04 | 0.4 |
| Copper | 0.6 | 0.7 | 4.9 | 6.4 | 0.1 | 0.2 | 0.5 | 0.7 | 3.4 | 4.5 | 0.96 | 1.3 |
| Lead | 9.3 | 93 | 3.1 | 31 | 3.8 | 38 | 0.9 | 9.0 | 185 | 1,847 | 2.3 | 23 |
| Nickel | 0.002 | 0.003 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.05 | 0.1 | 0.01 | 0.01 |
| Selenium | 0.08 | 0.2 | 0.5 | 0.8 | 0.5 | 0.9 | 1.3 | 2.1 | 4.6 | 9.2 | 1.7 | 2.8 |
| Silver | 0.01 | 0.02 | 0.1 | 1.2 | 0.0005 | 0.002 | 0.005 | 0.05 | 0.1 | 0.2 | 0.2 | 2.0 |
| Zinc | 0.021 | 0.2 | 0.02 | 0.035 | 0.3 | 2.6 | 0.1 | 0.2 | 3.1 | 28 | 0.2 | 0.3 |
| Hexavalent Chromium | 0.0052 | 0.052 | 0.031 | 0.12 | 0.0157 | 0.157 | 0.0276 | 0.111 | 0.11 | 1.1 | 0.030 | 0.12 |
| Acenaphthene | 0.00001 | 0.0001 | 0.0002 | 0.0018 | 0.0000001 | 0.000001 | 0.0000004 | 0.000004 | 0.0001 | 0.001 | 0.0001 | 0.001 |
| Acenaphthylene | 0.0000017 | 0.000017 | 0.000025 | 0.00025 | 0.00000005 | 0.000001 | 0.0000004 | 0.000004 | 0.0007 | 0.007 | 0.002 | 0.02 |
| Anthracene | 0.000001 | 0.00001 | 0.00002 | 0.0002 | 0.0000001 | 0.000001 | 0.000001 | 0.00001 | 0.0002 | 0.002 | 0.0004 | 0.004 |
| Benzo(a)anthracene | 0.0003 | 0.003 | 0.001 | 0.01 | 0.0001 | 0.001 | 0.0003 | 0.003 | 0.09 | 0.9 | 0.1 | 0.9 |
| Benzo(a)pyrene | 0.0002 | 0.002 | 0.002 | 0.02 | 0.0001 | 0.001 | 0.0006 | 0.01 | 0.07 | 0.7 | 0.03 | 0.3 |
| Benzo(b)fluoranthene | 0.0004 | 0.004 | 0.002 | 0.0192 | 0.0001 | 0.001 | 0.0005 | 0.005 | 0.2 | 2.0 | 0.2 | 2.1 |
| Benzo(g,h,i)perylene | 0.0008 | 0.008 | 0.01 | 0.1 | 0.0001 | 0.001 | 0.0002 | 0.002 | 0.1 | 1.1 | 0.1 | 1.1 |
| Benzo(k)fluoranthene | 0.0002 | 0.002 | 0.001 | 0.0117 | 0.0001 | 0.001 | 0.0003 | 0.003 | 0.1 | 1.2 | 0.1 | 1.3 |
| Chrysene | 0.0003 | 0.003 | 0.002 | 0.015 | 0.0001 | 0.001 | 0.0003 | 0.003 | 0.1 | 1.3 | 0.13 | 1.3 |
| Dibenzo(a,h)anthracene | 0.00005 | 0.0005 | 0.0002 | 0.0024 | 0.0000 | 0.0002 | 0.0001 | 0.001 | 0.02 | 0.2 | 0.02 | 0.2 |
| Fluoranthene | 0.003 | 0.03 | 0.02 | 0.198 | 0.0002 | 0.002 | 0.0006 | 0.006 | 0.3 | 3.2 | 0.3 | 3.2 |
| Fluorene | 0.00005 | 0.001 | 0.001 | 0.01 | 0.0000 | 0.000002 | 0.000002 | 0.00002 | 0.001 | 0.01 | 0.003 | 0.03 |
| Indeno(1,2,3-cd)pyrene | 0.0001 | 0.001 | 0.0006 | 0.01 | 0.00004 | 0.0004 | 0.0002 | 0.002 | 0.1 | 0.8 | 0.08 | 0.8 |
| Pentachlorophenol | 0.000002 | 0.00002 | 0.0001 | 0.001 | 0.0009 | 0.01 | 0.02 | 0.2 | 0.3 | 2.8 | 1.1 | 11 |
| Phenanthrene | 0.00005 | 0.0005 | 0.0008 | 0.01 | 0.000001 | 0.00001 | 0.00001 | 0.0001 | 0.0009 | 0.01 | 0.002 | 0.02 |
| Pyrene | 0.01 | 0.1 | 0.04 | 0.4 | 0.0002 | 0.002 | 0.001 | 0.01 | 0.3 | 2.7 | 0.3 | 2.7 |
| Alpha-Chlordane | 0.00001 | 0.00004 | 0.00003 | 0.0001 | 0.000238 | 0.00121 | 0.00045 | 0.00090 | 12 | 60 | 3.7 | 7.2 |
| Aroclor 1254 | 0.08 | 0.8 | 0.98398 | 10 | 2.5 | 24.9 | 4.3 | 21.4 | 19 | 192 | 16 | 156 |
| Aroclor 1260 | 0.0002 | 0.002 | 0.00218 | 0.0221 | 0.0055 | 0.055 | 0.0096 | 0.047 | 0.04 | 0.4 | 0.03 | 0.3 |
| 4,4'-DDD | 0.004 | 0.04 | 0.0001 | 0.0003 | 0.6 | 6.0 | 0.004 | 0.02 | 1.1 | 10 | 0.001 | 0.01 |
| 4,4'-DDE | 0.01 | 0.05 | 0.0001 | 0.0004 | 0.8 | 7.8 | 0.01 | 0.03 | 1.5 | 14 | 0.001 | 0.01 |
| 4,4'-DDT | 0.37579 | 3.5 | 0.006 | 0.03 | 46 | 430 | 0.3 | 1.4 | 80 | 751 | 0.1 | 0.4 |
| Dieldrin | 0.0003 | 0.003 | 0.003 | 0.03 | 0.006 | 0.06 | 0.02 | 0.2 | 0.04 | 0.4 | 0.02 | 0.2 |
| Endosulfan I | 0.0000004 | 0.000004 | 0.0001 | 0.0008 | 0.00000560 | 0.000056 | 0.00032 | 0.0032 | 0.003 | 0.03 | 0.03 | 0.3 |
| Endosulfan II | 0.00005 | 0.0005 | 0.008 | 0.1 | 0.00057 | 0.0057 | 0.033 | 0.33 | 0.3 | 3.5 | 3.3 | 33 |
| Endrin | 0.0003 | 0.003 | 0.0002 | 0.002 | 0.00810 | 0.0810 | 0.0014 | 0.014 | 65 | 653 | 1.9 | 19 |
| Gamma-Chlordane | 0.0001 | 0.0005 | 0.0005 | 0.001 | 0.0034 | 0.0175 | 0.0065 | 0.013 | 169 | 862 | 53 | 105 |
| Methoxychlor | 0.000001 | 0.00001 | 0.0001 | 0.0001 | 0.0000247 | 0.000247 | 0.00054 | 0.0011 | 0.16 | 1.6 | 0.6 | 1.1 |

Notes:
NOAEL = no observed adverse effect level
LOAEL = lowest observed adverse effect level
Shaded cells indicate hazard quotient greater than one

**Table 5-4**
**Comparison of Maximum Concentrations of Chemicals of Potential Concern**
**Detected in Area 9 Soil to Background Concentrations**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | CAS No. | Maximum Concentration | Background Concentration | | |
|---|---|---|---|---|---|
| | | | Minimum | Maximum | 95% UPL* |
| **Volatile Organic Compounds (µg/kg)** | | | | | |
| Fluorobenzene | 462-06-6 | 10 NJ | NA | NA | NA |
| Isopropylbenzene | 98-82-8 | 11 | ND | ND | ND |
| **Semi-volatile Organic Compounds (µg/kg)** | | | | | |
| 1,1'-Biphenyl | 92-52-4 | 77 J | ND | ND | ND |
| 2-Methylphenol | 95-48-7 | 170 J | ND | ND | ND |
| Benzaldehyde | 100-52-7 | 78 J | ND | ND | ND |
| Carbazole | 86-74-8 | 77 J | ND | ND | ND |
| Dibenzofuran | 132-64-9 | 58 J | ND | ND | ND |
| Fluoranthene | 206-44-0 | 1,200 | 53 | 53 | 53 |
| Pyrene | 129-00-0 | 2,100 J | 36 | 36 | 36 |
| **Pesticides/PCBs (µg/kg)** | | | | | |
| Aroclor 1254 | 11097-69-1 | 22,000 | ND | ND | ND |
| 4,4'-DDT | 50-29-3 | 1,300 NJ | 1.8 | 1.8 | 1.8 |
| Endosulfan II | 33213-65-9 | 280 | ND | ND | ND |
| **Inorganics (mg/kg)** | | | | | |
| Aluminum | 7429-90-5 | 10800 | 89.6 | 972 | 882 |
| Antimony | 7440-36-0 | 188 | 0.2 | 0.2 | 0.2 |
| Arsenic | 7440-38-2 | 179 | 0.34 | 3.1 | 3.1 |
| Cadmium | 7440-43-9 | 1.7 | 0.026 | 0.026 | 0.026 |
| Chromium | 7440-47-3 | 155 | 1.1 | 7.8 | 7.8 |
| Copper | 7440-50-8 | 1,170 | 0.44 | 2.4 | 2.21 |
| Iron | 7439-89-6 | 46800 | 1,010 | 1,010 | 1,010 |
| Lead | 7439-92-1 | 10,200 J | 1.1 | 6.9 | 5.7 |
| Manganese | 7439-96-5 | 368 | 1.6 | 26.5 | 20.9 |
| Mercury | 7439-97-6 | 0.47 | ND | ND | ND |
| Selenium | 7782-49-2 | 8.5 | 0.087 | 0.099 | 0.095 |
| Silver | 7440-22-4 | 9.2 J | ND | ND | ND |
| Tin | 7440-31-5 | 313 | NA | NA | NA |
| Vanadium | 7440-62-2 | 134 | 1.7 | 12.9 | 10.5 |
| Zinc | 7440-66-6 | 386 | 1.2 | 16 | 15 |

Notes:
mg/kg - milligram per kilogram
µg/kg - microgram per kilogram
NA - not analyzed
ND - not detected
J - estimated
NJ - tentatively identified
* 95% Upper Prediction Limit (UPL) is calculated using ProUCL version 4.01.00
If the 95% UPL was greater than the maximum background concentration, the former of the the two values was utilized

**Table 5-5**
**Comparison of Maximum Concentrations of Chemicals of Potential Concern**
**Detected in Area 8 and 9 Sediment to Background Concentrations**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | CAS No. | Maximum Concentration | | Background Concentration | | |
|---|---|---|---|---|---|---|
| | | Area 8 | Area 9 | Minimum | Maximum | 95% UPL* |
| **Semi-volatile Organic Compounds (µg/kg)** | | | | | | |
| Acenaphthene | 83-32-9 | BSL | 64 J | ND | ND | ND |
| Acenaphthylene | 208-96-8 | BSL | 110 J | 3.1 | 12 | 10.1 |
| Acetophenone | 98-86-2 | 60 J | 380 J | 33 | 65 | 65 |
| Anthracene | 120-12-7 | BSL | 95 J | ND | ND | ND |
| Benzaldehyde | 100-52-7 | 67 J | ND | ND | ND | ND |
| Benzo(a)anthracene | 56-55-3 | BSL | 550 J | 2.2 | 870 | 136.8 |
| Benzo(a)pyrene | 50-32-8 | BSL | 570 J | 2.4 | 73 | 60.5 |
| Benzo(b)fluoranthene | 205-99-2 | 250 | 1,000 | 39 | 98 | 98 |
| Benzo(g,h,i)perylene | 191-24-2 | BSL | 480 | ND | ND | ND |
| Benzo(k)fluoranthene | 207-08-9 | BSL | 480 | ND | ND | ND |
| Carbazole | 86-74-8 | 7.3 J | 73 J | ND | ND | ND |
| Chrysene | 218-01-9 | BSL | 610 J | 1.9 | 100 | 93.0 |
| Dibenzo(a,h)anthracene | 53-70-3 | BSL | 76 | 7.6 | 19 | 13.3 |
| Fluoranthene | 206-44-0 | BSL | 1,700 | 25 | 160 | 160 |
| Fluorene | 86-73-7 | BSL | 24 J | ND | ND | ND |
| Indeno(1,2,3-cd)pyrene | 193-39-5 | BSL | 430 | 37 | 43 | 43 |
| Naphthalene | 91-20-3 | BSL | 320 J | 130 | 130 | 130 |
| Phenanthrene | 85-01-8 | BSL | 490 | ND | ND | ND |
| Pyrene | 129-00-0 | BSL | 1,100 | 50 | 130 | 130 |
| **Pesticides/PCBs (µg/kg)** | | | | | | |
| Aroclor 1254 | 11097-69-1 | 720 | BSL | ND | ND | ND |
| Alpha-Chlordane | 5103-71-9 | ND | 9.2 J | ND | ND | ND |
| 4,4'-DDT | 50-29-3 | 96 J | ND | ND | ND | ND |
| Endosulfan II | 33213-65-9 | 36 | ND | ND | ND | ND |
| Endosulfan Sulfate | 1031-07-8 | 24 JN | ND | ND | ND | ND |
| Gamma-Chlordane | 5103-74-2 | 52 JN | BSL | ND | ND | ND |

**Table 5-5**
**Comparison of Maximum Concentrations of Chemicals of Potential Concern**
**Detected in Area 8 and 9 Sediment to Background Concentrations**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

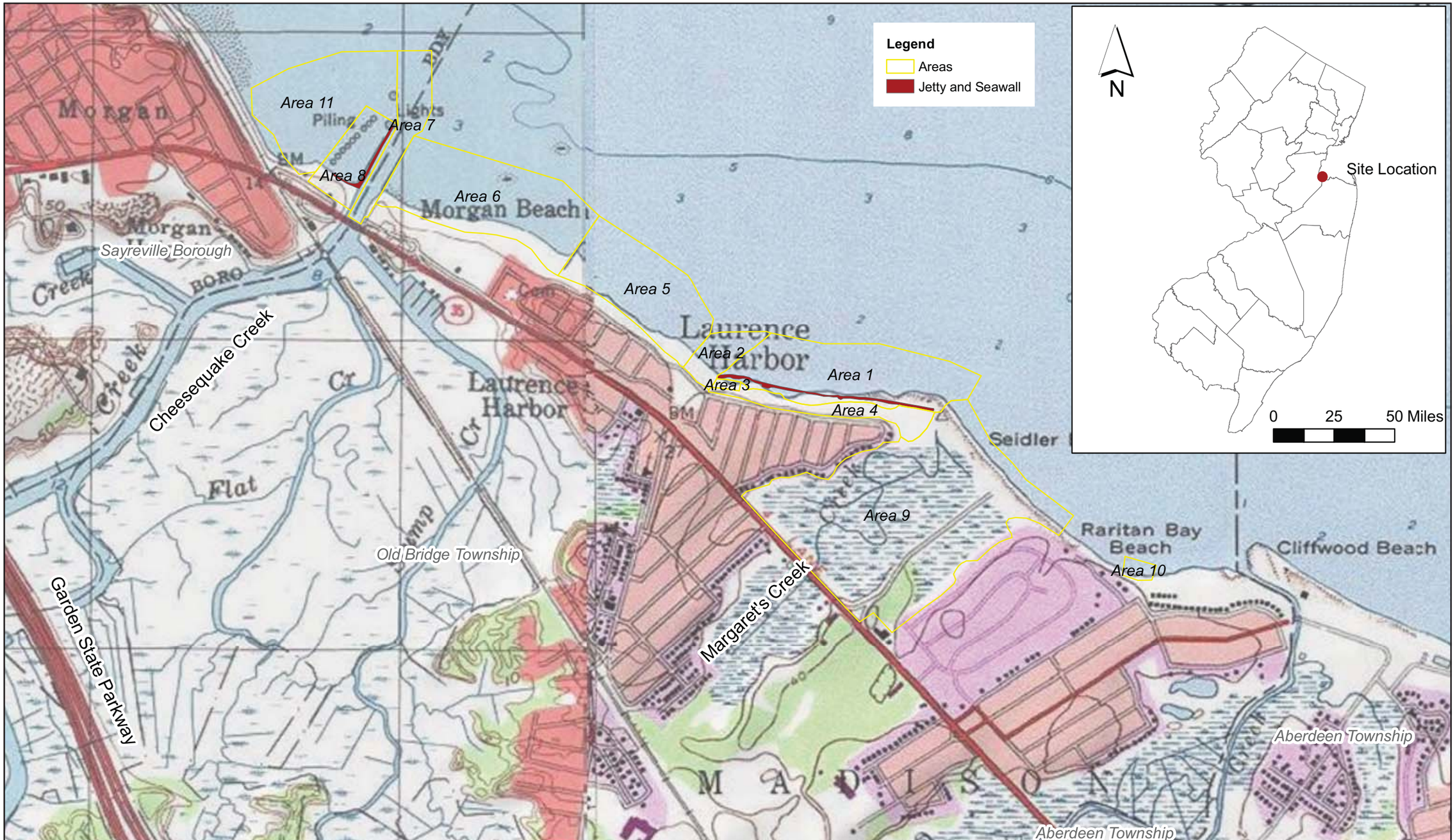
| Chemical | CAS No. | Maximum Concentration | | Background Concentration | | |
|---|---|---|---|---|---|---|
| | | Area 8 | Area 9 | Minimum | Maximum | 95% UPL* |
| **Inorganics (mg/kg)** | | | | | | |
| Aluminum | 7429-90-5 | 11000 J | 20900 | 423 | 11700 | 11260 |
| Antimony | 7440-36-0 | 1,720 | 10.9 | 0.79 | 2 | 2 |
| Arsenic | 7440-38-2 | 933 J | 88.9 | 0.88 | 49.5 | 38.7 |
| Barium | 7440-39-3 | 1,090 J | 138 | 12.6 | 36.4 | 31.3 |
| Beryllium | 7440-41-7 | 0.97 J | 1.5 J | 0.28 | 1.1 | 0.88 |
| Cadmium | 7440-43-9 | 22.1 | 3.8 | 0.14 | 0.69 | 0.69 |
| Chromium | 7440-47-3 | 3,500 | BSL | 3.8 | 84.2 | 75.1 |
| Copper | 7440-50-8 | 969 J | 1,790 | 2.4 | 176 | 176.0 |
| Iron | 7439-89-6 | 120000 | 89700 | 2530 | 41100 | 37580 |
| Lead | 7439-92-1 | 14,200 | 564 | 2.7 | 193 | 181.5 |
| Manganese | 7439-96-5 | 1,710 | BSL | 20.4 | 309 | 185.1 |
| Mercury | 7439-97-6 | 1.7 J | 2.6 | 0.037 | 0.99 | 0.88 |
| Nickel | 7440-02-0 | 1,500 | 232 | 1.9 | 23.8 | 22.0 |
| Selenium | 7782-49-2 | 2.4 J | 6.2 | 1.2 | 1.9 | 1.9 |
| Silver | 7440-22-4 | 3.3 J | 15.6 J | 0.68 | 1.5 | 1.3 |
| Thallium | 7440-28-0 | ND | 2.2 J | 0.31 | 0.31 | 0.31 |
| Tin | 7440-31-5 | 1,480 J | ND | NA | NA | NA |
| Vanadium | 7440-62-2 | 73.4 | 106 | 4.8 | 74.3 | 72.2 |
| Zinc | 7440-66-6 | 1,670 J | 300 | 14.6 | 184 | 143.5 |
| Hexavalent Chromium | 18540-29-9 | 0.98 J- | 1.8 | 0.41 | 2.8 | 1.95 |

Notes:
mg/kg - milligram per kilogram
µg/kg - microgram per kilogram
BSL - chemical detected at concentration below its respective screening levels and is not retained as a chemical of potential concern
J - estimated
J- - estimated biased low
NJ - tentatively identified
ND - not detected
* 95% Upper Prediction Limit (UPL) is calculated using ProUCL version 4.01.00
If the 95% UPL was greater than the maximum background concentration, the former of the the two values was utilized

**Table 5-6**
**Comparison of Maximum Concentrations of Chemicals of Potential Concern Detected in Area 8 and 9 Surface Water to Background Concentrations**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | CAS No. | Maximum Concentration | | Background Concentration | | |
|---|---|---|---|---|---|---|
| | | Area 8 | Area 9 | Minimum | Maximum | 95% UPL* |
| **Semi-volatile Organic Compounds (µg/L)** | | | | | | |
| Benzo(a)anthracene | 56-55-3 | ND | 0.053 | ND | ND | ND |
| **Inorganic Analytes (Total) (µg/L)** | | | | | | |
| Aluminum | 7429-90-5 | 12600 J | 6030 | ND | ND | ND |
| Antimony | 7440-36-0 | 53.2 J | 6.3 J | ND | ND | ND |
| Arsenic | 7440-38-2 | 70.9 | BSL | ND | ND | ND |
| Copper | 7440-50-8 | 154 J | 52.5 | ND | ND | ND |
| Iron | 7439-89-6 | 6320 J | 74400 | ND | ND | ND |
| Lead | 7439-92-1 | 1580 J | 298 | ND | ND | ND |
| Manganese | 7439-96-5 | 309 J | 764 J | 73.7 | 73.7 | 73.7 |
| Vanadium | 7440-62-2 | 65.2 J | BSL | ND | ND | ND |
| Zinc | 7440-66-6 | 255 J | 186 | ND | ND | ND |
| **Inorganic Analytes (Dissolved) (µg/L)** | | | | | | |
| Aluminum | 7429-90-5 | 15600 J | 2720 | ND | ND | ND |
| Antimony | 7440-36-0 | 61.6 | 2.8 J | ND | ND | ND |
| Arsenic | 7440-38-2 | 79.7 | BSL | ND | ND | ND |
| Copper | 7440-50-8 | 197 J | 43.5 | ND | ND | ND |
| Iron | 7439-89-6 | 7900 J | 58500 | ND | ND | ND |
| Lead | 7439-92-1 | 1810 J | 282 | ND | ND | ND |
| Manganese | 7439-96-5 | 330 J | 693 J | ND | ND | ND |
| Nickel | 7440-02-0 | 26.2 J | BSL | ND | ND | ND |
| Vanadium | 7440-62-2 | 63.8 J | ND | ND | ND | ND |
| Zinc | 7440-66-6 | 363 J | 151 | ND | ND | ND |

Note:
µg/L - microgram per liter
BSL - chemical detected at concentration below its respective screening levels and is not retained as a chemical of potential concer
J - estimated
ND - not detected
* 95% Upper Prediction Limit (UPL) is calculated using ProUCL version 4.01.00
If the 95% UPL was greater than the maximum background concentration, the former of the the two values was utilized




Source: USGS Topographic Quadrangle

0 500 1,000 2,000 3,000 Feet

N

EPA

Figure 1-1
Site Location Map
Raritan Bay Slag Superfund Site
Old Bridge/Sayreville, New Jersey

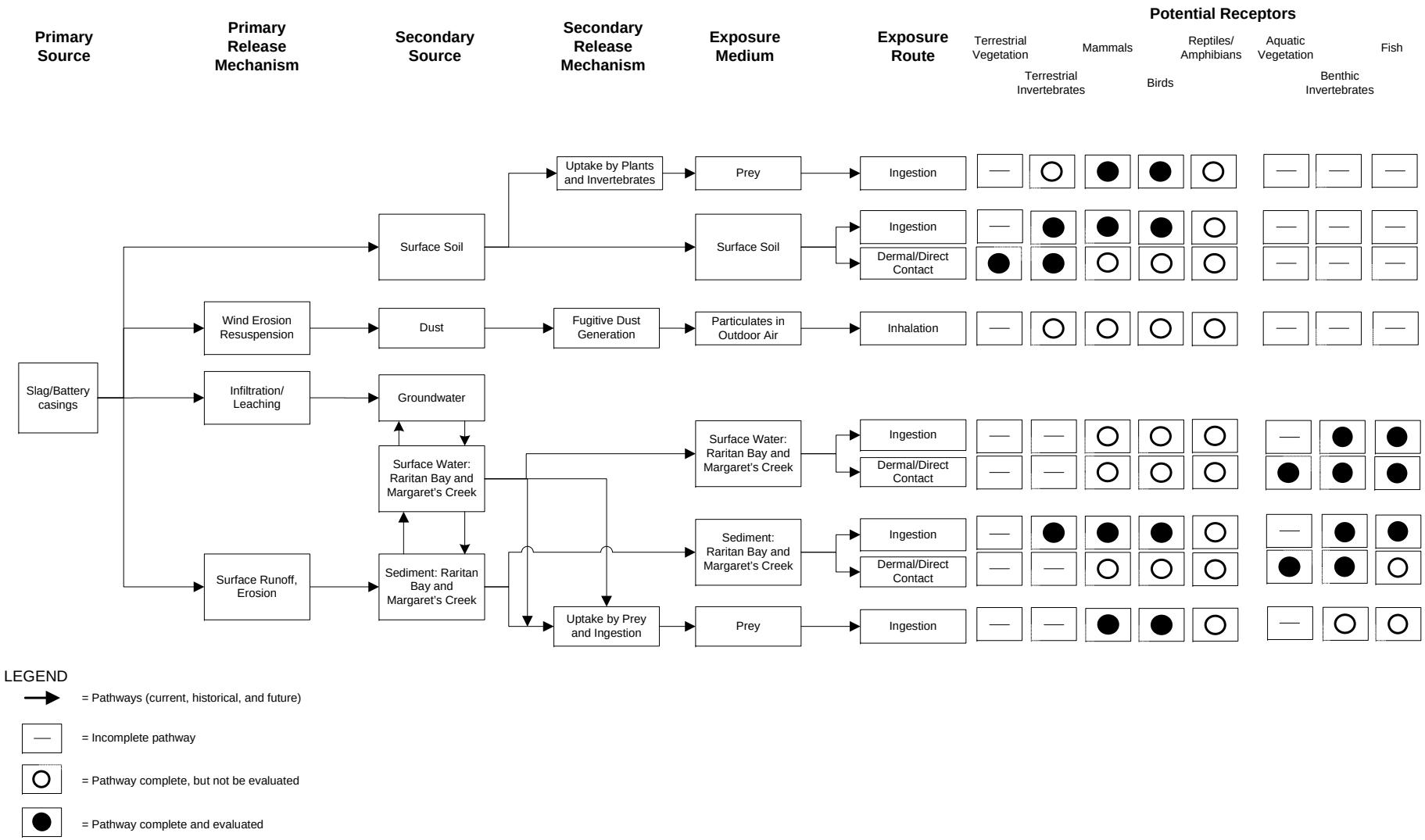
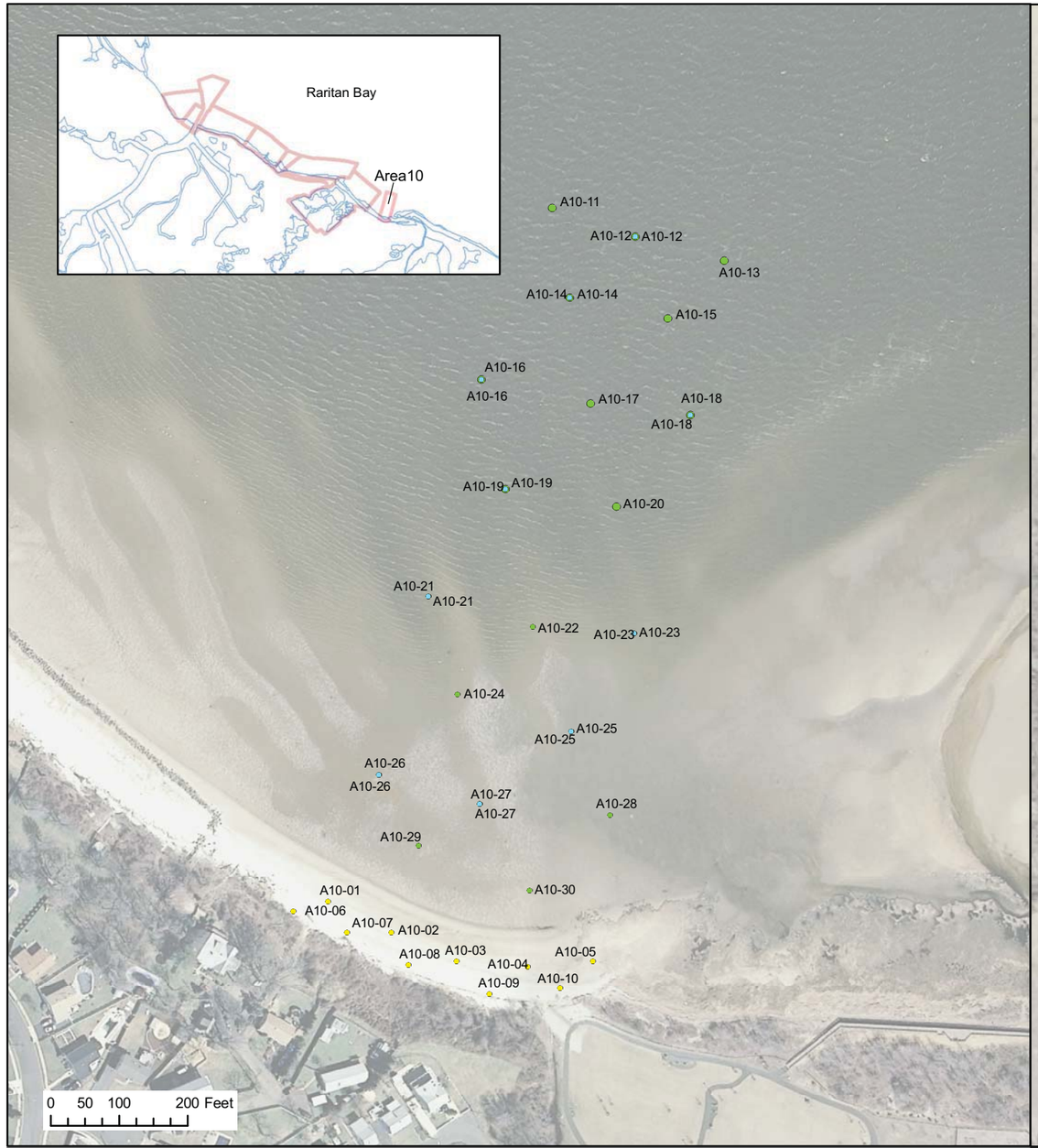
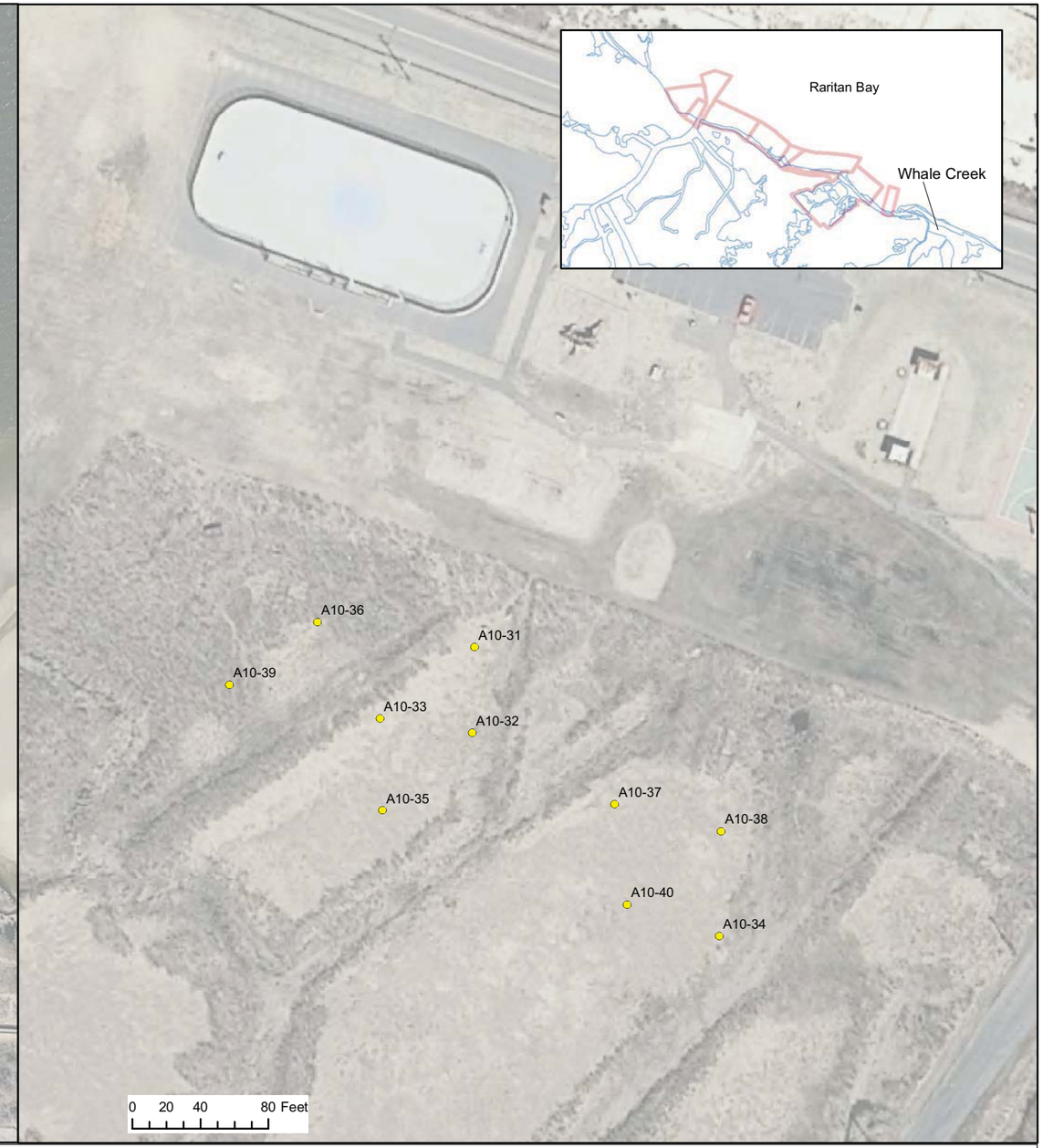



**Figure 2-1**
**Conceptual Site Model**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

R2-0006684




**LEGEND**

- Soil Location
- Surface Water location
- Sediment Location

Note: since many surface water and sediment samples are co-located, symbols for both matrices may not be visible at some locations.

