BASELINE ECOLOGICAL RISK ASSESSMENT

RED BANK LANDFILL SITE
RED BANK, NEW JERSEY

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LIST OF ACRONYMS AND ABBREVIATIONS

ACO	Administrative Consent Order
ADD	Average Daily Dose
AOC	Administrative Order on Consent
ARRCS	Administrative Requirements for Remediating Contaminated Sites
ASTM	American Society for Testing and Materials
AUF	Area Use Factor
BCF	Bioconcentration Factor
BERA	Baseline Ecological Risk Assessment
BSAF	Biota-Sediment Accumulation Factor
BW	Body Weight
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
COPEC	Contaminant of Potential Ecological Concern
CSM	Conceptual Site Model
EcoSSL	Ecological Soil Screening Level
EE	Ecological Evaluation
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
ERAGS	Ecological Risk Assessment Guidance for Superfund
ERAWP	Ecological Risk Assessment Work Plan
ESC	Ecological Screening Criteria
ESNR	Environmentally Sensitive Natural Resource
GIS	Geographic Information System
HQ	Hazard Quotient
K_{oc}	Organic Carbon Partition Coefficient
LOAEL	Lowest Observed Adverse Effects Level
LSRP	Licensed Site Remediation Professional
mg/kg	milligrams per kilogram
mg/mg-day	milligrams per kilogram per day
mg/L	milligrams per liter
N.J.A.C.	New Jersey Administrative Code
NJDEP	New Jersey Department of Environmental Protection
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No Observed Adverse Effects Level
NRDCSCC	Non-Residential Direct Contact Soil Cleanup Criteria
NWI	National Wetlands Inventory
PA/SI	Preliminary Assessment / Site Investigation
PCB	Polychlorinated Biphenyls
RDCSCC	Residential Direct Contact Soil Cleanup Criteria
RIR	Remedial Investigation Report
ROI	Receptor of Interest
SMDP	Scientific Management Decision Point
SRP	Site Remediation Program
SRRA	Site Remediation Reform Act

LIST OF ACRONYMS AND ABBREVIATIONS (continued)

SRT	Standard Reference Toxicant
SUF	Seasonal Use Factor
SWQS	Surface Water Quality Standards
SVOC	Semi-Volatile Organic Compound
T&M	T&M Associates, Inc.
TOC	Total organic carbon
TRSR	Technical Requirements for Site Remediation
TRV	Toxicity Reference Value
UCL	Upper Confidence Limit
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
WUF	Water Use Factor

EXECUTIVE SUMMARY

A Baseline Ecological Risk Assessment (BERA) was prepared for the Red Bank Landfill Site (the Site) located at the end of Sunset Avenue in the Borough of Red Bank, Monmouth County, New Jersey. Environmental concerns at the Site are being investigated under the New Jersey Department of Environmental Protection (NJDEP) Site Remediation Program (SRP). Information concerning environmental conditions at the Site was submitted to the NJDEP in a November 2010 Remedial Investigation Report (RIR), which concluded that a BERA should be performed.

The objective of the BERA is to evaluate the ecological risks to biological receptors living within the aquatic and terrestrial ecosystems located on or adjacent to the Site, as a result of exposures to Site-related constituents. The BERA is a baseline evaluation of ecological risks that utilizes both historical data regarding the Site and data that were collected as part of investigative activities within Swimming River and at the landfill. The BERA was prepared using conservative assumptions concerning potential exposures to ecological receptors.

Specifically, the principal functions of this BERA were to:

- Assess whether actual or potential ecological risks currently exist at the Site;
- Define the magnitude and extent of the constituents present at the Site that may pose potential ecological risks;
- Determine if constituents originating from the Site have been transported to on-site wetlands; and
- Generate data and information for risk management and risk reduction decisions, as warranted.

This BERA outlines the procedures by which data collected from aquatic and terrestrial habitats associated with the Site, recommended to close data gaps from the previous sampling efforts, were evaluated in order to assess the potential for adverse ecological effects.

This BERA was conducted in accordance with the *Ecological Risk Assessment Work Plan* and followed steps 3 through 8 of the *Ecological Risk Assessment Guidance for Superfund*

(ERAGS): Process for Designing and Conducting Ecological Risk Assessments (USEPA, 1997) pursuant to Section 6 of the *Ecological Evaluation Technical Guidance* (NJDEP, 2012). Data used in this BERA include analytical data on the concentrations of COPECs from various abiotic matrices associated with the Site and the Swimming River collected during field studies.

Swimming River Risk Conclusions

Food chain exposure modeling showed no potential risk to aquatic-feeding receptor species in the vicinity of the Site.

However, sediment toxicity was observed in a sample collected from mid-channel, at the downstream end of the Site. While none of the chemical analyses performed on the toxic sample showed exceedance of NJDEP ESC, and no relationship could be established between observed toxicity and Site-related contaminants of potential ecological concern (COPECs), the sample was acutely toxic to amphipods.

The maximum concentrations of COPECs in Site sediment in the Swimming River pose potential risk to benthic invertebrates and fish. However, the maximum concentrations of COPECs are each only found at one location, while the average exposure over the length of the Swimming River adjacent to the Site is significantly lower. The sample locations closest to the shoreline border of the Site (SED-1A, SED-3A, SED-3B, SED-4A, SED-5A, and SED-5B) show the most exceedances, with the highest COPEC concentrations.

Forested Wetland Area Risk Conclusions

The Site soil concentrations of dieldrin, PCBs, chromium, thallium, and vanadium may pose risk to invertivorous birds and mammals. It is noted that the potential risks to wildlife in this BERA are based on the use of literature-based BAFs. As such, there is the potential that these risks are overestimated and could ultimately be refined through the collection of site-related tissue residue data.

Estimated risks were related to: 1) the concentrations of COPECs in soil and sediment; and 2) the assumptions utilized in the BERA (NOAEL-based TRVs, literature-based BAFs, 95% UCL COPEC concentrations, and model estimates of tissue concentrations). However, the elevated HQs were not spread throughout the AOCs, but were instead localized at a few sample collection locations.

While some estimated risk to wildlife receptors for certain COPECs may still persist, the use of Site-specific biota tissue data (e.g., soil invertebrates, small mammals, plants) would be expected to reduce the calculated HQs and potentially eliminate the calculated risk for some receptors. Further field evaluation would be required to refine the BERA and to determine the extent of the impacted areas.

1.0 INTRODUCTION

Environmental concerns at the Red Bank Landfill Site (the Site) are being investigated under the New Jersey Department of Environmental Protection (NJDEP) Site Remediation Program (SRP) as a result of a November 2010 Remedial Investigation Report (RIR), which concluded that a Baseline Ecological Risk Assessment (BERA) should be performed.

The NJDEP *Technical Requirements for Site Remediation* (TRSR) states that all sites in New Jersey managed under the SRP must be evaluated for potential ecological impacts utilizing a phased approach. As outlined in the TRSR, and as modified by the *Site Remediation Reform Act* (SRRA) and the *Administrative Requirements for Remediating Contaminated Sites* (ARRCS), the first step is the completion of a qualitative Ecological Evaluation (EE) as part of the Receptor Evaluation (New Jersey Administrative Code (N.J.A.C.) 7:26E – 1.16).

If an EE indicates that a BERA is necessary, that step of the assessment process is conducted in accordance with N.J.A.C. 7:26E – 4.8. The regulatory objective of the BERA is to reduce uncertainty regarding any exceedances that were defined in the EE. The BERA is to be conducted by experienced biologists familiar with New Jersey natural resources and United States Environmental Protection Agency (USEPA) guidance on ecological assessments and is to be conducted in accordance the *Ecological Evaluation Technical Guidance* (NJDEP, 2012) for ESNRs associated with the Site. The protocols for conducting a BERA are to be outlined in a work plan that must be approved by the Licensed Site Remediation Professional (LSRP) for the Site, unless the Site is under state oversight. The work plan must define the assessment and measurement endpoints that will be used in the completion of the BERA.

Assessment endpoints are statements of the characteristics or attributes of the environment that are to be protected. Since assessment endpoints generally cannot be measured directly, measurement endpoints (sometimes known as measures of effects) must be identified as a means of indirectly evaluating the assessment endpoints. BERAs are generally completed through the execution of a variety of activities, including biological surveys, supplemental sampling, toxicity testing, bioassays and tissue analysis, and exposure modeling.

1.1 SITE HISTORY

The Red Bank Landfill Site is at the west end of Sunset Avenue, consisting of Block 84, Lot 64, in the Borough of Red Bank, Monmouth County, New Jersey. The property contained an abandoned incinerator building (demolished in 2009-2010). A landfill that was in use from the early 1900's and ceased operation in 1983 remains. The landfill has been closed in accordance with NJDEP requirements. The original incinerator burned coal for the incineration process and was modified and expanded in the 1930's to utilize natural gas. A Borough composting center operated on the western portion of the property from 1983 to 2005. The transfer station for Borough's recycling program is located on the south side of Sunset Avenue for bulk disposal of recyclable materials.

The 8.5 acre property is located north of Newman Springs Road, west of Tilton Avenue, south of James Parker Boulevard, and is situated along approximately 1,000 feet of the eastern shore of the Swimming River. Single and Multifamily residential buildings are located to the east, north, and south of the property, and undeveloped marshlands are located across the Swimming River.

Closure activities included covering the landfill with two feet of cover material and installing four groundwater monitoring wells, as specified in the NJDEP's Administrative Consent Order (ACO) dated August 1984.

1.2 PREVIOUS ENVIRONMENTAL INVESTIGATIONS

T&M Associates, Inc. (T&M) conducted a Preliminary Assessment/Site Investigation (PA/SI) in April 2007 in accordance with the NJDEP's TRSR (N.J.A.C. 7:26E). The PA/SI identified five areas of concern (AOCs) on the property.

AOC 1: Landfill – Sanborn Maps from 1922 depict a "Borough Garbage Dump" on the property. The Red Bank Landfill had NJDEP permits for acceptance of specific solid waste types (ID 13 Bulky Waste, ID 23 Vegetative Waste, and ID 27 Dry Industrial Waste). Wastes were incinerated in the incinerator building, and the residue was deposited in the landfill. The Red Bank Landfill is listed as being "closed" as of 1983.

AOC 2: Historic Fill – Review of the NJDEP Historic Fill of the Long Branch Quadrangle indicates historic fill was placed on the western border of the property. Historic fill is defined as non-indigenous material placed in order to raise the topographic elevation.

AOC 3: Incinerator Site – Surface soil samples were collected by T&M on September 21, 2006 in the vicinity of the incinerator building. Soil samples collected from the perimeter of the incinerator building and one sample of the stack residue revealed base / neutral semi-volatile organic compounds (SVOCs) and chlordane (pesticide) in excess of Residential and Non-Residential Direct Contact Soil Cleanup Criteria (RDCSCC and NRDCSCC).

AOC 4: Incinerator Stack – A sample of the incinerator stack residue (sample SB-6) collected by T&M in December, 2006 indicated elevated concentrations of antimony, arsenic, cadmium, lead, mercury, and zinc.

AOC 5: Groundwater – Four monitoring wells were placed on the property for groundwater characterization associated with the NJPDES permit and landfill closure plan. Quarterly sampling through 1990 indicated elevated levels of permitted parameters.

AOC 6: Swimming River – Investigated as part of a RIR performed by T&M between 2006 and 2010. This AOC is the primary focus of the BERA.

Surface water samples were collected from three locations along the shore of the Site, and found to exceed ecological screening values for metals. The RIR noted that environmental sampling of surface water, sediment, surface soil, and groundwater had identified metals, SVOCs, pesticides, and polychlorinated biphenyls (PCBs) in excess of NJDEP clean-up criteria. The RIR concluded that a BERA should be performed relative to the surface water and sediment sampling.

1.3 PURPOSE AND OBJECTIVES

The objective of this BERA was to evaluate potential ecological effects that may exist as a result of the presence of elevated levels of metals, SVOCs, pesticides, and PCBs that have been

previously identified within the Site. The BERA utilized data that were collected as part of investigative activities in November 2013 (collected by T&M and AMEC). This BERA was prepared using conservative assumptions about potential exposures.

Specifically, the principal functions of this BERA were to:

- Assess whether actual or potential ecological risks currently exist at the Site;
- Define the magnitude and extent of the constituents present at the Site that may pose potential ecological risks;
- Determine if constituents originating from the Site have been transported to on-site wetlands; and
- Generate data and information for risk management and risk reduction decisions, as warranted.

This BERA outlines the procedures by which data collected from aquatic and terrestrial habitats associated with the Site, recommended to close data gaps from the previous sampling efforts, were evaluated in order to assess the potential for adverse ecological effects.

1.4 ORGANIZATION OF THIS BERA

This BERA was conducted in accordance with the LSRP-approved *Ecological Risk Assessment Work Plan* (ERAWP) (**Appendix A**) and followed steps 3 through 8 of the *Ecological Risk Assessment Guidance for Superfund (ERAGS): Process for Designing and Conducting Ecological Risk Assessments* (USEPA, 1997) pursuant to Section 6 of the *Ecological Evaluation Technical Guidance* (NJDEP, 2012). Data used in this BERA include analytical data on the concentrations of COPECs from various abiotic matrices associated with the Site and the Swimming River collected during field studies.

The data included:

- Qualitative biological survey of flora and fauna on the Site including a photograph log of various habitats found throughout the Site (**Appendix B**);

- Surface water and sediment samples collected for chemical analyses from the Swimming River;
- Sediment samples collected for toxicity studies from the Swimming River (**Appendix C**); and
- Surface soil samples collected from the forested wetland located adjacent to the Site.

The Summary of the Ecological Evaluation (Section 2) discusses the ecological evaluation process and summarizes the findings of the Remedial Investigation Report. Section 3 details the Ecological Risk Assessment Process. The BERA Problem Formulation phase (Section 4) characterizes the environmental setting of the Site, develops the conceptual site model (CSM), and describes the assessment endpoints to be evaluated in the BERA. The CSM identifies potential site-related contaminants and describes contaminant fate and transport mechanisms, mechanisms of toxicity, complete exposure pathways, and discusses the COPECs that have been identified in the aquatic environment of the Swimming River and the terrestrial environment of the forested wetland located along the southern boundary of the Site. The BERA Site Investigation Results and Data Analysis (Section 5) details the data used in the BERA, the methods for evaluation of the data, and the effects evaluation.

During the Risk Characterization phase (Section 6), the information concerning exposure and the information concerning potential effects of exposure are integrated to estimate risks (the likelihood of effects given the exposure) or potential impacts. Uncertainties noted in the development of the aquatic and forested wetland ecological risk estimates are detailed in Section 7. The BERA conclusions are presented in Section 8.

2.0 SUMMARY OF THE FINDINGS OF THE ECOLOGICAL EVALUATION

2.1 OVERVIEW OF ECOLOGICAL EVALUATION PROCESS

The NJDEP TRSR states that all sites in New Jersey that are managed under the SRP must be evaluated for potential ecological impacts utilizing a phased approach. The first step is the completion of an EE. The EE is to be conducted by experienced biologists familiar with New Jersey natural resources and United States Environmental Protection Agency (USEPA) guidance on ecological assessments. The objectives of the EE are to:

- Identify environmentally sensitive areas and potential ecological receptors on and immediately adjacent to the Site;
- Identify chemical migration pathways to any sensitive areas and document observations of potential impact which may be attributable to the presence of chemicals; and
- Evaluate the nature of chemicals detected at the site and identify COPECs which may adversely impact ecological receptors.

The EE evaluates the potential for ecological impacts from the presence of COPECs at the Site. A COPEC is defined as a substance detected at a site that has the potential to adversely affect ecological receptors because of its concentration, distribution, and mode of toxicity. Contaminants with concentrations above their respective New Jersey Surface Water Quality Standards (SWQS) or Ecological Screening Criteria (ESC) are identified as COPECS.

The EE is intended to be qualitative in nature and is based on sampling results obtained during the site investigation. The results of the EE are intended to assess the *potential* for ecological effects from the exposure of environmentally sensitive natural resources (ESNRs) to COPECs and to focus future investigations, if needed. The EE will identify whether a BERA is necessary. Continued investigations are required (N.J.A.C. 7:26E – 4.8) if, and only if, the EE indicates the co-occurrence of the following three conditions:

1. COPECs exist on-site;
2. An ESNR exists on, or immediately adjacent to the Site; and
3. Potential contaminant migration pathways to ESNRs exist, or an impact to these areas is indicated based on visual observation.

2.2 SUMMARY OF THE REMEDIAL INVESTIGATION REPORT

The RIR (T&M 2010) noted that environmental sampling of surface water, sediment, and groundwater had identified metals, SVOCs, pesticides, and PCBs in excess of NJDEP clean-up criteria. The RIR concluded that a BERA should be performed relative to the Swimming River surface water and sediment.

Though a formal EE was not performed, the RIR findings satisfied the three EE conditions that would require a BERA: 1) presence of COPECs; 2) presence of ESNRs on or adjacent to the Site; and 3) contaminant migration pathways from the Site to the ESNR.

This BERA focuses on the Swimming River (AOC 6), and the forested wetland to the south of the landfill.

3.0 ECOLOGICAL RISK ASSESSMENT PROCESS

This BERA was conducted in a manner that conforms to Steps 3 through 7 of the eight step USEPA ERA process. USEPA has developed and issued guidance for conducting BERAs. In 1992, USEPA presented a general framework for conducting ERAs that outlined the concepts of assessment and measurement endpoints (USEPA, 1992a). The USEPA framework document was intended to be the first step in the promulgation of a simple and flexible structure for evaluating the potential for ecological risks. The framework document outlined the completion of an ERA in terms of:

1. Problem Formulation – This is the first phase of the ERA during which the goals, breadth, and focus of the assessment are articulated;
2. Analysis – The analysis phase consists of the technical evaluation, and is divided into the characterization of exposure and the characterization of ecological effects; and
3. Risk Characterization – During this phase, the likelihood of the expression of adverse effects resulting from the exposure of a receptor to a stressor is evaluated.

This framework approach was further defined in 1998 with the publishing of USEPA's general guidelines for conducting ERAs (USEPA, 1998), placing new emphasis on ensuring that the results of the assessment can be used to support risk management decisions.

Almost concurrent with the issuance of the 1998 guidance document, an interim final programmatic guide to the development of ERAs under CERCLA was developed by the USEPA Office of Emergency & Remedial Response (USEPA, 1997). This guide (*Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* or "ERAGs") placed the three phases of the ERA process into a more structured eight-step process for the development of ERAs specifically at CERCLA sites. This allowed for a more proactive mechanism to measure the progress and organization of the ERA. The eight steps outlined in that document (and applied to this BERA) are:

Step 1 – Preliminary Screening Level, which includes a site visit, preliminary problem formulation, and preliminary toxicity evaluation.

Step 2 – Screening Level, which includes development of exposure estimates and preliminary risk calculations. The step includes a Scientific/Management Decision Point (SMDPa).

Step 3 – Baseline Risk Assessment Problem Formulation, which includes toxicity evaluation, development of a preliminary site conceptual model and exposure pathways, and development of assessment endpoints. This step also includes SMDPb.

Step 4 – Study Design and Data Quality Objective (DQO) Development. This step includes development of the Work Plan, and Sampling and Analysis Plan, based upon results of the previous three steps. This step includes SMDPc.

Step 5 – Verification of Field Sampling Design. This step includes a determination of the feasibility of the field program as outlined in Step 4. This step includes SMDPd.

Step 6 - Site Investigation and Data Analysis. This step includes SMDPe.

Step 7 – Risk Characterization. More refined and detailed quantification of potential site risks, and a more realistic evaluation of risks than was performed in Step 2.

Step 8 – Risk Management, which includes selection of alternatives in the Record of Decisions as SMDPf.

SMDPs are checkpoints in the ERA process to:

1. Verify that the work that was conducted at each step is complete;
2. Determine whether the risk assessment is proceeding in a direction that will support decision making; and
3. Determine the need, if any, for proceeding to the next step.

SMDPs provide the opportunity to further focus assessment approaches or add additional activities to address the specific goals of the ERA. They also provide the opportunity to exit the process where the weight-of-evidence supports no further action, since all eight steps may not be required for all site evaluations.

4.0 BERA PROBLEM FORMULATION

The problem formulation consists of a description of the relevant features and the current condition of the environment, a description of the potential sources for Site-related COPECs, an identification of ecological receptors at the Site and surrounding area and the development of the CSM.

4.1 GENERAL ECOLOGICAL CHARACTERIZATION OF THE SITE

The Site is located at the west end of Sunset Avenue, Red Bank, Monmouth County, New Jersey. A Site location map, prepared from a United States Geological Survey New Jersey 7½ minute topographic quadrangle, is included as **Figure 1**. An aerial Site map showing property boundaries is provided as **Figure 2**.