N

EPA

Figure 2-2
Background Sample Locations
Raritan Bay Slag Superfund Site
Old Bridge/Sayreville, New Jersey

- Soil Location
- Sediment Location
- Surface Water Location

Note: since many surface water and sediment samples are co-located, symbols for both matrices may not be visible at some locations.

N

0 175 350 700 Feet

EPA

Figure 2-3
Area 9 Sample Locations
Raritan Bay Slag Superfund Site
Old Bridge/Sayreville, New Jersey

● Sediment Location
● Surface Water Location

Note: since many surface water and sediment samples are co-located, symbols for both matrices may not be visible at some locations.

Figure 2-4
Area 8 Sample Locations
Raritan Bay Slag Superfund Site
Old Bridge/Sayreville, New Jersey

EPA

R2-0006687

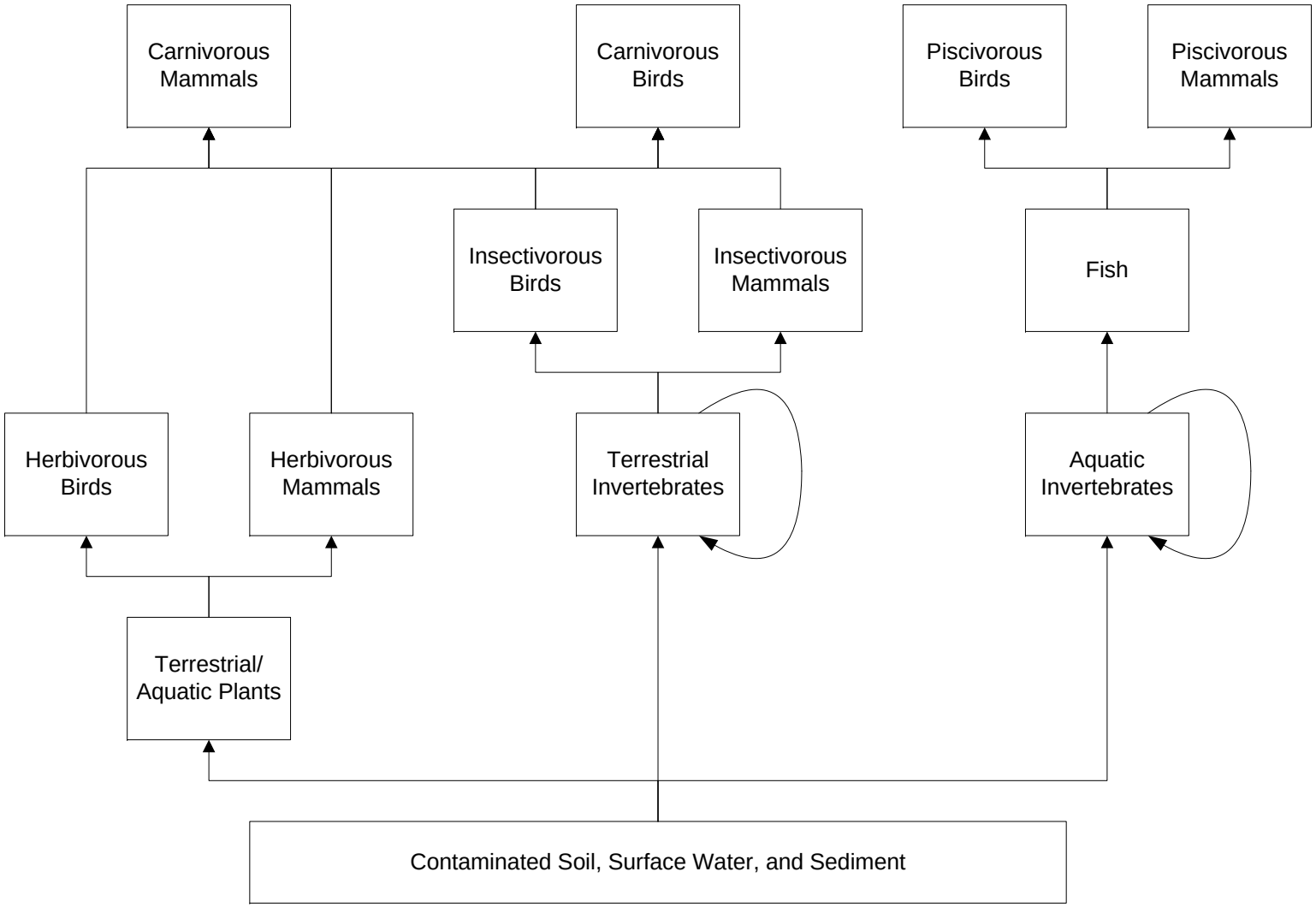



**Figure 3-1**
**Area 9 Simplified Food Web Model**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

EPA

R2-0006688

# Appendix A

# Letters from the United States Environmental Protection Agency and New Jersey Department of Environmental Protection

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 2
290 BROADWAY
NEW YORK, NY 10007-1866

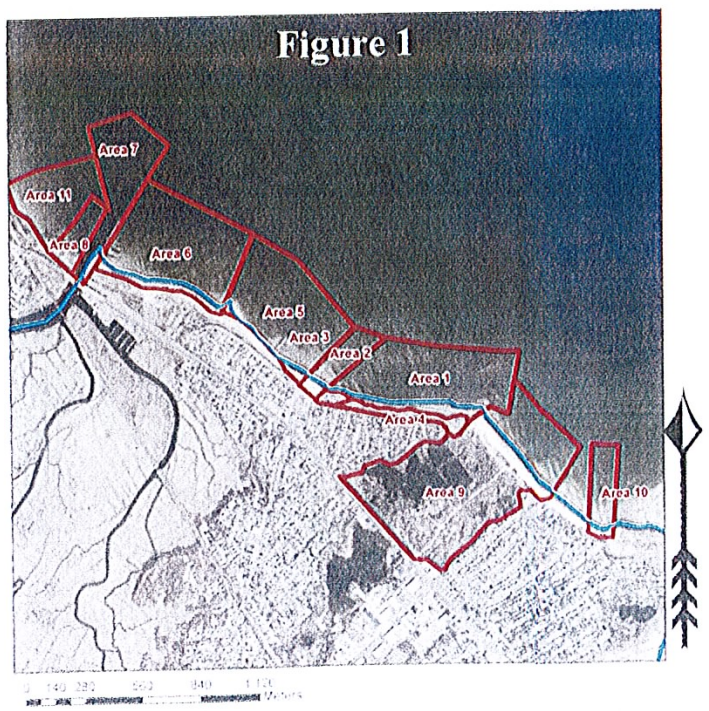
DEC 0 3 2010

George G. Molnar
Environmental Scientist
CDM Federal
1110 Fieldcrest Avenue, 6th Floor
Edison, New Jersey 08837

Dear Mr. Molnar:

I have received your request for information concerning Federally-listed endangered or threatened species or critical habitats located on or in the vicinity of the Raritan Bay Slag Superfund Site, located in Old Bridge Township and the Borough of Sayreville, Middlesex County, New Jersey. It is my understanding that this information is needed to assist in the preparation of a screening level ecological risk assessment for this project.

The Raritan Bay Slag Site is located in the Laurence Harbor section of Old Bridge and in Sayreville, Middlesex County, New Jersey. The Laurence Harbor seawall, which makes up part of the Site, was reported to have had metal slag from blast furnace bottoms deposited along the beachfront in the late 1960s and early 1970s. Approximately 2,500 feet of the seawall have been contaminated. Elevated levels of lead, antimony, arsenic and copper have been identified along the seawall near the area where the processing by-products were deposited. While site investigations were being conducted, another area of concern was identified on the Sayreville waterfront. This area consists of the western jetty at the Cheesequake Creek inlet and waterfront area. The areas under investigation are shown on Figure 1.






R2-0006690

Pursuant to the New Jersey Field Office of the U.S. Fish and Wildlife Service (FWS) request, the Environmental Protection Agency (EPA) has reviewed information on the FWS website to determine what, if any, impacts to Federally-listed endangered or threatened species or critical habitats are possible as a result of the implementation of this proposed project. Written consultation is necessary if EPA determines that the proposed project may affect Federally-listed species.

Accordingly, we have reviewed the available information located on the FWS website in relation to the proposed project impact area. The Bog Turtle (*Clemmys muhlenbergii*) and swamp pink (*Helonias bullata*) are listed as extirpated in the Borough of Sayreville, which means that while they have been recorded from this area in the past, they are no longer present. However, the Indiana Bat (*Myotis sodalis*) and swamp pink are still listed as potentially present within the adjacent Old Bridge Township. Consequently, a review of the habitat requirements of both species was required, to evaluate whether the Raritan Bay Slag Superfund site's project impact area contains potentially suitable habitat for either species.

According to the FWS website, swamp pink is an obligate wetland species, occurring in a variety of palustrine forested wetlands including swampy forested wetlands bordering meandering streamlets, headwater wetlands, sphagnous Atlantic white-cedar swamps, and spring seepage areas within New Jersey (see Figure 2). Specific hydrologic requirements of swamp pink limit its occurrence within these wetlands to areas that are perennially saturated, but not inundated, by floodwater. The water table must be at or near the surface, fluctuating only slightly during spring and summer months. Groundwater seepage with lateral groundwater movement is a common hydrologic characteristic of swamp pink habitat. Swamp pink is often found growing on the hummocks formed by trees, shrubs, and sphagnum mosses, and these micro-topographic conditions may be an important component of swamp pink habitat.

A review of available information indicates that no forested wetlands or other preferred habitats are located in the project area; impacts to swamp pink or its habitat are not anticipated as a result of any potential future remedial actions associated with this site.

According to the FWS website, the Indiana bat utilizes different habitat depending on the season within New Jersey (see Figure 3). Each fall from late August through October, Indiana bats migrate from their summer habitats to congregate in the vicinity of their hibernation sites, which include caves and abandoned mine shafts. During this time, the bats engage in mating activity and feed in the surrounding area to build the fat reserves needed during hibernation. The bats then hibernate from late October to April, the precise timing dependent on climatic conditions. After emerging from hibernation, Indiana bats forage in the vicinity of the hibernation site before migrating to summer habitats. Studies indicate that Indiana bats typically forage within 10 miles of hibernacula before and after hibernation. When not hibernating, Indiana bats roost under loose tree bark by day, and forage for flying insects in and around the tree canopy at night. A variety of upland and wetland habitats are used as foraging areas, including flood plain, riparian (along rivers), and upland forests; pastures; clearings with early successional vegetation; cropland borders; and wooded fencerows. Preferred foraging areas are streams, associated flood plain forests, and impounded bodies of water such as ponds and reservoirs. During the summer months, numerous female bats roost together in maternity colonies under the loose bark of dead or dying trees within riparian, flood plain, and upland forests. Adult males usually roost in trees near maternity roosts, but some males remain near the hibernaculum and have been found in caves and mines during the summer.

There are no hibernacula located in the vicinity of the project area; however, Indiana bats are potentially present during the summer months. In order to avoid potential impacts to Indiana bats, the FWS recommends that the following activities should be avoided: clearing trees over five inches Diameter Breast Height between April 1 and September 30; clearing greater than five acres of trees at any time during the year; large scale pesticide application that could depress insect populations, or construction of wind turbines. At this point in the remedial process, it is unlikely that the above noted activities will be part of any future Superfund remedial action.

Consequently, after our review, we have determined that the investigation and cleanup of the Raritan Bay Slag Superfund Site will have no effect on Federally-listed threatened or endangered species or their critical habitats. A letter from FWS confirming EPA's ability to make this determination has been enclosed.

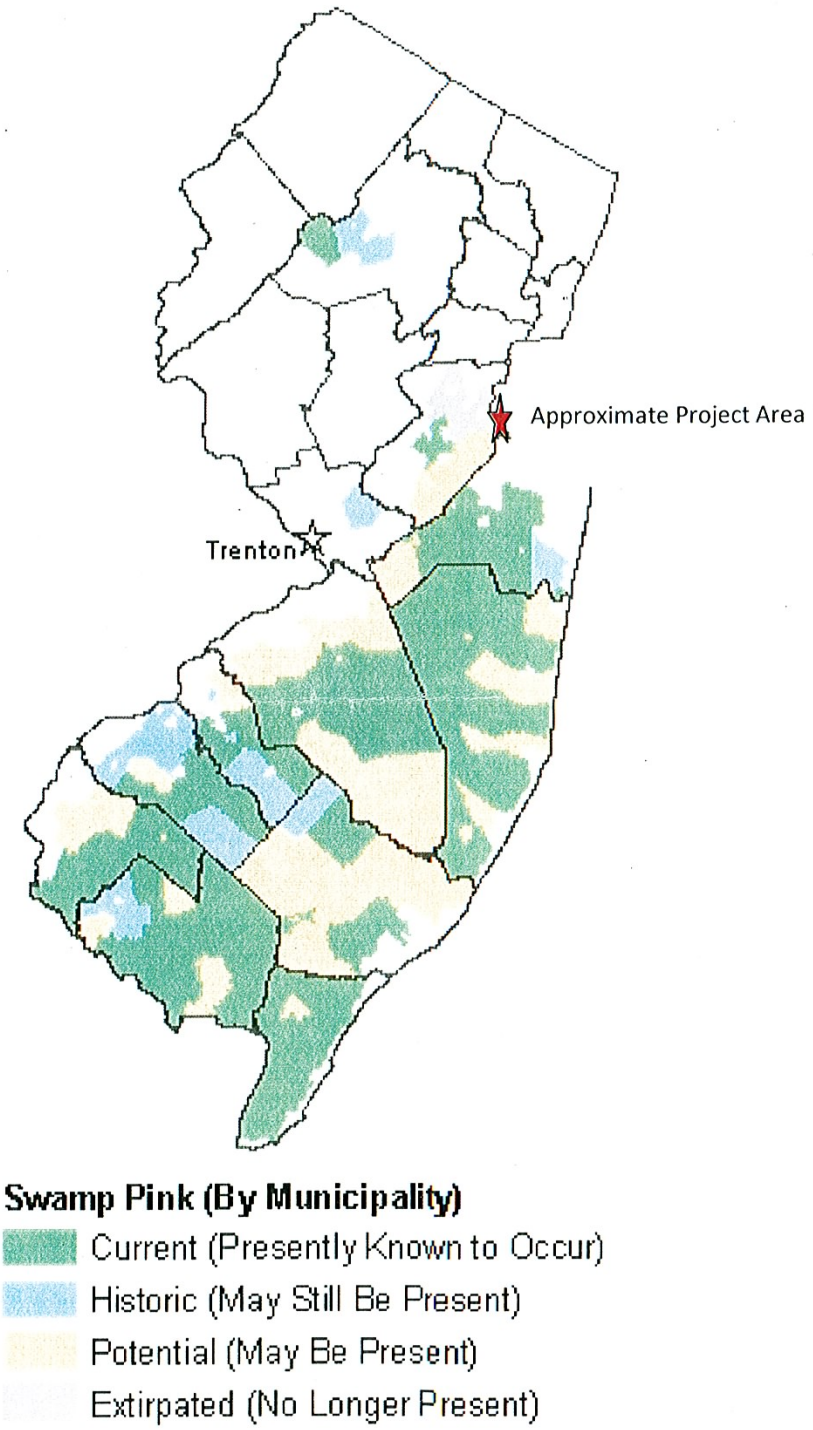
Please note that should the scope of future investigations or cleanups associated with this site go beyond the approximate boundaries of Figure 1, or should additional species be listed under the Endangered Species Act, a revised determination from this office will be needed.

Sincerely,

Steven J. Ferreira
Environmental Scientist
Environmental Review Section

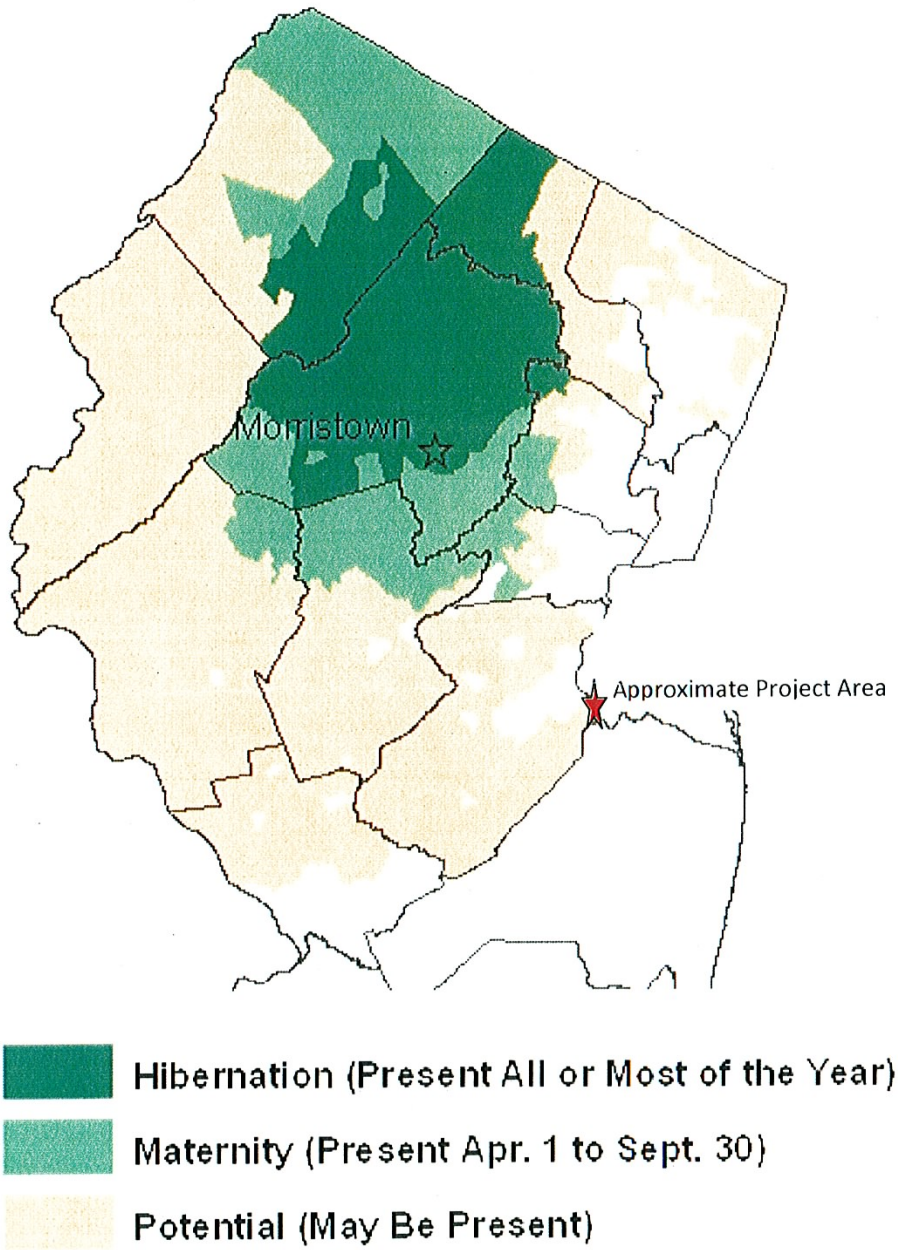
Enclosure

**Figure 2: Swamp Pink Distribution in New Jersey (US FWS)**




http://www.fws.gov/northeast/njfieldoffice/Endangered/swamppink.html#distribution

**Figure 3: Indiana Bat Distribution in New Jersey (US FWS)**




http://www.fws.gov/northeast/njfieldoffice/Endangered/Ibat.html#distribution

State of New Jersey

CHRIS CHRISTIE
*Governor*

KIM GUADAGNO
*Lt. Governor*

DEPARTMENT OF ENVIRONMENTAL PROTECTION
Division of Parks and Forestry
Mail Code 501-04
ONLM -Natural Heritage Program
P.O. Box 420
Trenton, NJ 08625-0420
Tel. #609-984-1339
Fax. #609-984-1427

BOB MARTIN
*Commissioner*

October 27, 2010

George C. Molnar
CDM
110 Fieldcrest Avenue, 6th Floor
Edison, NJ 08837

Re: Raritan Bay Slag Site

Dear Mr. Molnar:

Thank you for your data request regarding rare species information for the above referenced project site in Old Bridge Township and Sayreville Borough, Middlesex County.

Searches of the Natural Heritage Database and the Landscape Project (Version 3 for the highlands region, Version 2.1 elsewhere) are based on a representation of the boundaries of your project site in our Geographic Information System (GIS). We make every effort to accurately transfer your project bounds from the topographic map(s) submitted with the Request for Data into our Geographic Information System. We do not typically verify that your project bounds are accurate, or check them against other sources.

We have checked the Natural Heritage Database and the Landscape Project habitat mapping for occurrences of any rare wildlife species or wildlife habitat on the referenced site. Please see Table 1 for species list and conservation status.

Table 1 (on referenced site).

| Common Name | Scientific Name | Federal Status | State Status | Grank | Srank |
|---|---|---|---|---|---|
| black-crowned night-heron | *Nycticorax nycticorax* | | T/SC | G5 | S2B,S3N |
| glossy ibis | *Plegadis falcinellus* | | SC/S | G5 | S3B,S4N |
| snowy egret | *Egretta thula* | | SC/S | G5 | S3B,S4N |

We have also checked the Natural Heritage Database and the Landscape Project habitat mapping for occurrences of any rare wildlife species or wildlife habitat within 1/4 mile of the referenced site. Please see Table 2 for species list and conservation status. This table excludes any species listed in Table 1.

Table 2 (additional species within 1/4 mile of referenced site).

| Common Name | Scientific Name | Federal Status | State Status | Grank | Srank |
|---|---|---|---|---|---|
| eastern box turtle | *Terrapene carolina carolina* | | SC | G5T5 | S3 |
| Fowler's toad | *Bufo woodhousii fowleri* | | SC | G5 | S3 |
| northern diamondback terrapin | *Malaclemys terrapin terrapin* | | SC | G4T4 | S3 |
| northern parula | *Parula americana* | | P/S | G5 | S3B |
| osprey | *Pandion haliaetus* | | T/T | G5 | S2B |
| spotted turtle | *Clemmys guttata* | | SC | G5 | S3 |
| wood thrush | *Hylocichla mustelina* | | SC/S | G5 | S3B |

We have also checked the Natural Heritage Database for occurrences of rare plant species or ecological communities. The Natural Heritage Database does not have any records for rare plants or ecological communities on or within 1/4 mile of the site.

A list of rare plant species and ecological communities that have been documented from Middlesex County can be downloaded from http://www.state.nj.us/dep/parksandforests/natural/heritage/countylist.html. If suitable habitat is present at the project site, the species in that list have potential to be present.

Status and rank codes used in the tables and lists are defined in EXPLANATION OF CODES USED IN NATURAL HERITAGE REPORTS, which can be downloaded from http://www.state.nj.us/dep/parksandforests/natural/heritage/nhpcodes_2008.pdf.

If you have questions concerning the wildlife records or wildlife species mentioned in this response, we recommend that you visit the interactive I-Map-NJ website at the following URL, http://www.state.nj.us/dep/gis/depsplash.htm or contact the Division of Fish and Wildlife, Endangered and Nongame Species Program at (609) 292 9400.

PLEASE SEE 'CAUTIONS AND RESTRICTIONS ON NHP DATA', which can be downloaded from http://www.state.nj.us/dep/parksandforests/natural/heritage/newcaution2008.pdf.

Thank you for consulting the Natural Heritage Program. The attached invoice details the payment due for processing this data request. Feel free to contact us again regarding any future data requests.

Sincerely,

Robert J. Cartica
Administrator

c: NHP File No. 10-4007443-5966

# Appendix B

# Fate, Transport, and Toxicity of Chemicals of Potential Concern

# Appendix B
# Fate, Transport, and Toxicity of Chemicals of Potential Concern

## Introduction

Discussions on the fate, transport, and toxicity of chemicals of potential concern (COPCs) are presented below. Thus, the text is limited only to detected chemicals for which concentrations are above their respective screening value, or those for which no screening value was located. When applicable, individual organic COPCs are discussed collectively as a group (i.e. chlorinated pesticides) as modes of toxicity and fate of these compounds are expected to be similar and they are not site-related.

## B.1 Inorganics

Fate, transport and toxicity of inorganic COPCs are discussed in the following subsections.

### B.1.1 Aluminum

**Fate and Transport:** Because of its strong reactivity, aluminum is not found as a free metal in nature. Aluminum has only one oxidation state (+3), thus its behavior in the environment depends on its ordination chemistry and the surrounding conditions. In soils, a low pH generally results in an increase in aluminum mobility. In water, an equilibrium with a solid phase is established that controls the extent of aluminum dissolution (ATSDR 2008a).

Plants vary in their ability to remove aluminum from soils, although bioconcentration factors for plants are generally less than one. Biomagnification of aluminum in terrestrial food chains does not appear to occur. There is no data on the biomagnification of aluminum in aquatic food chains (ATSDR 2008a).

**Toxicity:** The nervous system may be a target area for aluminum. Aluminum may also interact with neuronal DNA to alter gene expression and protein formation. Mammalian studies do not indicate that aluminum affects reproduction although some developmental effects have been reported in mammals (ATSDR 2008a). In animals, ingestion of aluminum at levels of 1,400 ppm lowered levels of inorganic phosphorus in blood and bones (HSDB 2010). Severe aluminum intoxication, characterized by lethargy, anorexia, or death, was observed in rats following parenteral or oral administration of aluminum hydroxide, chloride, or sulfate. Other studies have found that intratracheal instillation of aluminum salts or metallic aluminum powder has produced pulmonary fibroses (HSDB 2010). LD50 values for aluminum ingestion are typically unavailable because aluminum is only sparingly absorbed from the gut, and because death occurs from intestinal blockage due to precipitated aluminum species rather than systemic aluminum toxicity (HSDB 2010).

### B.1.2 Antimony

**Fate and Transport:** Antimony is a silvery white metal of medium hardness and low solubility in water. Metallic antimony is stable under ordinary conditions and is not readily altered by air or water. Antimony displays four oxidation states, Sb(-3), Sb(0), Sb(+3), and Sb(+5); the +3 state is the most common and stable (ATSDR 1992a). Very little antimony occurs free in nature, and most is derived from stibnite ($Sb_2S_3$), which contains 71 to 75 percent of this element when nearly pure. Mean antimony concentration in the earth's crust has been estimated to be 0.2 parts per million (ppm) (NAS 1980). Antimony can be released from volcanic eruptions, sea spray, and forest fires. The majority of antimony released to the environment arises from anthropogenic sources including nonferrous metal mining, smelting and refining; the production, use and disposal of antimony alloys and compounds; coal combustion; and refuse and sludge combustion.

The speciation and physicochemical state of antimony are important to its behavior in the environment and availability to biota. Antimony that is incorporated into mineral lattices is inert and not bioavailable. Mobility of antimony released to the soil is determined by the nature of the soil, the form of antimony deposited, and the pH of the soil. Antimony sorbs strongly to soil and sediment; its sorption is primarily correlated with the content of iron, aluminum, and manganese in the soil with which it coprecipitates as hydroxylated oxides (ATSDR 1992a, Lintschinger *et al.* 1998). Trivalent antimony sorbs to soil more strongly than the pentavalent form (Lintschiner *et al.* 1998).

Antimony is transported into aquatic systems via natural weathering of soil and from anthropogenic sources. Antimony released to water will generally end up in sediment where it is associated with iron, manganese and aluminum hydroxyoxides. Antimony in aerobic water mostly occurs as Sb(+5), although small amounts of Sb(+3) are present. Trivalent antimony is the dominant form present in anaerobic water. Antimony can be reduced and methylated by microorganisms in anaerobic sediment, thereby mobilizing the antimony (ATSDR 1992a). Methylated antimony compounds are soluble and readily oxidized (HSDB 2010).

**Toxicity**: The majority of effects in animals resulting from the inhalation of antimony is attributed to the accumulation of antimony dust in the lung (pneumoconiosis), which may progress to a proliferation of alveolar macrophages to fibrosis. The heart is another target organ in antimony exposure, resulting in altered blood pressure, increased heart rate, and decreased contractile force. Antimony is known historically for its emetic properties, causing vomiting, diarrhea, gastric discomfort, and ulcers. Dietary exposure studies have reported decreased hemoglobin and hematocrit levels, altered erythrocyte counts, and swelling of the hepatic cords (ATSDR 1992a).

### B.1.3 Arsenic

**Fate and Transport**: Arsenic has four valence states (-3, 0, +3, and +5), rarely occurring in its free state in nature. It is usually a component of sulfidic ores, occurring as arsenides and arsenates, along with arsenic trioxide, which is a weathering product of arsenides. Biotransformations may occur, resulting in volatile arsenicals that normally are returned to land where soil adsorption, plant uptake,

erosion, leaching, reduction to arsines, and other processes occur. Inorganic arsenic is more mobile than organic arsenic, and thus poses greater problems by leaching into surface waters and groundwater. The trivalent arsenic species (+3) are generally considered to be more toxic, more soluble, and more mobile than As (+5) species (Eisler 1988a).

Arsenic in water exists primarily as a dissolved ionic species. Particulates account for less than one percent of the total measurable arsenic. Arsenates are more strongly adsorbed to sediments than are other arsenic forms. In bodies of water that become stratified in summer, arsenic released from sediments accumulates in the hypolimnion until turnover, when it is mixed with epilimnetic waters. This mixing may result in a ten to twenty percent increase in arsenic concentrations (Eisler 1988a).

**Toxicity:** Eisler (1988a) reports the following points: (1) arsenic may be absorbed by ingestion, inhalation, or permeation of the skin or mucous membrane, (2) cells accumulate arsenic by using an active transport system normally used in phosphate transport, (3) arsenicals are readily absorbed after ingestion, most being rapidly excreted in the urine during the first few days, (4) the toxicity of arsenicals conforms to the following order from greatest to least toxicity: arsines > inorganic arsenites > organic trivalent compounds (arsenoxides) > inorganic arsenates > organic pentavalent compounds > arsonium compounds > elemental arsenic, (5) solubility in water and body fluids appear to be directly related to toxicity, and (6) the mechanisms of arsenical toxicity differ considerably among arsenic species, although signs of poisoning appear similar for all arsenicals.

The primary mechanism of inorganic trivalent arsenic toxicity is through reaction with sulfhydryl groups of proteins and subsequent enzyme inhibition; inorganic pentavalent arsenic does not react as readily with sulfhydryl groups. Inorganic trivalent arsenic interrupts oxidative metabolic pathways and sometimes causes morphological changes in liver mitochondria. Methylation greatly reduces the toxicity of inorganic arsenic (both trivalent and pentavalent) and is usually the major detoxification mechanism (Eisler 1988a).

The mechanism of organic arsenic toxicity begins with its initial metabolism to the trivalent arsenoxide form, followed by its subsequent reaction with sulfhydryl groups of tissue proteins and enzymes, to form an arylbis (organylthio) arsine. This form inhibits oxidative degradation of carbohydrates and decreases cellular adenosine triphosphate (ATP) (Eisler 1988a).

### B.1.4 Barium

**Fate and Transport**: Barium is widely distributed in both terrestrial and aquatic environments. Although it is found in most aquatic environments, most barium precipitates out in the form of insoluble salts (EPA 1986). Transport of barium by suspended sediments in lotic water bodies may be significant. Barium is not expected to bioconcentrate significantly in plants or freshwater aquatic organisms.

Barium occurs naturally in most surface water and groundwater. In groundwater and surface water, barium is likely to precipitate out of solution as an insoluble salt (EPA

1986). The chemical form of barium largely dictates its adsorption into soils and sediments. Barium in sediments is found largely in the relatively insoluble form of barium sulfate and also in the insoluble form of barium carbonate. Humid and fulvic acid have not been found to increase the mobility of barium (ATSDR 2007).

**Toxicity**: The oral toxicity of barium compounds depends on their solubility. The soluble compounds, which include the chloride, nitrate, and hydroxide are the most toxic. The insoluble sulfate and carbonate are relatively nontoxic. The cardiovascular system appears to be a primary target of barium toxicity in humans and laboratory animals (ATSDR 2007). Barium has no known function in vertebrates, although it has been reported that insufficient dietary barium may depress growth rate in laboratory animals (NRC 1980).

Barium interacts with potassium, calcium, and magnesium. It has been shown that barium produces hypokalemia (i.e., lowered blood potassium), possibly by causing the build-up of intracellular potassium, and that symptoms of cardiotoxicity, muscle weakness, and paralysis resulting from barium exposure can be reversed in humans by potassium treatment (ATSDR 2007).

### B.1.5 Beryllium

**Fate and Transport**: Beryllium occurs naturally in the earth's crust, in coal, and in minerals such as plagiocase feldspar and beryl. Beryllium is found in the plant-derived organic component of coal (HSDB 2010). Beryllium is used in the manufacture of electrical components, in nuclear reactors, aerospace applications, ceramics and X-ray tubes. However, the majority of anthropomorphically produced beryllium in the environment is the result of coal and oil combustion.

If released to soil, beryllium is expected to be essentially immobile. Based on its geochemical similarity to aluminum, beryllium may be expected to adsorb onto clay surfaces at low pH, and it may remain precipitated as insoluble complexes at higher pH (ATSDR 2002). Beryllium enters aquatic systems through the weathering of rock and soil, deposition of atmospheric beryllium, and discharge from anthropogenic sources. Under typical environmental conditions, the hydroxo-complex $BeOH^+$ and Be (+2) are expected to be the dominant dissolved forms present in aquatic systems. $Be(OH)_2$ is expected to precipitate from water based on its low solubility at the pH range of most natural systems. Beryllium may adsorb to suspended mineral solids and to sediment. Beryllium is not expected to bioconcentrate in aquatic animals and no evidence for significant biomagnification within food chains has been found (ATSDR 2002).

**Toxicity:** The respiratory tract in humans and animals is the primary target of inhalation exposure to beryllium and its compounds. Inhalation exposure to beryllium has been associated with lung cancer in animals. Inhalation of some forms of beryllium can cause obstructive and restrictive diseases of the lung, known as chronic beryllium disease (berylliosis), and inhalation of high concentrations can cause chemical pneumonitis. The development of chronic beryllium disease appears to involve cell-mediated immune responses that are genetically regulated (ATSDR 2002).