The surrounding area to the northeast, east, and south of the Site is residential/commercial, and to the northwest (across the Swimming River) is undeveloped marsh land. Sunset Avenue ends at a gate leading to a dirt path into the landfill area (**Appendix B**, Photo 1). During a June 3, 2013 site visit, the dirt path was highly eroded by stormwater runoff (Photo 2). The middle of the landfill area is a partially open meadow, vegetated with sedges, common reed (Phragmites), and low shrubs (Photo 3). The southern end of the landfill, leading to the forested wetland is densely vegetated with Phragmites, Japanese knotweed (*Fallopia japonica*), briars, and ruderal species (Photo 4). There is a forested wetland at the southern end of the Site, with steep banks (Photo 5) sloping down to a small drainage that leads to the river (Photo 6). The drainage appeared to be a stormwater conveyance rather than a creek, and the water at the mouth of the drainage appeared to be the river water moving in and out with the tide.

The portion of the landfill Site that borders the river is steeply banked, and vegetated with small trees, vines, and shrubs (Photo 7). Passing the landfill and the salt marsh to the west (Photo 8), the river flows north and joins with the discharge from Shadow Lake to become the Shrewsbury River, approximately 3/4 mile downstream from the Site.

There is a large earthen mound near the entrance to the landfill area. While the mound is at ground level near the Sunset Avenue gate, where it is used as a recycling collection center

(Photo 9), the landfill property slopes down toward the river, and the landfill side of the mound is steeply banked, and the slope is approximately 20 feet high (Photo 10). The slope is not vegetated, and the soil has been eroded by storm runoff (Photo 11). There are residential properties adjacent to the landfill, to the southeast of the mound, and at the head of the forested wetland swale (Photo 12).

During the course of the field activities supporting the BERA, a more thorough understanding of the characteristics of the terrestrial, wetland, and aquatic ecosystem associated with the Site were developed. Wetland and aquatic sampling provided a qualitative assessment of the benthic macroinvertebrate community as well as physical characteristics of, and concentration of constituents within, the sediments and surface water of the river. A description of the surrounding upland and aquatic habitats and dominant vegetative communities of both, including a qualitative determination of community makeup, density, frequency and abundance are provided below, based on observations and information collected during implementation of the field sampling program.

4.1.1 UPLAND HABITAT

The upland wooded areas located around the perimeter of the Site support a diverse and dense vegetative community. The upland canopy in these sections was dominated by deciduous tree species, such as Norway maple (*Acer platanoides*), silver maple (*Acer saccharinum*), box elder (*Acer negundo*), chestnut oak (*Quercus Montana*), tree-of-heaven (*Ailanthus altissima*), black locust (*Robinia pseudoacacia*), and sycamore (*Platanus occidentalis*).

The herbaceous layer was comprised of species such as mugwort (*Artemisia vulgaris*), Japanese knotweed (*Fallopia japonica*), garlic mustard (*Alliaria petiolata*), white wood aster (*Eurybia divaricata*), curly dock (*Rumex crispus*), bluegrass (*Poa* spp), hawthorn (*Crataegus* spp), vines such as oriental bittersweet (*Celastrus orbiculatus*), Japanese honeysuckle (*Lonicera japonica*), and poison ivy (*Toxicodendron radicans*), and saplings of the above tree species.

The central open area of the landfill supports a mixture of short and tall grassy areas dominated by common reed (*Phragmites australis*). Evidence of the wildlife in the community, including

calls or songs, tracks and scat, was documented during the sampling event to further understand the avian and mammalian populations that utilize the river for various activities including foraging, drinking, or resting.

Photos of the typical flora, and the upland communities, and the river habitat are provided in **Appendix B**.

4.1.2 FORESTED WETLAND HABITAT

According to the New Jersey Freshwater Wetlands Map, the forested wetland area to the south of the landfill, the marsh along the southern shore upstream of the Site, and the salt marsh across the Swimming River from the Site area described as natural wetlands (**Figure 3)**.

The Borough of Red Bank also received from the NJDEP Division of Land Use Regulations a Freshwater Wetlands Letter of Interpretation: Line Verification (**Appendix D**), providing a jurisdictional determination of wetlands adjacent to the Site.

The terrain slopes steeply from the landfill surface down to a small drainage that leads to the river. The drainage appeared to be a stormwater conveyance rather than a creek, and it is unknown whether the water at the bottom of the swale is permanent. The water at the mouth of the drainage appeared to be tidal flow of river water.

The soil on the slope of the landfill leading down into the forested wetland was sandy and loose, and ranged from a dark brown near the head of the swale (**Appendix B**; Photo 13) to a rusty color at the end of the swale closer to the river (Photo 14).

The United States Fish and Wildlife Service's (USFWS) National Wetlands Inventory (NWI) Map describes the open water community of the Swimming River as an estuarine, subtidal, unconsolidated bottom community. The forested wetland area is listed as a palustrine, forested, broad-leaved deciduous, seasonal-tidal wetland. The shoreline of the Swimming River upstream of the Site is described as an estuarine, intertidal, emergent, *Phragmites australis* wetland. The salt marsh across the Swimming River from the Site is described as estuarine, intertidal, emergent, persistent wetland (**Figure 4**).

4.1.3 SWIMMING RIVER AQUATIC HABITAT

The Swimming River in the vicinity of the Red Bank Landfill Site is approximately 100 feet to 150 feet across, and approximately six feet deep at mid-channel (at low tide). The tidal flow during the November sampling event was approximately two to three knots at peak flow. The flow in the channel is strong enough to scour fine sediment, and leave a firm-packed medium-coarse sand substrate.

The marsh side of the channel is bordered by a dense *Phragmites* marsh, with a steep slope from the base of the reeds to the river channel (**Appendix B**; Photo 15). The sediment on the marsh side of the channel was softer and finer than in the center of the channel, indicating a slower water flow. The water at high tide extends well into the Phragmites, creating potential shelter for myriad cryptic species.

The landfill side of the channel is bordered by a steep, rocky shoreline composed of chunks of rock armor, and waste concrete (Photos 16, 17, and 18). The sediment close to shore on the landfill side of the channel is coarse and rocky for 20 or 30 feet from shore, until it becomes the firm-packed medium-coarse sand found in the center of the channel.

The Swimming River is described by the National Wetlands Inventory as estuarine, subtidal, unconsolidated bottom (**Figure 4**).

4.1.4 SENSITIVE RECEPTORS

Sensitive receptors include those natural habitats that could support threatened and/or endangered species (either federally or state listed) or could support wetlands, or the endangered and/or threatened species themselves. Endangered species are those organisms whose prospects for survival in an area are assumed to be in immediate danger because of a loss or change in habitat, over-exploitation, predation, competition, or disease. Threatened species are those who may become endangered if conditions surrounding the species begin, or continue, to deteriorate.

According to the New Jersey Freshwater Wetlands Map (**Figure 3**) and the NWI Map (**Figure 4**), wetlands are present on and immediately adjacent to the Site. It is cautioned that wetlands shown on these maps may significantly overestimate the actual amount of land covered by wetlands, due to the basis by which wetland maps are prepared (aerial photo-interpretation versus actual field evaluation). Field delineations, which were not performed, are required to define the regulatory boundaries of wetlands for permitting purposes.

Wildlife use of the site and the adjacent river includes mammals and birds observed during the June site visit (white-tailed deer (*Odocoileus virginianus*), grey squirrel (*Sciurus carolinensis*), raccoon (*Procyon lotor*), great blue heron (*Ardea herodias*), osprey (*Pandion haliaetus*), red-winged blackbird (*Agelaius phoeniceus*), and numerous passerines). The great blue heron is a state species of special concern and the osprey is a state threatened species.

In addition, the NJDEP Landscape Project files for this property on NJ-GeoWeb (NJDEP, 2012) show the emergent marsh area and the riparian corridor adjacent to the Site have been designated as habitat suitable for foraging by the state threatened black-crowned night heron (*Nycticorax nycticorax*), the common tern (*Sterna hirundo*), a state species of special concern, and/or the state endangered/federally threatened bald eagle (*Haliaeetus leucocephalus*). The Swimming River is anticipated to provide additional habitat for marine/estuarine fish and invertebrates.

4.2 PHYSICAL SITE SETTING

The following sections provide the regional ecological conditions and a general understanding of the ecological receptors, communities, and setting found within and adjacent to the Site.

4.2.1 TOPOGRAPHY AND DRAINAGE

The Site topography generally slopes toward the river, with a steeper slope from the end of Sunset Avenue down to a relatively flat central plain, and steep slopes around the perimeter of the Site dropping into the forested wetland swale or down to the river. The approximate elevation of the Site is less than 10 feet above mean sea level. Drainage in the area is

generally via overland flow and from the wetland swale that discharges into the Swimming River.

4.2.2 SOILS

A review of the Natural Resources Conservation Service Soils Map indicates that the soils surrounding the Site are of several different general soil units. The following soil mapping units were located on and immediately adjacent to the landfill (**Figure 5**):

- Freehold sandy loam, 15-25% slopes, eroded
- Humaquepts, 0-3% slopes, frequently flooded
- Tinton loamy sand, 5-10% slopes; and
- Tinton-Urban land complex, 0-5% slopes

The Freehold sandy loam soil is classified as moderately deep, well drained soil, 35 to 70 inches deep or more to the restrictive feature. The Humaquepts soil is moderately deep, poorly drained, with a depth to the water table of 0-12 inches. The Tinton loamy sand soil is classified as moderately deep, well drained soil, with a depth to the water table of more than 80 inches (USDA, 2013).

4.2.3 GEOLOGY

The Site is located in the Coastal Plain physiographic province of New Jersey. The Coastal Plain extends from the Delaware Bay in the southwest to the Raritan Bay in the northeast and from the “Fall Line” (boundary line with the Piedmont province) in the northwest to the Atlantic Ocean in the southeast. The Coastal Plain province is approximately 4,667 square miles in area and occupies about three-fifths of the state. The unconsolidated deposits that make up the Coastal Plain range in age from the upper Lower Cretaceous to the Miocene period (90 to 10 million years old) and dip gently to the southeast towards the Atlantic Ocean. The altitude for the Coastal Plain is between sea level and 391 feet above sea level (NJGS, 2003).

4.2.4 HYDROLOGY

The entire property lies in the Navesink River/Lower Shrewsbury River Watershed. The Swimming River borders the Site on its western/northwestern boundary. A tidal marsh exists across the river from the Site. No ponds or impoundments are present on, or adjacent to the Site. The forested wetland feature at the southern end of the landfill acts as a large drainage ditch located between the landfill and the residential neighborhood to the south.

4.3 IDENTIFICATION OF CONSTITUENTS OF POTENTIAL ECOLOGICAL CONCERN

The target parameters or analytes of concern for the Red Bank Landfill Site are metals, SVOCs, pesticides and PCBs identified in the sediments during the initial RIR process. The results of the sampling and analysis of soil, sediment, and surface water were used to determine where the COPECs are present in the forested wetland and the Swimming River, and if there are potential impacts to ecological receptors from site-specific COPECs.

4.4 CONCEPTUAL SITE MODEL

One of the most critical elements of the BERA scoping process is the development of the CSM. The CSM describes the hypothesized source of COPECs, routes of transport, potential fate mechanisms, potential exposure pathways, and ecological receptors associated with the Site. The CSM serves as the rationale for the development of sampling plans and protocols, the selection of assessment and measurement endpoints, and the identification of receptors of concern. The CSM can be revised as new Site-related information becomes available.

The following sections describe in greater detail the CSMs for the aquatic and terrestrial pathways associated with the Site. The CSMs are graphically described in **Figures 6a** and **6b**, respectively.

4.4.1 AQUATIC PATHWAYS

The contamination within the landfill portion of the Site is based on historic dumping. Therefore, the primary aquatic pathways would be the mechanisms by which chemicals migrate into sediments and surface water through groundwater migration, surface runoff, physical disturbance, and food chain transport.

In coarse-grained sediments with little organic material, dissolved COPECs will pass directly into the water column. In fine-grained or organic rich sediments, a portion of the constituents may adhere to sediment particles. Whether the constituents remain in the sediment or are dissolved again will depend on their chemical characteristics. Those chemicals with high organic carbon partition coefficient (K_{oc}) values will have a greater affinity for sediment, especially sediment that is high in organic matter. Such constituents would tend to remain sorbed onto sediment particles and migration would occur as a result of sediment movement, not chemical movement.

A physical disturbance of the sediment by anthropogenic activities, like dredging, or natural processes such as erosion, can cause resuspension and/or dissolution of the chemicals within the sediment. This effect may be long- or short-term depending upon the size and solubility of the compound and the size of the sediment particle. While in the water column, pelagic flora and fauna may be directly exposed to the re-suspended chemicals as they are transported to other sites. Mobilized constituents in surface water may then be transported through the food chain to higher order trophic levels (e.g., piscivorous and omnivorous wildlife). Indirect exposure through the food chain occurs when a COPEC is assimilated by a species (e.g., prey/food item) at one trophic level, bioaccumulated by that trophic level, and transferred to the next trophic level through consumption.

Constituents that are dissolved in the surface water may be diffused by the larger volume of the receiving water body. Diffusion is further enhanced by the flow of water within a water body, by increasing the rate of diffusion and moving the diluted chemicals out of the recharge zone. However, if the water body is low in volume and flow, the settling of suspended constituents back into the sediment is possible.

4.3.2 TERRESTRIAL PATHWAYS

The contamination within the terrestrial portion of the landfill is based on historic dumping. While the landfill closure included covering the landfill with two feet of soil, the forested wetland ESNR adjacent to the former landfill area provides a potential exposure pathway for Site-related contaminants to impact ecological receptors. Therefore, the primary terrestrial pathway would

be the mechanisms by which chemicals migrate into soils through groundwater migration, surface runoff, physical disturbance, and food chain transport.

4.5 IDENTIFICATION OF RECEPTORS OF INTEREST

The first step in the assessment of effects is the identification of those Receptors of Interest (ROIs) that will be evaluated in the BERA. As it is not feasible to evaluate the relationship of COPECs to every species at the Site, ROIs have been selected to represent the organisms that might be present at the Site most often or are likely to be most sensitive to the effects of the COPECs. Selection criteria for ROIs include the following factors specified in USEPA guidance (1989, 1992a, 1994, 1997, 1998): (1) the occurrence of potentially complete pathways for exposure of ecological resources to chemicals in environmental media; (2) resident communities or species exposed to the highest concentrations of COPECs in environmental media; (3) species or functional groups considered to be essential to, or indicative of, the normal functioning of the affected habitat; and (4) the feasibility of completing a quantitative assessment for the identified pathways and receptors.

Species were selected as ROIs for this assessment using the following criteria:

- Relative abundance and ecological importance within the identified habitats;
- Availability and quality of appropriate ecotoxicological research;
- The sensitivity of the organism to the COPECs;
- Importance of the trophic level in the ecosystem;
- The relative mobility and type of feeding habits; and
- The ability to bioaccumulate COPECs.

The following ROIs were selected for this BERA because they were either observed at the Site or are expected to utilize the habitat in or around the landfill and the Swimming River. In addition, these species are well documented in terms of ecological risk exposure modeling information:

- Benthic invertebrates
- Fish

- Birds
  - Piscivorous birds (bald eagle and great blue heron)
  - Invertivorous birds (American robin (*Turdus migratorius*), spotted sandpiper (*Actitis macularia*) and mallard duck (*Anas platyrhynchos*))
- Mammals
  - Invertivorous mammal (short-tailed shrew (*Blarina brevicauda*))
  - Omnivorous mammal (raccoon)

Benthic invertebrates were selected as ROIs because they are sensitive to environmental stressors and they are susceptible to localized contamination due to their relative immobility. Because benthic invertebrates and fish form the prey base for higher trophic level organisms, and some of the constituents tend to bioaccumulate or biomagnify up the food chain, higher trophic-level birds (bald eagle, great blue heron, spotted sandpiper, and mallard) and mammals (raccoon) were selected for the aquatic pathway risk assessment.

Terrestrial ROIs were also chosen because COPECs in soil can be accumulated by soil invertebrates which act as prey for higher trophic level birds (robin) and mammals (shrew and raccoon), which were selected for the terrestrial pathway risk assessment.

4.6 ASSESSMENT AND MEASUREMENT ENDPOINTS

Assessment endpoints are explicit expressions of the actual environmental values (e.g., ecological resources) that are to be protected. Valuable ecological resources include those without which ecosystem function would be significantly impaired, those providing critical resources (e.g., habitat), and those perceived as valuable (e.g., endangered species). Assessment endpoints are selected based on key ecosystems, communities, or ecological functions; contaminants present; the extent and magnitude of contamination; mechanisms of toxicity; and potential exposure pathways. It is not practical or possible to directly evaluate risks to all of the individual components of the ecosystem at the site, so assessment endpoints are used to focus the risk assessment on particular components of the ecosystem that could be at greatest risk from exposure to contaminants associated with the site. The assessment endpoints in this BERA were developed based on the four selection criteria described in the USEPA ERAGS (USEPA, 1997).

Because assessment endpoints generally cannot be measured directly, measurement endpoints have been identified. There are four types of measurement endpoints, or lines of evidence that were used to assess the status and potential changes in the attributes of the environment. Those lines of evidence are:

- Determination of the potential for ecological effects through the comparison of COPEC concentrations to media-specific ecotoxicological benchmarks derived from the literature, when available;
- Qualitative and semi-qualitative biological survey data of various ROIs which are direct estimates of the assessment endpoint;
- Direct measurement of sediment toxicity using surrogate benthic invertebrates in laboratory exposures; and
- Estimation of the potential for ecological effects on higher trophic level organisms from COPECs based on dietary exposure modeling.

A weight-of-evidence approach was utilized in evaluating different lines of evidence collected for each of the measurement endpoints. Each line of evidence used in the weight-of-evidence approach was correlated in an exposure-response relationship in an attempt to demonstrate a relationship between the magnitude of exposure and the magnitude of effects. A weight-of-evidence approach weighs each of the measurement endpoints by considering the strength of association between the measurement and assessment endpoints, the quality of the available data, and the study design and execution.

The strength of association refers to how well a measurement endpoint represents an assessment endpoint such that the greater the correlation between the measurement and assessment endpoints, the greater the weight given to that measure of effect.

The weight assigned to a measurement endpoint also depends on the quality of the data as well as the overall study design and execution. The sampling program provided information to evaluate each measurement endpoint. However, the BERA also evaluated the variability and uncertainties associated with the results following implementation of the sampling effort. The risk characterization gives higher weight to measurement endpoints that are based on good

quality data and are obtained using study designs that account for confounding variables. Nonetheless, there is considerable uncertainty associated with estimating potential ecological risks, because ecological systems are complex and exhibit high natural variability.

Measurement endpoints typically have specific strengths and weaknesses related to the factors discussed above. Therefore, it is common practice to use more than one measurement endpoint to evaluate each assessment endpoint.

Assessment Endpoint #1: Evaluate the potential for adverse changes in the survival, reproduction, and growth of benthic invertebrate populations utilizing the Swimming River, resulting from potential exposures to COPECs in sediments and/or surface water;

Measurement Endpoints for Assessment Endpoint #1

a) The first line of evidence was the evaluation of COPEC data obtained through the chemical analysis of sediments. The ability of the benthic community to perform its role as a prey base was evaluated by comparing the concentrations of COPECs to appropriate sediment quality benchmarks based on the protection of benthic macroinvertebrates (e.g., NJDEP Ecological Screening Criteria (ESC); NJDEP, 2009).

b) Another line of evidence was the evaluation of COPEC data obtained through the chemical analysis of surface water. This was assessed for benthos by comparing concentrations of Site-related COPECs identified in surface water samples collected from the river to the New Jersey Surface Water Quality Standards (NJSWQS) (NJDEP, 2006) which are based on the protection of aquatic organisms. If appropriate NJSWQS benchmarks were not available, then NJDEP's ESC (NJDEP, 2009) or USEPA Region 3 Marine Surface Water Screening Values for Hazardous Waste Sites (USEPA, 2001b), or other appropriate surface water criteria were used as secondary sources for benchmarks.

c) A qualitative biological survey of the river and surrounding communities was used as another line of evidence. As part of that, AMEC assessed the possible presence of

gross level changes in the biological community. Visible indicators, such as areas that are devoid of plant material, were noted.

d) The qualitative evaluation of benthic community structure was also used as a line of evidence. Evaluations included a presence/absence determination of benthic invertebrates from each sediment sample collected as well as documenting the dominant species to the lowest practical taxon.

e) A direct measurement of sediment toxicity was also made through laboratory sediment toxicity studies using the marine amphipod, *Leptocheirus plumulosus*.

Rationale for Measurement Endpoints 1a through 1e

The release of COPECs in sufficient concentrations could have an ecological impact on the benthic community. The measurement endpoints above were selected to evaluate potential pathways that would result in the exposure of benthos to COPECs. Those endpoints associated with sediment and surface water measurements were intended to provide an assessment of the ability of those matrices to potentially support benthic macroinvertebrates. The sampling area represents only a small portion of the aquatic system, as such, assumptions were made based on best professional judgment, regarding the potential exposure-response relationship for the Swimming River.