Oral exposure to beryllium compounds has been shown to result in hepatic necrosis. Ingested soluble beryllium compounds may interact with phosphate to form insoluble beryllium phosphate particles that are sequestered in Kupffer cells of the liver. Diffusion of beryllium from the deposited particulates may cause damage to these cells and necrosis of the liver. Beryllium may also be taken up by lysosomes and cause release of lysosomal enzymes, and it may interfere with DNA synthesis in the nucleus (ATSDR 2002).

The degree of beryllium toxicity to freshwater fishes is related to hardness, with toxicity decreasing with increasing hardness (EPA 1980). This is partially due to the increasing buffering capacity of hard water and the antagonism of calcium to beryllium. It is also possible that beryllium may penetrate to vital organs more readily in soft water than hard water. Beryllium toxicity to fish appears to be a function of the effects on vital organs, rather than a function of total beryllium uptake. In an uptake study in guppies, beryllium levels were shown to be highest in the gastrointestinal tract, followed by kidneys and ovaries. Pre-exposure to low levels of beryllium can increase the tolerance of fish to very high concentrations at a later time (Drury *et al.* 1978).

### B.1.6 Cadmium

**Fate and Transport**: Cadmium is a naturally occurring, rare, but widely distributed element. It may enter the environment through mining, ore processing, and smelting of zinc and zinc-lead ores; the recovery of metal by processing scrap; the casting of alloys for coating products (telephone cables, electrodes, sprinkling systems, fire alarms, switches, relays, circuit breakers, solder, and jewelry); the production of sewage-sludges and phosphate fertilizers; the combustion of coal and fossil fuels, and the use of paint, pigment, and batteries, (Eisler 1985a).

In the environment, cadmium occurs primarily as a divalent metal that is insoluble in water, but its chloride and sulfate salts are freely soluble (Eisler 1985a). If released or deposited on soil, cadmium is largely retained in the surface layers; it is adsorbed to soil but to a much lesser extent than most other heavy metals. Because adsorption increases with pH and organic content, solublization and leaching is more apt to occur under acid conditions in sandy soil.

The bioavailability of cadmium is dependent on a number of factors including pH, Eh (redox potential), concentration, and chemical speciation (Eisler 1985a). Cadmium enters the food chain through uptake by plants from soils; only cadmium in soil solution is thought to be directly available for uptake (Shore and Douben 1994). The main routes of cadmium absorption for mammals are via respiration and ingestion, including dietary transfer. Factors that appear to affect dietary cadmium absorption from the gastrointestinal tract include age, sex, chemical form, and protein concentration of the diet, and is inversely proportional to dietary intake of other metals, particularly iron and calcium (Friberg 1979).

**Toxicity**: Cadmium does not have any known essential or beneficial biological function (Eisler 1985a). It is classified as a B1, probable human carcinogen. Cadmium replaces essential metals (e.g., zinc) at critical sites on proteins and enzymes and may

inhibit a variety of enzymatic reactions. Concentrations increase with the age of an organism and eventually act as a cumulative poison (Hammons *et al.* 1978).

Cadmium is readily taken up from soil through plant roots and interferes with root uptake of essential elements including iron, manganese, magnesium, nitrogen, and possibly calcium. Symptoms of cadmium toxicity in plants include poor root development, reduced conductivity of stems, tissue necrosis, reduced growth, and reduced photosynthetic activity due to impaired stomatal functioning (Bazzaz *et al.* 1974, as cited in EPA 2005a; Efroymson *et al.* 1997). Mammals and birds are more resistant to effects of cadmium contamination than are aquatic organisms, but may show toxicological effects including growth retardation, anemia, impaired kidney function, poor reproductive capacity, and birth defects (Eisler 1985a).

### B.1.7 Chromium

**Fate and Transport**: Chromium is widely distributed in the earth's crust. Major atmospheric emissions of chromium are from the chromium alloy and metal producing industries; lesser amounts come from coal combustion, municipal incinerators, cement production, and cooling towers (Towill *et al.* 1978, as cited in Eisler 1986a). Chromium in phosphates used as fertilizers may be an important source of chromium in soil, water, and some foods (Langard and Norseth 1979, as cited in Eisler 1986a).

Chromium can exist in oxidation states ranging from Cr (+2) to Cr (+6), but it is most frequently converted to the relatively stable chromium (+3) and chromium (+6) oxidation states (Eisler 1986a). The solubility and bioavailability of chromium are governed by soil pH and organic complexing substances, although organic complexes play a more significant role (James and Bartlett 1983a,b, as cited in Eisler 1986a). Hexavalent chromium is not strongly sorbed to soil components and may be mobile in groundwater; however, it is quickly reduced to chromium (+3) in poorly drained soils having a high organic content.

Chromium may biomagnify, although because of its relatively low membrane permeability, chromium (+3) generally does not have the biomagnification potential of chromium (+6). However, organo-trivalent chromium compounds may have very different bioaccumulation tendencies; some cases of large degrees of accumulation by aquatic and terrestrial plants and animals in lower trophic levels have been documented, though the mechanism of accumulation remains largely unknown (Eisler 1986a).

**Toxicity**: The biological effects of chromium depend upon the chemical form, solubility, and valence. Chromium (+3) is the form usually found in biological materials. Chromium is beneficial, but not essential, to higher plants (Eisler 1986a). It functions as an essential element in mammals and birds by maintaining vascular integrity and efficient glucose, lipid, and protein metabolism (Steven *et al.* 1976, as cited in Eisler 1986a). However, chromium may also be mutagenic, carcinogenic, and teratogenic. While EPA regards all chromium compounds as toxic, the most toxic tend to be strongly oxidizing forms of chromium (+6). Toxic effects of chromium in plants include the disruption of carbon, nitrogen, phosphorus, and iron metabolism;

inhibition of photosynthesis and reduced growth; poorly developed roots; and curled leaves. Chromium toxicity in birds and mammals is associated with abnormal histopathology, enzyme activity and blood chemistry; lowered resistance to pathogenic organisms; behavioral modifications; disrupted feeding; and alterations in population structure (Eisler 1986a). However, in mammalian species, chromium is considered one of the least toxic trace elements, because hexavalent chromium is converted to trivalent chromium under the normal stomach conditions of low pH (Irwin *et al.* 1997).

### B.1.8 Cobalt

**Fate and Transport:** Cobalt is widely distributed in nature and comprises 0.001 to 0.002 percent of the earth's crust. Based on its dissociation constant (Kd) (45 in Baes et al. [1984]), cobalt would be expected to adhere to particulate matter. Most cobalt in water is precipitated or adsorbed onto suspended soils and sediments. Cobalt may bioaccumulate in plants and aquatic organisms (ATSDR 1992b; HSDB 2010). Cobalt is relatively insoluble in cold and hot water, but is soluble under acidic conditions. The speciation and subsequent transport of cobalt in water is affected by a number of factors including the presence of ligands, concentration of anions and pH. Depending on the nature of the water, the amount of dissolved, suspended, and sedimented forms may vary substantially. Cobalt is not significantly adsorbed by organic materials (e.g. humic and fulvic materials) in water. Most cobalt in water is precipitated or adsorbed onto suspended solids and sediments (ATSDR 1992b).

Cobalt is usually found in soils in the divalent state. Based on its Kd (45 in Baes et al. [1984]), cobalt would be expected to adhere to particulate matter. The mobility of cobalt in soils is primarily regulated by pH, with increasing mobility as the pH decreases (HSDB 2010; ATSDR 1992b). The mobility of cobalt also decreases as the availability of oxides (such as iron and manganese oxides), crystalline materials, and other adsorbents in soil decreases (ATSDR 1992b).

Cobalt will be taken up by plants, but generally at concentrations less than the surrounding soil (Baes et al. 1994). In highly acidic soils, significantly higher than normal concentrations of cobalt have been found in plants. The translocation of cobalt from roots to above-ground parts of plants is not significant in most soils. The bioaccumulation factors for cobalt in marine and freshwater fish are 100 to 4,000 and 40 to 1,000, respectively, indicating some potential for bioaccumulation (ATSDR 1992b).

**Toxicity:** Cobalt is an essential nutrient in mammals. It is part of vitamin B12, which is needed for the production of red blood cells. Oral exposure of animals to cobalt has resulted in a wide range of toxic effects including cardiovascular, hematological, hepatic, respiratory, renal, immunological, and neurological toxicity. It also has been associated with toxicity to the male reproductive system (ATSDR 1992b).

Single-dose or longer-term oral exposure of mammals to cobalt has resulted in increased hematocrit and hemoglobin levels, kidney damage, and liver effects. Liver effects include hyperemia and cytoplasmic changes after single-dose exposures and increased liver weight after longer-term exposures. Longer-term exposures also have

resulted in cardiotoxicity, characterized by abnormal electrocardiograms (EKG), an increase in heart weight, and cardiac lesions. Other long-term effects include testicular atrophy and degeneration, increased lung weight, decreased body weight, a decline in phagocytic activity, and neurological effects manifested as changes in behavioral parameters. Hypothermia, decreased activity, ataxia, diarrhea, and salivation have been observed in LD50 (i.e., acute dose mortality) studies (ATSDR 1992b).

In chickens, cobalt has been shown to decrease growth rate and feed intake, and to increase erythropoiesis. The erythropoietic effect has been associated with pulmonary hypertension and right ventricular hypertrophy (Diaz et al. 1994a, 1994b). Cobalt also has been shown to affect chick embryonic development (Gilani and Alibha, 1990) and to increase the susceptibility of chickens to infectious disease (Southern and Baker 1981).

Cobalt exerts toxic action in animal tissues by inactivating thiol groups (e.g., the thiol groups of alpha-lipoic acid, a cofactor of alpha-ketoglutarate dehydrogenase). Cobalt inhibition of alpha-ketoglutarate dehydrogenase and pyruvate dehydrogenase results in the depression of oxygen uptake by heart mitochondria (Venugopal and Luckey 1978). The cardiotoxicity of cobalt also has been associated with its antagonistic action towards calcium and with its interaction with intracellular macromolecules (Diaz et al. 1994a). Cobalt induces polycythemia by stimulating the production of erythropoietin in the kidney and liver (Diaz et al. 1994a, 1994b). It has been suggested than the testicular degeneration associated with cobalt exposure is due to hypoxia resulting from the blockage of veins and arteries by red blood cells, and to changes in permeability resulting from the thickening of the basal lamina and basement membranes (Mollenhauer et al. 1985). Cobalt has been shown experimentally to block the peripheral release of acetylcholine at myoneural junctions in the frog and to alter the release of central nervous system (CNS) transmitters in mammals (Nation et al. 1983).

In chickens, cobalt toxicity is increased by low dietary levels of iron. It has been postulated that these two metals compete for absorption in the intestinal tract (Southern and Baker 1981). Sulfur-containing amino acids (e.g., methionine and cysteine) have been shown to decrease cobalt toxicity in chickens, possibly due to the formation of nontoxic complexes (Southern and Baker 1981). The cobalt-induced increase in blood viscosity resulting from increased hemoglobin content may be responsible, in part, for the associated pulmonary hypertension reported in chickens, which, in turn may be partially responsible for right ventricular hypertrophy (Diaz et al. 1994a).

### B.1.9 Copper

**Fate and Transport**: Copper is an essential element and widely distributed in nature (Amdur et al. 1993). Naturally occurring concentrations of copper have been calculated at 70 ppm in the earth's crust and 0.001 to 0.02 ppm in seawater (HSDB 2010). Artificial sources of copper include smelting processes and non-ferrous metal production. The terrestrial fate of copper is related to degree of weathering, the nature and intensity of soil formation, drainage, pH, re-dox potential and organic

content (HSDB 2010). The relationship between pH and copper determines the fate of copper where alkaline conditions in soil and surface water promote precipitation while acidic conditions favor solubility of copper.

**Toxicity**: Copper is caustic, and acute toxicity is primarily related to this property (Hatch 1978). Copper is an essential element for animals and is a component of many metalloenzymes and respiratory pigments (Demayo *et al.* 1982). It is also essential for iron utilization and functions in enzymes for energy production, connective tissue formation, and pigmentation. Excess copper ingestion leads to accumulation in tissues, especially in the liver. High levels of copper modify hepatic metabolism (Brooks 1988), which may lead to inability of the liver to store and excrete additional copper. When the liver concentration exceeds a certain level, the metal is released into the blood, causing hemolysis and jaundice. High copper levels also inhibit essential metabolic enzymes (Demayo *et al*. 1982). Toxic symptoms appear when the liver accumulates 3 to 15 times the normal level of copper (Demayo *et al*. 1982).

### B.1.10 Iron

**Fate and Transport:** Iron is the fourth most common element in the earth's crust. Iron concentrations in soil can range from 0.2 to 55 percent and can vary significantly even within localized areas (Bodek et al. 1988). Iron is used primarily in the production of steel and other alloys. The iron ore formed is dependent upon the availability of other chemicals (e.g., sulfur is required to produce FeS2, or pyrite). Important iron ores are hematite, magnetite, limonite and siderite.

Under typical environmental conditions, iron is found in either the more soluble and bioavailable divalent form (ferrous iron or Fe+2) or the less soluble and less bioavailable trivalent form (ferric iron or Fe+3) (EPA 2003). Valence state is determined by the pH and Eh of the system. In general, oxidizing and alkaline conditions promote the precipitation of insoluble ferric oxide or hydroxic precipitates, while acidic and reducing conditions promote the solution of ferrous compounds. Iron does not bioaccumulate because it is regulated by the body and excess iron is eliminated.

**Toxicity:** Iron is an essential micro-nutrient to most forms of life, from plants to man, and is internally regulated by most organisms. In plants, iron is a critical component of energy transformations needed for syntheses and other life processes of the cells. In animals, iron is a component of various enzymes and proteins, including hemoglobin, which carries oxygen to the cells.

If excess ferrous iron is present, toxicity to plants may occur. However, sensitivity to iron is highly dependent upon plant species. In animals, adverse effects of iron toxicity may include renal failure and hepatic cirrhosis. The mechanism of toxicity begins with acute mucosal cell damage and absorption of ferrous ions directly into circulation, resulting in capillary endothelial cell damage to the liver (Shacklette and Boerngen 1984). However, the greatest environmental threat posed by high iron concentrations typically relates to the precipitation of iron oxides in aquatic systems, resulting in the smothering and embedding of the bottom substrate of the water body. Iron in soil generally does not impart significant ecological risk.

### B.1.11 Lead

**Fate and Transport**: Lead is present in the earth's crust at a concentration of approximately 15 grams per ton (g/ton). Lead naturally enters the environment from lead bearing minerals and median lead concentrations in soil are 15 to16 µg. The processes of erosion and leaching may transfer lead from soil into surface waters and the atmosphere. Anthropogenic sources via smelting, mining, ore processing, refining use, recycling or disposal, are the most common release sources of lead into the environment. In soil, lead is typically in the upper 2 to 5 centimeter (cm) and leaching is not expected to be significant. In water, precipitation of lead is significant if the pH is relatively high where the amount of lead that can remain in water is related to pH and dissolved salt content. Metallic lead will simply sink into the sediment and will adsorb to organic matter and clay minerals or precipitate out as an insoluble salt. Bioconcentration does not appear to be high in fish although bioconcentration factors (BCF) for various saltwater bivalves, molluscs, diatoms and phytoplankton have been found to range from 1.24 after 56 days in hard clams to 3.40 after 130 days in mussels (HSDB 2010).

**Toxicity**: Lead does not biomagnify to a great extent in food chains, although accumulation by plants and animals has been extensively documented (Wixson and Davis 1993; Eisler 1988b). Older organisms typically contain the highest tissue lead concentrations, with the majority of the accumulation occurring in the bony tissue of vertebrates (Eisler 1988b).

The toxic effects of lead on aquatic and terrestrial organisms are extremely varied and include mortality, reduced growth and reproductive output, blood chemistry alterations, lesions, and behavioral changes. However, many effects exhibit general trends in their toxic mechanism. Generally, lead inhibits the formation of heme, adversely affects blood chemistry, and accumulates at hematopoietic organs (Eisler 1988b). At high concentrations near levels causing mortality, marked changes to the CNS occur prior to death (Eisler 1988b).

### B.1.12 Manganese

**Fate and Transport**: Manganese does not occur as a free metal in the environment but is a component of numerous minerals. Elemental manganese and inorganic manganese compounds have negligible vapor pressures, but may exist in air as suspended particulate matter derived from industrial emissions or the erosion of soil. Removal from the atmosphere is mostly through gravitational settling. The transport and partitioning of manganese in water are controlled by the solubility of the specific chemical form present. The metal may exist in water in any of four oxidation states (2+, 3+, 4+, or 7+). Divalent manganese ($Mn^{+2}$) predominates in most waters (pH 4 to 7), but may become oxidized at a pH greater than 8 or 9. Manganese is often transported in moving water as suspended sediments. The tendency of soluble manganese compounds to adsorb to soils and sediments depends mainly on the cation exchange capacity (CEC). Cation exchange capacity is related to soil's organic content and texture; where CEC increases with organic matter and in finer textured soils. Increasing pH also increases CEC. Adsorption of manganese and other metals to soil colloid particles increases with increasing CEC (Brady 1974). Manganese in

water may be significantly bioconcentrated at lower trophic levels. However, biomagnification in the food chain may not be significant (ATSDR 2008b).

**Toxicity**: Manganese is a common element that is essential for normal physiologic functioning in all animal species. In most animals, the amount of manganese absorbed across the gastrointestinal tract is variable and less than 5 percent. There does not appear to be a marked difference between manganese ingested in food or in water. One of the key determinants of absorption appears to be dietary iron intake, with low iron levels leading to increased manganese absorption. This is probably because both iron and manganese are absorbed by the same transport system in the gut in aquatic and terrestrial species (ATSDR 2008).

In studies where repeated oral doses were given to animals in an attempt to induce chronic manganese disease, moderate doses did not induce any injury (HSDB 2010). Female rats fed a concentration of 154 to 1004 milligram per kilogram (mg/kg) dry weight during pregnancy and weaning had fetuses with elevated concentrations of manganese in the liver although no gross malformations were observed (HSDB 2010). When manganese was administered orally to monkeys, degenerative, histological changes (demyelination of the posterior column) were observed in the chiasma and spinal cord (HSDB 2010).

### B.1.13 Mercury

**Fate and Transport:** Mercury has been used by man for thousands of years, most recently as a fungicide in agriculture, in the manufacture of chlorine, sodium hydroxide, electronics, and plastics, as a slime control agent in the pulp and paper industry, and in mining and smelting operations (Eisler 1987a). Mercury is persistent in the environment, with organisms in contaminated habitats showing elevated mercury burdens for as long as 100 years after the pollution source has been removed (Eisler 1987a).

Mercury is present in the environment in both inorganic and organic forms. Inorganic mercury exists in three valence states: mercuric (Hg2+), mercurous (Hg1+), and elemental (Hg) mercury. Inorganic mercury compounds are less toxic than organomercury compounds; the mercuric ion is the most toxic inorganic chemical form (Clarkson and Marsh 1982). However, the inorganic forms are readily converted to organic forms by bacteria commonly present in the environment. The organomercury compound of greatest concern is methylmercury, due to its high stability, lipid solubility, and ability to penetrate membranes in living organisms (Beijer and Jernalov 1979). Mercury can become methylated biologically or chemically. Microbial methylation of mercury occurs most rapidly under anaerobic conditions, which are common in wetlands and aquatic sediments but may also be found in soils. Most mercury detected in biological tissues is present in the form of methylmercury (Huckabee *et al*. 1979), which is known to biomagnify in food chains.

**Toxicity:** Mercury is a highly toxic mutagenic and teratogenic compound with no known natural biological function. A number of toxic effects of mercury exposure have been reported, although little information is available regarding its effect on terrestrial plants. In birds, mammals, and fish, mercury acts as a potent neurotoxin,

resulting in impaired muscular coordination, vision, and hearing; depressed growth and reproduction; weight loss; and apathy, with early developmental stages being the most sensitive (Eisler 1987a). Other effects include changes in enzyme activity levels and histopathology. In mammals, methylmercury irreversibly destroys the neurons of the CNS.

### B.1.14 Nickel

**Fate and Transport:** Pure nickel is a hard, white metal that is usually used in the formation of alloys (such as stainless steel), and nickel combined with other elements is found in all soils. Nickel is the twenty-fourth most abundant element and is found in the environment as oxides or sulfides. It may be released into the environment through mining, oil-burning power plants, coal-burning power plants, and incinerators. Nickel will attach to soil or sediment particles, especially those containing iron or manganese. Under acidic conditions, nickel may become more mobile and seep into the groundwater. The typical nickel concentration reported in soils is from 4 to 80 mg/kg. The speciation and physicochemical state of nickel is important in considering its behavior in the environment and its availability to biota (ATSDR 2005a).

**Toxicity:** The most probable exposure routes of nickel are through dermal contact, inhalation of dust, and ingestion of nickel-contaminated soil. The respiratory system is the primary target of nickel exposure following inhalation. Manifestations such as inflammation of the lungs, fibrosis, macrophage hyperplasia, and increased lung weight have been noted in animals exposed to nickel. Animals (species not given) exposed to nickel through oral exposure were noted to have lethargy, ataxia, irregular breathing, salivation, and squinting (ATSDR 2005a).

In a 1.5 year study on the effects of nickel inhalation in guinea pigs, rats, mice and hamsters, 15 grams per cubic meter ($g/m^3$) of metallic nickel powder caused lung irritation in rats and guinea pigs and nasal sinus inflammations and ulcers in rats. No adverse effects and no tissue accumulation were observed in 104 mice administered 5 ppm of nickel in drinking water for the duration of their life. The prenatal effects of nickel result from direct insults to the mammalian embryo and from indirect effects of maternal damage.

Maternally, nickel may upset the mother's hormonal balance thereby impairing the development of the preimplantation embryo. The fetus is affected as nickel can cross the feto-maternal barrier and directly enter the fetus. In addition to increases in prenatal and neonatal mortality, nickel can produce different types of malformations in the surviving embryos but its teratogenic action seems to be delayed, probably as a result of retarded transfer via the placenta. However, no definite conclusions can be reached as to whether the embryotoxicity and fetal toxicity of nickel are eventually related to its mutagenic properties. Nickel alters macromolecular synthesis but no convincing evidence has been provided of its ability to produce gene mutations or structural chromosome aberrations in mammalian cells (HSDB 2010).

### B.1.15 Selenium

**Fate and Transport:** Selenium was used as a plant pesticide in the early 1900's and is still used sparingly to control pests of greenhouse chrysanthemums and carnations (Eisler 1985b). The use of selenium pesticides has generally been discontinued, however, because of their high price, their stability in soils and resultant contamination of food crops, and their proven toxicity to mammals. Shampoos containing small amounts (about 1 percent) of selenium are still used to control dandruff, dermatitis, and mange (Eisler 1985b). Selenium is also extensively used in the manufacture and production of glass, pigments, rubber, metal alloys, textiles, petroleum, medical therapeutic agents, and photographic emulsions.
Selenium chemistry is complex; there are six stable isotopes of varying allopatric forms and valence states. Isotopes Se-80 and Se-78 are the most common. Soluble selenates (+6), which are readily taken up by plants, occur in alkaline soil and are slowly reduced to less soluble selenites (+4). In acid or neutral soils, the amount of biologically available selenium steadily declines; selenites are easily reduced to elemental selenium, which is insoluble and largely not bioavailable, although it is capable of satisfying nutritional requirements for selenium (Eisler 1985b). Selenium volatilizes from soils at rates that are modified by temperature, moisture, time, season, concentration of water-soluble selenium, and microbiological activity (Eisler 1985b). Selenium bioaccumulates, but does not appear to biomagnify.

**Toxicity:** Selenium is an essential nutrient for some plants and animals, constituting an integral part of proteins and enzymes including cytochrome C, hemoglobin, myoglobin, myosin, glutathione peroxidase, and various ribonucleoproteins (Eisler 1985b). It may also play a role in the formation of other compounds, such as vitamin E and the enzyme formic dehydrogenase. In many systems, selenium deficiency is a greater problem than selenium toxicity, though the dividing line between selenium acting as a micronutrient or as a toxin may be fine. Additionally, sensitivity to selenium varies widely, even among similar taxonomic groups (Eisler 1985b).

Selenium accumulation in certain species of plants may be extremely high. Plants that accumulate selenium tend to be more deep-rooted than grasses, thereby serving as principal forage for herbivorous animals during dry conditions and potentially leading to high rates of selenium intake. Toxic effects resulting from consumption of selenium accumulating plants include reproductive sterility, congenital malformations, growth retardation, anemia, respiratory failure, chromosomal aberrations, intestinal lesions, behavioral modifications, and death (Eisler 1985b). Selenium appears to bioaccumulate in animals as well as plants, since concentrations tend to be higher in older than in younger individuals. However, some organisms (e.g., rats) appear able to regulate selenium. Excretion occurs primarily through urine, with smaller amounts excreted in feces, breath, perspiration, and bile (Eisler 1985b).

### B.1.16 Silver

**Fate and Transport:** Silver is a rare but naturally occurring metal, often found deposited as a mineral ore. The principal industrial use of silver is as silver halide in the manufacturing of photographic imaging materials; other uses include jewelry,

coins, inks, and silverware. Silver is also used for medical purposes. In the United States, the photographic industry accounts for about 47 percent of all anthropogenically discharged silver (Eisler 1996). Other sources include mining and smelting operations, the disposal of electrical supplies, coal combustion, and cloud seeding.

Silver occurs naturally in several oxidation states, the most common being elemental silver (Ag0) and the monovalent ion (Ag+). The primary silver compounds formed under oxidizing conditions are bromides, chlorides, and iodides; under reducing conditions, the free metal and silver sulfide predominate (ATSDR 1990, as cited by Eisler 1996). Silver is leached from soils by an acidic environment and good drainage; soil organisms that render nitrogen compounds soluble as nitrates also increase mobility of silver (Smith and Carson 1977).

An alkaline environment, potassium clay minerals, negatively charged hydrated iron and manganese oxides, organic matter, and precipitating anions tend to fix silver in the soil. Thus, while the redox potential of soils has little direct effect on silver bioavailability, soil Eh indirectly plays a major role in determining the mobility and bioavailability of silver because of its impact on soil processes including the hydrolysis of iron and manganese and precipitation of their oxide hydrates, the production of sulfide ions, and the oxidation of organic material. Silver is considered bioaccumulative; however, considerable differences exist in the ability of animals to accumulate, retain, and eliminate silver (Baudin et al. 1994, as cited in Eisler 1996).

**Toxicity:** Silver is a normal trace constituent of many organisms (Smith and Carson 1977). It is not known to be mutagenic, teratogenic, or carcinogenic. However, effects of silver toxicity have been documented in a wide variety of organisms including crop plants, numerous aquatic species, avian and mammalian livestock, and laboratory animals, although little research has been done on terrestrial wildlife species. Observed effects include reduced growth and death in plants and weight loss, cardiac enlargement, vascular hypertension, hepatic necrosis, anemia, enzyme inhibition, lowered immunological activity, ocular and neurological impairment, kidney damage, and mortality in animals (Smith and Carson 1977, Eisler 1996).

### B.1.17 Thallium

**Fata and Transport**: Thallium is a common element with a concentration of about 0.3 to 0.6 ppm in the earth crust (HSDB 2010). The metal cation commonly occurs in potash minerals, pyrites, and is a minor constituent of many iron, copper sulfide and selenite ore; in nature it does not occur in the elemental state. It is one of the most toxic of the heavy metals. Metallic thallium is soft and malleable, similar to lead in both appearance and physical properties. Freshly-prepared thallium oxidizes rapidly. Thallium is mainly used in the electrical and electronic industries, and in the production of special glasses. Thallium is also found in pyrites used to make sulfuric acid. Mining and smelting, sulfuric acid production, cement factories, and coal burning power plants are the major anthropogenic sources of thallium to the environment (Mulkey and Oehme 1993).

**Toxicity**: Thallium has been shown to adversely affect protein synthesis. Mammalian ribosomes are strictly dependent on potassium and magnesium for normal interactions between ribosomal subunits. Thallium (+) can replace K+ causing progressive destabilization and irreversible damage to ribosomes. Interactions between thallium and riboflavin may play a role in toxicity. Thallium may impair cell energy metabolism by causing a deficiency of riboflavin and riboflavin-derived cofactors (Mulkey and Oehme 1993).

Thallium is teratogenic in chick embryos, causing achondoplasia, leg bone curvature, parrot-beak deformity, microcephaly, and decreased fetal size. Teratological investigations in mammals have produced conflicting results (Mulkey and Oehme 1993).

### B.1.18 Tin

**Fate and Transport:** Tin is a natural element in the earth's crust. It is a soft, white, silvery metal that does not dissolve in water. It is present in brass, bronze, pewter, and some soldering materials. Tin metal is used to line cans for food, beverages, and aerosols (ATSDR 2005b).

Tin is released into the environment by both natural processes and human activities, such as mining, coal and oil combustion, and the production and use of tin compounds. Metallic tin released to the environment will quickly form inorganic tin compounds. By binding with carbon tin can form various organotin compounds (i.e., dibutyltin, tributyltin, triphenyltin). Both inorganic and organic forms of tin can be found in the environment near places where they are naturally present, or where they are mined, manufactured, or used (ATSDR 2005b).

Inorganic tin does not degrade; it can only change its form. Organic tin compounds can be degraded to inorganic tin via exposure to sunlight and bacteria. In the atmosphere, tin exists as gases and fumes, and attaches to dust particles. Particles in the air containing tin may be transported by wind or washed out of the air by rain or snow. Inorganic tin binds to soil and to sediments. Some inorganic tin compounds dissolve in water. Organic tin compounds adsorb to soil sediment, and particles in water. Residence time of organotins in the environment differs between compounds. Organotins may bioaccumulate in fish, other organisms, and plants (ATSDR 2005b).

**Toxicity:** Metallic tin is not very toxic due to its poor gastrointestinal absorption. Human and animal studies show that ingestion of large amounts of inorganic tin compounds can cause stomachache, anemia, and liver and kidney problems (ATSDR 2005b). Tin may interact with the absorption and metabolism of biologically essential metals such as copper, zinc, and iron. Results of animal tests where test organisms were fed considerable quantities of powdered tin caused vomiting but no permanent injury (HSDB 2010).

Breathing, swallowing, or skin contact with some organotins, such as trimethyltin and triethyltin compounds, can interfere with the CNS. In severe cases, it can cause death (ATSDR 2005b). Some organotin compounds, such as dibutyltins and tributyltins, have been shown to affect the immune system in animals. Studies in animals also

have shown that some organotins, such as dibutyltins, tributyltins, and triphenyltins can affect the reproductive system. Inorganic or organic tin compounds placed on the skin or in the eyes can produce skin and eye irritation (ATSDR 2005b).

### B.1.19 Vanadium

**Fate and Transport**: Elemental vanadium does not occur free in nature but is a component of dozens of different minerals and fossil fuels (EPA 2005b). Anthropogenic sources include acid-mine leachate, sewage sludge, and fertilizers. It is also a by-product of petroleum refining and the combustion of hydrocarbon fuels (EPA 2005b). Vanadium is principally used as an alloy constituent, especially in steel, as well as in pigment manufacturing, photography, and insecticides.

Vanadium can take various valence states, from +2 to +5. It is found in rocks and soil in the relatively insoluble trivalent form, and as vanadates of a variety of metals in the +5 oxidation state (EPA 2005b). It can also form both cationic and anionic salts. The release of vanadium to soil occurs as a result of the weathering of rocks and from soil erosion, both of which generally convert the less-soluble trivalent form to the more-soluble pentavalent form. Mobility of vanadium in soils is determined by pH, Eh, and organic content. In contrast to most metals, vanadium is fairly mobile in neutral or alkaline soils and less mobile in acidic soils. Soluble vanadium in soils appears to be easily taken up by plant roots (Hopkins *et al.* 1977, as cited by EPA 2005b). Vanadium is not considered bioaccumulative.

**Toxicity**: Toxicity of vanadium has not been demonstrated in plants. In animals, the toxic action is largely confined to the respiratory tract, because inhalation is the most common route of exposure; absorption of vanadium through the gastrointestinal tract of animals is low. Inhalation of vanadium damages the alveolar macrophages by decreasing the macrophage membrane integrity; damaged macrophages inhibit the ability of the respiratory system to clear itself of other particles. However, ingestion of high concentrations of vanadium compounds ($V_2O_5$) may lead to acute poisoning characterized by marked effects on the nervous system, hemorrhage, paralysis, convulsions, and respiratory depression. Subacute exposures at high concentrations may adversely affect the liver, adrenals, and bone marrow (Klassen *et al.* 1986). In vitro experiments in mice indicate that the mechanism of toxicity of vanadium is by inhibiting sodium-potassium ATPase activity, which inhibits the sodium-potassium pump. This pump is necessary for the transport of material across cell membranes (Nechay and Saunders 1978).

### B.1.20 Zinc

**Fate and Transport:** Zinc occurs naturally in the earth's crust. It is used primarily in the production of brass and other alloys, galvanization of iron and steel products, and formulation of white pigments. It is also used as a fungicide in agriculture and is applied to soils to prevent zinc deficiency (Eisler 1993). Anthropogenic releases of zinc in the environment occur through smelting and ore processing, mine drainage, sewage, combustion of solid wastes and fossil fuels, road surface runoff, corrosion of zinc alloys and galvanized surfaces, and erosion of agricultural soils (Eisler 1993). Zinc is not found free in nature, but often occurs in the +2 oxidation state as zinc

sulfide, zinc carbonate, or zinc oxide. Zinc compounds also exist in the particulate phase in the atmosphere and are physically removed from the air by wet or dry deposition. Zinc is strongly adsorbed to soil at pH 5 or greater, and zinc compounds have low mobility in most soils (Blume and Brummer 1991). Clay minerals, hydrous oxides, and pH are the most important factors controlling zinc solubility. Soluble forms of zinc are readily absorbed by plants. Uptake is dependent on soil type; for example, uptake is lower in coarse loamy soils than in fine loamy soils (Chang et al. 1983, as cited by Eisler 1993). Zinc is essential for normal growth and reproduction in plants and animals and is regulated by the body.