While the analysis of sediments and surface water provided an estimate of potential exposure, the biological survey provided a qualitative visual assessment of the effects, if any, of sediment and surface water COPECs on the flora and fauna communities. It also assessed habitat suitability for various wildlife activities, such as breeding and foraging.

The qualitative evaluation of the benthic macroinvertebrate community provided evidence of its ability to function as a prey base. The BERA was designed to correlate chemical concentrations in sediments to possible benthic community effects.

The direct measure of sediment toxicity to marine amphipods provided quantitative and qualitative evidence of the sediment's suitability as habitat. By examining the sediment toxicity,

the BERA was designed to correlate COPEC concentrations in the sediment to observed toxic effects.

Assessment Endpoint #2: Evaluate the potential for adverse changes in the survival, reproduction, and growth of fish populations utilizing the Swimming River, resulting from potential exposures to COPECs in sediments and/or surface water;

Measurement Endpoints for Assessment Endpoint #2

a) The first line of evidence was the evaluation of COPEC data obtained through the chemical analysis of sediments. The ability of the river to support fish was evaluated by comparing the concentrations of COPECs in sediments collected from the river to appropriate sediment quality benchmarks based on the protection of fish and/or aquatic biota (e.g., NJDEP ESCs).

b) Another line of evidence was the evaluation of COPEC data obtained through the chemical analysis of surface water. This was assessed for fish by comparing concentrations of Site-related COPECs identified in surface water samples collected from within the river to the NJSWQS (NJDEP, 2006) which are based on the protection of aquatic organisms. If appropriate NJSWQS benchmarks were not available, then NJDEP's ESC or USEPA Region 3 Marine Surface Water Screening Values, or other appropriate surface water criteria were used as secondary sources for constituent benchmarks.

Rationale for Measurement Endpoints 2a and 2b

The potential release of COPECs in sufficient concentrations could have an ecological impact on the fish community. The measurement endpoints were selected to evaluate potential pathways that would result in the exposure of fish to COPECs. Those endpoints associated with sediment and surface water measurements were intended to provide an assessment of the ability of those matrices to potentially support fish. The sampling area represents only a small portion of the aquatic system, as such, assumptions were made based on best professional judgment, regarding the potential exposure-response relationship for the entire Swimming River.

Assessment Endpoint #3: Evaluate the potential for adverse changes in the survival, reproduction, and growth of populations of piscivorous, omnivorous and invertivorous species potentially utilizing the Swimming River, resulting from exposures to COPECs in sediments, surface water and/or prey.

Measurement Endpoints for Assessment Endpoint #3

a) Potential ecological risks to piscivorous birds (bald eagle and great-blue heron), invertivorous birds (spotted sandpiper and mallard), and an omnivorous mammal (raccoon) were measured using dietary exposure modeling based on body burden concentrations of COPECs in sediments and surface water collected at the Site, compared to associated toxicity reference values (TRVs) identified in the literature. Exposure concentrations to ROIs were estimated using food chain models.

Rationale for Measurement Endpoint #3a

Measured concentrations of COPECs in the sediment and surface water may not produce direct ecotoxicological effects. However, if COPECs are bioavailable and bioaccumulative, they could potentially produce adverse effects to higher trophic levels. This may result in indirect impacts to more wide-ranging species, to species that are especially sensitive to particular COPECs, or to species that have special status because of population levels or habitat requirements. For that reason, dietary exposure was employed to assess the upper level aquatic species to COPECs in sediments and surface water. The potential for ecological risks to these ROIs feeding at the Site were calculated through an average daily dose (ADD) then compared to COPEC-specific TRVs.

Assessment Endpoint #4: Evaluate the potential for adverse changes in the survival, reproduction, and growth of populations of omnivorous and invertivorous species potentially utilizing the forested wetland adjacent to the former landfill area, resulting from exposures to COPECs in soil and/or prey.

Measurement Endpoints for Assessment Endpoint #4

a) Potential ecological risks to invertivorous birds (American robin), omnivorous mammals (raccoon), and invertivorous mammals (short-tailed shrew) were measured using a dietary exposure based on body burden concentrations estimated from COPEC concentrations in soil collected at the Site, compared to associated TRVs identified in the literature. Exposure concentrations to ROIs were estimated using food chain models.

Rationale for Measurement Endpoint #4a

Measured concentrations of COPECs in the soil may not produce direct ecotoxicological effects. However, if COPECs are bioavailable and bioaccumulative, they could potentially produce adverse effects to higher trophic levels. This may result in indirect impacts to more wide-ranging species, to species that are especially sensitive to particular COPECs, or to species that have special status because of population levels or habitat requirements. For that reason, dietary exposure was employed to assess the potential exposure of upper level terrestrial species to COPECs in soil. The potential for ecological risks to these ROIs feeding at the Site were calculated through an ADD then compared to COPEC-specific TRVs.

5.0 BERA SITE INVESTIGATION RESULTS AND DATA ANALYSIS

This section describes the data and information that form the basis of the BERA. Following the discussion of available data, the approach used to estimate potential exposures is described, including detailed descriptions of the methods used to estimate exposure point concentrations and the exposure models used to estimate food web exposures.

5.1 DATA USED IN THIS BERA

Chemical data used for the BERA includes data collected by T&M and AMEC in November 2013. All chemical data were collected in accordance with the ERAWP (**Appendix A**). Sediment and surface water sampling locations were developed based on historic sampling events. Data from the RIR showed five sediment and surface water sampling locations along the Swimming River, adjacent to the Site. For this BERA, 23 sediment samples were collected from transects across the Swimming River: two samples were collected near-shore from each of the five historical sediment sampling locations; one sample was collected mid-stream between each of the five existing locations; three samples were collected in the far-shore environment (one each across from historical locations #1, #3, and #5); three background location samples were collected upstream of the Site; and two samples were collected from downstream of the Site. Soil sample locations are shown on **Figure 7**. Sediment and surface water sample locations area shown on **Figure 8**.

Eleven surface water samples were co-located with 11 of the sediment samples. Five surface soil samples were collected in the forested wetland area adjacent to the Site. Soil collection locations were chosen based on the terrain, and included potential locations where soil runoff may have deposited site-related contaminants. Five of the sediment samples were subjected to a 10-day acute toxicity study with the marine amphipod, *Leptocheirus plumulosus*. Sample locations are provided in **Figure 8**.

Tables 5-1 and **5-2** summarize the sediment and soil COPECs, and list the maximum detected concentration of each COPEC collected during the November 2013 sampling event. The tables also list the sample locations at which the maximum COPEC concentration was detected. The complete list of sediment analyte concentrations are listed in **Table 5-3**. The complete list of

Surface water analyte concentrations are listed in **Table 5-4**. The complete list of soil analyte concentrations are listed in **Table 5-5**.

5.2 DATA ANALYSIS AND REFINEMENT OF COPEC SELECTION

The results of the chemical analyses of sediment and surface water in the Swimming River, and soil from the forested wetland, were used to develop the list of COPECs for the Site and surrounding environment. The number of samples and the sample locations were selected to update and expand upon previous sampling.

COPECs in surface water, sediment, and soil were identified through a multi-step process. Step 1 included the screening of chemical data obtained through sampling. The initial data screening included:

- Comparison to ESC – The BERA eliminated from further analysis a constituent that was not detected at or above the ESC for each media. In addition, any constituent that was not detected in any sample was also eliminated from further analysis.
- Comparison to Reference Concentrations – The BERA also eliminated from further consideration any constituent with a maximum detection that was below the upstream reference concentrations for surface water or sediment.

If the constituent was not eliminated through this initial screening process, it was carried through the full risk assessment process. The analytes retained as COPECs in sediment are listed in **Table 5-1**. The analytes retained as COPECs in soil are listed in **Table 5-2**. There were no COPECs carried through for surface water, as none exceeded ESC and/or the upstream reference.

5.3 ESTIMATES OF POTENTIAL EXPOSURE

In this section, the methods used to estimate potential exposures of ecological receptors are described, along with the approaches used to estimate exposure point concentrations for each environmental medium.

5.3.1 METHODS FOR ESTIMATING EXPOSURE POINT CONCENTRATIONS

A conservative estimate of exposure was estimated by first using the maximum COPEC concentration from each environmental media. Any COPECs that were shown to pose potential risk at the sampling point of maximum concentration were then recalculated using exposure point concentrations. The EPCs were estimated using all analytical data collected from the November 2013 sampling effort. The following sections describe the approaches used to develop EPCs for sediment (Section 5.3.1.1), soil (Section 5.3.1.2) and surface water (Section 5.3.1.3). Dietary component EPCs are described in Section 5.3.1.4.

5.3.1.1 Sediment EPCs

EPCs for sediment COPECs shown to pose potential risk at the sampling point of maximum concentration were estimated using the analytical data from all field samples. Sediment samples were collected from the top six inches, as receptors evaluated in this assessment are assumed to be exposed to surficial sediment.

EPCs were estimated as the 95% UCL concentration, calculated using EPA's ProUCL software (USEPA 2010). All analytical data was used, including both detected values and non-detected values, as specified in the EPA ProUCL guidance manual. ProUCL output for each sediment COPEC are presented in **Appendix E**.

5.3.1.2 Soil EPCs

Because only five soil samples were collected, the sample number was insufficient for use in the USEPA's ProUCL program. Therefore, 95% UCL values could not be calculated for the forested wetland area. Maximum COPEC concentrations were used for risk calculations of soil data. EPCs for soil COPECs were estimated using all of the supplemental sampling analytical data.

5.3.1.3 Surface Water EPCs

Because none of the Site-related COPECs in surface water exceeded the NJDEP ESC and the upstream reference concentrations, there was no need to develop EPCs for surface water COPECs. Additionally, because the Swimming River is saline, it is not used as a drinking water source by the ROIs.

5.3.1.4 Dietary Component EPCs

Receptors are exposed to COPECs in sediment, surface water, and soil, but also in other items that are consumed as part of their normal diets, including invertebrates, small mammals and birds, and vegetation that have themselves accumulated COPECs from the various environmental media. The COPEC concentrations in these dietary components were estimated using previously measured concentrations in environmental media (sediment, surface water, and soil) in combination with bioconcentration factors.

A bioconcentration factor represents the ratio of a constituent's concentration in a dietary component to its concentration in the environmental medium contacting that dietary component. Bioconcentration factors are developed based on actual measured concentrations in both the dietary component and the environmental medium at a test location. Because no dietary components (e.g., tissue from plants, small mammals, or fish) were collected for tissue COPEC analyses, all bioconcentration factors used in this BERA are from published guidance documents or from available scientific literature. Once a bioconcentration factor has been derived, constituent concentrations in dietary components at other locations do not have to be measured directly, but can be estimated as the product of the site-specific constituent concentration in the environmental medium and the bioconcentration factor, using the following equation:

$$EPC_{DC} = EPC_{EM} \times BCF_{EM\text{-}DC}$$

where:

EPC_{DC} = Exposure Point Concentration in dietary component (mg/kg)

EPC_{EM} = Exposure Point Concentration in environmental medium (mg/kg)

$BCF_{EM\text{-}DC}$ = Environmental medium-to-dietary component bioconcentration factor [(mg/kg) / (mg/kg)]

Bioconcentration factors and bioconcentration model equation parameters were obtained from EPA's EcoSSL derivation guidance (USEPA, 2007a), and are listed in **Tables 5-6** through **5-10**.

5.3 ANALYSIS OF SEDIMENT TOXICITY DATA

Sediments from upstream of the Site, downstream of the Site, and from five locations adjacent to the Site were subject to 10-day acute toxicity tests using a marine amphipod, *Leptocheirus plumulosus*. The endpoint of the test was survival. To ensure the validity of the study, Site and reference samples were run along with a laboratory control sample. An additional quality control measure was a standard reference toxicant (SRT) study that was performed using a subset of the organisms used in the Site sediment study. The SRT results were compared to the laboratory's on-going SRT control chart. A summary of the sediment toxicity study results can be found in **Table 5-11**. The complete laboratory report, including raw laboratory data sheets and a complete set of statistical analyses is in **Appendix C**.

Organism survival was compared between the Site samples and both the upstream and downstream reference samples. All statistical analyses were performed in accordance with the ASTM guidance, and the Summary of Procedures (**Appendix C**).

5.4 FOOD CHAIN EXPOSURE MODELS

Food chain exposure modeling is widely used to assess potential wildlife exposures. Although models can range from simplistic to very complex, all food web models share a common basic framework. In this framework, an average daily dose (ADD) is calculated for a wildlife receptor by estimating or measuring:

- The receptor's dietary composition (the food items that comprise the receptor's diet);
- Biological characteristics of the receptor (such as body weight and dietary intake rates);
- EPCs in the various dietary components; and
- The temporal and spatial fraction of the receptor's total exposure derived from the Site.

The exposures estimated from food chain models are then compared to dietary-based toxicity reference values (TRVs). The following sections describe the types and sources of information that were used in the BERA to estimate ADDs for wildlife receptors using food chain models.

Exposure calculations were conducted with EPCs derived from either measured concentrations or concentrations predicted from literature-based accumulation factors. Estimates of average daily exposure potentially experienced by receptors were calculated using the following exposure model, which is consistent with the approach in EPA's Screening-Level Risk Assessment Guidance (USEPA 1999):

$$ADD = \left\{ \left[\left[\left(C_{soil} \times IR_{soil} \right) + \sum_{i-1}^{n} \left(C_{diet(i)} \times IR_{diet(i)} \right) \right] \times AUF \times SUF \right] + \left[\left[\left(C_{water} \times IR_{water} \right) + \left(C_{sed} \times IR_{sed} \right) \times AUF \times WUF \right] \times SUF \left(if WUF = 1 \right) \right] \right\}$$

where:

ADD	=	Average daily dose (mg/kg BW-d)
C_{soil}	=	Concentration in soil (mg/kg)
IR_{soil}	=	Soil ingestion rate (kg soil/kg BW – d)
C_{diet}	=	Concentration in dietary item i (mg/kg)
IR_{diet}	=	Ingestion rate of dietary item i (kg dietary item/kg BW – d)
AUF	=	Area use factor
C_{water}	=	Concentration in water (mg/L)
IR_{water}	=	Water ingestion rate (L water/kg BW – d)
C_{sed}	=	Concentration in sediment (mg/kg)
IR_{sed}	=	Sediment Ingestion rate (kg sediment/kg BW-d)
WUF	=	Water use factor
SUF	=	Seasonal use factor

5.4.1 POTENTIAL EXPOSURE ASSUMPTIONS

The primary source of exposure factors for ecological receptors evaluated using food chain exposure models was EPA's Wildlife Exposure Factors Handbook (USEPA, 1993). Additional information was obtained from peer-reviewed scientific literature, data collected during field reconnaissance activities, and professional judgment. Whenever available, Site-specific and/or

region-specific exposure information was utilized. Receptors were assumed to be exposed via consumption of dietary items, and (for some receptors) via incidental soil or sediment ingestion.

5.4.2 Habitat Use Factors

The extent of a wildlife receptor's potential exposure via dietary intake from a particular habitat depends upon the portion of the receptor's exposure that occurs in that habitat. Receptors may spend only a portion of their life cycle in the habitat if they migrate to other areas during certain seasons, or receptors may utilize the habitat for only one phase of the life cycle. Additionally, some receptors forage over an area larger than the AOCs being evaluated in the BERA.

Area Use Factors (AUF) account for the fraction of a receptor's foraging range that is comprised of a Site. For receptors whose foraging range is smaller than the size of an AOC evaluated in this BERA, some members of the population utilizing the study area may forage only in that AOC, while other members have no exposure to that AOC.

For receptors whose foraging range is larger than the size an AOC evaluated in this BERA, the receptor will forage inside and outside the AOC. For receptors evaluated in this BERA, foraging ranges have been identified from EPA's Exposure Factors Handbook (USEPA, 1993). The size of each AOC was computed using geographical information system (GIS) techniques, working with geo-referenced aerial photographs. AUFs estimated using foraging range information and AOC size were used to estimate potential exposures to sediment, surface water, soil, vegetation, soil invertebrates, and small animals.

Water is present in the Swimming River, but it is saline, and is not utilized as a drinking water source. At the time of the November 2013 sampling event, there was water flowing along the bottom of the ravine in the forested wetland area, but no surface water samples were collected. Therefore, while surface water contaminant uptake is considered for fish and benthic invertebrates, it is not considered in the food chain exposure modeling for higher trophic level receptors, and the water use factor (WUF) is considered to be zero for this BERA.

A Seasonal Use Factor (SUF) accounts for the fraction of the year spent by a receptor in a particular habitat area. For receptors assumed to spend the entire year in one location, the SUF

is assumed to be 1. For receptors assumed to migrate to other locations during parts of the year, the SUF is estimated based on the fraction of the year spent in the area of the habitat. Because of the temperate climate in New Jersey, it was conservatively assumed that none of the receptors migrate, so the SUF is assumed to be 1 for all receptors.

5.5 EFFECTS EVALUATION

In the effects assessment, available toxicological data are reviewed, and TRVs and benchmarks for COPECs are selected for use in the BERA. A TRV is a concentration of a chemical in water, food, or receptor tissue, or a dietary exposure dose of a chemical, below which adverse effects are not expected. For receptors and COPECs evaluated via food chain exposure models, dietary exposure TRVs were used. For other receptors, exposure medium concentration benchmarks were used. Matrix concentration benchmarks were obtained from NJDEP, EPA guidance, and peer-reviewed scientific literature.

The TRVs used in this BERA represent potential exposures that are expected to result in no observed adverse effects levels (NOAEL) to ecological species. TRVs based on the lowest observed adverse effect level (LOAEL) were also utilized to represent exposures that could potentially affect sensitive individuals in a population. **Table 5-12** provides information on avian and mammalian dietary exposure NOAEL TRVs that have been used in this BERA. **Table 5-13** provides information on avian and mammalian dietary exposure LOAEL TRVs that have been used in this BERA.

5.5.1 AVIAN TRVS

The primary source for TRVs for avian receptors was EPA's Eco-SSL derivation documents. If no TRV was available, the secondary source for avian TRVs was the compilation of wildlife TRVs for the US Department of Energy (Sample, *et al*. 1996). If no TRV was available from these sources, toxicity studies from the literature were used. **Tables 5-12** and **5-13** provide information on TRVs that have been used to evaluate avian receptors.

5.3.2 MAMMALIAN TRVS

The primary source for TRVs for mammalian receptors was EPA's Eco-SSL derivation documents. If no TRV was available, the secondary source for mammalian TRVs was the compilation of wildlife TRVs for the US Department of Energy (Sample, *et al*. 1996). If no TRV was available from these sources, toxicity studies from the literature were used. When TRVs are based on a toxicity study using a species different from the BERA species of interest, dietary exposure TRVs for mammalian receptors were adjusted to account for differences in body weight between the study species and the receptor species, using the appropriate body weight values. **Tables 5-12** and **5-13** provide information on TRVs that have been used to evaluate mammalian receptors.

6.0 RISK CHARACTERIZATION

The section presents the results of the risk characterization for each receptor in each AOC evaluated. Section 6.1 describes the overall approach to risk characterization. Using the framework described in Section 6.1, Section 6.2 then presents the risk characterization findings for each AOC. A full discussion of the risk characterization findings and the BERA conclusions can be found in Section 8.

6.1 RISK CHARACTERIZATION PROCEDURES

The purpose of the BERA is to provide an assessment of potential risks associated with constituents at or from the Site. To accomplish this, one or more lines of evidence are presented to provide information on the potential for adverse effects to ecological receptors. When multiple lines of evidence are available, certain lines of evidence may be considered to carry more weight than other lines of evidence because they are based on input parameter values and/or methodologies that are more appropriate for and relevant to the Site. While conclusions in the BERA are made based on the breadth of information available and all evaluations conducted, lines of evidence that provide estimates of potential risk based on Site-specific inputs and methodologies are afforded more weight than lines of evidence based on default non-Site-specific evaluations in making decisions regarding whether adverse ecological effects are occurring or are likely to occur.

This BERA used lines of evidence based on analysis of sediment, surface water, and soil collected in each of the AOCs. These direct measurements of constituents in Site media were used to develop literature-based HQ calculations through comparison to ecological screening values and through food chain exposure modeling.

For each of the wildlife receptors evaluated in each AOC, potential Hazard Quotients (HQs) were estimated by comparing estimated food web exposures to food web TRVs. Potential HQs were estimated as the ratio of the estimated exposure to the TRV for each COPEC in each environmental medium. The equation used to estimate food web HQs is as follows:

$$HQ = \frac{ADD(mg/kg-day)}{TRV(mg/kg-day)}$$

where:

HQ = Hazard quotient

ADD = Average daily dose

TRV = Toxicity reference value

For each wildlife receptor, two sets of potential HQs were estimated: using NOAEL-based TRVs and LOAEL-based TRVs.