**Toxicity:** Because zinc is an essential element, maintaining a balance between excess and insufficient zinc is important. Zinc deficiency occurs in many species of plants and animals and has severe adverse effects on all stages of growth, development, reproduction, and survival (Eisler 1993). Zinc is a component of several essential enzymes that regulate the biosynthesis and catabolic rate of RNA and DNA.

A wide safety margin appears to exist between required and toxic zinc intakes. However, high levels of zinc can cause copper deficiency and interfere with metabolism of calcium and iron (Goyer 1986, as cited by Eisler 1993). Terrestrial plants growing in soil with high zinc concentrations (such as beneath corroded galvanized fencing or near zinc smelters) showed poor seedling establishment and decreased photosynthesis, respiration, and seedling root elongation, resulting in negative impacts on measures of species richness and abundance (Nash 1975, as cited by Eisler 1993). Zinc poisoning has also been documented in a variety of animal species, usually through the ingestion of zinc-containing products such as galvanized metal objects, zinc containing coins, and skin and sunblock preparations containing zinc oxide (Eisler 1993).

The pancreas and bone seem to be the primary targets of zinc toxicity in birds and mammals. Signs of acute poisoning include impaired reproduction, anorexia, depression, enteritis, diarrhea, decreased milk yield, decreased growth, excessive eating and drinking and, in severe cases, convulsions and death (Ogden *et al.* 1988, as cited in Eisler 1993). Zinc preferentially accumulates in bone, where it induces osteomalacia, a softening of bone caused by a deficiency of calcium, phosphorus, and other minerals (Kaji *et al*. 1988). Pancreatic effects include reduced activity of digestive enzymes, cytoplasmic vacuolation, cellular atrophy, and cell death (Lu and Combs 1988, Kazacos and Van Vleet 1989).

## B.2 Volatile Organic Compounds

Fate, transport and toxicity of VOC COPCs are discussed in the following subsections. Acetone and 2-butanone are not discussed as these compounds are typically classified as common laboratory contaminants; carbon disulfide is considered to be a naturally occurring compound and is also not discussed as per Section 5.3 of the SLERA report.

### B.2.1 Isopropylbenzene

**Fate and Transport:** Isopropylbenzene is a water insoluble petrochemical used in the manufacture of several chemicals, including phenol and acetone. Isopropylbenzene

occurs in a variety of natural substances including essential oils from plants and foodstuffs. If released to soil isopropylbenzene is expected to have low mobility; adsorption to soil is expected to attenuate volatilization. Isopropylbenzene is expected to undergo considerable biodegradation in soil environments. If released into water, it is expected to adsorb to sediment and suspended solids. Using river water and sediment, the aerobic biodegradation of isopropylbenzene was studied in a closed system. Based on the results of this experiment, residence time of isopropylbenzene in aquatic ecosystems will likely be brief. Estimated volatilization half-lives for a model river and model lake are 1.2 hrs and 4.4 days, respectively. However, volatilization from water surfaces is expected to be attenuated by adsorption to sediment and suspended solids in the water column. A BCF of 35 suggests bioconcentration in aquatic organisms is moderate. Isopropylbenzene is widely detected in the atmosphere mainly due to its presence in gasoline and as a natural component in plants (HSDB 2010).

**Toxicity:** In general, the majority of studies located regarding the toxicity of isopropylbenzene are inhalation-based; however, some oral-based studies were found. In one study, rats were given 139 oral doses of isopropylbenzene over 194 days at 154, 462, or 769 mg/kg body weight per dose. No effects on weight or on hematological or histopathological indices were noted at 154 milligrams per kilogram per day (mg/kg/day). At the two higher concentrations, only a dose-related increase in kidney weight was observed. Other studies investigating oral-based toxicity of isopropylbenzene resulted in an LD50s of 1400 mg/kg, for the rat (HSDB 2010).

### B.2.2 Fluorobenzene

No information on the fate, transport, or toxicity of fluorobenzene was located.

## B.3 Semi-volatile Organic Compounds

Fate, transport, and toxicity of SVOCs are discussed in the following subsections. Compounds classified as polycyclic aromatic hydrocarbons (PAHs) are discussed collectively as a group. Phthalates are not discussed as these chemicals are not site-related and are typically classified as common laboratory contaminants as discussed in Section 5.3 of the SLERA report.

### B.3.1 2,4-Dimethylphenol

**Fate and Transport:** 2,4-Dimethylphenol is a naturally occurring constituent of coal and has also been detected in tobacco smoke. Artificial sources of 2,4-dimethylphenol include release in wastewater during coal processing and coal tar refining. It is also released during its use in the manufacture of plastics and resins, pharmaceuticals, insecticides and fungicides, disinfectants and solvents (HSDB 2010). It would adsorb moderately if spilled on soil and has been reported to degrade in soil in 4 days at 19 degrees Celsius (HSDB 2010). In water, 2,4-dimethylphenol may adsorb moderately to sediment and will be readily biodegradable, but biodegradation rates were not available for rivers. It was stated as having the possibility to bioaccumulate in fish based on several studies.

**Toxicity**: In mammals, no appreciable toxic effect of acute oral administration has been seen at 273 to 425 mg/kg in rabbits. Acute and chronic toxicity studies on 2,4-dimethylphenol in mice at a concentration of 26 to 30 milligrams/cubic meter ($mg/m^3$) showed no lethality but caused irritation of the mucous membrane (HSDB 2010). Embryos of fathead minnows were more resistant to 2,4-dimethylphenol than were larval or juvenile life stages. Growth of 28-day old fish was the most sensitive indicator of stress during exposure to 2,4-dimethylphenol. Based on these studies a maximum acceptable toxicant concentration (MATC) of 1,970 to 3,110 µg/L was established for fathead minnows in Lake Superior (HSDB 2010).

### B.3.2 Acetophenone

**Fate and Transport:** Acetophenone is released to the environment from a variety of combustion processes and may be released during its manufacture and the manufacture of propylene oxide, kraft bleaching and from its use in certain perfumes. In soils, microbial degradation is likely to be the major degradation pathway. It is expected to be moderately to highly mobile in soil and it therefore has the potential to migrate into the groundwater. Evaporation from dry soil surfaces is another important terrestrial fate process. In aquatic systems biodegradation and volatilization are expected to be the major loss processes. Acetophenone is very soluble in water.

The estimated biodegradation half-lives in groundwater, river water and lake water samples were 32 days, 8 days and 4.5 days, respectively. Hydrolysis, oxidation, bioconcentration, and adsorption to sediments and suspended particles are not likely to be important fate processes. Oxidation by hydroxyl radicals in air has an estimated half-life of 2.2 days. Other oxidants (e.g., ozone) and photolysis do not appear to be important loss mechanism of this compound in air (HSDB 2010).

**Toxicity:** Little information was located on the toxicity of acetophenone. Moderate to low acute oral toxicity in laboratory animals and low dermal toxicity in guinea-pigs has been observed. Central nervous system depression occurred in laboratory animals exposed orally and by injection. Oral-based LD50s of 3.0 g/kg and 0.9 g/kg have been reported in rats. Aquatic studies results report an LC50 and EC50 of 162 mg/L during a 96 hour test using the fathead minnow (HSDB 2010).

### B.3.3 1,1′-Biphenyl

**Fate and Transport:** 1,1′-Biphenyl is primarily manufactured for use as a heat transfer agent, in plant disease control, manufacture of benzidene, as a dyeing assistant for polyesters and its former use as a fungistat on shipping papers for oranges. Biphenyl is synthesized in certain plants and in algae. If released to soil, biphenyl is expected to have low to slight mobility; biodegradation in soil is variable. If released into water, biphenyl is expected to adsorb to suspended solids and sediment. Biodegradation may be an important environmental fate process under aerobic conditions, as indicated by a reported half-life of 2-3 days in a river die-away test. Biphenyl may be resistant to biodegradation under anaerobic conditions. Estimated volatilization half-lives based on a model river and lake are 4 hours and 6 days,

respectively. However, volatilization from water surfaces is expected to be attenuated by adsorption to suspended solids and sediment in the water column. BCF values from 280 to 4,500 suggest bioconcentration in aquatic organisms is high to very high (HSDB 2010).

**Toxicity:** 1,1′-biphenyl is well absorbed through the gastrointestinal tract. In test species examined, the metabolites of 1,1′-biphenyl, mainly 4-hydroxybiphenyl, are excreted rapidly and almost exclusively in the urine. Acute oral toxicity is moderate. It is non-irritating to the skin and only slightly irritating to the eyes. There is no evidence of dermal sensitization. Subchronic exposure by inhalation caused bronchopulmonary changes, whereas long term toxicity studies following inhalation were not identified in literature. In toxicological studies in which rodents have been administered diets containing 1,1′-biphenyl for various periods of time, effects on the urinary system have often been reported (HSDB 2010).

Single, unspecified doses of 1,1′-biphenyl to rats and rabbits showed increased rates of respiration, lacrimation, anorexia and weight loss, along with muscular weakness, followed by death within 2 hours to 18 days of dose delivery. Pathological results of exposed populations included visceral congestion, myocarditis, hepatitis, nephritis, and pneumonia (HSDB 2010).

Studies conducted on aquatic organisms resulted in LC50s of 4.6mg/L and 4.7mg/L during a 96 hour test using the sheepshead minnow and bluegill, respectively. During a 24 hour test using the water flea an LC50 of 1.3 mg/L was noted (HSDB 2010).

### B.3.4 Polycyclic Aromatic Hydrocarbons

**Fate and Transport:** PAHs are organic substances made up of carbon and hydrogen atoms grouped into at least two condensed aromatic ring structures. These are divided into two categories: low molecular weight compounds composed of fewer than four rings and high molecular weight compounds of four or more rings.

PAHs can be introduced to the environment by residential wood burning, cooking foods, and combustion of fossil fuels, as well as discharges from industrial plants, waste water treatment plants, and escape from waste storage containers. Other industrial sources of PAHs are machine lubricating, cutting, and color printing oils. PAHs are found in creosote which is used as a wood preservative. PAHs are also found in coal tar which is used in roofing, surface coatings, and as a binder for aluminum smelting electrons in the aluminum reduction process. PAHs are released to the environment in nature by volcanic activity and forest fires. Only a few PAHs are produced commercially. In general, PAHs are unintentionally generated during combustion or pyrolysis processes (HSDB 2010).

**Toxicity:** In general, it appears that toxicity associated with PAHs is due not to the initial compound, but rather to metabolized intermediates (Fourman 1989). The majority of the enzymatic activity associated with the metabolism of PAH compounds takes place in the liver (Fourman 1989). The first step in the metabolic process is the

oxidation of PAHs by cytochrome P450 and P448 enzyme systems. The metabolic by-products go through a series of reactions, ultimately forming diol-epoxides and phenol-oxides, which are believed to be the carcinogenic intermediates of PAHs (Stein *et al.* 1990). These compounds have the ability to form DNA adducts by covalently bonding with genetic material (Varnasi *et al.* 1989). Metabolic activation of PAHs can also involve the formation of free radicals and carbonium ions as metabolized intermediates; these are potential carcinogens and will affect metabolic pathways (HSDB 2010).

PAHs are also potent immunotoxic compounds, suppressing humoral and cell-mediated immune response. Many PAHs have been shown to adversely affect host tumoricidal activities, resulting in tumor formation (Peakall 1993). For example, application of carcinogenic PAHs to skin leads to destruction of sebaceous glands, hyperplasia, hyperkeratosis, ulceration, and potential tumor induction (Eisler 1987b).

Target organs for PAH toxic effects are diverse because these compounds are extensively distributed in the body and they tend to selectively attack proliferating cells. Damage to the hematopoietic and lymphoid system in experimental animals is common. Target organs can also be species specific. In rats, the target organs for 7,12-dimethylbenz(a)anthracene are skin, small intestine, kidney and mammary gland, whereas in fish the primary target organ is the liver (Eisler 1987b).

### B.3.5 Carbazole

**Fate and Transport:** Release of carbazole into the environment occurs primarily by emissions from waste incineration; tobacco smoke; petroleum, coal and wood combustion; and in the effluents of wood treating facilities. Carbazole occurs naturally in coal, petroleum and peat and will be released into the environment through incomplete combustion of these materials (HSDB 2010). With an average Koc value of 637, it is assumed that carbazole is not very mobile in soil but may biodegrade in soil and water if specific degrading bacteria are present (HSDB 2010). Bioconcentration and volatilization are not important in aquatic systems.

**Toxicity:** An LD50 of greater than 5,000 mg/kg was calculated for rats in an oral dosing study (HSDB 2010). Male (50) and female (50) mice were fed a pellet diet containing technical grade carbazole (purity, 96 percent) at concentrations of 0.6, 0.3 or 0.15 or 0.0 (control) for 96 weeks. Upon examination, neoplastic lesions were found in the liver and forestomach, and the liver lesions were classified as neoplastic nodules and hepatocellular carcinomas (HSDB 2010). The incidence of lesions was significantly greater in the highest dosed animals.

### B.3.6 Dibenzofuran

**Fate and Transport:** Dibenzofuran can be found in coal-tar, heat-transfer oils, used as a carrier for dyeing and printing textiles, as an intermediate for production of dyes, and as an antioxidant in plastics. If released to air dibenzofuran will exist solely as a vapor in the ambient atmosphere. Half-life in air is estimated to be 4 days. If released to soil, dibenzofuran is expected to have slight mobility; adsorption to soil is expected to attenuate volatilization. Indigenous soil microorganisms at contaminated sites can degrade dibenzofuran if stimulated. If released into water, dibenzofuran is expected

to adsorb to suspended solids and sediment. Biodegradation screening tests indicate that dibenzofuran is not readily biodegradable. However in some laboratory studies, dibenzofuran was degraded in a few days using subsurface materials which had been contaminated by creosote chemicals. Once microbial adaptation had occurred, dibenzofuran rapidly biotransformed under aerobic conditions. Estimated volatilization from water half-lives for a model river and model lake are 5 hours and 7 days, respectively. However, volatilization from water surfaces is expected to be attenuated by adsorption to suspended solids and sediment. BCF values for fish of 524 to 947 are high and from 1,100 to 2,420 are very high (HSDB 2010).

**Toxicity:** Little toxicity information was located for dibenzofuran. Two studies using the water flea report LC50s of 7500 µg/L for a 24 hour test and 1700 µg/L for a 48 hour test (HSDB 2010).

### B.3.7 2-Methylphenol

**Fate and Transport:** 2-methylphenol, also commonly referred to as o-cresol, is used as a solvent, disinfectant and chemical intermediate in the production of synthetic resins. It may also be released into the environment through automobile exhaust, coal tar and petroleum refining and wood pulping. If released to air, vapor-phase 2-methylphenol will degraded in the atmosphere with an estimated half life of 9 hours. If released to soil, it is expected to be highly mobile; however, it expected to biodegrade rapidly based upon half-lives of 1.6 and 5.1 days. If released into water, it is not expected to adsorb to suspended solids and sediment, and is expected to biodegrade in water based on a reported half-life of 50 days in southern California coastal waters and a half-life of 20 days in gasoline contaminated groundwater. Estimated volatilization half-lives for a model river and model lake are 21 and 235 days, respectively. An estimated BCF of 6 suggests the potential for bioconcentration in aquatic organisms is low (HSDB 2010).

**Toxicity:** Studies on aquatic organisms have shown that 2-methylphenol is moderately toxic to aquatic bacteria, cyanobacteria (blue-green algae) and protozoa. Tilapia exposed to a sublethal concentration of 2-methylphenol for 30 days was observed to show degenerative changes. A LC50 value for a 96 hour exposure of 23.5 mg/L resulted in pathological changes such as vacuolation, necrosis, interzonal separation, blood capillary dilation, and fibrosis in the optic tectum.

In mammals, signs of acute 2-methylphenol poisoning include muscular convulsions, coma, and death. An acute oral LD50 value for the rat was 1.35 g/kg and 344 mg/kg for the mouse; LD50 for dermal exposure for the mouse was 620 mg/kg (HSDB 2010).

### B.3.8 Benzaldehyde

**Fate and Transport:** Benzaldehyde is a naturally occurring volatile plant product with a characteristic bitter almond aroma. It is found in almonds, apricot, peach, and cherry seeds, and is used in dyes, drugs, perfumes, and flavoring agents. It is also a byproduct of toluene degradation in the atmosphere.

If released to the atmosphere, benzaldehyde will degrade by reacting with photochemically produced hydroxyl radicals. Estimated soil organic carbon-water partitioning coefficients (Koc) for benzaldehyde suggest that it will leach readily in soils. A number of biological screening studies have demonstrated that benzaldehyde is readily biodegradable. If released into water, benzaldehyde is not expected to adsorb to suspended solids and sediment based upon the estimated Koc. It is not believed to bioaccumulate (HSDB 2010).

**Toxicity:** Two year studies were conducted by administering various concentrations of benzaldehyde in corn oil by gavage to groups of 50 male mice. The only effects of benzaldehyde were those seen in the forestomach of mice. The incidences of uncommonly occurring squamous cell papillomas of the forestomach in both exposure groups were significantly greater than those in controls. Little information was available on the toxicity of benzaldehyde in aquatic organisms. A study using the fathead minnow derived an LC50 of 35 mg/L/24 hr and 7.6 mg/L/96 hr. An additional study derived an LC50 for *Daphnia magna* exposed to 50 mg/L 24hr (HSDB 2010).

## B.4 Chlorinated Pesticides

**Fate and Transport:** Pesticides are not a site-related contaminant; however, they are evaluated due to their persistence, toxicity, and bioaccumulation potential. Chlorinated pesticides, regardless of form of release can have the potential to be transported by air. Airborne pesticides can move very long distances and can be carried in the wind during application, on small particulates such as soil or on larger objects that are caught up by wind, and can volatilize off of any surface to which they are applied. Once a pesticide is released to soil it will most likely follow one of three pathways. It will move through the soil with water, attach to soil particles, or be metabolized by organisms in the soil. For chlorinated pesticides, binding to soil particles, particularly organic matter, is the most important. In addition, many persistent pesticides no longer in use, such as DDT, bioaccumulate in the tissues of organisms. Pesticides that bioaccumulate in organisms to the greatest degree are often very persistent in the environment.

Water transport of pesticides can occur through wet deposition, run-off from surfaces, infiltration of water through the ground, ditches, storm sewers, tile lines, drains, rivers, and open water currents. Pesticides in open water systems may float on the water, diffuse into the water, or deposit onto the sediments at the bottom of the water body. Pesticides that move from the ground surface through the soil may reach shallow groundwater or deeper aquifers. However, chlorinated pesticides, such as DDT, are highly insoluble and have low potential for migration.

**Toxicity:** Chlorinated pesticides as a group are highly toxic to a wide variety of ecological receptors and readily accumulate in biological tissues. Some are known to biomagnify, resulting in higher concentrations in higher trophic level biota. For this reason, even very low concentrations of these compounds can contribute to severe adverse effects at the top of food webs. The adverse effect of DDT and related compounds on bald eagles (due primarily to eggshell thinning) is a well-known

example of biomagnification from water and sediment to fish to piscivorous birds. Many pesticides are persistent in the environment and degradation by biological and other means is minimal. Most of these compounds are lipophilic, with a tendency to accumulate in the liver and other fatty tissues of biota. Levels of pesticides assumed to be safe for exposed biota are often very low due to bioaccumulation-related risks.

## B.5 Polychlorinated Biphenyls

**Fate and Transport:** Polychlorinated Biphenyls (PCBs) are a group of 209 synthetic halogenated aromatic hydrocarbons that are extremely stable, bioaccumulate, and are resistant to most chemical and biological degradation processes (Eisler 1986b, Hornshaw et al. 1983). The persistence and stability of PCBs in the environment are due to chemical
properties such as their lipophilicity and stable carbon-halogen bonds (Risebrough et al. 1968). In general, polychlorinated biphenyls have low aqueous solubility (Chou and Griffin 1986).

In terrestrial systems, PCBs are not readily leachable in soils and strongly sorb to soil constituents (Chou and Griffin 1986, Strek and Weber 1982). Their level in soil is proportional to the organic matter and clay content of the soil (Chou and Griffin 1986). Upon entering an aquatic system, PCBs may partition between the water, sediment, air, particulate matter, and biota (Koslowski et al. 1994). The more lipophilic and hydrophobic a substance, the more concentrated it will be in the sediment and phytoplankton of an aquatic system (Loizeau and Menesguen 1993). While it has been shown that transport of PCBs in the dissolved phase can be important during the warmer low flow periods of summer, PCBs are extremely lipophilic, and they generally sorb strongly to sediment particles. It has been shown that PCBs discharged to aquatic environments rapidly sorb to sediment and are usually deposited in bottom sediments, often close to the area of discharge (Kalmaz and Kalmaz 1979). After this, dispersal and movement of PCBs in aquatic systems depends largely on the movement of the associated sediments (Connell and Miller 1984).

**Toxicity:** Much of the toxicity caused by PCBs has been attributed to the planar congeners that resemble 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) (Geisy et al. 1994). The toxic nature of some prepared PCB mixtures may be associated with trace levels of compounds having four or more chlorine atoms at both the para and meta positions (Koslowski et al. 1994; Tanabe et al. 1987); the biphenyl structure may be substituted with one to ten chlorine atoms. These isostereomers of 2,3,7,8-TCDD are known to elicit toxic biological responses in animals such as hepatic damage, weight loss, thymic atrophy, dermal disorder, reproductive toxicity, immunosuppresion, teratogenicity, and functional effects to the spleen, adrenal and testis (Batty et al. 1990, Sanders et al. 1974, Tanabe et al. 1988).

Chlorinated hydrocarbons such as PCBs have been implicated as a cause of reproductive dysfunction and mortality in wildlife species (Heaton et al. 1995, Hoffman et al. 1986, Langford 1979). Exposure to PCBs has been found to reduce litter sizes at birth, number of litters, and longer birthing intervals in mice (Linzey

1987, Merson and Kirkpatrick 1976) and reduce plasma concentrations of estradiol and progesterone in female rats (Johnson et al. 1976). Transplacental movement of PCBs has been reported for humans, rabbits, monkeys, and rats causing a dose-dependent reduction in the body weights and survival of pre-natally, as well as post-natally, exposed mammalian offspring (Barsotti et al. 1976, Brezner et al. 1984, Fein et al. 1984; Heaton et al. 1995, Wren et al. 1987). PCB transfer to mammalian offspring continues via mother's milk (Wren et al. 1987). Polychlorinated biphenyls have been implicated as the cause of low embryonic weight in black-crowned night herons (*Nycticorax nycticorax*) (Hoffman et al. 1986). PCBs have also been shown to transfer from the mother to her eggs in fish (Niimi 1982; Mac and Schwartz 1992) and have been implicated in reduced hatching success, larval mortality, and larval growth of fish (Mac and Schwartz 1992; Mac et al. 1993). PCBs have also been associated with toxic effects on benthic invertebrates in freshwater systems (Smith et al. 1996).

## Literature Cited

Agency for Toxic Substances and Disease Registry (ATSDR). 2008a. Toxicological Profile for Aluminum. U.S. Department of Health and Human Service, Agency for Toxic Substances and Disease Registry, Atlanta, GA.

ATSDR. 2008b. Toxicological Profile for Manganese. U.S. Department of Health and Human Service, Agency for Toxic Substances and Disease Registry, Atlanta, GA.

ATSDR. 2007. Toxicological Profile for Barium and Compounds. U.S. Department of Health and Human Service, Agency for Toxic Substances and Disease Registry, Atlanta, GA.

ATSDR. 2005a. Toxicological Profile for Nickel. U.S. Department of Health and Human Service, Agency for Toxic Substances and Disease Registry, Atlanta, GA.

ATSDR. 2005b. Toxicological Profile for Tin. U.S. Department of Health and Human Service, Agency for Toxic Substances and Disease Registry, Atlanta, GA.

ATSDR. 2002. Toxicological Profile for Beryllium. U.S. Department of Health and Human Service, Agency for Toxic Substances and Disease Registry, Atlanta, GA.

ATSDR. 1992a. Toxicological Profile for Antimony. U.S. Department of Health and Human Service, Agency for Toxic Substances and Disease Registry, Atlanta, GA.

ATSDR. 1992b. Toxicological Profile for Cobalt. U.S. Department of Health and Human Service, Agency for Toxic Substances and Disease Registry, Atlanta, GA.

ATSDR. 1990. Toxicological Profile for Silver. U.S. Department of Health and Human Service, Agency for Toxic Substances and Disease Registry, Atlanta, GA.

Amdur, M.O., J. Doull and C.D. Klaassen (eds.). 1993. Casarett and Doull's Toxicology: The Basic Science of Poisons. Fourth Edition. New York, New York: McGraw-Hill, Inc.

Baes, C.F. III., R.D. Sharp, A.L. Sjoreen, and R.W. Shor. 1984. A review and analysis of parameters for assessing transport of environmentally released radionuclides through agriculture. Oak Ridge National Laboratory Report ORNL-5786.

Barsotti, D.A., R.J. Marlor, and J.R. Allen. 1976. Reproductive Dysfunction in Rhesus Monkeys Exposed to Low Levels of Polychlorinated Biphenyls (Aroclor® 1248). Fd. Cosmet. Toxicol., 14:99-103. In: Heaton, S.N., S.J. Bursian, J.P. Giesy, D.E. Tillitt, J.A. Render, P.D. Jones, D.A. Verbrugge, T.J. Kubiak, and R.J. Aulerich. 1995. Dietary Exposure of Mink to Carp from Saginaw Bay, Michigan. 1. Effects on Reproduction and Survival, and the Potential Risks to Wild Mink Populations. Arch. Environ. Contam. Toxicol., 28:334-343.

Batty, J., R.A. Leavitt, N. Biondo, and D. Polin. 1990. An Ecotoxicological Study of a Population of the White Footed Mouse (Peromyscus leucopus) Inhabiting a Polychlorinated Biphenyls-Contaminated Area. Arch. Environ. Contam. Toxicol. 19:283-290.

Baudin, J. P., J. Garnier-Laplace, and A. Lambrechts. 1994. Uptake from water, depuration and tissue distribution of 110m Ag in a freshwater fish Cyprinus carpio L. Water, Air, and Soil Pollution 72:129-141.

Bazzaz, F. A., R.W. Carlson, and G.L. Rolfe. 1974. The effect of heavy metals on plants: Part 1. Inhibition of gas exchange in sunflower by Pb, Cd, Ni, and Ti. Environ Pollut. 7:241-246.

Beijer, K., and A. Jernalov. 1979. Methylation of mercury in natural waters. Pages 201-210 in J.O. Nriagu (ed.). The Biogeochemistry of Mercury in the Environment. Elsevier/North-Holland Biomedical Press, New York.

Blume H.P. and G. Brummer. 1991. Prediction of heavy metal behaviour in soil by means of simple field tests. Ecotoxicol Environ Safety 22:164-174.

Bodek, I., W. J. Lyman, W. F. Reehl, and D. H. Rosenblatt. 1988. Environmental Inorganic Chemistry: Properties, Processes, and Estimation Methods. New York, NY: Pergamon Press.

Brady, N.C. 1974. The Nature and Property of Soils. 8th Edition. New York, NY: MacMillan Publishing Co. On. 639 p.

Brezner, S., J. Terkel, and A.S. Perry. 1984. The Effect of Aroclor® 1254 (PCB) on the Physiology of Reproduction in the Female Rat - I. Comp. Biochem. Physiol., 77C(1):65-70. In: Heaton, S.N., S.J. Bursian, J.P. Giesy, D.E. Tillitt, J.A. Render, P.D. Jones, D.A. Verbrugge, T.J. Kubiak, and R.J. Aulerich. 1995. Dietary Exposure of Mink to Carp from Saginaw Bay, Michigan. 1. Effects on Reproduction and Survival, and the Potential Risks to Wild Mink Populations. Arch. Environ. Contam. Toxicol., 28:334-343.

Brooks, L. 1988. Inhibition of NADPH-cytochrome c reductase and attenuation of

acute diethylnitrosamine hepatotoxicity by copper. Ph.D. Dissertation, Rutgers University, New Brunswick, N.J.

Chang, A. C., A. L. Page, J. E. Warneke, M. R. Resketo, and T. E. Jones. 1983. Accumulation of cadmium and zinc in barley grown on sludge-treated soils: a longterm field study. Journal of Environmental Quality 12:391-397.

Chou, S.F.J. and R.A. Griffin. 1986. Solubility and Soil Mobility of Polychlorinated Biphenyls." Pages 101-120 in "PCBs and the Environment, Volume I. (J.S. Waid, ed.). CRC Press, Boca Raton, Florida. 228p.

Clarkson, T.W. and D.O. Marsh. 1982. Mercury toxicity in man. Pp. 549-568 in: Prasad, A.S. (ed.). Clinical, Biochemical, and Nutritional Aspects of Trace Elements. Vol. 6. Alan R. Liss, Inc., New York, NY.

Connell, D.W. and G.J. Miller. 1984. Chemistry and Ecotoxicology of Pollution. New York, NY: John Wiley & Sons, Inc. 444 p.

Demayo, A., M.C. Taylor and K.W. Taylor. 1982. Effects of copper on humans, laboratory and farm animals, terrestrial plants and aquatic life. *CRC Critical Reviews in Environmental Control*, 12(3):183-255.

Diaz, G.J., R.J. Julian, and E.J. Squires. 1994a. "Cobalt-induced polycythaemia causing right ventricular hypertrophy and ascites in meat-type chickens." Avian Pathol., 23:91-104.

Diaz, G.J., R.J. Julian, and E.J. Squires. 1994b. "Lesions in broiler chickens following experimental intoxication with cobalt." Avian Diseases, 38:308-316.

Drury, J.S., C.R. Shriner, E.B. Lewis, L.E. Towill, and A.S. Hammons. 1978. Reviews of the environmental effects of pollutants: VI. Beryllium\rdblquote. Prepared for Office of Research and Development, U.S. Environmental Protection Agency. EPA-600/1-78-028.

Efroymson, R.A., M. E. Will, G.W. Suter, and A.C. Wooten. 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN.

Eisler, R. 1996. Silver hazards to fish, wildlife, and invertebrates: A synoptic review. National Biological Service Biological Report 32. 44 pp.

Eisler, R. 1993. Zinc Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. U. S. Fish and Wildlife Service Biological Report 10. 106 pp.

Eisler, R. 1988a. Arsenic Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. U.S. Fish and Wildlife Service Biological Report, 85(1.12). 92 p.

Eisler, R. 1988b. Lead Hazards to Fish, Wildlife, and Invertebrates: A Synoptic

Review. U.S. Fish and Wildlife Service Biological Report, 85(1.14). 134 p.

Eisler, R. 1987a. Mercury Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. U.S. Fish and Wildlife Service Biological Report 85(1.10).

Eisler, R. 1987b. Polycyclic Aromatic Hydrocarbon Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. U.S. Fish and Wildlife Service Biological Report, 85(1.11). 81 p.

Eisler, R. 1986a. Chromium Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. U.S. Fish and Wildlife Service Biological Report 85 (1.6).

Eisler, R. 1986b. Polychlorinated Biphenyl Hazards to Fish, Wildlife and Invertebrates: A Synoptic Review. U.S. Fish and Wildlife Service Biological Report, 85 (1.7). 72 pp.

Eisler, R. 1985a. Cadmium Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. U.S. Fish and Wildlife Service Biological Report 85 (1.2).

Eisler R. 1985b. Selenium Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. U.S. Fish and Wildlife Service Biological Report 85 (1.5).

EPA. 2005a. Ecological Soil Screening Levels (Eco-SSLs). Cadmium. Washington, D.C.: U.S. Environmental Protection Agency.

EPA. 2005b. Ecological Soil Screening Levels (Eco-SSLs). Vanadium. Washington, D.C.: U.S. Environmental Protection Agency.

EPA. 2003. Ecological Soil Screening Levels (Eco-SSLs). Iron. Washington, D.C.: U.S. Environmental Protection Agency.

EPA. 1986. Quality Criteria for Water. U.S. Environmental Protection. Agency Rep. 440-5-86-001.

EPA. 1980. Ambient Water Quality Criteria for Beryllium. Office of Water Regulations and Standards. PB81-117350.

Fein, C.G., J.L. Jacobsen, S.W. Jacobsen, P.M. Schwartz, and J.K. Dowler. 1984. Prenatal Exposure to Polychlorinated Biphenyls: Effects on Birth Size and Gestational Age. J. Ped., 105(2):315-320. In: Heaton, S.N., S.J. Bursian, J.P. Giesy, D.E. Tillitt, J.A. Render, P.D. Jones, D.A. Verbrugge, T.J. Kubiak, and R.J. Aulerich. 1995. Dietary Exposure of Mink to Carp from Saginaw Bay, Michigan. 1. Effects on Reproduction and Survival, and the Potential Risks to Wild Mink Populations. Arch. Environ. Contam. Toxicol., 28:334-343.

Friberg, L., G. F. Norberg, and V. B. Vouk (editors). 1979. Handbook of the Toxicity of Metals. Elsevier/North-Holland Biomedical Press, Amsterdam, NY. 748 pp.

Fourman, G.L. 1989. Enzymes involved in the metabolism of PAHs by fish and other

aquatic animals: Part II, conjugative enzymes (or Phase II enzymes). In: Metabolism of Polycyclic Aromatic Hydrocarbons in the Aquatic Environment. Ed. U. Varnasi. Boca Raton, FL: CRC Press. p. 185-202.

Giesy, J.P., D.A. Verbugge, R.A. Othout, W.W. Bowerman, M.A. Mora, P.D. Jones, J.L. Newsted, C. Vandervoort, S.N. Heaton, R.J. Aulerich, S.J. Bursian, J.P. Ludwig, G.A. Dawson, T.J. Kubiak, D.A. Best, and D.E. Tillitt. 1994. "Contaminants in Fishes from Great Lakes-Influenced Sections and Above Dams of Three Michigan Rivers. II: Implications for Health of Mink. Arch. Environ. Contam. Toxicol., 27:213-223.

Gilani, S.H. and Y. Alibhai. 1990. "Teratogenicity of metals to chick embryos." J. Tox. Environ. Health, 30:23-31.

Goyer, R.A. 1986. "Toxic effects of metals." In: Casarett and Doull's Toxicology. Eds. C.D. Klaussen, M.O. Amdur, and J. Doull. Third Edition. New York, NY: Macmillan. p. 582-635.