In other evaluations, COPEC concentrations in environmental media were compared to concentration-based TRVs. The equation used to estimate food web HQs is as follows:

$$HQ = \frac{COPEC\,concentration\,(mg/L\,water; mg/kg\,soil; mg/kg\,sediment)}{TRV(mg/L\,water; mg/kg\,soil; mg/kg\,sediment)}$$

When assessing food chain exposure HQs, the total HQ represents the sum of all applicable HQs for each receptor (e.g., the total HQ for the shrew is equal to the sum of HQs calculated from soil and invertebrates).

- If the HQ is less than (<) 1, ecological risk is not likely;
- If the HQ equals (=) 1, the constituent alone is not likely to cause ecological risk; and
- If the HQ is greater than (>) 1, there is potential for adverse effects due to the constituent in question that should be further evaluated through the use of other lines of evidence.

Concentrations of COPECs have been measured in background area surface water and sediment locations, outside of the influence of the Site. For the purpose of interpreting the HQs estimated in the BERA, HQs were also estimated for ecological receptors exposure to constituents at background areas. Estimated HQs for ecological receptors are traditionally interpreted by comparison to a target HQ. This comparison provides one piece of information necessary for risk managers to make decisions regarding the need for and benefits of undertaking corrective measures. However, unlike the comparison of AOC HQs to target HQs, the comparison of AOC HQs to background area HQs provides important additional information about: 1) the likelihood that adverse effects may actually occur to ecological receptors in

habitats outside the Site; and 2) about whether constituents in the AOCs may be present as a result of naturally occurring conditions or other conditions that are not related to current or historic Site activities.

For example, if a receptor's HQ for a COPEC in an AOC exceeds a target HQ and does not exceed the HQ in a background area, then that COPEC is consistent with background conditions and the presence of the COPEC in the AOC is not likely to pose an unacceptable Site-related potential risk to the receptor, despite its exceeding the target HQ. Moreover, if a receptor's HQ for a COPEC exceeds a target HQ in both an AOC and the background area, and no adverse effects are occurring in the reference area, this provides strong evidence that adverse effects related to that COPEC are also unlikely in the AOC. Because the risk characterization information derived from a simple comparison of AOC HQs to target HQs is incomplete, the risk characterization discussions below provide information on the comparison of AOC HQs both to a target HQ of 1 and to background area HQs.

6.2 RISK CHARACTERIZATION FINDINGS

This section presents the results of the risk characterization conducted for each AOC evaluated in the BERA. For each AOC, the ecological receptors, assessment endpoints, and measurement endpoints are briefly reviewed, and estimated HQs are presented. Conclusions are then presented regarding the likelihood that conditions in the AOC pose an unacceptable potential risk to the reproductive success and population sustainability of ecological receptors due to Site-related impacts.

6.2.1 SWIMMING RIVER

As shown in the CSM for the Swimming River (**Figure 6a**), five ecological receptors were identified as having complete exposures to COPECs in surface water and sediment. The risk characterization includes evaluations of potential risk to these receptors. Three Assessment Endpoints and multiple Measurement Endpoints were identified for the Swimming River. The results of the evaluations conducted to assess these endpoints are discussed below.

6.2.1.1 Sediment Toxicity Study

A 10-day acute sediment toxicity study was performed in accordance with American Society for Testing and Materials (ASTM) guidance (ASTM 2008), using the euryhaline amphipod, *Leptocheirus plumulosus*. Sediment samples were collected from mid-channel at five locations (**Figure 8**): one upstream reference (UPREF-SED2), three Site-adjacent locations (SED-1C, SED-3C, and SED-5C), and one downstream reference (DNREF-SED2). The full report can be found in **Appendix C**.

Location SED-5C (mid-channel, at the downstream end of the Site) was the only sample to exhibit a significant reduction in survival (76%), as compared to the Reference samples (92% to 95% survival) (**Table 5-11**). Sediment from SED-5C did not have any COPECs that exceeded either the NJDEP ESC, or the concentrations of COPECs in the Reference sediment. Sediment location SED-5C had the lowest total organic carbon (TOC), and the coarsest sediment (42% medium sand), but the TOC and grain size were within acceptability parameters for *Leptocheirus* survival (ASTM 2008).

With the exception of arsenic, none of the sediment samples submitted for toxicity testing had detected concentrations of COPECs (metals, pesticides, PCBs, SVOCs) that exceeded the NJDEP ESC (**Table 5-3**). None of the Site samples (SED-1C, SED-3C, SED-5C) exceeded the COPEC concentrations (including arsenic) detected in the Reference samples. Therefore, no statistical correlation can be made between observed toxicity and sediment COPEC concentration. None of the analytes detected in Swimming River sediment appear to be related to observed toxicity.

The TOC measured in the sediment samples submitted for toxicity testing was comparable between locations (**Table 5-3**), though UPREF-SED2 (2,990 milligrams per kilogram [mg/kg]) and DNREF-SED2 (3,540 mg/kg) were somewhat higher than SED-1C (2,570 mg/kg), SED-3C (2,640 mg/kg), and SED-5C (2,470 mg/kg). This is likely due to the fact that both Reference locations were collected from areas of the river that were more depositional, with finer sediment (and associated organic matter) than the reach of the river that passes the Site. However, even the highest measured TOC (3,540 mg/kg) is slightly more than 0.3% organic carbon, which is quite low. The typical dredged sediment TOC range in the New York/New Jersey Harbor

system is 2% to 10% (USEPA 1999a), though dredging generally only occurs in depositional areas.

The sediment particle grain size for the samples submitted for toxicity testing were all predominantly (≥ 98%) in the sand range (**Table 5-3**). Though UPREF-SED2 and DNREF-SED2 were significantly finer-grained (90% to 93% fine sand) than the three Site-related samples (54% to 67% fine sand). This confirms that the upstream and downstream Reference locations were more depositional than the Site-related sample locations.

Field investigators noted very few benthic invertebrates present in any of the sediment samples collected from the Swimming River (a few small polychaetes and a few isopod crustaceans). This was not a sign of Site-related environmental impact, since the lack of invertebrates was noted at both the upstream and downstream reference locations as well as at the Site-related locations.

The toxicity observed in the SED-5C sediment sample does not appear to be related to COPEC concentrations, and can't be defensibly explained by the TOC or grain size. Though the toxic sample was collected from mid-channel at the downstream end of the Site, it is unknown whether the observed toxicity was Site-related.

6.2.1.2 Risk Characterization for Wildlife Receptors

The risk characterization for wildlife receptors consisted of comparing an estimated ADD derived using a food web model to NOAEL and LOAEL-based TRVs for each COPEC.

- NOAEL TRVs for avian and mammalian receptors are shown in **Table 5-12; and**
- LOAEL TRVs for avian and mammalian receptors are shown in **Table 5-13.**

The wildlife exposure risk characterizations are based on maximum COPEC concentrations and EPCs measured in surface water and sediment collected from the Swimming River. Because no prey items were collected for laboratory tissue analysis, all food ingestion exposures are based on modeled estimates of prey item tissue concentrations (see Section 7 for a discussion of the conservative nature of modeled estimates). Bioconcentration factors derived from the

literature were used to estimate tissue concentrations for: water to fish and sediment to benthic invertebrates (**Tables 5-6** through **5-8**).

Section 4-6 details the assessment endpoints selected for the Swimming River. Assessment Endpoints 1 and 2 are based on an evaluation of the potential for adverse changes in the survival, growth and reproduction of populations of benthic invertebrates and fish. Assessment Endpoint 3 is based on an evaluation of the potential for adverse changes in the survival, growth, and reproduction of populations of each of the five surrogate wildlife receptors below. Each assessment endpoint has a single risk question: "Does exposure to Site-related COPECs result in any potential risk to the survival, growth or reproductive success of receptor species populations?"

As noted in Section 6.1, a HQ <1 indicates that risk is not likely; a HQ=1 indicates that the constituent alone is not likely to pose risk; and a HQ>1 indicates that there is potential for adverse effects due to the constituent in question that should be further evaluated through the use of additional lines of evidence.

Maximum Site Concentration HQs:

The maximum HQs estimated for wildlife receptors in the Swimming River, using the maximum Site sediment concentrations are shown in the following tables:

Table 6-1: Benthic Invertebrates and Fish
Table 6-2: Piscivorous Avian (Bald Eagle)
Table 6-3: Piscivorous Avian (Great Blue Heron)
Table 6-4: Omnivorous Avian (Mallard)
Table 6-5: Invertivorous Avian (Spotted Sandpiper)
Table 6-6: Omnivorous Mammal (Raccoon)

Benthic Invertebrates and Fish – Direct comparison of maximum sediment COPEC concentrations to NJDEP ESC yielded HQs equal to or greater than 1 for six SVOCs, nine pesticides, three PCBs, and six metals (**Table 6-1**). The maximum concentrations of COPECs in Site sediment in the Swimming River pose potential risk to benthic invertebrates and fish. However, the maximum concentrations of COPECs are each only found at one location, while

the average exposure over the length of the Swimming River adjacent to the Site is significantly lower. **Table 5-3** lists the sediment analytical results for all sample locations, with COPECs in excess of NJDEP ESC and the background concentrations highlighted. **Figure 8** also highlights the COPECs by sample location. The sample locations closest to the shoreline border of the Site (SED-1A, SED-3A, SED-3B, SED-4A, SED-5A, and SED-5B) show the most exceedances, with the highest COPEC concentrations. However, two locations on the opposite shore of the Swimming River (SED-1D and SED-3D) also yielded exceedances of NJDEP ESC.

Bald Eagle – Exposure modeling yielded a NOAEL-based lead HQ=5.8. No other COPEC HQs were equal to or greater than 1 (**Table 6-2**). The maximum concentration of lead detected in the sediment of the Swimming River (1,960 mg/kg from Location SED-5B) poses potential risk to bald eagles.

Great Blue Heron – No COPEC HQs were equal to or greater than 1 (**Table 6-3**). The maximum concentrations of COPECs in Swimming River sediment do not pose risk to the great blue heron.

Mallard – Exposure modeling yielded a NOAEL-based lead HQ=1.6. No other COPEC HQs were equal to or greater than 1 (**Table 6-4**). The maximum concentration of lead detected in the sediment of the Swimming River (1,960 mg/kg from Location SED-5B) poses potential risk to omnivorous birds.