Hammons, A.S., J.E. Huff, H.M. Braunstein, J.S. Drury, C.R. Shriner, E.B. Lewis, B.L. Whitfield, and L.E. Towill. 1978. Reviews of the Environmental Effects of Pollutants: IV Cadmium. EPA 600/1-78-026. 251pp.

Hatch, R.C. 1978. "Poisons Causing Respiratory Insufficiency. In: Veterinary Pharmacology and Therapeutics. L.M. Jones, N.H. Booth and L.E. McDonald (eds.). Ames Press, Iowa State University. Ames, Iowa.

Hazardous Substances Data Bank (HSDB). 2010. National Library of Medicine, online database (http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB)

Heaton, S.N., S.J. Bursian, J.P. Giesy, D.E. Tillitt, J.A. Render, P.D. Jones, D.A. Verbrugge, T.J. Kubiak, and R.J. Aulerich. 1995. Dietary Exposure of Mink to Carp from Saginaw Bay, Michigan. 1. Effects on Reproduction and Survival, and the Potential Risks to Wild Mink Populations. Arch. Environ. Contam. Toxicol., 28:334-343.

Hoffman, D.J., B.A. Rattner, C.M. Bunck, H.M. Ohlendorf, and R.W. Lowe. 1986. Association Between PCBs and Lower Embryonic Weight in Black-Crowned Night Herons in San Francisco Bay. J. Toxicol. Environ. Health, 19:383-391.

Hopkins, L. L., H.L. Cannon, A.T. Musch, R.M. Welch, and F.H. Neilsen. 1977. Vanadium. Geochem. Environ. 2: 93-107.

Hornshaw, T.C., R.J. Aulerich, H.E. Johnson. 1983. Feeding Great Lakes Fish to Mink: Effects on Mink and Accumulation and Elimination of PCBs by Mink. J. Toxicol. Environ. Health, 11:933-946.

Huckabee, J.W., J.M. Elwood, and S.G. Hildebrand. 1979. Accumulation of Mercury in Freshwater Biota. Pp. 277-302 in Nriagu, J.O. (ed). The Biogeochemistry of Mercury in the Environment. New York, NY: Elsevier/North-Holland Biomedical Press.

Irwin, R.J., M. Van Mouwerik, L. Stevens, M.D. Seese, and W. Basham. 1997. Environmental Contaminants Encyclopedia. National Park Service, Water Resources Division, Fort Collins, Colorado.

James, B.R., and R.J. Bartlett. 1983a. Behavior of chromium in soils: V. Fate of organically complexed Cr(III) added to soil. J. Environ. Qual. 12:169-172.

James, B.R., and R.J. Bartlett. 1983b. Behavior of chromium in soils: VI. Interactions between oxidation-reduction and organic complexation. J. Environ. FQual. 12:173-176.

Johnson, H.T., J.E. Keil, R.G. Gaddy, C.B. Loadholt, G.R. Henigar, and E.M. Walker. 1976. Prolonged Ingestion of Commercial DDT and PCB: Effects on Progesterone Levels and Reproduction in the Mature Female Rat. Arch. Environ. Contam. Toxicol. 3:479-490. In: Linzey, A.V. 1987. Effects of Chronic Polychlorinated Biphenyls Exposure on Reproductive Success of White-footed Mice (*Peromyscus leucopus*). Arch. Environ. Contam. Toxicol. 16:455-460.
-95/R4.

Kaji, T., R. Kawatani, M. Takata, T. Hoshino, T. Miyahara, H. Konzuka, and F. Koizumi. 1988. The effects of cadmium, copper or zinc on formation of embryonic chick bone in tissue culture. Toxicology, 50:303-316.
Kalmaz, E.V. and Kalmaz, G.D. 1979. Transport, Distribution, and Toxic Effects of Polychlorinated Biphenyls in Ecosystems: Review. Ecological Modelling, 6:223.

Kazacos, E.A. and J.F. Van Vleet. 1989. Sequential ultrastructural changes of the pancreas in zinc toxicosis in ducklings. American Journal of Pathology 134:581-595.

Klassen, C.D., M.O. Amdur and J. Doull. 1986. Casarett and Doull's Toxicology. 3rd ed. New York: MacMillan Publishing Company. 974 p.

Koslowski, S.E., C.D. Metcalfe, R. Lazar, and G.D. Haffner. 1994. The Distribution of 42 PCBs, Including Three Coplanar Congeners, in the Food Web of the Western Basin of Lake Erie. J. Great Lakes Res. 20:260-270.

Langard, S. and T. Norseth. 1979. Chromium. Pages 383-397 in L. Friberg, G. F. Nordberg, and V. B. Vouk (eds.). Handbook on the toxicology of metals. Elsevier/North Holland Biomedical Press.

Langford, H.D. 1979. Looking at Polychlorinated Biphenyls as Environmental Object Lesson. News Rep., 29(9):1-5. In: Heaton, S.N., S.J. Bursian, J.P. Giesy, D.E. Tillitt, J.A. Render, P.D. Jones, D.A. Verbrugge, T.J. Kubiak, and R.J. Aulerich. 1995. Dietary Exposure of Mink to Carp from Saginaw Bay, Michigan. 1. Effects on Reproduction and Survival, and the Potential Risks to Wild Mink Populations. Arch. Environ. Contam. Toxicol., 28:334-343.

Lintschinget, J. B. Michalke, S. Schulte-Hostede and P. Schramel. 1998. Studies on speciation of antimony in soil contaminated by industrial activity. Intern. J. Environ. Anal. Chem. 72(1):11-25.

Linzey, A.V. 1987. Effects of Chronic Polychlorinated Biphenyls Exposure on Reproductive Success of White-footed Mice (*Peromyscus leucopus*). Arch. Environ. Contam. Toxicol. 16:455-460.

Loizeau, V. and A. Menesguen. 1993. A Steady-state Model of PCB Accumulation in Dab Food Web. Oceanologica Acta, 16:633-640.

Lu, J. and G.F. Combs. 1988. Effects of excess dietary zinc on pancreatic exocrine function in the chick. J. Nutrition 118:681-689.

Mac, M.J., T.R. Schwartz, C.C. Edsall, and A.M. Frank. 1993. Polychlorinated biphenyls in Great Lakes lake trout and their eggs: Relations to survival and congener composition 1979-1988. J. Great Lakes Res., 19:752-765.

Mac, M.J. and T.R. Schwartz. 1992. Investigations into the Effects of PCB Congeners on Reproduction in Lake Trout from the Great Lakes. Chemosphere, 25:189-192.
Mac, M.J. and C.C. Edsall. 1991. Environmental Contaminants and the Reproductive Success of Lake Trout in the Great Lakes: An Epidemiological Approach. Journal of Toxicology and Environmental Health, 33:375-394.

Merson, M.H. and R.L. Kirkpatrick. 1976. Reproductive Performance of Captive White-footed Mice Fed a PCB. Bull. Environ. Contam. Toxicol. 16:392-398.

Mollenhauer, H.H., D.E. Corrier, D.E. Clark, M.F. Hare, and M.H. Elissalde. 1985. "Effects of dietary cobalt on testicular structure." Virchow Arch (Cell Pathol), 49:241-248.

Mulkey , J.P. and F.W. Oehme. 1993. A review of thallium toxicity. Vet. Human Toxicol., 35(5):445-453.

Nash, T. H., III. 1975. Influence of effluents from a zinc factory on lichens. Ecological Monograph 4,5: 183-198.

Nation, J.R., A.E. Bourgeois, D.E. Clark, and M.F. Hare. 1983. "The effects of chronic cobalt exposure on behavior and metallothionein levels in the adult rat." Neurobehav. Toxicol. Teratol., 5:9-15.

National Academy of Sciences (NAS). 1980. Antimony. Pages 24- 39 in: Mineral Tolerance of Domestic Animals.

Nechay, B.R. and J.P. Saunders. 1978. Inhibition by vanadium of sodium and potassium dependent ATPase derived from animal and human tissues. J. Environ. Pathol. Toxicol. 2:247-262.

Niimi, A.J. 1982. Biological and Toxicological Effects of Environmental Contaminants in Fish and Their Eggs. Can. J. Fish. Aquat. Sci., 40:306-312.

NRC. 1980. Drinking Water and Health, Volume 3. National Research Council. Washington, D.C.: National Academy Press.

Ogden, L., W. C. Edwards, and N. A. Nail. 1988. Zinc intoxication in a dog from the ingestion of copper clad zinc pennies. Veterinary and Human Toxicology 30:577-578.

Peakall, D. 1993. Animal Biomarkers as Pollution Indicators. Ecotoxicology Series 1. London, England: Chapman and Hall.

Risebrough, R.W., P. Rieche, D.B. Peakall, S.G. Herman, and M.N. Kirven. 1968. Polychorinated Biphenyls in the Global Ecosystem. Nature (Lond.) 220:1098-1102. In: Kluwe, W.M., C.L. Herrmann, and J.B. Hook. 1979. Effects of Dietary Polychlorinated Biphenyls and Polybrominated Biphenyls on the Renal and Hepatic Toxicities of Several Chlorinated Hydrocarbon Solvents in Mice. J. Toxicol. Environ. Health 5:605-615.

Sanders, O.T., R.L. Zepp, and R.L. Kirkpatrick. 1974. Effect of PCB Ingestion on Sleeping Times, Organ Weights, Food Consumption, Serum Corticosterone and Survival of Albino Mice. Bull. Environ. Contam. Toxicol. 12:394-398.

Shacklette, H.T. and J.G. Boerngen. 1984. Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States. Alexandria, VA: USGS. 105 p.

Shore, R. and P. Douben. 1994. The ecotoxicological significance of cadmium intake and residues in terrestrial small mammals. Ecotoxicol. Environ. Safe. 29: 101-112.

Smith, I.C. and B.L. Carson. 1977. Trace metals in the environment. Vol 2: Silver. Ann Arbor Science Publishers, Ann Arbor, MI. 469 pp.

Smith, S.L., D.D. MacDonald, K.A. Keenleyside, C.G. Ingersoll, and L.J. Field. 1996. A preliminary evaluation of sediment quality assessment values for freshwater ecosystems. J. Great Lakes Res., 22:624-638.

Southern, L.L. and D.H. Baker, 1981. "The effect of methionine or cysteine on cobalt toxicity in the chick." Poultry Sci., 60:1303-1308.

Stein, J.E., W.L. Reichert, M. Nishimoto and U. Varnasi. 1990. Overview of studies on liver carcinogenesis in English sole from Puget Sound: evidence for a xenobiotic chemical etiology. II: biochemical studies. Sci. Tot. Environment, 94:51-69.

Steven, J. D., L. J. Davies, E. K. Stanley, R. A. Abbott, M. Ihnat, L. Bidstrup, and J. F. Jaworski. 1976. Effects of Chromium in the Canadian Environment. Nat. Res. Coun. Canada, NRCC No. 15017. 168 pp. Avail. from Publications, NRCC/CNRC, Ottawa, Canada, K1A OR6.

Strek, H.J. and J.B. Weber. 1982. Behavior of Polychlorinated Biphenyls (PCBs) in Soils and Plants. Environ. Poll. (Series A). 28:291-312.

Tanabe, S. 1988. PCB Problems in the Future: Foresight from Current Knowledge. Environ. Pollut., 50:5-28.

Towill, L. E., C. R. Shriner, J. S. Drury, A. S. Hammons, and J. W. Holleman. 1978.

Reviews of the Environmental Effects of Pollutants: III Chromium. EPA 600/1-78-023. 287 pp.

Venugopal, B. and T.D. Luckey. 1978. Metal Toxicity in Mammals. 2. Chemical Toxicity of Metals and Metalloids. Plenum Press, New York, NY, pp. 24-32.

Wixson, B.G. and B.E. Davis. 1993. Lead in Soil. Lead in Soil Task Force, Science Reviews, Northwood.132 p.

Wren, C.D., D.B. Hunter, J.F. Leatherland, and P.M. Stokes. 1987. The Effects of Polychlorinated Biphenyls and Methylmercury, Singly and in Combination on Mink. I: Uptake and Toxic and Toxic Responses. Arch. Environ. Contam. Toxicol., 16:441-447.

Varnasi, U., W.L. Reichert and J.E. Stein. 1989. $^{32}$P-Postlabeling Analysis of DNA adducts in liver of wild English sole (*Parophrys vetulus*) and winter flounder (*Pseudopleuronectes americanus*). Cancer Research, 49:1171-1177.

# Appendix C

# Comparison of One Half of the Maximum Reporting Limits for Non-Detected Chemicals to Ecological Screening Levels

**Appendix C**
**Comparison of One Half of the Maximum Reporting Limits for Non-Detected Chemicals in Area 9 Soil to Ecological Screening Levels**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | CAS No. | Reporting Limit | | Screening Level | Hazard Quotient |
|---|---|---|---|---|---|
| | | Maximum | One Half Maximum | | |
| **Volatile Organic Compounds (µg/kg)** | | | | | |
| 1,1,2-Trichloro-1,2,2-trifluoroethane | 76-13-1 | 7.7 | 3.85 | NL | NC |
| Bromochloromethane | 74-97-5 | 7.7 | 3.85 | NL | NC |
| Chloroethane | 75-00-3 | 7.7 | 3.85 | NL | NC |
| cis-1,2-Dichloroethene | 156-59-2 | 7.7 | 3.85 | NL | NC |
| Cyclohexane | 110-82-7 | 7.7 | 3.85 | NL | NC |
| Methyl Acetate | 79-20-9 | 7.7 | 3.85 | NL | NC |
| Methyl tert-Butyl Ether | 1634-04-4 | 7.7 | 3.85 | NL | NC |
| Methylcyclohexane | 108-87-2 | 7.7 | 3.85 | NL | NC |
| **Semi-volatile Organic Compounds (µg/kg)** | | | | | |
| 2,4-Dimethylphenol | 105-67-9 | 130 | 65 | 10 | **6.5** |
| 2,6-Dinitrotoluene | 606-20-2 | 130 | 65 | 32.8 | **2.0** |
| 2-Chloronaphthalene | 91-58-7 | 190 | 95 | 12.2 | **7.8** |
| 2-Chlorophenol | 95-57-8 | 250 | 125 | 243 | 0.5 |
| 4,6-Dinitro-2-Methylphenol | 534-52-1 | 380 | 190 | 144 | **1.3** |
| 4-Bromophenyl Phenyl Ether | 101-55-3 | 250 | 125 | NL | NC |
| 4-Chloro-3-Methylphenol | 59-50-7 | 250 | 125 | NL | NC |
| 4-Chlorophenyl Phenylether | 7005-72-3 | 250 | 125 | NL | NC |
| Atrazine | 1912-24-9 | 250 | 125 | NL | NC |
| Bis(2-Chloroethoxy) methane | 111-91-1 | 250 | 125 | 302 | 0.4 |
| Bis-Chloroisopropyl ether | 108-60-1 | 250 | 125 | NL | NC |
| Caprolactam | 105-60-2 | 250 | 125 | NL | NC |
| Chlorophenols | 58-90-2 | 250 | 125 | 243 | 0.5 |
| Hexachlorobenzene | 118-74-1 | 250 | 125 | 199 | 0.6 |
| Hexachlorobutadiene | 87-68-3 | 190 | 95 | 39.8 | **2.4** |
| N-Nitroso-Di-N-Propylamine | 621-64-7 | 190 | 95 | NL | NC |
| **Pesticides (µg/kg)** | | | | | |
| Aldrin | 309-00-2 | 13 | 6.5 | 3.32 | **2.0** |
| Beta-BHC | 319-85-7 | 13 | 6.5 | 3.98 | **1.6** |
| Chlorinated Camphene | 8001-35-2 | 910 | 455 | NL | NC |
| Endrin Aldehyde | 7421-93-4 | 25 | 12.5 | 10.5 | **1.2** |
| Endrin Ketone | 53494-70-5 | 25 | 12.5 | 10.1 | **1.2** |
| Gamma-BHC (Lindane) | 58-89-9 | 13 | 6.5 | 5 | **1.3** |
| Heptachlor | 76-44-8 | 13 | 6.5 | 5.98 | **1.1** |

Notes:
NC - Hazard quotient not calculated
NL - Ecological screening level not located
µg/kg - micrograms per kilogram
mg/kg - milligrams per kilogram
Bold - Hazard Quotient greater than 1.0

**Appendix C**
**Comparison of One Half of the Maximum Reporting Limits for Non-Detected Chemicals in Area 9 Sediment to Ecological Screening Levels**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | CAS No. | Reporting Limit | | Screening Level | Hazard Quotient |
|---|---|---|---|---|---|
| | | Maximum | One Half Maximum | | |
| **Volatile Organic Compounds (µg/kg)** | | | | | |
| 1,1,2-Trichloro-1,2,2-trifluoroethane | 76-13-1 | 35 | 17.5 | NL | NC |
| 1,1-Dichloroethane | 75-34-3 | 7.1 | 3.55 | NL | NC |
| 1,2-Dibromo-3-chloropropane | 96-12-8 | 35 | 17.5 | NL | NC |
| 1,2-Dibromoethane | 106-93-4 | 35 | 17.5 | NL | NC |
| 1,2-Dichloroethane | 107-06-2 | 35 | 17.5 | NL | NC |
| 1,2-Dichloropropane | 78-87-5 | 35 | 17.5 | NL | NC |
| 2-Hexanone | 591-78-6 | 69 | 34.5 | NL | NC |
| 4-Methyl-2-Pentanone | 108-10-1 | 69 | 34.5 | NL | NC |
| Bromochloromethane | 74-97-5 | 35 | 17.5 | NL | NC |
| Bromodichloromethane | 75-27-4 | 35 | 17.5 | NL | NC |
| Bromomethane | 74-83-9 | 35 | 17.5 | NL | NC |
| Chloroethane | 75-00-3 | 35 | 17.5 | NL | NC |
| Chloroform | 67-66-3 | 35 | 17.5 | NL | NC |
| Chloromethane | 74-87-3 | 35 | 17.5 | NL | NC |
| cis-1,2-Dichloroethene | 156-59-2 | 35 | 17.5 | NL | NC |
| cis-1,3-Dichloropropene | 10061-01-5 | 35 | 17.5 | NL | NC |
| Cyclohexane | 110-82-7 | 35 | 17.5 | NL | NC |
| Dibromochloromethane | 124-48-1 | 35 | 17.5 | NL | NC |
| Dichlorodifluoromethane | 75-71-8 | 35 | 17.5 | NL | NC |
| Methyl Acetate | 79-20-9 | 35 | 17.5 | NL | NC |
| Methyl tert-Butyl Ether | 1634-04-4 | 35 | 17.5 | NL | NC |
| Methylcyclohexane | 108-87-2 | 35 | 17.5 | NL | NC |
| Methylene chloride | 75-09-2 | 35 | 17.5 | NL | NC |
| trans-1,3-Dichloropropene | 10061-02-6 | 35 | 17.5 | NL | NC |
| Trichlorofluoromethane | 75-69-4 | 35 | 17.5 | NL | NC |
| Vinyl Chloride | 75-01-4 | 35 | 17.5 | NL | NC |
| **Semi-volatile Organic Compounds (µg/kg)** | | | | | |
| 2,4,5-Trichlorophenol | 95-95-4 | 1000 | 500 | 819 | 0.6 |
| 2,4-Dichlorophenol | 120-83-2 | 500 | 250 | 117 | **2.1** |
| 2,4-Dimethylphenol | 105-67-9 | 500 | 250 | 29 | **8.6** |
| 2,4-Dinitrophenol | 51-28-5 | 500 | 250 | NL | NC |
| 2,4-Dinitrotoluene | 121-14-2 | 500 | 250 | 41.6 | **6.0** |
| 2,6-Dinitrotoluene | 606-20-2 | 500 | 250 | NL | NC |
| 2-Chloronaphthalene | 91-58-7 | 1000 | 500 | NL | NC |
| 2-Chlorophenol | 95-57-8 | 500 | 250 | 344 | 0.7 |
| 2-Methylphenol | 95-48-7 | 500 | 250 | NL | NC |
| 2-Nitroaniline | 88-74-4 | 1900 | 950 | NL | NC |
| 2-Nitrophenol | 88-75-5 | 1000 | 500 | NL | NC |
| 3-Nitroaniline | 99-09-2 | 1900 | 950 | NL | NC |
| 4,6-Dinitro-2-Methylphenol | 534-52-1 | 1900 | 950 | NL | NC |
| 4-Bromophenyl Phenyl Ether | 101-55-3 | 1000 | 500 | 1230 | 0.4 |
| 4-Chloro-3-Methylphenol | 59-50-7 | 1000 | 500 | NL | NC |
| 4-Chloroaniline | 106-47-8 | 500 | 250 | NL | NC |

**Appendix C**
**Comparison of One Half of the Maximum Reporting Limits for Non-Detected Chemicals in Area 9 Sediment to Ecological Screening Levels**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | CAS No. | Reporting Limit | | Screening Level | Hazard Quotient |
|---|---|---|---|---|---|
| | | Maximum | One Half Maximum | | |
| 4-Chlorophenyl Phenylether | 7005-72-3 | 1000 | 500 | NL | NC |
| 4-Methylphenol | 106-44-5 | 1000 | 500 | 670 | 0.7 |
| 4-Nitroaniline | 100-01-6 | 1900 | 950 | NL | NC |
| 4-Nitrophenol | 100-02-7 | 1900 | 950 | NL | NC |
| Atrazine | 1912-24-9 | 500 | 250 | 6.62 | **38** |
| Benzaldehyde | 100-52-7 | 1000 | 500 | NL | NC |
| Bis(2-Chloroethoxy) methane | 111-91-1 | 1000 | 500 | NL | NC |
| Bis(2-Chloroethyl) ether | 111-44-4 | 1000 | 500 | NL | NC |
| Bis-Chloroisopropyl ether | 108-60-1 | 1000 | 500 | NL | NC |
| Caprolactam | 105-60-2 | 1000 | 500 | NL | NC |
| Chlorophenols | 58-90-2 | 1000 | 500 | 344 | **1.5** |
| Diethylphthalate | 84-66-2 | 1000 | 500 | 218 | **2.3** |
| Dimethylphthalate | 131-11-3 | 1000 | 500 | NL | NC |
| Di-N-Octyl Phthalate | 117-84-0 | 1000 | 500 | NL | NC |
| Hexachlorobenzene | 118-74-1 | 500 | 250 | NL | NC |
| Hexachlorobutadiene | 87-68-3 | 1000 | 500 | NL | NC |
| Hexachlorocyclopentadiene | 77-47-4 | 1000 | 500 | 139 | **3.6** |
| Hexachloroethane | 67-72-1 | 1000 | 500 | 804 | 0.6 |
| Isophorone | 78-59-1 | 1000 | 500 | NL | NC |
| Nitrobenzene | 98-95-3 | 1000 | 500 | NL | NC |
| N-Nitroso-Di-N-Propylamine | 621-64-7 | 1000 | 500 | NL | NC |
| Phenol | 108-95-2 | 1000 | 500 | 420 | **1.2** |
| **Pesticides/PCBs (µg/kg)** | | | | | |
| 4,4'-DDD | 72-54-8 | 7.6 | 3.8 | 2 | **1.9** |
| 4,4'-DDE | 72-55-9 | 7.6 | 3.8 | 2.2 | **1.7** |
| 4,4'-DDT | 50-29-3 | 7.6 | 3.8 | 1 | **3.8** |
| Aldrin | 309-00-2 | 3.9 | 1.95 | 2 | 1.0 |
| Alpha-BHC | 319-84-6 | 3.9 | 1.95 | 3 | 0.7 |
| Beta-BHC | 319-85-7 | 3.9 | 1.95 | 3 | 0.7 |
| Chlorinated Camphene | 8001-35-2 | 390 | 195 | NL | NC |
| Delta-BHC | 319-86-8 | 3.9 | 1.95 | 3 | 0.7 |
| Endosulfan I | 959-98-8 | 3.9 | 1.95 | 2.9 | 0.7 |
| Endosulfan II | 33213-65-9 | 7.6 | 3.8 | 14 | 0.3 |
| Endosulfan Sulfate | 1031-07-8 | 7.6 | 3.8 | 0.357 | **11** |
| Endrin | 72-20-8 | 7.6 | 3.8 | 3 | **1.3** |
| Endrin Aldehyde | 7421-93-4 | 7.6 | 3.8 | NL | NC |
| Endrin Ketone | 53494-70-5 | 7.6 | 3.8 | NL | NC |
| Gamma-BHC (Lindane) | 58-89-9 | 3.9 | 1.95 | 0.32 | **6.1** |
| Aroclor 1016 | 12674-11-2 | 36 | 18 | 7 | **2.6** |
| Aroclor 1221 | 11104-28-2 | 36 | 18 | 23 | 0.8 |
| Aroclor 1232 | 11141-16-5 | 36 | 18 | 23 | 0.8 |
| Aroclor 1242 | 53469-21-9 | 36 | 18 | 23 | 0.8 |

**Appendix C**
**Comparison of One Half of the Maximum Reporting Limits for Non-Detected Chemicals in Area 9 Sediment to Ecological Screening Levels**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | CAS No. | Reporting Limit | | Screening Level | Hazard Quotient |
|---|---|---|---|---|---|
| | | Maximum | One Half Maximum | | |
| Aroclor 1248 | 12672-29-6 | 36 | 18 | 30 | 0.6 |
| Aroclor 1260 | 11096-82-5 | 36 | 18 | 5 | **3.6** |
| Aroclor 1262 | 37324-23-5 | 36 | 18 | 23 | 0.8 |
| Aroclor 1268 | 11100-14-4 | 36 | 18 | 23 | 0.8 |
| **Inorganics (mg/kg)** | | | | | |
| Tin | 7440-31-5 | 10 | 5 | NL | NC |

Notes:
NC - Hazard quotient not calculated
NL - Ecological screening level not located
µg/kg - micrograms per kilogram
mg/kg - milligrams per kilogram
Bold - Hazard Quotient greater than 1.0

**Appendix C**
**Comparison of One Half of the Maximum Reporting Limits for Non-Detected Chemicals in Area 9 Surface Water to Ecological Screening Levels**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | CAS No. | Reporting Limit | | Screening Level | Hazard Quotient |
|---|---|---|---|---|---|
| | | Maximum | One Half Maximum | | |
| **Volatile Organic Compounds (µg/L)** | | | | | |
| 1,1,2-Trichloro-1,2,2-trifluoroethane | 76-13-1 | 0.5 | 0.25 | NL | NC |
| 1,2-Dibromo-3-chloropropane | 96-12-8 | 0.5 | 0.25 | NL | NC |
| 1,2-Dibromoethane | 106-93-4 | 0.5 | 0.25 | NL | NC |
| Bromochloromethane | 74-97-5 | 0.5 | 0.25 | NL | NC |
| Bromodichloromethane | 75-27-4 | 0.5 | 0.25 | NL | NC |
| Chloroethane | 75-00-3 | 0.5 | 0.25 | NL | NC |
| cis-1,2-Dichloroethene | 156-59-2 | 0.5 | 0.25 | NL | NC |
| cis-1,3-Dichloropropene | 10061-01-5 | 0.5 | 0.25 | 7.9 | 0.03 |
| Cyclohexane | 110-82-7 | 0.5 | 0.25 | NL | NC |
| Dibromochloromethane | 124-48-1 | 0.5 | 0.25 | NL | NC |
| Dichlorodifluoromethane | 75-71-8 | 0.5 | 0.25 | NL | NC |
| Methyl Acetate | 79-20-9 | 0.5 | 0.25 | NL | NC |
| Methylcyclohexane | 108-87-2 | 0.5 | 0.25 | NL | NC |
| o-Xylene | 95-47-6 | 0.5 | 0.25 | 19 | 0.01 |
| trans-1,3-Dichloropropene | 10061-02-6 | 0.5 | 0.25 | 7.9 | 0.03 |
| Trichlorofluoromethane | 75-69-4 | 0.5 | 0.25 | NL | NC |
| **Semi-volatile Organic Compounds (µg/L)** | | | | | |
| 2,4-Dimethylphenol | 105-67-9 | 5 | 2.5 | NL | NC |
| 2-Chloronaphthalene | 91-58-7 | 5 | 2.5 | NL | NC |
| 2-Methylnaphthalene | 91-57-6 | 5 | 2.5 | 4.2 | 0.60 |
| 2-Nitroaniline | 88-74-4 | 10 | 5 | NL | NC |
| 3-Nitroaniline | 99-09-2 | 10 | 5 | NL | NC |
| 4,6-Dinitro-2-Methylphenol | 534-52-1 | 10 | 5 | NL | NC |
| 4-Bromophenyl Phenyl Ether | 101-55-3 | 5 | 2.5 | 1.5 | **1.7** |
| 4-Chloro-3-Methylphenol | 59-50-7 | 5 | 2.5 | NL | NC |
| 4-Chlorophenyl Phenylether | 7005-72-3 | 5 | 2.5 | NL | NC |
| 4-Nitroaniline | 100-01-6 | 10 | 5 | NL | NC |
| Acenaphthylene | 208-96-8 | 5 | 2.5 | NL | NC |
| Acetophenone | 98-86-2 | 5 | 2.5 | NL | NC |
| Anthracene | 120-12-7 | 5 | 2.5 | 0.18 | **14** |
| Atrazine | 1912-24-9 | 5 | 2.5 | 1.8 | **1.4** |
| Benzaldehyde | 100-52-7 | 5 | 2.5 | NL | NC |
| Benzo(a)pyrene | 50-32-8 | 5 | 2.5 | 0.015 | **167** |
| Benzo(b)fluoranthene | 205-99-2 | 5 | 2.5 | NL | NC |
| Benzo(g,h,i)perylene | 191-24-2 | 5 | 2.5 | NL | NC |
| Benzo(k)fluoranthene | 207-08-9 | 5 | 2.5 | NL | NC |
| Bis(2-Chloroethoxy) methane | 111-91-1 | 5 | 2.5 | NL | NC |
| Bis(2-Chloroethyl) ether | 111-44-4 | 5 | 2.5 | NL | NC |
| Bis-Chloroisopropyl ether | 108-60-1 | 5 | 2.5 | NL | NC |
| Caprolactam | 105-60-2 | 5 | 2.5 | NL | NC |
| Carbazole | 86-74-8 | 5 | 2.5 | NL | NC |
| Chlorophenols | 58-90-2 | 5 | 2.5 | 265 | 0.01 |
| Chrysene | 218-01-9 | 5 | 2.5 | NL | NC |
| Dibenzo(a,h)anthracene | 53-70-3 | 5 | 2.5 | NL | NC |
| Di-N-Butylphthalate | 84-74-2 | 5 | 2.5 | 3.4 | 0.7 |

**Appendix C**
**Comparison of One Half of the Maximum Reporting Limits for Non-Detected Chemicals in Area 9 Surface Water to Ecological Screening Levels**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | CAS No. | Reporting Limit | | Screening Level | Hazard Quotient |
|---|---|---|---|---|---|
| | | Maximum | One Half Maximum | | |
| Fluoranthene | 206-44-0 | 5 | 2.5 | 1.6 | **1.6** |
| Fluorene | 86-73-7 | 5 | 2.5 | 2.5 | 1.0 |
| Hexachlorobenzene | 118-74-1 | 5 | 2.5 | 0.0003 | **8333** |
| Hexachlorobutadiene | 87-68-3 | 5 | 2.5 | 0.3 | **8.3** |
| Hexachlorocyclopentadiene | 77-47-4 | 5 | 2.5 | 0.07 | **36** |
| Hexachloroethane | 67-72-1 | 5 | 2.5 | 9.4 | 0.3 |
| Indeno(1,2,3-cd)pyrene | 193-39-5 | 5 | 2.5 | NL | NC |
| Naphthalene | 91-20-3 | 5 | 2.5 | 1.4 | **1.8** |
| Phenanthrene | 85-01-8 | 5 | 2.5 | 1.5 | **1.7** |
| **Pesticides/PCBs (µg/L)** | | | | | |
| 4,4'-DDD | 72-54-8 | 0.1 | 0.05 | 0.025 | **2** |
| 4,4'-DDT | 50-29-3 | 0.1 | 0.05 | 0.001 | **50** |
| Alpha-Chlordane | 5103-71-9 | 0.05 | 0.025 | 0.004 | **6.3** |
| Beta-Bhc | 319-85-7 | 0.05 | 0.025 | NL | NC |
| Chlorinated Camphene | 8001-35-2 | 5 | 2.5 | NL | NC |
| Dieldrin | 60-57-1 | 0.1 | 0.05 | 0.0019 | **26** |
| Endosulfan I | 959-98-8 | 0.05 | 0.025 | 0.0087 | **2.9** |
| Endosulfan II | 33213-65-9 | 0.1 | 0.05 | 0.0087 | **5.7** |
| Endosulfan Sulfate | 1031-07-8 | 0.1 | 0.05 | 0.009 | **5.6** |
| Endrin | 72-20-8 | 0.1 | 0.05 | 0.0023 | **22** |
| Endrin Aldehyde | 7421-93-4 | 0.1 | 0.05 | 0.0023 | **22** |
| Endrin Ketone | 53494-70-5 | 0.1 | 0.05 | 0.0023 | **22** |
| Gamma-Chlordane | 5103-74-2 | 0.05 | 0.025 | 0.004 | **6.3** |
| Heptachlor | 76-44-8 | 0.05 | 0.025 | 0.0036 | **6.9** |
| Heptachlor Epoxide | 1024-57-3 | 0.05 | 0.025 | 0.0036 | **6.9** |
| Methoxychlor | 72-43-5 | 0.5 | 0.25 | 0.03 | **8.3** |
| Aroclor 1016 | 12674-11-2 | 1 | 0.5 | 0.03 | **17** |
| Aroclor 1232 | 11141-16-5 | 1 | 0.5 | 0.03 | **17** |
| Aroclor 1242 | 53469-21-9 | 1 | 0.5 | 0.03 | **17** |
| Aroclor 1248 | 12672-29-6 | 1 | 0.5 | 0.03 | **17** |
| Aroclor 1254 | 11097-69-1 | 1 | 0.5 | 0.03 | **17** |
| Aroclor 1260 | 11096-82-5 | 1 | 0.5 | 0.03 | **17** |
| Aroclor 1262 | 37324-23-5 | 1 | 0.5 | 0.03 | **17** |
| Aroclor 1268 | 11100-14-4 | 1 | 0.5 | 0.03 | **17** |
| **Inorganics (µg/L)** | | | | | |
| Silver | 7440-22-4 | 100 | 50 | 1.9 | **26** |
| Thallium | 7440-28-0 | 250 | 125 | 21.3 | **5.9** |
| Tin | 7440-31-5 | 100 | 50 | 73 | 0.7 |

Notes:
NC - Hazard quotient not calculated
NL - Ecological screening level not located
µg/L - micrograms per liter
Bold - Hazard Quotient greater than 1.0

**Appendix C**
**Comparison of One Half of the Maximum Reporting Limits for Non-Detected Chemicals in Area 8 Sediment to Ecological Screening Levels**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | CAS No. | Reporting Limit | | Screening Level | Hazard Quotient |
|---|---|---|---|---|---|
| | | Maximum | One Half Maximum | | |
| **Volatile Organic Compounds (µg/kg)** | | | | | |
| 1,1,2-Trichloro-1,2,2-trifluoroethane | 76-13-1 | 15 | 7.5 | NL | NC |
| 1,1-Dichloroethane | 75-34-3 | 15 | 7.5 | NL | NC |
| 1,2-Dibromo-3-chloropropane | 96-12-8 | 15 | 7.5 | NL | NC |
| 1,2-Dibromoethane | 106-93-4 | 15 | 7.5 | NL | NC |
| 1,2-Dichloroethane | 107-06-2 | 15 | 7.5 | NL | NC |
| 1,2-Dichloropropane | 78-87-5 | 15 | 7.5 | NL | NC |
| 2-Butanone | 78-93-3 | 29 | 14.5 | NL | NC |
| 2-Hexanone | 591-78-6 | 29 | 14.5 | NL | NC |
| 4-Methyl-2-Pentanone | 108-10-1 | 29 | 14.5 | NL | NC |
| Acetone | 67-64-1 | 29 | 14.5 | NL | NC |
| Bromochloromethane | 74-97-5 | 15 | 7.5 | NL | NC |
| Bromomethane | 74-83-9 | 15 | 7.5 | NL | NC |
| Chloroethane | 75-00-3 | 15 | 7.5 | NL | NC |
| Chloroform | 67-66-3 | 15 | 7.5 | NL | NC |
| Chloromethane | 74-87-3 | | 0 | NL | NC |
| cis-1,2-Dichloroethene | 156-59-2 | 15 | 7.5 | NL | NC |
| cis-1,3-Dichloropropene | 10061-01-5 | 15 | 7.5 | NL | NC |
| Cyclohexane | 110-82-7 | 15 | 7.5 | NL | NC |
| Dibromochloromethane | 124-48-1 | 15 | 7.5 | NL | NC |
| Dichlorodifluoromethane | 75-71-8 | 15 | 7.5 | NL | NC |
| Methyl Acetate | 79-20-9 | 15 | 7.5 | NL | NC |
| Methyl tert-Butyl Ether | 1634-04-4 | 15 | 7.5 | NL | NC |
| Methylcyclohexane | 108-87-2 | 15 | 7.5 | NL | NC |
| Methylene chloride | 75-09-2 | 15 | 7.5 | NL | NC |
| trans-1,3-Dichloropropene | 10061-02-6 | 15 | 7.5 | NL | NC |
| Trichlorofluoromethane | 75-69-4 | 15 | 7.5 | NL | NC |
| Vinyl Chloride | 75-01-4 | 15 | 7.5 | NL | NC |
| **Semi-volatile Organic Compounds (µg/kg)** | | | | | |
| 2,4-Dichlorophenol | 120-83-2 | 340 | 170 | 117 | **1.5** |
| 2,4-Dimethylphenol | 105-67-9 | 340 | 170 | 29 | **5.9** |
| 2,4-Dinitrophenol | 51-28-5 | 670 | 335 | NL | NC |
| 2,4-Dinitrotoluene | 121-14-2 | 340 | 170 | 41.6 | **4.1** |
| 2,4-Dinitrotoluene | 121-14-2 | 340 | 170 | 41.6 | **4.1** |
| 2,6-Dinitrotoluene | 606-20-2 | 340 | 170 | NL | NC |
| 2-Chloronaphthalene | 91-58-7 | 340 | 170 | NL | NC |
| 2-Methylphenol | 95-48-7 | 340 | 170 | NL | NC |
| 2-Nitroaniline | 88-74-4 | 670 | 335 | NL | NC |
| 2-Nitrophenol | 88-75-5 | 340 | 170 | NL | NC |
| 3-Nitroaniline | 99-09-2 | 670 | 335 | NL | NC |
| 4,6-Dinitro-2-Methylphenol | 534-52-1 | 670 | 335 | NL | NC |
| 4-Chloro-3-Methylphenol | 59-50-7 | 340 | 170 | NL | NC |
| 4-Chloroaniline | 106-47-8 | 340 | 170 | NL | NC |
| 4-Chlorophenyl Phenylether | 7005-72-3 | 340 | 170 | NL | NC |

**Appendix C**
**Comparison of One Half of the Maximum Reporting Limits for Non-Detected Chemicals in Area 8 Sediment to Ecological Screening Levels**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | CAS No. | Reporting Limit | | Screening Level | Hazard Quotient |
|---|---|---|---|---|---|
| | | Maximum | One Half Maximum | | |
| 4-Nitroaniline | 100-01-6 | 670 | 335 | NL | NC |
| 4-Nitrophenol | 100-02-7 | 670 | 335 | NL | NC |
| Acetophenone | 98-86-2 | 340 | 170 | NL | NC |
| Atrazine | 1912-24-9 | 340 | 170 | 6.62 | **26** |
| Bis(2-Chloroethoxy) methane | 111-91-1 | 340 | 170 | NL | NC |
| Bis(2-Chloroethyl) ether | 111-44-4 | 340 | 170 | NL | NC |
| Bis-Chloroisopropyl ether | 108-60-1 | 340 | 170 | NL | NC |
| Caprolactam | 105-60-2 | 340 | 170 | NL | NC |
| Chlorophenols | 58-90-2 | 340 | 170 | 344 | 0.5 |
| Dimethylphthalate | 131-11-3 | 340 | 170 | NL | NC |
| Di-N-Octyl Phthalate | 117-84-0 | 340 | 170 | NL | NC |
| Hexachlorobenzene | 118-74-1 | 340 | 170 | NL | NC |
| Hexachlorobutadiene | 87-68-3 | 340 | 170 | NL | NC |
| Hexachlorocyclopentadiene | 77-47-4 | 340 | 170 | 139 | **1.2** |
| Isophorone | 78-59-1 | 340 | 170 | NL | NC |
| Nitrobenzene | 98-95-3 | 340 | 170 | NL | NC |
| N-Nitroso-Di-N-Propylamine | 621-64-7 | 340 | 170 | NL | NC |
| **Pesticides/PCBs (µg/kg)** | | | | | |
| 4,4'-DDD | 72-54-8 | 6.7 | 3.35 | 2 | **1.7** |
| Aldrin | 309-00-2 | 3.4 | 1.7 | 2 | 0.9 |
| Alpha-BHC | 319-84-6 | 3.4 | 1.7 | 3 | 0.6 |
| Beta-BHC | 319-85-7 | 3.4 | 1.7 | 3 | 0.6 |
| Chlorinated Camphene | 8001-35-2 | 340 | 170 | NL | NC |
| Delta-BHC | 319-86-8 | 3.4 | 1.7 | 3 | 0.6 |
| Dieldrin | 60-57-1 | 6.7 | 3.35 | 2 | **1.7** |
| Endosulfan I | 959-98-8 | 3.4 | 1.7 | 2.9 | 0.6 |
| Endrin | 72-20-8 | 6.7 | 3.35 | 3 | **1.1** |
| Endrin Aldehyde | 7421-93-4 | 6.7 | 3.35 | NL | NC |
| Endrin Ketone | 53494-70-5 | 6.7 | 3.35 | NL | NC |
| Gamma-BHC (Lindane) | 58-89-9 | 3.4 | 1.7 | 0.32 | **5.3** |
| Methoxychlor | 72-43-5 | 34 | 17 | 29.6 | 0.6 |
| Aroclor 1016 | 12674-11-2 | 67 | 33.5 | 7 | **4.8** |
| Aroclor 1221 | 11104-28-2 | 67 | 33.5 | 23 | **1.5** |
| Aroclor 1232 | 11141-16-5 | 7 | 3.5 | 23 | 0.2 |
| Aroclor 1242 | 53469-21-9 | 7 | 3.5 | 23 | 0.2 |
| Aroclor 1248 | 12672-29-6 | 7 | 3.5 | 30 | 0.1 |
| Aroclor 1260 | 11096-82-5 | 7 | 3.5 | 5 | 0.7 |
| Aroclor 1262 | 37324-23-5 | 7 | 3.5 | 23 | 0.2 |
| Aroclor 1268 | 11100-14-4 | 7 | 3.5 | 23 | 0.2 |
| **Inorganics (mg/kg)** | | | | | |
| Thallium | 7440-28-0 | 64 | 32 | NL | NC |

Notes:
NC - Hazard quotient not calculated
NL - Ecological screening level not located
µg/kg - micrograms per kilogram
mg/kg - milligrams per kilogram
Bold - Hazard Quotient greater than 1.0

**Appendix C**
**Comparison of One Half of the Maximum Reporting Limits for Non-Detected Chemicals in Area 8 Surface Water to Ecological Screening Levels**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | CAS No. | Reporting Limit | | Screening Level | Hazard Quotient |
|---|---|---|---|---|---|
| | | Maximum | One Half Maximum | | |
| **Volatile Organic Compounds (µg/L)** | | | | | |
| 1,1,2-Trichloro-1,2,2-trifluoroethane | 76-13-1 | 0.5 | 0.25 | NL | NC |
| 1,2-Dibromo-3-chloropropane | 96-12-8 | 0.5 | 0.25 | NL | NC |
| 1,2-Dibromoethane | 106-93-4 | 0.5 | 0.25 | NL | NC |
| Bromochloromethane | 74-97-5 | 0.5 | 0.25 | NL | NC |
| Bromodichloromethane | 75-27-4 | 0.5 | 0.25 | NL | NC |
| Chloroethane | 75-00-3 | 0.5 | 0.25 | NL | NC |
| cis-1,2-Dichloroethene | 156-59-2 | 0.5 | 0.25 | NL | NC |
| Cyclohexane | 110-82-7 | 0.5 | 0.25 | NL | NC |
| Dibromochloromethane | 124-48-1 | 0.5 | 0.25 | NL | NC |
| Dichlorodifluoromethane | 75-71-8 | 0.5 | 0.25 | NL | NC |
| Methyl Acetate | 79-20-9 | 0.5 | 0.25 | NL | NC |
| Methylcyclohexane | 108-87-2 | 0.5 | 0.25 | NL | NC |
| o-Xylene | 95-47-6 | 0.5 | 0.25 | 19 | 0.01 |
| Trichlorofluoromethane | 75-69-4 | 0.5 | 0.25 | NL | NC |
| **Semi-volatile Organic Compounds (µg/L)** | | | | | |
| 2,4-Dimethylphenol | 105-67-9 | 5 | 2.5 | NL | NC |
| 2-Chloronaphthalene | 91-58-7 | 5 | 2.5 | NL | NC |
| 2-Methylnaphthalene | 91-57-6 | 5 | 2.5 | 4.2 | 0.6 |
| 2-Nitroaniline | 88-74-4 | 10 | 5 | NL | NC |
| 3-Nitroaniline | 99-09-2 | 10 | 5 | NL | NC |
| 4,6-Dinitro-2-Methylphenol | 534-52-1 | 10 | 5 | NL | NC |
| 4-Bromophenyl Phenyl Ether | 101-55-3 | 5 | 2.5 | 1.5 | **1.7** |
| 4-Chloro-3-Methylphenol | 59-50-7 | 5 | 2.5 | NL | NC |
| 4-Chlorophenyl Phenylether | 7005-72-3 | 5 | 2.5 | NL | NC |
| 4-Nitroaniline | 100-01-6 | 10 | 5 | NL | NC |
| Acenaphthylene | 208-96-8 | 5 | 2.5 | NL | NC |
| Acetophenone | 98-86-2 | 5 | 2.5 | NL | NC |
| Anthracene | 120-12-7 | 5 | 2.5 | 0.18 | **14** |
| Benzaldehyde | 100-52-7 | 5 | 2.5 | NL | NC |
| Benzo(a)anthracene | 56-55-3 | 5 | 2.5 | 0.018 | **139** |
| Benzo(a)pyrene | 50-32-8 | 5 | 2.5 | 0.015 | **167** |
| Benzo(b)fluoranthene | 205-99-2 | 5 | 2.5 | NL | NC |
| Benzo(g,h,i)perylene | 191-24-2 | 5 | 2.5 | NL | NC |
| Benzo(k)fluoranthene | 207-08-9 | 5 | 2.5 | NL | NC |
| Bis(2-Chloroethoxy) methane | 111-91-1 | 5 | 2.5 | NL | NC |
| Bis(2-Chloroethyl) ether | 111-44-4 | 5 | 2.5 | NL | NC |
| Caprolactam | 105-60-2 | 5 | 2.5 | NL | NC |
| Carbazole | 86-74-8 | 5 | 2.5 | NL | NC |
| Chlorophenols | 58-90-2 | 5 | 2.5 | 265 | 0.01 |
| Chrysene | 218-01-9 | 5 | 2.5 | NL | NC |
| Dibenzo(a,h)anthracene | 53-70-3 | 5 | 2.5 | NL | NC |
| Di-N-Butylphthalate | 84-74-2 | 5 | 2.5 | 3.4 | 0.7 |
| Fluoranthene | 206-44-0 | 5 | 2.5 | 1.6 | **1.6** |

**Appendix C**
**Comparison of One Half of the Maximum Reporting Limits for Non-Detected Chemicals in Area 8 Surface Water to Ecological Screening Levels**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | CAS No. | Reporting Limit | | Screening Level | Hazard Quotient |
|---|---|---|---|---|---|
| | | Maximum | One Half Maximum | | |
| Fluorene | 86-73-7 | 5 | 2.5 | 2.5 | 1.0 |
| Hexachlorobenzene | 118-74-1 | 5 | 2.5 | 0.0003 | **8333** |
| Hexachlorobutadiene | 87-68-3 | 5 | 2.5 | 0.3 | **8.3** |
| Hexachlorocyclopentadiene | 77-47-4 | 5 | 2.5 | 0.07 | **36** |
| Indeno(1,2,3-cd)pyrene | 193-39-5 | 5 | 2.5 | NL | NC |
| Naphthalene | 91-20-3 | 5 | 2.5 | 1.4 | **1.8** |
| Pentachlorophenol | 87-86-5 | 10 | 5 | 7.9 | 0.6 |
| Phenanthrene | 85-01-8 | 5 | 2.5 | 1.5 | **1.7** |
| **Pesticides/PCBs (µg/L)** | | | | | |
| 4,4'-DDT | 50-29-3 | 0.1 | 0.05 | 0.001 | **50** |
| Alpha-Chlordane | 5103-71-9 | 0.05 | 0.025 | 0.004 | **6.3** |
| Beta-BHC | 319-85-7 | 0.05 | 0.025 | NL | NC |
| Chlorinated Camphene | 8001-35-2 | 5 | 2.5 | NL | NC |
| Dieldrin | 60-57-1 | 0.1 | 0.05 | 0.0019 | **26** |
| Endosulfan II | 33213-65-9 | 0.1 | 0.05 | 0.0087 | **5.7** |
| Endosulfan Sulfate | 1031-07-8 | 0.1 | 0.05 | 0.009 | **5.6** |
| Endrin | 72-20-8 | 0.1 | 0.05 | 0.0023 | **22** |
| Endrin Aldehyde | 7421-93-4 | 0.1 | 0.05 | 0.0023 | **22** |
| Endrin Ketone | 53494-70-5 | 0.1 | 0.05 | 0.0023 | **22** |
| Gamma-Chlordane | 5103-74-2 | 0.05 | 0.025 | 0.004 | **6.3** |
| Heptachlor | 76-44-8 | 0.05 | 0.025 | 0.0036 | **6.9** |
| Heptachlor Epoxide | 1024-57-3 | 0.05 | 0.025 | 0.0036 | **6.9** |
| Aroclor 1016 | 12674-11-2 | 1 | 0.5 | 0.03 | **17** |
| Aroclor 1221 | 11104-28-2 | 1 | 0.5 | 0.03 | **17** |
| Aroclor 1232 | 11141-16-5 | 1 | 0.5 | 0.03 | **17** |
| Aroclor 1242 | 53469-21-9 | 1 | 0.5 | 0.03 | **17** |
| Aroclor 1248 | 12672-29-6 | 1 | 0.5 | 0.03 | **17** |
| Aroclor 1254 | 11097-69-1 | 1 | 0.5 | 0.03 | **17** |
| Aroclor 1260 | 11096-82-5 | 1 | 0.5 | 0.03 | **17** |
| Aroclor 1262 | 37324-23-5 | 1 | 0.5 | 0.03 | **17** |
| Aroclor 1268 | 11100-14-4 | 1 | 0.5 | 0.03 | **17** |
| **Inorganics (µg/L)** | | | | | |
| Beryllium | 7440-41-7 | 50 | 25 | 0.66 | **38** |
| Thallium | 7440-28-0 | 25 | 12.5 | 21.3 | 0.6 |

Notes:
NC - Hazard quotient not calculated
NL - Ecological screening level not located
µg/L - micrograms per liter
Bold - Hazard Quotient greater than 1.0

# Appendix D

# Food Chain Exposure Models

**Appendix D**
**Food Chain Exposure Model for the Belted Kingfisher**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayerville, New Jersey**

| Chemical | Sediment | | | Fish | | | Food | | Site Foraging Factor | Body Weight | Dose | LOAEL | | NOAEL | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Concentration mg/kg w.w. | Ingestion Rate kg/day | Total Ingested Chemical mg/day | Biota-Sediment Accumulation Factor | Concentration mg/kg w.w. | Percent of Diet | Ingestion Rate kg/day | Total Ingested Chemical mg/day | | kg | mg/kg/day | Value mg/kg/day | Hazard Quotient | Value mg/kg/day | Hazard Quotient |
| Arsenic | 22 | 0.00224 | 0.049 | 0.12 | 2.6 | 100% | 0.068 | 0.18 | 1 | 0.136 | 1.69 | 7.4 | 0.23 | 2.50 | 0.7 |
| Cadmium | 0.9 | 0.00224 | 0.002 | 2.0 | 1.9 | 100% | 0.068 | 0.13 | 1 | 0.136 | 0.96 | 20.0 | 0.048 | 1.45 | 0.66 |
| Copper | 444 | 0.00224 | 0.994 | 1.0 | 444 | 100% | 0.068 | 30.2 | 1 | 0.136 | 229.27 | 61.7 | **3.7** | 47.0 | **4.9** |
| Lead | 140 | 0.00224 | 0.313 | 0.43 | 60.1 | 100% | 0.068 | 4.1 | 1 | 0.136 | 32.38 | 11.3 | **2.9** | 1.13 | **28.7** |
| Nickel | 140 | 0.00224 | 0.314 | 1.0 | 140 | 100% | 0.068 | 9.5 | 1 | 0.136 | 72.49 | 107 | 0.68 | 77.4 | 0.94 |
| Selenium | 4.7 | 0.00224 | 0.010 | 1.0 | 4.7 | 100% | 0.068 | 0.32 | 1 | 0.136 | 2.418 | 1.00 | **2.4** | 0.500 | **4.8** |
| Silver | 7.3 | 0.00224 | 0.016 | 1.0 | 7.3 | 100% | 0.068 | 0.50 | 1 | 0.136 | 3.787 | 60.5 | 0.063 | 20.2 | 0.19 |
| Zinc | 77 | 0.00224 | 0.172 | 5.0 | 384 | 100% | 0.068 | 26.1 | 1 | 0.136 | 193.26 | 131 | **1.5** | 14.5 | **13.3** |
| Hexavalent Chromium | 1.3 | 0.00224 | 0.003 | 1.0 | 1.3 | 100% | 0.068 | 0.09 | 1 | 0.136 | 0.652 | 26.6 | 0.024 | 2.66 | 0.24 |
| Acenaphthene | 0.018 | 0.00224 | 0.00004 | 0.03 | 0.001 | 100% | 0.068 | 0.00004 | 1 | 0.136 | 0.001 | 4,550 | 0.0000001 | 445 | 0.000001 |
| Acenaphthylene | 0.031 | 0.00224 | 0.0001 | 0.0003 | 0.00001 | 100% | 0.068 | 0.000001 | 1 | 0.136 | 0.001 | 4,550 | 0.0000001 | 445 | 0.000001 |
| Anthracene | 0.050 | 0.00224 | 0.0001 | 0.008 | 0.0004 | 100% | 0.068 | 0.00003 | 1 | 0.136 | 0.001 | 4,550 | 0.0000002 | 445 | 0.000002 |
| Benzo(a)anthracene | 0.292 | 0.00224 | 0.001 | 0.094 | 0.027 | 100% | 0.068 | 0.002 | 1 | 0.136 | 0.019 | 20.0 | 0.001 | 2.00 | 0.01 |
| Benzo(a)pyrene | 0.302 | 0.00224 | 0.001 | 0.0002 | 0.00007 | 100% | 0.068 | 0.000005 | 1 | 0.136 | 0.005 | 20.0 | 0.0003 | 2.00 | 0.003 |
| Benzo(b)fluoranthene | 0.530 | 0.00224 | 0.001 | 0.002 | 0.001 | 100% | 0.068 | 0.00007 | 1 | 0.136 | 0.009 | 20.0 | 0.0005 | 2.00 | 0.005 |
| Benzo(g,h,i)perylene | 0.254 | 0.00224 | 0.001 | 0.07 | 0.018 | 100% | 0.068 | 0.001 | 1 | 0.136 | 0.013 | 20.0 | 0.001 | 2.00 | 0.01 |
| Benzo(k)fluoranthene | 0.254 | 0.00224 | 0.001 | 0.002 | 0.001 | 100% | 0.068 | 0.00004 | 1 | 0.136 | 0.004 | 20.0 | 0.0002 | 2.00 | 0.002 |
| Chrysene | 0.323 | 0.00224 | 0.0007 | 0.06 | 0.021 | 100% | 0.068 | 0.001 | 1 | 0.136 | 0.016 | 20.0 | 0.0008 | 2.00 | 0.008 |
| Dibenzo(a,h)anthracene | 0.040 | 0.00224 | 0.00009 | 0.001 | 0.00005 | 100% | 0.068 | 0.000004 | 1 | 0.136 | 0.001 | 20.0 | 0.00003 | 2.00 | 0.0003 |
| Fluoranthene | 0.901 | 0.00224 | 0.0020 | 0.04 | 0.034 | 100% | 0.068 | 0.002 | 1 | 0.136 | 0.032 | 20.0 | 0.002 | 2.00 | 0.02 |
| Fluorene | 0.007 | 0.00224 | 0.00002 | 0.526 | 0.004 | 100% | 0.068 | 0.0002 | 1 | 0.136 | 0.002 | 4,550 | 0.0000004 | 445 | 0.000004 |
| Indeno(1,2,3-cd)pyrene | 0.228 | 0.00224 | 0.001 | 0.076 | 0.017 | 100% | 0.068 | 0.001 | 1 | 0.136 | 0.012 | 20.0 | 0.0006 | 2.00 | 0.006 |
| Phenanthrene | 0.260 | 0.00224 | 0.001 | 0.018 | 0.005 | 100% | 0.068 | 0.0003 | 1 | 0.136 | 0.007 | 4,550 | 0.000001 | 445 | 0.00001 |
| Pyrene | 0.583 | 0.00224 | 0.001 | 0.039 | 0.023 | 100% | 0.068 | 0.002 | 1 | 0.136 | 0.021 | 20.0 | 0.001 | 2.00 | 0.0104 |
| Alpha-Chlordane | 0.005 | 0.00224 | 0.00001 | 0.146 | 0.001 | 100% | 0.068 | 0.00005 | 1 | 0.136 | 0.0004 | 10.7 | 0.00004 | 2.10 | 0.0002 |
| Aroclor 1254 | 0.011 | 0.00224 | 0.00002 | 2.3 | 0.025 | 100% | 0.068 | 0.002 | 1 | 0.136 | 0.01 | 1.80 | 0.007 | 0.180 | 0.1 |
| Dieldrin | 0.001 | 0.00224 | 0.000002 | 1.6 | 0.002 | 100% | 0.068 | 0.0001 | 1 | 0.136 | 0.001 | 0.770 | 0.001 | 0.077 | 0.01 |
| Gamma-Chlordane | 0.003 | 0.00224 | 0.000007 | 0.49 | 0.001 | 100% | 0.068 | 0.0001 | 1 | 0.136 | 0.0008 | 10.7 | 0.0001 | 2.10 | 0.0004 |
| Methoxychlor | 0.003 | 0.00224 | 0.00001 | 1.8 | 0.005 | 100% | 0.068 | 0.0003 | 1 | 0.136 | 0.003 | 200 | 0.00001 | 20.0 | 0.0001 |

Notes:
NOAEL = no observed adverse effect level
LOAEL = lowest observed adverse effect level
NA = Input variable not located
NC = Not calculated
kg = kilogram
kg/day = kilogram per day
mg/kg w.w. = milligram per kilograms wet weight
mg/kg/day = milligram per kilograms per day
**Bold** - indicates hazard quotient greater than threshold of one

wet weight concentrations converted as follow: ww = Cs x (1 - % moisture)
where:
ww - wet weight concentration
Cs - dry weight concentration in sediment
% moisture - percent moisture
For example, dry weight concentration and % moisture for arsenic were 88.9 mg/kg and 75.2%, respectively.
ww = 88.9 x (1- .752)
ww = 22 mg/kg

**Appendix D**
**Food Chain Exposure Model for the Mink**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | Sediment | | | Fish | | | Food | | Site Foraging Factor | Body Weight | Dose | LOAEL | | NOAEL | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Concentration mg/kg w.w. | Ingestion Rate kg/day | Total Ingested Chemical mg/day | Biota-Sediment Accumulation Factor | Concentration mg/kg w.w. | Percent of Diet | Ingestion Rate kg/day | Total Ingested Chemical mg/day | | kg | mg/kg/day | Value mg/kg/day | Hazard Quotient | Value mg/kg/day | Hazard Quotient |
| Arsenic | 22 | 0.0147 | 0.324 | 0.12 | 2.65 | 100% | 0.156 | 0.41 | 1 | 0.974 | 0.756 | 0.524 | **1.4** | 0.052 | **14.5** |
| Cadmium | 0.9 | 0.0147 | 0.014 | 2.0 | 1.9 | 100% | 0.156 | 0.3 | 1 | 0.974 | 0.756 | 7.42 | 0.10 | 0.742 | 1.0 |
| Copper | 444 | 0.0147 | 6.53 | 1.0 | 444 | 100% | 0.156 | 69.3 | 1 | 0.974 | 77.80 | 15.4 | **5.1** | 12 | **6.6** |
| Lead | 140 | 0.0147 | 2.06 | 0.43 | 60.1 | 100% | 0.156 | 9.4 | 1 | 0.974 | 11.74 | 61.5 | 0.19 | 6.2 | **1.9** |
| Nickel | 140 | 0.0147 | 2.06 | 1.0 | 140 | 100% | 0.156 | 21.9 | 1 | 0.974 | 24.60 | 61.5 | 0.40 | 31 | 0.8 |
| Selenium | 4.7 | 0.0147 | 0.069 | 1.0 | 4.68 | 100% | 0.156 | 0.73 | 1 | 0.974 | 0.820 | 0.254 | **3.2** | 0.154 | **5.3** |
| Silver | 7.3 | 0.0147 | 0.108 | 1.0 | 7.33 | 100% | 0.156 | 1.14 | 1 | 0.974 | 1.285 | 6.02 | 0.21 | 0.600 | **2.1** |
| Zinc | 77 | 0.0147 | 1.13 | 5.0 | 384 | 100% | 0.156 | 59.9 | 1 | 0.974 | 62.66 | 246 | 0.25 | 123 | 0.51 |
| Hexavalent Chromium | 1.3 | 0.0147 | 0.019 | 1.0 | 1.26 | 100% | 0.156 | 0.20 | 1 | 0.974 | 0.2211 | 10.1 | 0.022 | 2.52 | 0.09 |
| Acenaphthene | 0.018 | 0.0147 | 0.0003 | 0.029 | 0.0005 | 100% | 0.156 | 0.0001 | 1 | 0.974 | 0.0004 | 656 | 0.000001 | 65.6 | 0.00001 |
| Acenaphthylene | 0.031 | 0.0147 | 0.0005 | 0.0003 | 0.00001 | 100% | 0.156 | 0.000002 | 1 | 0.974 | 0.0005 | 656 | 0.000001 | 65.6 | 0.00001 |
| Anthracene | 0.050 | 0.0147 | 0.001 | 0.008 | 0.0004 | 100% | 0.156 | 0.0001 | 1 | 0.974 | 0.0008 | 656 | 0.000001 | 65.6 | 0.0000 |
| Benzo(a)anthracene | 0.292 | 0.0147 | 0.004 | 0.094 | 0.027 | 100% | 0.156 | 0.004 | 1 | 0.974 | 0.0088 | 6.15 | 0.001 | 0.615 | 0.01 |
| Benzo(a)pyrene | 0.302 | 0.0147 | 0.004 | 0.0002 | 0.0001 | 100% | 0.156 | 0.00001 | 1 | 0.974 | 0.0046 | 4.16 | 0.001 | 0.420 | 0.01 |
| Benzo(b)fluoranthene | 0.530 | 0.0147 | 0.008 | 0.002 | 0.001 | 100% | 0.156 | 0.0002 | 1 | 0.974 | 0.0082 | 6.15 | 0.001 | 0.615 | 0.01 |
| Benzo(g,h,i)perylene | 0.254 | 0.0147 | 0.004 | 0.07 | 0.018 | 100% | 0.156 | 0.003 | 1 | 0.974 | 0.0067 | 6.15 | 0.001 | 0.615 | 0.01 |
| Benzo(k)fluoranthene | 0.254 | 0.0147 | 0.004 | 0.002 | 0.0006 | 100% | 0.156 | 0.0001 | 1 | 0.974 | 0.0039 | 6.15 | 0.0006 | 0.615 | 0.01 |
| Chrysene | 0.323 | 0.0147 | 0.005 | 0.064 | 0.021 | 100% | 0.156 | 0.003 | 1 | 0.974 | 0.0082 | 6.15 | 0.001 | 0.615 | 0.01 |
| Dibenzo(a,h)anthracene | 0.040 | 0.0147 | 0.001 | 0.001 | 0.0001 | 100% | 0.156 | 0.00001 | 1 | 0.974 | 0.0006 | 6.15 | 0.0001 | 0.615 | 0.001 |
| Fluoranthene | 0.901 | 0.0147 | 0.013 | 0.038 | 0.034 | 100% | 0.156 | 0.005 | 1 | 0.974 | 0.0191 | 6.15 | 0.003 | 0.615 | 0.03 |
| Fluorene | 0.007 | 0.0147 | 0.000 | 0.526 | 0.004 | 100% | 0.156 | 0.001 | 1 | 0.974 | 0.0007 | 656 | 0.000001 | 66 | 0.00001 |
| Indeno(1,2,3-cd)pyrene | 0.228 | 0.0147 | 0.003 | 0.076 | 0.017 | 100% | 0.156 | 0.003 | 1 | 0.974 | 0.0062 | 6.15 | 0.001 | 0.615 | 0.01 |
| Phenanthrene | 0.260 | 0.0147 | 0.004 | 0.018 | 0.005 | 100% | 0.156 | 0.0007 | 1 | 0.974 | 0.0047 | 656 | 0.000007 | 65.6 | 0.00007 |
| Pyrene | 0.583 | 0.0147 | 0.009 | 0.039 | 0.023 | 100% | 0.156 | 0.004 | 1 | 0.974 | 0.0124 | 6.15 | 0.002 | 0.615 | 0.02 |
| Alpha-Chlordane | 0.005 | 0.0147 | 0.00007 | 0.146 | 0.001 | 100% | 0.156 | 0.0001 | 1 | 0.974 | 0.0002 | 3.80 | 0.00005 | 1.90 | 0.0001 |
| Aroclor 1254 | 0.011 | 0.0147 | 0.0002 | 2.3 | 0.025 | 100% | 0.156 | 0.004 | 1 | 0.974 | 0.0041 | 0.690 | 0.006 | 0.140 | 0.03 |
| Dieldrin | 0.001 | 0.0147 | 0.00002 | 1.6 | 0.002 | 100% | 0.156 | 0.0003 | 1 | 0.974 | 0.0003 | 0.154 | 0.002 | 0.015 | 0.02 |
| Gamma-Chlordane | 0.003 | 0.0147 | 0.00004 | 0.49 | 0.001 | 100% | 0.156 | 0.0002 | 1 | 0.974 | 0.0003 | 3.80 | 0.0001 | 1.90 | 0.0001 |
| Methoxychlor | 0.003 | 0.0147 | 0.00004 | 1.8 | 0.005 | 100% | 0.156 | 0.001 | 1 | 0.974 | 0.0008 | 6.20 | 0.0001 | 3.10 | 0.0003 |

Notes:

NOAEL = no observed adverse effect level
LOAEL = lowest observed adverse effect level
NA = Input variable not located
NC = Not calculated
kg = kilogram
kg/day = kilogram per day
mg/kg w.w. = milligram per kilograms wet weight
mg/kg/day = milligram per kilograms per day
**Bold** - indicates hazard quotient greater than threshold of one

wet weight concentrations converted as follow: ww = Cs x (1 - % moisture)
where:
ww - wet weight concentration
Cs - dry weight concentration in sediment
% moisture - percent moisture
For example, dry weight concentration and % moisture for arsenic were 88.9 mg/kg and 75.2%, respectively.
ww = 88.9 x (1- .752)
ww = 22 mg/kg

**Appendix D**
**Food Chain Exposure Model for the American Robin**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | Soil | | | Invertebrates | | | Food | | Site Foraging Factor | Body Weight | Dose | LOAEL | | NOAEL | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Concentration mg/kg w.w. | Ingestion Rate kg/day | Total Ingested Chemical mg/day | Bioaccumulation Factor | Concentration mg/kg w.w. | Percent of Diet | Ingestion Rate kg/day | Total Ingested Chemical mg/day | | kg | mg/kg/day | Value mg/kg/day | Hazard Quotient | Value mg/kg/day | Hazard Quotient |
| Arsenic | 153 | 0.013 | 1.99 | 0.11 | 16.8 | 100% | 0.124 | 2.09 | 1 | 0.0635 | 64.2 | 7.4 | **8.7** | 2.5 | **26** |
| Cadmium | 1.3 | 0.013 | 0.017 | 0.96 | 1.27 | 100% | 0.124 | 0.157 | 1 | 0.0635 | 2.75 | 20 | 0.1 | 1.45 | **1.9** |
| Copper | 742 | 0.013 | 9.64 | 0.04 | 29.7 | 100% | 0.124 | 3.68 | 1 | 0.0635 | 210 | 62 | **3.4** | 47 | **4.5** |
| Lead | 7,925 | 0.013 | 103 | 0.03 | 237.8 | 100% | 0.124 | 29.5 | 1 | 0.0635 | 2,087 | 11 | **185** | 1.13 | **1,847** |
| Nickel | 21 | 0.013 | 0.271 | 0.02 | 0.418 | 100% | 0.124 | 0.052 | 1 | 0.0635 | 5.09 | 107 | 0.05 | 77 | 0.1 |
| Selenium | 7.3 | 0.013 | 0.094 | 0.22 | 1.60 | 100% | 0.124 | 0.198 | 1 | 0.0635 | 4.60 | 1.0 | **4.6** | 0.500 | **9.2** |
| Silver | 7.1 | 0.013 | 0.093 | 0.22 | 1.57 | 100% | 0.124 | 0.195 | 1 | 0.0635 | 4.53 | 61 | 0.1 | 20 | 0.2 |
| Zinc | 309 | 0.013 | 4.01 | 0.56 | 172.9 | 100% | 0.124 | 21.4 | 1 | 0.0635 | 401 | 131 | **3.1** | 15 | **28** |
| Hexavalent Chromium | 1.3 | 0.013 | 0.017 | 1.0 | 1.33 | 100% | 0.124 | 0.165 | 1 | 0.0635 | 2.87 | 27 | 0.11 | 2.66 | **1.1** |
| Acenaphthene | 0.077 | 0.013 | 0.001 | 1.47 | 0.113 | 100% | 0.124 | 0.014 | 1 | 0.0635 | 0.237 | 4,550 | 0.0001 | 445 | 0.001 |
| Acenaphthylene | 0.072 | 0.013 | 0.0009 | 22.9 | 1.65 | 100% | 0.124 | 0.205 | 1 | 0.0635 | 3.25 | 4,550 | 0.0007 | 445 | 0.007 |
| Anthracene | 0.168 | 0.013 | 0.002 | 2.42 | 0.407 | 100% | 0.124 | 0.050 | 1 | 0.0635 | 0.828 | 4,550 | 0.0002 | 445 | 0.002 |
| Benzo(a)anthracene | 0.518 | 0.013 | 0.007 | 1.59 | 0.824 | 100% | 0.124 | 0.102 | 1 | 0.0635 | 1.71 | 20 | 0.09 | 2 | 0.9 |
| Benzo(a)pyrene | 0.483 | 0.013 | 0.006 | 1.33 | 0.642 | 100% | 0.124 | 0.080 | 1 | 0.0635 | 1.35 | 20 | 0.07 | 2 | 0.7 |
| Benzo(b)fluoranthene | 0.770 | 0.013 | 0.010 | 2.6 | 2.00 | 100% | 0.124 | 0.248 | 1 | 0.0635 | 4.07 | 20 | 0.2 | 2 | **2.0** |
| Benzo(g,h,i)perylene | 0.378 | 0.013 | 0.005 | 2.94 | 1.11 | 100% | 0.124 | 0.138 | 1 | 0.0635 | 2.25 | 20 | 0.1 | 2 | **1.1** |
| Benzo(k)fluoranthene | 0.470 | 0.013 | 0.006 | 2.60 | 1.22 | 100% | 0.124 | 0.151 | 1 | 0.0635 | 2.48 | 20 | 0.1 | 2 | **1.2** |
| Chrysene | 0.553 | 0.013 | 0.007 | 2.29 | 1.27 | 100% | 0.124 | 0.157 | 1 | 0.0635 | 2.59 | 20 | 0.1 | 2 | **1.3** |
| Dibenzo(a,h)anthracene | 0.100 | 0.013 | 0.001 | 2.31 | 0.231 | 100% | 0.124 | 0.029 | 1 | 0.0635 | 0.47 | 20 | 0.02 | 2 | 0.2 |
| Fluoranthene | 1.0 | 0.013 | 0.013 | 3.04 | 3.14 | 100% | 0.124 | 0.389 | 1 | 0.0635 | 6.34 | 20 | 0.3 | 2 | **3.2** |
| Fluorene | 0.319 | 0.013 | 0.004 | 9.57 | 3.05 | 100% | 0.124 | 0.378 | 1 | 0.0635 | 6.02 | 4,550 | 0.001 | 445 | 0.01 |
| Indeno(1,2,3-cd)pyrene | 0.266 | 0.013 | 0.003 | 2.86 | 0.761 | 100% | 0.124 | 0.094 | 1 | 0.0635 | 1.54 | 20 | 0.1 | 2 | 0.8 |
| Pentachlorophenol | 0.009 | 0.013 | 0.0001 | 1034 | 10 | 100% | 0.124 | 1.18 | 1 | 0.0635 | 18.7 | 67 | 0.3 | 6.73 | **2.8** |
| Phenanthrene | 1.1 | 0.013 | 0.014 | 1.72 | 1.88 | 100% | 0.124 | 0.233 | 1 | 0.0635 | 3.89 | 4,550 | 0.0009 | 445 | 0.01 |
| Pyrene | 1.5 | 0.013 | 0.019 | 1.75 | 2.6 | 100% | 0.124 | 0.319 | 1 | 0.0635 | 5.32 | 20 | 0.3 | 2 | **2.7** |
| Alpha-Chlordane | 0.008 | 0.013 | 0.00011 | 7,926 | 64.3 | 100% | 0.124 | 7.97 | 1 | 0.0635 | 125 | 11 | **12** | 2.1 | **60** |
| Aroclor 1254 | 14.3 | 0.013 | 0.186 | 1.13 | 16.2 | 100% | 0.124 | 2.00 | 1 | 0.0635 | 34.5 | 1.8 | **19** | 0.180 | **192** |
| Aroclor 1260 | 0.032 | 0.013 | 0.0004 | 1.13 | 0.036 | 100% | 0.124 | 0.004 | 1 | 0.0635 | 0.076 | 1.8 | 0.04 | 0.180 | 0.4 |
| 4,4'-DDD | 0.012 | 0.013 | 0.000 | 1.26 | 0.015 | 100% | 0.124 | 0.002 | 1 | 0.0635 | 0.031 | 0.028 | **1.1** | 0.003 | **10** |
| 4,4'-DDE | 0.015 | 0.013 | 0.00020 | 1.26 | 0.019 | 100% | 0.124 | 0.002 | 1 | 0.0635 | 0.041 | 0.028 | **1.5** | 0.003 | **14** |
| 4,4'-DDT | 0.845 | 0.013 | 0.011 | 1.26 | 1.06 | 100% | 0.124 | 0.132 | 1 | 0.0635 | 2.25 | 0.028 | **80** | 0.003 | **751** |
| Dieldrin | 0.004 | 0.013 | 0.00005 | 4.27 | 0.017 | 100% | 0.124 | 0.002 | 1 | 0.0635 | 0.035 | 0.77 | 0.04 | 0.077 | 0.4 |
| Endosulfan I | 0.002 | 0.013 | 0.00002 | 97.9 | 0.175 | 100% | 0.124 | 0.022 | 1 | 0.0635 | 0.342 | 100 | 0.003 | 10 | 0.03 |
| Endosulfan II | 0.182 | 0.013 | 0.002 | 97.9 | 17.8 | 100% | 0.124 | 2.21 | 1 | 0.0635 | 34.8 | 100 | 0.3 | 10 | **3.5** |
| Endrin | 0.003 | 0.013 | 0.00003 | 1,297 | 3.35 | 100% | 0.124 | 0.415 | 1 | 0.0635 | 6.53 | 0.1 | **65** | 0.010 | **653** |
| Gamma-Chlordane | 0.117 | 0.013 | 0.002 | 7,926 | 927.3 | 100% | 0.124 | 115 | 1 | 0.0635 | 1,811 | 11 | **169** | 2.1 | **862** |
| Methoxychlor | 0.016 | 0.013 | 0.0002 | 1,034 | 16.3 | 100% | 0.124 | 2.02 | 1 | 0.0635 | 31.8 | 200 | 0.16 | 20 | **1.6** |

Notes:

NOAEL = no observed adverse effect level
LOAEL = lowest observed adverse effect level
NA = Input variable not located
NC = Not calculated
kg = kilogram
kg/day = kilogram per day
mg/kg w.w. = milligram per kilograms wet weight
mg/kg/day = milligram per kilograms per day
**Bold** - indicates hazard quotient greater than threshold of one

wet weight concentrations converted as follow: ww = Cs x (1 - % moisture)
where:
ww - wet weight concentration
Cs - dry weight concentration in soil
% moisture - percent moisture
For example, dry weight concentration and % moisture for arsenic were 179 mg/kg and 14.5%, respectively.
ww = 179 x (1- .145)
ww = 153 mg/kg

**Appendix D**
**Food Chain Exposure Model for the Short-Tailed Shrew**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayerville, New Jersey**

| Chemical | Soil | | | Invertebrates | | | Food | | Site Foraging Factor | Body Weight | Dose | LOAEL | | NOAEL | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Concentration mg/kg w.w. | Ingestion Rate kg/day | Total Ingested Chemical mg/day | Bioaccumulation Factor | Concentration mg/kg w.w. | Percent of Diet | Ingestion Rate kg/day | Total Ingested Chemical mg/day | | kg | mg/kg/day | Value mg/kg/day | Hazard Quotient | Value mg/kg/day | Hazard Quotient |
| Arsenic | 153 | 0.00048 | 0.073 | 0.11 | 16.8 | 100% | 0.0093 | 0.157 | 1 | 0.015 | 15.3 | 1.50 | **10** | 0.150 | **102** |
| Cadmium | 1.3 | 0.00048 | 0.001 | 0.96 | 1.27 | 100% | 0.0093 | 0.012 | 1 | 0.015 | 0.828 | 21 | 0.04 | 2.12 | 0.4 |
| Copper | 742 | 0.00048 | 0.356 | 0.04 | 29.7 | 100% | 0.0093 | 0.276 | 1 | 0.015 | 42.1 | 44 | 0.96 | 33.4 | **1.3** |
| Lead | 7925 | 0.00048 | 3.8 | 0.03 | 237.8 | 100% | 0.0093 | 2.21 | 1 | 0.015 | 401 | 176 | **2.3** | 17.6 | **23** |
| Nickel | 21 | 0.00048 | 0.010 | 0.02 | 0.418 | 100% | 0.0093 | 0.004 | 1 | 0.015 | 0.927 | 176 | 0.01 | 87.9 | 0.01 |
| Selenium | 7.3 | 0.00048 | 0.003 | 0.22 | 1.60 | 100% | 0.0093 | 0.015 | 1 | 0.015 | 1.22 | 0.725 | **1.7** | 0.440 | **2.8** |
| Silver | 7.1 | 0.00048 | 0.003 | 0.22 | 1.57 | 100% | 0.0093 | 0.015 | 1 | 0.015 | 1.20 | 6.02 | 0.2 | 0.600 | **2.0** |
| Zinc | 309 | 0.00048 | 0.148 | 0.56 | 173 | 100% | 0.0093 | 1.61 | 1 | 0.015 | 117 | 703 | 0.2 | 352 | 0.3 |
| Hexavalent Chromium | 1.3 | 0.00048 | 0.0006 | 1.0 | 1.33 | 100% | 0.0093 | 0.012 | 1 | 0.015 | 0.868 | 28.9 | 0.03 | 7.21 | 0.12 |
| Acenaphthene | 0.077 | 0.00048 | 0.00004 | 1.47 | 0.113 | 100% | 0.0093 | 0.001 | 1 | 0.015 | 0.073 | 656 | 0.0001 | 65.6 | 0.001 |
| Acenaphthylene | 0.072 | 0.00048 | 0.00003 | 23 | 1.65 | 100% | 0.0093 | 0.015 | 1 | 0.015 | 1.03 | 656 | 0.002 | 65.6 | 0.02 |
| Anthracene | 0.168 | 0.00048 | 0.00008 | 2.42 | 0.407 | 100% | 0.0093 | 0.004 | 1 | 0.015 | 0.257 | 656 | 0.0004 | 65.6 | 0.004 |
| Benzo(a)anthracene | 0.518 | 0.00048 | 0.0002 | 1.59 | 0.824 | 100% | 0.0093 | 0.008 | 1 | 0.015 | 0.527 | 6.15 | 0.1 | 0.615 | 0.9 |
| Benzo(a)pyrene | 0.483 | 0.00048 | 0.0002 | 1.33 | 0.642 | 100% | 0.0093 | 0.006 | 1 | 0.015 | 0.414 | 11.9 | 0.03 | 1.19 | 0.3 |
| Benzo(b)fluoranthene | 0.770 | 0.00048 | 0.0004 | 2.6 | 2.00 | 100% | 0.0093 | 0.019 | 1 | 0.015 | 1.27 | 6.15 | 0.2 | 0.615 | **2.1** |
| Benzo(g,h,i)perylene | 0.378 | 0.00048 | 0.0002 | 2.94 | 1.11 | 100% | 0.0093 | 0.010 | 1 | 0.015 | 0.701 | 6.15 | 0.1 | 0.615 | **1.1** |
| Benzo(k)fluoranthene | 0.470 | 0.00048 | 0.0002 | 2.60 | 1.22 | 100% | 0.0093 | 0.011 | 1 | 0.015 | 0.772 | 6.15 | 0.1 | 0.615 | **1.3** |
| Chrysene | 0.553 | 0.00048 | 0.0003 | 2.29 | 1.27 | 100% | 0.0093 | 0.0118 | 1 | 0.015 | 0.803 | 6.15 | 0.13 | 0.615 | **1.3** |
| Dibenzo(a,h)anthracene | 0.100 | 0.00048 | 0.00005 | 2.31 | 0.231 | 100% | 0.0093 | 0.002 | 1 | 0.015 | 0.147 | 6.15 | 0.02 | 0.615 | 0.2 |
| Fluoranthene | 1.0 | 0.00048 | 0.0005 | 3.04 | 3.14 | 100% | 0.0093 | 0.029 | 1 | 0.015 | 1.98 | 6.15 | 0.3 | 0.615 | **3.2** |
| Fluorene | 0.319 | 0.00048 | 0.0002 | 9.57 | 3.05 | 100% | 0.0093 | 0.028 | 1 | 0.015 | 1.90 | 656 | 0.003 | 65.6 | 0.03 |
| Indeno(1,2,3-cd)pyrene | 0.266 | 0.00048 | 0.0001 | 2.86 | 0.761 | 100% | 0.0093 | 0.007 | 1 | 0.015 | 0.480 | 6.15 | 0.08 | 0.615 | 0.8 |
| Pentachlorophenol | 0.009 | 0.00048 | 0.000004 | 1,034 | 9.55 | 100% | 0.0093 | 0.089 | 1 | 0.015 | 5.92 | 5.28 | **1.1** | 0.527 | **11** |
| Phenanthrene | 1.1 | 0.00048 | 0.0005 | 1.72 | 1.88 | 100% | 0.0093 | 0.017 | 1 | 0.015 | 1.20 | 656 | 0.002 | 65.6 | 0.02 |
| Pyrene | 1.5 | 0.00048 | 0.0007 | 1.75 | 2.57 | 100% | 0.0093 | 0.0239 | 1 | 0.015 | 1.64 | 6.15 | 0.3 | 0.615 | **2.7** |
| Alpha-Chlordane | 0.008 | 0.00048 | 0.000004 | 7,926 | 64.3 | 100% | 0.0093 | 0.598 | 1 | 0.015 | 39.8 | 10.9 | **3.7** | 5.50 | **7.2** |
| Aroclor 1254 | 14.3 | 0.00048 | 0.007 | 1.13 | 16.2 | 100% | 0.0093 | 0.150 | 1 | 0.015 | 10.48 | 0.668 | **16** | 0.067 | **156** |
| Aroclor 1260 | 0.032 | 0.00048 | 0.00002 | 1.13 | 0.036 | 100% | 0.0093 | 0.0003 | 1 | 0.015 | 0.023 | 0.668 | 0.03 | 0.067 | 0.3 |
| 4,4'-DDD | 0.012 | 0.00048 | 0.000006 | 1.26 | 0.015 | 100% | 0.0093 | 0.0001 | 1 | 0.015 | 0.010 | 8.79 | 0.001 | 1.76 | 0.01 |
| 4,4'-DDE | 0.015 | 0.00048 | 0.00001 | 1.26 | 0.019 | 100% | 0.0093 | 0.0002 | 1 | 0.015 | 0.012 | 8.79 | 0.001 | 1.76 | 0.01 |
| 4,4'-DDT | 0.845 | 0.00048 | 0.0004 | 1.26 | 1.06 | 100% | 0.0093 | 0.010 | 1 | 0.015 | 0.69 | 8.79 | 0.1 | 1.76 | 0.4 |
| Dieldrin | 0.004 | 0.00048 | 0.000002 | 4.27 | 0.017 | 100% | 0.0093 | 0.0002 | 1 | 0.015 | 0.011 | 0.440 | 0.02 | 0.044 | 0.2 |
| Endosulfan I | 0.002 | 0.00048 | 0.0000009 | 97.9 | 0.175 | 100% | 0.0093 | 0.002 | 1 | 0.015 | 0.11 | 3.30 | 0.03 | 0.330 | 0.3 |
| Endosulfan II | 0.182 | 0.00048 | 0.00009 | 97.9 | 17.8 | 100% | 0.0093 | 0.1657 | 1 | 0.015 | 11.1 | 3.30 | **3.3** | 0.330 | **33** |
| Endrin | 0.003 | 0.00048 | 0.000001 | 1,297 | 3.35 | 100% | 0.0093 | 0.031 | 1 | 0.015 | 2.07 | 1.09 | **1.9** | 0.109 | **19** |
| Gamma-Chlordane | 0.117 | 0.00048 | 0.00006 | 7,926 | 927 | 100% | 0.0093 | 8.62 | 1 | 0.015 | 575 | 10.9 | **53** | 5.50 | **105** |
| Methoxychlor | 0.016 | 0.00048 | 0.000008 | 1,034 | 16.3 | 100% | 0.0093 | 0.152 | 1 | 0.015 | 10.1 | 17.6 | 0.6 | 8.80 | **1.1** |

Notes:

NOAEL = no observed adverse effect level
LOAEL = lowest observed adverse effect level
NA = Input variable not located
NC = Not calculated
kg = kilogram
kg/day = kilogram per day
mg/kg w.w. = milligram per kilograms wet weight
mg/kg/day = milligram per kilograms per day
**Bold** - indicates hazard quotient greater than threshold of one

wet weight concentrations converted as follow: ww = Cs x (1 - % moisture)
where:
ww - wet weight concentration
Cs - dry weight concentration in soil
% moisture - percent moisture
For example, dry weight concentration and % moisture for arsenic were 179 mg/kg and 14.5%, respectively.
ww = 179 x (1- .145)
ww = 153 mg/kg

**Appendix D**
**Food Chain Exposure Model for the Kestrel**
**Raritan Bay Slag Superfund Site**
**Old Bridge/ Sayreville, New Jersey**

| Chemical | Soil | | | Small Mammals | | | Food | | Site Foraging Factor | Body Weight | Dose | LOAEL | | NOAEL | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Concentration mg/kg w.w. | Ingestion Rate kg/day | Total Ingested Chemical mg/day | Bioaccumulation Factor | Concentration[1] mg/kg w.w. | Percent of Diet | Ingestion Rate kg/day | Total Ingested Chemical mg/day | | kg | mg/kg/day | Value mg/kg/day | Hazard Quotient | Value mg/kg/day | Hazard Quotient |
| Arsenic | 153 | 0.00032 | 0.049 | NA | 0.48 | 100% | 0.032 | 0.015 | 1 | 0.103 | 0.625 | 7.40 | 0.08 | 2.50 | 0.2 |
| Cadmium | 1.3 | 0.00032 | 0.0004 | NA | 0.32 | 100% | 0.032 | 0.010 | 1 | 0.103 | 0.104 | 20.0 | 0.005 | 1.45 | 0.07 |
| Copper | 742 | 0.00032 | 0.237 | NA | 20 | 100% | 0.032 | 0.640 | 1 | 0.103 | 8.52 | 61.7 | 0.1 | 47.0 | 0.2 |
| Lead | 7925 | 0.00032 | 2.54 | NA | 57.2 | 100% | 0.032 | 1.83 | 1 | 0.103 | 42.4 | 11.3 | **3.8** | 1.13 | **38** |
| Nickel | 21 | 0.00032 | 0.007 | NA | 3.20 | 100% | 0.032 | 0.102 | 1 | 0.103 | 1.06 | 107 | 0.01 | 77.4 | 0.01 |
| Selenium | 7.3 | 0.00032 | 0.002 | NA | 1.40 | 100% | 0.032 | 0.045 | 1 | 0.103 | 0.457 | 1.00 | 0.5 | 0.5 | 0.9 |
| Silver | 7.1 | 0.00032 | 0.002 | NA | 0.03 | 100% | 0.032 | 0.001 | 1 | 0.103 | 0.032 | 60.5 | 0.0005 | 20.2 | 0.002 |
| Zinc | 309 | 0.00032 | 0.099 | NA | 117.7 | 100% | 0.032 | 3.77 | 1 | 0.103 | 37.5 | 131 | 0.3 | 14.5 | **2.6** |
| Hexavalent Chromium | 1.3 | 0.00032 | 0.0004 | 1.0 | 1.3 | 100% | 0.032 | 0.0426 | 1 | 0.103 | 0.418 | 26.6 | 0.02 | 2.66 | 0.16 |
| Acenaphthene | 0.077 | 0.00032 | 0.00002 | 0.0 | 0.0 | 100% | 0.032 | 0.0 | 1 | 0.103 | 0.0002 | 4550 | 0.0000001 | 445 | 0.000001 |
| Acenaphthylene | 0.072 | 0.00032 | 0.00002 | 0.0 | 0.0 | 100% | 0.032 | 0.0 | 1 | 0.103 | 0.0002 | 4550 | 0.00000005 | 445 | 0.000001 |
| Anthracene | 0.168 | 0.00032 | 0.0001 | 0.0 | 0.0 | 100% | 0.032 | 0.0 | 1 | 0.103 | 0.001 | 4550 | 0.0000001 | 445 | 0.000001 |
| Benzo(a)anthracene | 0.518 | 0.00032 | 0.0002 | 0.0 | 0.0 | 100% | 0.032 | 0.0 | 1 | 0.103 | 0.002 | 20.0 | 0.0001 | 2.00 | 0.001 |
| Benzo(a)pyrene | 0.483 | 0.00032 | 0.0002 | 0.0 | 0.0 | 100% | 0.032 | 0.0 | 1 | 0.103 | 0.002 | 20.0 | 0.0001 | 2.00 | 0.001 |
| Benzo(b)fluoranthene | 0.770 | 0.00032 | 0.0002 | 0.0 | 0.0 | 100% | 0.032 | 0.0 | 1 | 0.103 | 0.002 | 20.0 | 0.0001 | 2.00 | 0.001 |
| Benzo(g,h,i)perylene | 0.378 | 0.00032 | 0.0001 | 0.0 | 0.0 | 100% | 0.032 | 0.0 | 1 | 0.103 | 0.001 | 20.0 | 0.0001 | 2.00 | 0.001 |
| Benzo(k)fluoranthene | 0.470 | 0.00032 | 0.0002 | 0.0 | 0.0 | 100% | 0.032 | 0.0 | 1 | 0.103 | 0.001 | 20.0 | 0.0001 | 2.00 | 0.001 |
| Chrysene | 0.553 | 0.00032 | 0.0002 | 0.0 | 0.0 | 100% | 0.032 | 0.0 | 1 | 0.103 | 0.002 | 20.0 | 0.0001 | 2.00 | 0.001 |
| Dibenzo(a,h)anthracene | 0.100 | 0.00032 | 0.00003 | 0.0 | 0.0 | 100% | 0.032 | 0.0 | 1 | 0.103 | 0.0003 | 20.0 | 0.0000 | 2.00 | 0.0002 |
| Fluoranthene | 1.0 | 0.00032 | 0.0003 | 0.0 | 0.0 | 100% | 0.032 | 0.0 | 1 | 0.103 | 0.003 | 20.0 | 0.0002 | 2.00 | 0.002 |
| Fluorene | 0.319 | 0.00032 | 0.0001 | 0.0 | 0.0 | 100% | 0.032 | 0.0 | 1 | 0.103 | 0.001 | 4550 | 0.0000 | 445 | 0.000002 |
| Indeno(1,2,3-cd)pyrene | 0.266 | 0.00032 | 0.0001 | 0.0 | 0.0 | 100% | 0.032 | 0.0 | 1 | 0.103 | 0.001 | 20 | 0.00004 | 2.00 | 0.0004 |
| Pentachlorophenol | 0.009 | 0.00032 | 0.000003 | NA | 0.2 | 100% | 0.032 | 0.006 | 1 | 0.103 | 0.062 | 67.3 | 0.0009 | 6.73 | 0.01 |
| Phenanthrene | 1.1 | 0.00032 | 0.0003 | 0.0 | 0.0 | 100% | 0.032 | 0.0 | 1 | 0.103 | 0.003 | 4550 | 0.000001 | 445 | 0.00001 |
| Pyrene | 1.5 | 0.00032 | 0.0005 | 0.0 | 0.0 | 100% | 0.032 | 0.0 | 1 | 0.103 | 0.005 | 20.0 | 0.0002 | 2.00 | 0.002 |
| Alpha-Chlordane | 0.008 | 0.00032 | 0.000003 | 1.0 | 0.01 | 100% | 0.032 | 0.00 | 1 | 0.103 | 0.003 | 10.7 | 0.0002 | 2.10 | 0.001 |
| Aroclor 1254 | 14.3 | 0.00032 | 0.00458 | 1.0 | 14.3 | 100% | 0.032 | 0.4576 | 1 | 0.103 | 4.487 | 1.8 | **2.5** | 0.18 | **24.9** |
| Aroclor 1260 | 0.032 | 0.00032 | 0.00001 | 1.0 | 0.03 | 100% | 0.032 | 0.0010 | 1 | 0.103 | 0.010 | 1.8 | 0.01 | 0.18 | 0.06 |
| 4,4'-DDD | 0.012 | 0.00032 | 0.000004 | 4.9 | 0.058 | 100% | 0.032 | 0.002 | 1 | 0.103 | 0.018 | 0.028 | 0.6 | 0.003 | **6.0** |
| 4,4'-DDE | 0.015 | 0.00032 | 0.000005 | 4.9 | 0.075 | 100% | 0.032 | 0.002 | 1 | 0.103 | 0.023 | 0.028 | 0.8 | 0.003 | **7.8** |
| 4,4'-DDT | 0.845 | 0.00032 | 0.0003 | 4.9 | 4.14 | 100% | 0.032 | 0.132 | 1 | 0.103 | 1.29 | 0.028 | **46** | 0.003 | **430** |
| Dieldrin | 0.004 | 0.00032 | 0.000001 | 3.8 | 0.015 | 100% | 0.032 | 0.0005 | 1 | 0.103 | 0.005 | 0.77 | 0.006 | 0.077 | 0.06 |
| Endosulfan I | 0.002 | 0.00032 | 0.000001 | 1.0 | 0.002 | 100% | 0.032 | 0.00006 | 1 | 0.103 | 0.001 | 100 | 0.000006 | 10.0 | 0.0001 |
| Endosulfan II | 0.182 | 0.00032 | 0.000058 | 1.0 | 0.2 | 100% | 0.032 | 0.006 | 1 | 0.103 | 0.057 | 100 | 0.001 | 10.0 | 0.01 |
| Endrin | 0.003 | 0.00032 | 0.000001 | 1.0 | 0.003 | 100% | 0.032 | 0.000 | 1 | 0.103 | 0.001 | 0.1 | 0.008 | 0.01 | 0.08 |
| Gamma-Chlordane | 0.117 | 0.00032 | 0.00004 | 1.0 | 0.1 | 100% | 0.032 | 0.0037 | 1 | 0.103 | 0.037 | 10.7 | 0.003 | 2.10 | 0.02 |
| Methoxychlor | 0.016 | 0.00032 | 0.00001 | 1.0 | 0.02 | 100% | 0.032 | 0.0005 | 1 | 0.103 | 0.005 | 200 | 0.00002 | 20.0 | 0.0002 |

Notes:

1 = No BAFs for soil to small mammals available for arsenic, cadmium, copper, lead, nickel, selenium, silver, zinc, and pentachlorophenl; concentrations in small mammals estimated using regression equations per Tables 4a and 4c in Attachment 4-1, Guidance for Developing Ecological Soil Screenng Levels (EPA 2005).

NOAEL = no observed adverse effect level

LOAEL = lowest observed adverse effect level

NA - no BAF required see note 1

kg = kilogram

kg/day = kilogram per day

mg/kg w.w. = milligram per kilograms wet weight

mg/kg/day = milligram per kilograms per day

**Bold** - indicates hazard quotient greater than threshold of one

wet weight concentrations converted as follow: ww = Cs x (1 - % moisture)

where:

ww - wet weight concentration

Cs - dry weight concentration in soil

% moisture - percent moisture

For example, dry weight concentration and % moisture for arsenic were 179 mg/kg and 14.5%, respectively.

ww = 179 x (1- .145)

ww = 153 mg/kg

**Appendix D**
**Food Chain Exposure Model for the Red Fox**
**Raritan Bay Slag Superfund Site**
**Old Bridge/ Sayreville, New Jersey**

| Chemical | Soil | | | Small Mammals | | | Food | | Site Foraging Factor | Body Weight | Dose | LOAEL | | NOAEL | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Concentration mg/kg w.w. | Ingestion Rate kg/day | Total Ingested Chemical mg/day | Bioaccumulation Factor | Concentration[1] mg/kg w.w. | Percent of Diet | Ingestion Rate kg/day | Total Ingested Chemical mg/day | | kg | mg/kg/day | Value mg/kg/day | Hazard Quotient | Value mg/kg/day | Hazard Quotient |
| Arsenic | 153 | 0.015 | 2.30 | NA | 0.48 | 100% | 0.552 | 0.265 | 1 | 3.94 | 0.650 | 0.360 | **1.8** | 0.036 | **18** |
| Cadmium | 1.3 | 0.015 | 0.020 | NA | 0.32 | 100% | 0.552 | 0.177 | 1 | 3.94 | 0.050 | 5.09 | 0.01 | 0.509 | 0.1 |
| Copper | 742 | 0.015 | 11.1 | NA | 20 | 100% | 0.552 | 11 | 1 | 3.94 | 5.63 | 10.6 | 0.5 | 8.00 | 0.7 |
| Lead | 7925 | 0.015 | 119 | NA | 57.2 | 100% | 0.552 | 31.6 | 1 | 3.94 | 38.2 | 42.3 | 0.9 | 4.22 | **9.0** |
| Nickel | 21 | 0.015 | 0.313 | NA | 3.20 | 100% | 0.552 | 1.77 | 1 | 3.94 | 0.528 | 42.3 | 0.01 | 21.1 | 0.02 |
| Selenium | 7.3 | 0.015 | 0.109 | NA | 1.40 | 100% | 0.552 | 0.773 | 1 | 3.94 | 0.224 | 0.174 | **1.3** | 0.106 | **2.1** |
| Silver | 7.1 | 0.015 | 0.107 | NA | 0.03 | 100% | 0.552 | 0.017 | 1 | 3.94 | 0.031 | 6.020 | 0.005 | 0.600 | 0.05 |
| Zinc | 309 | 0.015 | 4.63 | NA | 117.7 | 100% | 0.552 | 65 | 1 | 3.94 | 17.7 | 169 | 0.1 | 84.5 | 0.2 |
| Hexavalent Chromium | 1.3 | 0.015 | 0.020 | 1.0 | 1.3 | 100% | 0.552 | 0.735 | 1 | 3.94 | 0.2 | 6.94 | 0.03 | 1.73 | 0.11 |
| Acenaphthene | 0.077 | 0.015 | 0.001 | 0.0 | 0.0 | 100% | 0.552 | 0.0 | 1 | 3.94 | 0.0003 | 656 | 0.0000004 | 65.6 | 0.000004 |
| Acenaphthylene | 0.072 | 0.015 | 0.001 | 0.0 | 0.0 | 100% | 0.552 | 0.0 | 1 | 3.94 | 0.0003 | 656 | 0.0000004 | 65.6 | 0.000004 |
| Anthracene | 0.168 | 0.015 | 0.003 | 0.0 | 0.0 | 100% | 0.552 | 0.0 | 1 | 3.94 | 0.001 | 656 | 0.000001 | 65.6 | 0.00001 |
| Benzo(a)anthracene | 0.518 | 0.015 | 0.008 | 0.0 | 0.0 | 100% | 0.552 | 0.0 | 1 | 3.94 | 0.002 | 6.15 | 0.0003 | 0.615 | 0.003 |
| Benzo(a)pyrene | 0.483 | 0.015 | 0.007 | 0.0 | 0.0 | 100% | 0.552 | 0.0 | 1 | 3.94 | 0.002 | 2.86 | 0.0006 | 0.290 | 0.01 |
| Benzo(b)fluoranthene | 0.770 | 0.015 | 0.012 | 0.0 | 0.0 | 100% | 0.552 | 0.0 | 1 | 3.94 | 0.003 | 6.15 | 0.0005 | 0.615 | 0.005 |
| Benzo(g,h,i)perylene | 0.378 | 0.015 | 0.006 | 0.0 | 0.0 | 100% | 0.552 | 0.0 | 1 | 3.94 | 0.001 | 6.15 | 0.0002 | 0.615 | 0.002 |
| Benzo(k)fluoranthene | 0.470 | 0.015 | 0.007 | 0.0 | 0.0 | 100% | 0.552 | 0.0 | 1 | 3.94 | 0.002 | 6.15 | 0.0003 | 0.615 | 0.003 |
| Chrysene | 0.553 | 0.015 | 0.008 | 0.0 | 0.0 | 100% | 0.552 | 0.0 | 1 | 3.94 | 0.002 | 6.15 | 0.0003 | 0.615 | 0.003 |
| Dibenzo(a,h)anthracene | 0.100 | 0.015 | 0.002 | 0.0 | 0.0 | 100% | 0.552 | 0.0 | 1 | 3.94 | 0.0004 | 6.15 | 0.0001 | 0.615 | 0.001 |
| Fluoranthene | 1.0 | 0.015 | 0.015 | 0.0 | 0.0 | 100% | 0.552 | 0.0 | 1 | 3.94 | 0.004 | 6.15 | 0.0006 | 0.615 | 0.006 |
| Fluorene | 0.319 | 0.015 | 0.005 | 0.0 | 0.0 | 100% | 0.552 | 0.0 | 1 | 3.94 | 0.001 | 656 | 0.000002 | 65.6 | 0.00002 |
| Indeno(1,2,3-cd)pyrene | 0.266 | 0.015 | 0.004 | 0.0 | 0.0 | 100% | 0.552 | 0.0 | 1 | 3.94 | 0.001 | 6.15 | 0.0002 | 0.615 | 0.002 |
| Pentachlorophenol | 0.009 | 0.015 | 0.0001 | NA | 0.200 | 100% | 0.552 | 0.110 | 1 | 3.94 | 0.028 | 1.27 | 0.02 | 0.127 | 0.2 |
| Phenanthrene | 1.1 | 0.015 | 0.016 | 0.0 | 0.0 | 100% | 0.552 | 0.0 | 1 | 3.94 | 0.004 | 656 | 0.00001 | 65.6 | 0.0001 |
| Pyrene | 1.5 | 0.015 | 0.022 | 0.0 | 0.0 | 100% | 0.552 | 0.0 | 1 | 3.94 | 0.006 | 6.15 | 0.001 | 0.615 | 0.01 |
| Alpha-Chlordane | 0.008 | 0.015 | 0.0001 | 1.0 | 0.0 | 100% | 0.552 | 0.004 | 1 | 3.94 | 0.001 | 2.60 | 0.00045 | 1.300 | 0.00090 |
| Aroclor 1254 | 14.3 | 0.015 | 0.215 | 1.0 | 14.3 | 100% | 0.552 | 7.894 | 1 | 3.94 | 2.1 | 0.474 | 4.3 | 0.096 | 21.4 |
| Aroclor 1260 | 0.032 | 0.015 | 0.0005 | 1.0 | 0.0 | 100% | 0.552 | 0.017 | 1 | 3.94 | 0.005 | 0.474 | 0.0096 | 0.096 | 0.047 |
| 4,4'-DDD | 0.012 | 0.015 | 0.0002 | 4.9 | 0.058 | 100% | 0.552 | 0.032 | 1 | 3.94 | 0.008 | 2.11 | 0.004 | 0.420 | 0.02 |
| 4,4'-DDE | 0.015 | 0.015 | 0.0002 | 4.9 | 0.075 | 100% | 0.552 | 0.042 | 1 | 3.94 | 0.011 | 2.11 | 0.01 | 0.420 | 0.03 |
| 4,4'-DDT | 0.845 | 0.015 | 0.013 | 4.9 | 4.14 | 100% | 0.552 | 2.29 | 1 | 3.94 | 0.583 | 2.11 | 0.3 | 0.420 | **1.4** |
| Dieldrin | 0.004 | 0.015 | 0.0001 | 3.8 | 0.015 | 100% | 0.552 | 0.008 | 1 | 3.94 | 0.002 | 0.106 | 0.02 | 0.011 | 0.2 |
| Endosulfan I | 0.002 | 0.015 | 0.00003 | 1.0 | 0.0 | 100% | 0.552 | 0.001 | 1 | 3.94 | 0.0003 | 0.800 | 0.00032 | 0.080 | 0.0032 |
| Endosulfan II | 0.182 | 0.015 | 0.003 | 1.0 | 0.2 | 100% | 0.552 | 0.100 | 1 | 3.94 | 0.0262 | 0.800 | 0.0327 | 0.080 | 0.327 |
| Endrin | 0.003 | 0.015 | 0.00004 | 1.0 | 0.0 | 100% | 0.552 | 0.001 | 1 | 3.94 | 0.0004 | 0.263 | 0.00141 | 0.026 | 0.0143 |
| Gamma-Chlordane | 0.117 | 0.015 | 0.002 | 1.0 | 0.1 | 100% | 0.552 | 0.065 | 1 | 3.94 | 0.0168 | 2.60 | 0.0065 | 1.30 | 0.0130 |
| Methoxychlor | 0.016 | 0.015 | 0.0002 | 1.0 | 0.0 | 100% | 0.552 | 0.009 | 1 | 3.94 | 0.0023 | 4.20 | 0.00054 | 2.10 | 0.00108 |

Notes:

1 = No BAFs for soil to small mammals available for arsenic, cadmium, copper, lead, nickel, selenium, silver, zinc, and pentachlorophenl; concentrations in small mammals estimated using regression equations per Tables 4a and 4c in Attachment 4-1, Guidance for Developing Ecological Soil Screenng Levels (EPA 2005).

NOAEL = no observed adverse effect level

LOAEL = lowest observed adverse effect level

NA - no BAF required see note 1

kg = kilogram

kg/day = kilogram per day

mg/kg w.w. = milligram per kilograms wet weight

mg/kg/day = milligram per kilograms per day

**Bold** - indicates hazard quotient greater than threshold of one

wet weight concentrations converted as follow: ww = Cs x (1 - % moisture)

where:

ww - wet weight concentration

Cs - dry weight concentration in soil

% moisture - percent moisture

For example, dry weight concentration and % moisture for arsenic were 179 mg/kg and 14.5%, respectively.

ww = 179 x (1- .145)

ww = 153 mg/kg

**Appendix D**
**Food Chain Exposure Model for the Northern Bobwhite**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemcial | Soil | | | Plants | | | Food | | Site Foraging Factor | Body Weight | Dose | LOAEL | | NOAEL | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Concentration mg/kg w.w. | Ingestion Rate kg/day | Total Ingested Chemical mg/day | Bioaccumulation Factor | Concentration mg/kg w.w. | Percent of Diet | Ingestion Rate kg/day | Total Ingested Chemical mg/day | | kg | mg/kg/day | Value mg/kg/day | Hazard Quotient | Value mg/kg/day | Hazard Quotient |
| Arsenic | 153 | 0.0014 | 0.214 | 0.036 | 5.51 | 100% | 0.015 | 0.083 | 1 | 0.157 | 1.89 | 7.40 | 0.3 | 2.50 | 0.8 |
| Cadmium | 1.3 | 0.0014 | 0.002 | 0.364 | 0.481 | 100% | 0.015 | 0.007 | 1 | 0.157 | 0.058 | 20.0 | 0.003 | 1.45 | 0.04 |
| Copper | 742 | 0.0014 | 1.04 | 0.4 | 297 | 100% | 0.015 | 4.45 | 1 | 0.157 | 35.0 | 61.7 | 0.6 | 47.0 | 0.7 |
| Lead | 7925 | 0.0014 | 11.1 | 0.045 | 357 | 100% | 0.015 | 5.35 | 1 | 0.157 | 105 | 11.3 | **9.3** | 1.13 | **93** |
| Nickel | 21 | 0.0014 | 0.029 | 0.032 | 0.668 | 100% | 0.015 | 0.010 | 1 | 0.157 | 0.250 | 107 | 0.002 | 77.4 | 0.003 |
| Selenium | 7.3 | 0.0014 | 0.010 | 0.016 | 0.116 | 100% | 0.015 | 0.002 | 1 | 0.157 | 0.076 | 1.00 | 0.08 | 0.500 | 0.2 |
| Silver | 7.1 | 0.0014 | 0.010 | 0.4 | 2.86 | 100% | 0.015 | 0.043 | 1 | 0.157 | 0.337 | 60.5 | 0.01 | 20.2 | 0.02 |
| Zinc | 309 | 0.0014 | 0.432 | 0.000000000001 | 0.0000000004 | 100% | 0.015 | 0.00000000001 | 1 | 0.157 | 2.75 | 131 | 0.021 | 14.5 | 0.2 |
| Hexavalent Chromium | 1.3 | 0.0014 | 0.002 | 1.0 | 1.33 | 100% | 0.015 | 0.02 | 1 | 0.157 | 0.14 | 26.6 | 0.0052 | 2.66 | 0.052 |
| Acenaphthene | 0.077 | 0.0014 | 0.0001 | 7.3 | 0.562 | 100% | 0.015 | 0.008 | 1 | 0.157 | 0.054 | 4,550 | 0.00001 | 445 | 0.0001 |
| Acenaphthylene | 0.072 | 0.0014 | 0.0001 | 1.0 | 0.072 | 100% | 0.015 | 0.001 | 1 | 0.157 | 0.01 | 4,550 | 0.0000017 | 445 | 0.000017 |
| Anthracene | 0.168 | 0.0014 | 0.0002 | 0.31 | 0.052 | 100% | 0.015 | 0.001 | 1 | 0.157 | 0.006 | 4,550 | 0.000001 | 445 | 0.00001 |
| Benzo(a)anthracene | 0.518 | 0.0014 | 0.001 | 0.0202 | 0.010 | 100% | 0.015 | 0.0002 | 1 | 0.157 | 0.006 | 20.0 | 0.0003 | 2.00 | 0.003 |
| Benzo(a)pyrene | 0.483 | 0.0014 | 0.001 | 0.0 | 0.0 | 100% | 0.015 | 0.0 | 1 | 0.157 | 0.004 | 20.0 | 0.0002 | 2.00 | 0.002 |
| Benzo(b)fluoranthene | 0.770 | 0.0014 | 0.001 | 0.0101 | 0.008 | 100% | 0.015 | 0.0001 | 1 | 0.157 | 0.008 | 20.0 | 0.0004 | 2.00 | 0.004 |
| Benzo(g,h,i)perylene | 0.378 | 0.0014 | 0.001 | 0.361 | 0.136 | 100% | 0.015 | 0.002 | 1 | 0.157 | 0.016 | 20.0 | 0.0008 | 2.00 | 0.008 |
| Benzo(k)fluoranthene | 0.470 | 0.0014 | 0.001 | 0.0101 | 0.005 | 100% | 0.015 | 0.0001 | 1 | 0.157 | 0.005 | 20.0 | 0.0002 | 2.00 | 0.002 |
| Chrysene | 0.553 | 0.0014 | 0.001 | 0.0187 | 0.010 | 100% | 0.015 | 0.0002 | 1 | 0.157 | 0.006 | 20.0 | 0.0003 | 2.00 | 0.003 |
| Dibenzo(a,h)anthracene | 0.100 | 0.0014 | 0.0001 | 0.0064 | 0.001 | 100% | 0.015 | 0.00001 | 1 | 0.157 | 0.001 | 20.0 | 0.00005 | 2.00 | 0.0005 |
| Fluoranthene | 1.0 | 0.0014 | 0.001 | 0.5 | 0.516 | 100% | 0.015 | 0.008 | 1 | 0.157 | 0.059 | 20.0 | 0.003 | 2.00 | 0.03 |
| Fluorene | 0.319 | 0.0014 | 0.0004 | 7.3 | 2.33 | 100% | 0.015 | 0.035 | 1 | 0.157 | 0.225 | 4,550 | 0.00005 | 445 | 0.001 |
| Indeno(1,2,3-cd)pyrene | 0.266 | 0.0014 | 0.0004 | 0.0039 | 0.001 | 100% | 0.015 | 0.00002 | 1 | 0.157 | 0.002 | 20.0 | 0.0001 | 2.00 | 0.001 |
| Pentachlorophenol | 0.009 | 0.0014 | 0.00001 | 0.0449 | 0.0004 | 100% | 0.015 | 0.00001 | 1 | 0.157 | 0.0001 | 67.3 | 0.000002 | 6.73 | 0.00002 |
| Phenanthrene | 1.1 | 0.0014 | 0.002 | 2.1 | 2.29 | 100% | 0.015 | 0.034 | 1 | 0.157 | 0.229 | 4,550 | 0.00005 | 445 | 0.0005 |
| Pyrene | 1.5 | 0.0014 | 0.002 | 0.72 | 1.06 | 100% | 0.015 | 0.016 | 1 | 0.157 | 0.114 | 20.0 | 0.01 | 2.00 | 0.1 |
| Alpha-Chlordane | 0.008 | 0.0014 | 0.00001 | 0.0086 | 0.0001 | 100% | 0.015 | 0.000001 | 1 | 0.157 | 0.0001 | 10.7 | 0.00001 | 2.10 | 0.00004 |
| Aroclor 1254 | 14.3 | 0.0014 | 0.020 | 0.01 | 0.143 | 100% | 0.015 | 0.002 | 1 | 0.157 | 0.141 | 1.80 | 0.08 | 0.180 | 0.8 |
| Aroclor 1260 | 0.032 | 0.0014 | 0.00004 | 0.01 | 0.0003 | 100% | 0.015 | 0.000005 | 1 | 0.157 | 0.0003 | 1.80 | 0.0002 | 0.180 | 0.002 |
| 4,4'-DDD | 0.012 | 0.0014 | 0.00002 | 0.00937 | 0.0001 | 100% | 0.015 | 0.000002 | 1 | 0.157 | 0.0001 | 0.028 | 0.004 | 0.003 | 0.04 |
| 4,4'-DDE | 0.015 | 0.0014 | 0.00002 | 0.00937 | 0.0001 | 100% | 0.015 | 0.000002 | 1 | 0.157 | 0.0002 | 0.028 | 0.01 | 0.003 | 0.05 |
| 4,4'-DDT | 0.845 | 0.0014 | 0.001 | 0.037 | 0.031 | 100% | 0.015 | 0.0005 | 1 | 0.157 | 0.011 | 0.028 | 0.37579 | 0.003 | **3.5** |
| Dieldrin | 0.004 | 0.0014 | 0.00001 | 0.41 | 0.002 | 100% | 0.015 | 0.00002 | 1 | 0.157 | 0.0002 | 0.770 | 0.0003 | 0.077 | 0.003 |
| Endosulfan I | 0.002 | 0.0014 | 0.000002 | 0.17 | 0.0003 | 100% | 0.015 | 0.000005 | 1 | 0.157 | 0.00004 | 100 | 0.0000004 | 10.0 | 0.000004 |
| Endosulfan II | 0.182 | 0.0014 | 0.0003 | 0.17 | 0.031 | 100% | 0.015 | 0.00046 | 1 | 0.157 | 0.005 | 100 | 0.00005 | 10.0 | 0.0005 |
| Endrin | 0.003 | 0.0014 | 0.000004 | 0.046 | 0.0001 | 100% | 0.015 | 0.000002 | 1 | 0.157 | 0.00003 | 0.100 | 0.0003 | 0.010 | 0.003 |
| Gamma-Chlordane | 0.117 | 0.0014 | 0.0002 | 0.0086 | 0.001 | 100% | 0.015 | 0.00002 | 1 | 0.157 | 0.001 | 10.7 | 0.0001 | 2.10 | 0.0005 |
| Methoxychlor | 0.016 | 0.0014 | 0.00002 | 0.045 | 0.001 | 100% | 0.015 | 0.00001 | 1 | 0.157 | 0.0002 | 200 | 0.000001 | 20.0 | 0.00001 |

Notes:

NOAEL = no observed adverse effect level
LOAEL = lowest observed adverse effect level
NA = Input variable not located
NC = Not calculated
kg = kilogram
kg/day = kilogram per day
mg/kg w.w. = milligram per kilograms wet weight
mg/kg/day = milligram per kilograms per day
**Bold** - indicates hazard quotient greater than threshold of one

wet weight concentrations converted as follow: ww = Cs x (1 - % moisture)
where:
ww - wet weight concentration
Cs - dry weight concentration in soil
% moisture - percent moisture
For example, dry weight concentration and % moisture for arsenic were 179 mg/kg and 14.5%, respectively.
ww = 179 x (1- .145)
ww = 153 mg/kg

**Appendix D**
**Food Chain Exposure Model for the Eastern Cottontail**
**Raritan Bay Slag Superfund Site**
**Old Bridge/Sayreville, New Jersey**

| Chemical | Soil | | | Plants | | | Food | | Site Foraging Factor | Body Weight | Dose | LOAEL | | NOAEL | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Concentration mg/kg w.w. | Ingestion Rate kg/day | Total Ingested Chemical mg/day | Bioaccumulation Factor | Concentration mg/kg w.w. | Percent of Diet | Ingestion Rate kg/day | Total Ingested Chemical mg/day | | kg | mg/kg/day | Value mg/kg/day | Hazard Quotient | Value mg/kg/day | Hazard Quotient |
| Arsenic | 153 | 0.015 | 2.30 | 0.036 | 5.51 | 100% | 0.237 | 1.31 | 1 | 1.132 | 3.18 | 0.501 | **6.4** | 0.050 | **64** |
| Cadmium | 1.3 | 0.015 | 0.020 | 0.364 | 0.481 | 100% | 0.237 | 0.114 | 1 | 1.132 | 0.118 | 7.09 | 0.02 | 0.709 | 0.2 |
| Copper | 742 | 0.015 | 11.1 | 0.4 | 297 | 100% | 0.237 | 70.3 | 1 | 1.132 | 72.0 | 14.7 | **4.9** | 11.2 | **6.4** |
| Lead | 7925 | 0.015 | 119 | 0.045 | 357 | 100% | 0.237 | 84.5 | 1 | 1.132 | 180 | 58.8 | **3.1** | 5.88 | **31** |
| Nickel | 21 | 0.015 | 0.313 | 0.032 | 0.668 | 100% | 0.237 | 0.158 | 1 | 1.132 | 0.417 | 58.8 | 0.01 | 29.4 | 0.01 |
| Selenium | 7.3 | 0.015 | 0.109 | 0.016 | 0.116 | 100% | 0.237 | 0.027 | 1 | 1.132 | 0.120 | 0.243 | 0.5 | 0.147 | 0.8 |
| Silver | 7.1 | 0.015 | 0.107 | 0.4 | 2.86 | 100% | 0.237 | 0.678 | 1 | 1.132 | 0.693 | 6.02 | 0.1 | 0.600 | **1.2** |
| Zinc | 309 | 0.015 | 4.63 | 0.000000000001 | 0.0000000004 | 100% | 0.237 | 0.0000000001 | 1 | 1.132 | 4.09 | 235 | 0.02 | 118 | 0.035 |
| Hexavalent Chromium | 1.3 | 0.015 | 0.020 | 1.0 | 1.33 | 100% | 0.237 | 0.32 | 1 | 1.132 | 0.30 | 9.66 | 0.031 | 2.41 | 0.12 |
| Acenaphthene | 0.077 | 0.015 | 0.001 | 7.3 | 0.562 | 100% | 0.237 | 0.133 | 1 | 1.132 | 0.119 | 656 | 0.0002 | 65.6 | 0.0018 |
| Acenaphthylene | 0.072 | 0.015 | 0.001 | 1.0 | 0.072 | 100% | 0.237 | 0.02 | 1 | 1.132 | 0.02 | 656 | 0.000025 | 65.6 | 0.00025 |
| Anthracene | 0.168 | 0.015 | 0.003 | 0.31 | 0.052 | 100% | 0.237 | 0.012 | 1 | 1.132 | 0.013 | 656 | 0.00002 | 65.6 | 0.0002 |
| Benzo(a)anthracene | 0.518 | 0.015 | 0.008 | 0.0202 | 0.010 | 100% | 0.237 | 0.002 | 1 | 1.132 | 0.009 | 6.15 | 0.001 | 0.615 | 0.01 |
| Benzo(a)pyrene | 0.483 | 0.015 | 0.007 | 0.0 | 0.0 | 100% | 0.237 | 0.0 | 1 | 1.132 | 0.006 | 3.98 | 0.002 | 0.400 | 0.02 |
| Benzo(b)fluoranthene | 0.770 | 0.015 | 0.012 | 0.0101 | 0.008 | 100% | 0.237 | 0.002 | 1 | 1.132 | 0.012 | 6.15 | 0.002 | 0.615 | 0.0192 |
| Benzo(g,h,i)perylene | 0.378 | 0.015 | 0.006 | 0.361 | 0.136 | 100% | 0.237 | 0.032 | 1 | 1.132 | 0.034 | 6.15 | 0.01 | 0.615 | 0.1 |
| Benzo(k)fluoranthene | 0.470 | 0.015 | 0.007 | 0.0101 | 0.005 | 100% | 0.237 | 0.001 | 1 | 1.132 | 0.007 | 6.15 | 0.001 | 0.615 | 0.0117 |
| Chrysene | 0.553 | 0.015 | 0.008 | 0.0187 | 0.010 | 100% | 0.237 | 0.002 | 1 | 1.132 | 0.009 | 6.15 | 0.002 | 0.615 | 0.015 |
| Dibenzo(a,h)anthracene | 0.100 | 0.015 | 0.002 | 0.0064 | 0.001 | 100% | 0.237 | 0.0002 | 1 | 1.132 | 0.001 | 6.15 | 0.0002 | 0.615 | 0.0024 |
| Fluoranthene | 1.0 | 0.015 | 0.015 | 0.5 | 0.516 | 100% | 0.237 | 0.122 | 1 | 1.132 | 0.122 | 6.15 | 0.02 | 0.615 | 0.198 |
| Fluorene | 0.319 | 0.015 | 0.005 | 7.3 | 2.33 | 100% | 0.237 | 0.551 | 1 | 1.132 | 0.491 | 656 | 0.001 | 65.6 | 0.01 |
| Indeno(1,2,3-cd)pyrene | 0.266 | 0.015 | 0.004 | 0.0039 | 0.001 | 100% | 0.237 | 0.0002 | 1 | 1.132 | 0.004 | 6.15 | 0.0006 | 0.615 | 0.01 |
| Pentachlorophenol | 0.009 | 0.015 | 0.0001 | 0.0449 | 0.0004 | 100% | 0.237 | 0.0001 | 1 | 1.132 | 0.0002 | 1.76 | 0.0001 | 0.176 | 0.001 |
| Phenanthrene | 1.1 | 0.015 | 0.016 | 2.1 | 2.29 | 100% | 0.237 | 0.543 | 1 | 1.132 | 0.495 | 656 | 0.0008 | 65.6 | 0.01 |
| Pyrene | 1.5 | 0.015 | 0.022 | 0.72 | 1.06 | 100% | 0.237 | 0.251 | 1 | 1.132 | 0.241 | 6.15 | 0.04 | 0.615 | 0.4 |
| Alpha-Chlordane | 0.008 | 0.015 | 0.0001 | 0.0086 | 0.0001 | 100% | 0.237 | 0.00002 | 1 | 1.132 | 0.0001 | 3.70 | 0.00003 | 1.80 | 0.0001 |
| Aroclor 1254 | 14.3 | 0.015 | 0.215 | 0.01 | 0.143 | 100% | 0.237 | 0.034 | 1 | 1.132 | 0.219 | 0.223 | 0.98398 | 0.022 | **10** |
| Aroclor 1260 | 0.032 | 0.015 | 0.0005 | 0.01 | 0.0003 | 100% | 0.237 | 0.00008 | 1 | 1.132 | 0.0005 | 0.223 | 0.00218 | 0.022 | 0.0221 |
| 4,4'-DDD | 0.012 | 0.015 | 0.0002 | 0.00937 | 0.0001 | 100% | 0.237 | 0.00003 | 1 | 1.132 | 0.0002 | 2.94 | 0.0001 | 0.590 | 0.0003 |
| 4,4'-DDE | 0.015 | 0.015 | 0.0002 | 0.00937 | 0.0001 | 100% | 0.237 | 0.00003 | 1 | 1.132 | 0.0002 | 2.94 | 0.0001 | 0.590 | 0.0004 |
| 4,4'-DDT | 0.845 | 0.015 | 0.013 | 0.037 | 0.031 | 100% | 0.237 | 0.007 | 1 | 1.132 | 0.018 | 2.94 | 0.006 | 0.590 | 0.03 |
| Dieldrin | 0.004 | 0.015 | 0.0001 | 0.41 | 0.002 | 100% | 0.237 | 0.0004 | 1 | 1.132 | 0.0004 | 0.147 | 0.003 | 0.015 | 0.03 |
| Endosulfan I | 0.002 | 0.015 | 0.00003 | 0.17 | 0.0003 | 100% | 0.237 | 0.00007 | 1 | 1.132 | 0.0001 | 1.10 | 0.0001 | 0.110 | 0.0008 |
| Endosulfan II | 0.182 | 0.015 | 0.003 | 0.17 | 0.031 | 100% | 0.237 | 0.007 | 1 | 1.132 | 0.009 | 1.10 | 0.008 | 0.110 | 0.1 |
| Endrin | 0.003 | 0.015 | 0.00004 | 0.046 | 0.0001 | 100% | 0.237 | 0.00003 | 1 | 1.132 | 0.0001 | 0.366 | 0.0002 | 0.037 | 0.002 |
| Gamma-Chlordane | 0.117 | 0.015 | 0.002 | 0.0086 | 0.001 | 100% | 0.237 | 0.0002 | 1 | 1.132 | 0.002 | 3.70 | 0.0005 | 1.80 | 0.001 |
| Methoxychlor | 0.016 | 0.015 | 0.0002 | 0.045 | 0.001 | 100% | 0.237 | 0.0002 | 1 | 1.132 | 0.0004 | 5.90 | 0.0001 | 2.90 | 0.0001 |

Notes:

NOAEL = no observed adverse effect level
LOAEL = lowest observed adverse effect level
NA = Input variable not located
NC = Not calculated
kg = kilogram
kg/day = kilogram per day
mg/kg w.w. = milligram per kilograms wet weight
mg/kg/day = milligram per kilograms per day
**Bold** - indicates hazard quotient greater than threshold of one

wet weight concentrations converted as follow: ww = Cs x (1 - % moisture)
where:
ww - wet weight concentration
Cs - dry weight concentration in soil
% moisture - percent moisture
For example, dry weight concentration and % moisture for arsenic were 179 mg/kg and 14.5%, respectively.
ww = 179 x (1- .145)
ww = 153 mg/kg

**Appendix D**
**Food Chain Exporsure Model for the Muskrat**
**Raritan Bay Slag Superfund Site**
**Old Bridge.Sayreville, New Jersey**

| Chemcial | Sediment | | | Plants | | | Food | | Site Foraging Factor | Body Weight | Dose | LOAEL | | NOAEL | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Concentration mg/kg w.w. | Ingestion Rate kg/day | Total Ingested Chemical mg/day | Bioaccumulation Factor | Concentration mg/kg w.w. | Percent of Diet | Ingestion Rate kg/day | Total Ingested Chemical mg/day | | kg | mg/kg/day | Value mg/kg/day | Hazard Quotient | Value mg/kg/day | Hazard Quotient |
| Arsenic | 22 | 0.0431 | 0.950 | 0.036 | 0.794 | 100% | 0.459 | 0.364 | 1 | 1.35 | 0.974 | 0.524 | **1.9** | 0.052 | **19** |
| Cadmium | 0.9 | 0.0431 | 0.041 | 0.364 | 0.343 | 100% | 0.459 | 0.157 | 1 | 1.35 | 0.147 | 7.42 | 0.02 | 0.742 | 0.2 |
| Copper | 444 | 0.0431 | 19.1 | 0.4 | 178 | 100% | 0.459 | 81.5 | 1 | 1.35 | 74.5 | 15.4 | **4.8** | 11.7 | **6.4** |
| Lead | 140 | 0.0431 | 6.03 | 0.045 | 6.29 | 100% | 0.459 | 2.89 | 1 | 1.35 | 6.61 | 61.5 | 0.1 | 6.15 | **1.1** |
| Nickel | 140 | 0.0431 | 6.05 | 0.032 | 4.49 | 100% | 0.459 | 2.06 | 1 | 1.35 | 6.01 | 61.5 | 0.1 | 30.8 | 0.2 |
| Selenium | 4.7 | 0.0431 | 0.202 | 0.016 | 0.075 | 100% | 0.459 | 0.034 | 1 | 1.35 | 0.175 | 0.254 | 0.7 | 0.154 | **1.1** |
| Silver | 7.3 | 0.0431 | 0.316 | 0.4 | 2.93 | 100% | 0.459 | 1.35 | 1 | 1.35 | 1.23 | 6.02 | 0.2 | 0.600 | **2.1** |
| Zinc | 77 | 0.0431 | 3.31 | 0.000000000001 | 0.0000000001 | 100% | 0.459 | 0.00000000004 | 1 | 1.35 | 2.45 | 246 | 0.01 | 123 | 0.02 |
| Hexavalent Chromium | 1.3 | 0.0431 | 0.054 | 1.0 | 1.262 | 100% | 0.459 | 0.579 | 1 | 1.35 | 0.469 | 10.1 | 0.046 | 2.52 | 0.19 |
| Acenaphthene | 0.018 | 0.0431 | 0.001 | 7.3 | 0.131 | 100% | 0.459 | 0.060 | 1 | 1.35 | 0.045 | 656 | 0.00007 | 65.6 | 0.001 |
| Acenaphthylene | 0.031 | 0.0431 | 0.001 | 1.0 | 0.031 | 100% | 0.459 | 0.014 | 1 | 1.35 | 0.011 | 656 | 0.000017 | 65.6 | 0.00017 |
| Anthracene | 0.050 | 0.0431 | 0.002 | 0.31 | 0.016 | 100% | 0.459 | 0.007 | 1 | 1.35 | 0.007 | 656 | 0.00001 | 65.6 | 0.0001 |
| Benzo(a)anthracene | 0.292 | 0.0431 | 0.013 | 0.0202 | 0.006 | 100% | 0.459 | 0.003 | 1 | 1.35 | 0.011 | 6.15 | 0.002 | 0.615 | 0.02 |
| Benzo(a)pyrene | 0.302 | 0.0431 | 0.013 | 0.0 | 0.0 | 100% | 0.459 | 0.0 | 1 | 1.35 | 0.010 | 4.16 | 0.002 | 0.420 | 0.02 |
| Benzo(b)fluoranthene | 0.530 | 0.0431 | 0.023 | 0.0101 | 0.005 | 100% | 0.459 | 0.002 | 1 | 1.35 | 0.019 | 6.15 | 0.003 | 0.615 | 0.03 |
| Benzo(g,h,i)perylene | 0.254 | 0.0431 | 0.011 | 0.361 | 0.092 | 100% | 0.459 | 0.042 | 1 | 1.35 | 0.039 | 6.15 | 0.01 | 0.615 | 0.1 |
| Benzo(k)fluoranthene | 0.254 | 0.0431 | 0.011 | 0.0101 | 0.003 | 100% | 0.459 | 0.001 | 1 | 1.35 | 0.009 | 6.15 | 0.001 | 0.615 | 0.01 |
| Chrysene | 0.323 | 0.0431 | 0.014 | 0.0187 | 0.006 | 100% | 0.459 | 0.003 | 1 | 1.35 | 0.012 | 6.15 | 0.002 | 0.615 | 0.02 |
| Dibenzo(a,h)anthracene | 0.040 | 0.0431 | 0.002 | 0.0064 | 0.0003 | 100% | 0.459 | 0.000 | 1 | 1.35 | 0.001 | 6.15 | 0.0002 | 0.615 | 0.002 |
| Fluoranthene | 0.901 | 0.0431 | 0.039 | 0.5 | 0.451 | 100% | 0.459 | 0.207 | 1 | 1.35 | 0.182 | 6.15 | 0.0296 | 0.615 | 0.3 |
| Fluorene | 0.007 | 0.0431 | 0.0003 | 7.3 | 0.049 | 100% | 0.459 | 0.023 | 1 | 1.35 | 0.017 | 656 | 0.00003 | 65.6 | 0.0003 |
| Indeno(1,2,3-cd)pyrene | 0.228 | 0.0431 | 0.010 | 0.0039 | 0.001 | 100% | 0.459 | 0.0004 | 1 | 1.35 | 0.008 | 6.15 | 0.001 | 0.615 | 0.01 |
| Phenanthrene | 0.260 | 0.0431 | 0.011 | 2.1 | 0.545 | 100% | 0.459 | 0.250 | 1 | 1.35 | 0.194 | 656 | 0.0003 | 65.6 | 0.003 |
| Pyrene | 0.583 | 0.0431 | 0.025 | 0.72 | 0.420 | 100% | 0.459 | 0.193 | 1 | 1.35 | 0.161 | 6.15 | 0.02623 | 0.615 | 0.3 |
| Alpha-Chlordane | 0.005 | 0.0431 | 0.0002 | 0.0086 | 0.00004 | 100% | 0.459 | 0.00002 | 1 | 1.35 | 0.0002 | 3.80 | 0.00004 | 1.90 | 0.00009 |
| Aroclor 1254 | 0.011 | 0.0431 | 0.0005 | 0.01 | 0.0001 | 100% | 0.459 | 0.00005 | 1 | 1.35 | 0.0004 | 0.690 | 0.0005 | 0.140 | 0.003 |
| Dieldrin | 0.001 | 0.0431 | 0.00005 | 0.41 | 0.0004 | 100% | 0.459 | 0.0002 | 1 | 1.35 | 0.0002 | 0.154 | 0.00118 | 0.015 | 0.0121 |
| Gamma-Chlordane | 0.003 | 0.0431 | 0.0001 | 0.0086 | 0.00003 | 100% | 0.459 | 0.00001 | 1 | 1.35 | 0.0001 | 3.80 | 0.00003 | 1.90 | 0.0001 |
| Methoxychlor | 0.003 | 0.0431 | 0.0001 | 0.045 | 0.0001 | 100% | 0.459 | 0.0001 | 1 | 1.35 | 0.0001 | 6.20 | 0.00002 | 3.10 | 0.00004 |

Notes:

NOAEL = no observed adverse effect level
LOAEL = lowest observed adverse effect level
NA = Input variable not located
NC = Not calculated
kg = kilogram
kg/day = kilogram per day
mg/kg w.w. = milligram per kilograms wet weight
mg/kg/day = milligram per kilograms per day
**Bold** - indicates hazard quotient greater than threshold of one

wet weight concentrations converted as follow: ww = Cs x (1 - % moisture)
where:
ww - wet weight concentration
Cs - dry weight concentration in sediment
% moisture - percent moisture
For example, dry weight concentration and % moisture for arsenic were 88.9 mg/kg and 75.2%, respectively.
ww = 88.9 x (1- .752)
ww = 22 mg/kg