Spotted Sandpiper – Food chain exposure modeling yielded NOAEL-based HQs in excess of 1 for five COPECs: endrin HQ=3.5, arsenic HQ=1.3, chromium HQ=1.5, lead HQ=55, and the vanadium HQ=2.6. No other COPEC HQs were equal to or greater than 1 (**Table 6-5**). The maximum concentrations of these COPECs in the sediment of the Swimming River pose potential risk to aquatic invertivorous birds.

Raccoon – No COPEC HQs were equal to or greater than 1 (**Table 6-6**). The maximum concentrations of COPECs in Swimming River sediment do not pose risk to omnivorous mammals.

95% UCL Site Sediment Concentration HQs:

Because the maximum sediment concentrations are each reflective of only a single sampling location, the exposure models that indicated potential exposure risk to receptors were re-calculated using the 95% UCL of all Site sediment concentrations. The 95% UCL is higher (more conservative) than the average of all of the sediment locations, but it is lower (more representative) than using only the maximum concentrations. The 95% UCL HQs were estimated only for those COPECs and receptors which yielded a maximum concentration HQ that was greater than 1. The 95% UCL HQs for wildlife receptors in the Swimming River are shown in the following tables:

Table 6-7: Piscivorous Avian (Bald Eagle)
Table 6-8: Omnivorous Avian (Mallard)
Table 6-9: Invertivorous Avian (Spotted Sandpiper)

Bald Eagle – Exposure modeling with the 95% UCL sediment concentrations yielded a NOAEL-based lead HQ=1.6. No other COPEC HQs were equal to or greater than 1 (**Table 6-7**). The 95% UCL concentration of lead detected in the sediment of the Swimming River (556 mg/kg) may pose potential risk to bald eagles.

Mallard – Exposure modeling with the 95% UCL sediment concentrations yielded no HQs equal to or greater than 1 (**Table 6-8**). The 95% UCL concentrations of COPECs detected in the sediment of the Swimming River do not pose risk to omnivorous birds.

Spotted Sandpiper – Exposure modeling with 95% UCL sediment concentrations yielded NOAEL-based HQs in excess of 1 for three COPECs: endrin HQ=2, lead HQ=16, and vanadium HQ=1.3. No other COPEC HQs were equal to or greater than 1 (**Table 6-9**). The 95% UCL concentrations of these COPECs in the sediment of the Swimming River may pose potential risk to aquatic invertivorous birds.

Maximum Upstream Concentration HQs:

The maximum HQs estimated for wildlife receptors in the Swimming River, using the maximum Upstream sediment concentrations are shown in the following tables:

Table 6-1: Benthic Invertebrates and Fish

Table 6-10: Piscivorous Avian (Bald Eagle)

Table 6-11: Piscivorous Avian (Great Blue Heron)

Table 6-12: Omnivorous Avian (Mallard)

Table 6-13: Invertivorous Avian (Spotted Sandpiper)

Table 6-14: Omnivorous Mammal (Raccoon)

Benthic Invertebrates and Fish – Direct comparison of maximum upstream sediment COPEC concentrations to NJDEP ESC yielded HQs equal to or greater than 1 for three SVOCs, one pesticide, and arsenic (**Table 6-1**). The maximum concentrations of COPECs in upstream sediment in the Swimming River pose potential risk to benthic invertebrates and fish. However, the upstream HQs are lower for each of the COPECs that exceed ESC than the Site HQs. The concentrations of COPECs detected at the Upstream reference locations can be considered to be background for this BERA, and are reflective of a heavily developed watershed.

Bald Eagle – No COPEC HQs were equal to or greater than 1 (**Table 6-10**). The upstream sediment of the Swimming River poses no risk to piscivorous birds.

Great Blue Heron – No COPEC HQs were equal to or greater than 1 (**Table 6-11**). The upstream sediment of the Swimming River poses no risk to piscivorous birds.

Mallard – No COPEC HQs were equal to or greater than 1 (**Table 6-12**). The upstream sediment of the Swimming River poses no risk to omnivorous birds.

Spotted Sandpiper – No COPEC HQs were equal to or greater than 1 (**Table 6-13**). The upstream sediment of the Swimming River poses no risk to invertivorous birds.

Raccoon – No COPEC HQs were equal to or greater than 1 (**Table 6-14**). The upstream sediment of the Swimming River poses no risk to omnivorous mammals.

Maximum Downstream Concentration HQs:

The maximum HQs estimated for wildlife receptors in the Swimming River, using the maximum downstream sediment concentrations are shown in the following tables:

Table 6-1: Benthic Invertebrates and Fish

Table 6-15: Piscivorous Avian (Bald Eagle)

Table 6-16: Piscivorous Avian (Great Blue Heron)

Table 6-17: Omnivorous Avian (Mallard)

Table 6-18: Invertivorous Avian (Spotted Sandpiper)

Table 6-19: Omnivorous Mammal (Raccoon)

Benthic Invertebrates and Fish – Direct comparison of maximum downstream sediment COPEC concentrations to NJDEP ESC yielded HQs equal to or greater than 1 for two SVOCs, one pesticide, and arsenic (**Table 6-1**). The maximum concentrations of COPECs in downstream sediment in the Swimming River pose potential risk to benthic invertebrates and fish. However, the downstream HQs are lower for each of the COPECs that exceed ESC than the Site HQs, and are equal or lower than the upstream reference locations (except for benzo(g,h,i)perylene). The concentrations of COPECs detected at the upstream reference locations are considered to be background for this BERA, and the concentrations of COPECs detected at the downstream locations are no higher than the upstream locations. This indicates that the elevated COPECs detected in sediment adjacent to the Site are not being transported downstream.

Bald Eagle – No COPEC HQs were equal to or greater than 1 (**Table 6-15**). The downstream sediment of the Swimming River poses no risk to piscivorous birds.

Great Blue Heron – No COPEC HQs were equal to or greater than 1 (**Table 6-16**). The downstream sediment of the Swimming River poses no risk to piscivorous birds.

Mallard – No COPEC HQs were equal to or greater than 1 (**Table 6-17**). The downstream sediment of the Swimming River poses no risk to omnivorous birds.

Spotted Sandpiper – No COPEC HQs were equal to or greater than 1 (**Table 6-18**). The downstream sediment of the Swimming River poses no risk to invertivorous birds.

Raccoon – No COPEC HQs were equal to or greater than 1 (**Table 6-19**). The downstream sediment of the Swimming River poses no risk to omnivorous mammals.

6.2.2 FORESTED WETLAND

As shown in the CSM for the Forested Wetland Area (**Figure 6b**), three ecological receptors were identified as having complete exposures to COPECs in soil. There is no permanent surface water in the Forested Wetland Area, and no surface water samples were collected. So there is no complete exposure pathway for surface water. The risk characterization includes evaluations of risk to these receptors. As shown in Section 4.6, one Assessment Endpoint and one Measurement Endpoint were identified for the Forested Wetland Area. The results of the evaluations conducted to assess this Measurement Endpoint are discussed below.

6.2.2.1 Risk Characterization for Wildlife Receptors

The risk characterization for wildlife receptors consisted of comparing an estimated ADD derived using a food web model to NOAEL and LOAEL-based TRVs for each COPEC.

- NOAEL TRVs for avian and mammalian receptors are shown in **Table 5-12;** and
- LOAEL TRVs for avian and mammalian receptors are shown in **Table 5-13.**

The wildlife exposure risk characterizations are based on maximum COPEC concentrations measured in soil collected from the Forested Wetland Area. Because no prey items were collected for laboratory tissue analysis, all food ingestion exposures are based on modeled estimates of prey item tissue concentrations. Bioconcentration factors derived from the literature were used to estimate tissue concentrations for soil to invertebrates and soil to small mammals (**Tables 5-9** and **5-10**).

Assessment Endpoint 4 is based on an evaluation of the potential for adverse changes in the survival, growth and reproduction of populations of each of the three surrogate wildlife receptors below. Each assessment endpoint has a single risk question: “Does exposure to Site-related COPECs result in any potential risk to the survival, growth or reproductive success of receptor species populations?” Each risk question has a single measurement endpoint; that is, to compare estimated average daily dose of COPECs to appropriate TRVs to estimate a HQ for each wildlife receptor.

As noted in Section 6.1, a HQ <1 indicates that risk is not likely; a HQ=1 indicates that the constituent alone is not likely to pose risk; and a HQ>1 indicates that there is potential for adverse effects due to the constituent in question that should be further evaluated through the use of additional lines of evidence. The HQs estimated for wildlife receptors in the Wooded Area are shown in the following tables:

- **Table 6-20**: Omnivorous Avian (American Robin)
- **Table 6-21**: Omnivorous Mammal (Raccoon)
- **Table 6-22**: Invertivorous Mammal (Short-tailed Shrew)

American Robin - Food chain exposure modeling yielded NOAEL-based HQs that exceeded 1 for eight metals (cadmium, chromium, copper, lead, mercury, thallium, vanadium, and zinc) for the robin (**Table 6-20**). No other COPEC HQs were equal to or greater than 1. The maximum concentrations of these COPECs in the soil of the Forested Wetland pose potential risk to omnivorous birds.

Raccoon - No COPEC HQs were equal to or greater than 1 (**Table 6-21**). The maximum concentrations of COPECs in the soil of the Forested Wetland do not pose any risk to omnivorous mammals.

Short-tailed Shrew – Food chain exposure modeling yielded NOAEL-based HQs that exceeded 1 for on pesticide (dieldrin), two PCBs (aroclor 1254 and total PCBs), and nine metals (antimony, cadmium, chromium, lead, mercury, selenium, thallium, vanadium, and zinc) for the shrew (**Table 6-20**). No other COPEC HQs were equal to or greater than 1. The maximum concentrations of these COPECs in the soil of the Forested Wetland pose potential risk to invertivorous mammals.

7.0 UNCERTAINTIES ANALYSIS

There are several sources of uncertainty associated with ecological risk estimates. This includes initial selection of COPECs based on the sampling data, estimates of toxicity to ecological receptors based on limited laboratory data (usually on other species), and uncertainties in exposure and effects assessment (USEPA 1997). This section describes some of these uncertainties along with what actions have been taken to manage this uncertainty within the assessment.

7.1 COMPONENTS OF THE UNCERTAINTY ANALYSIS

Uncertainty in risk estimation has both qualitative and quantitative components. Qualitative uncertainty analyses are recommended by guidance (*e.g.,* USEPA, 1988, page 96) and contribute to the confidence with which risk assessment conclusions can be drawn and applied (USEPA 1989; 1992a). Where possible, quantitative uncertainty analysis provides objective measures of the relative confidence in conclusions and applications.

In general, uncertainty surrounding risk assessment conclusions has important implications for risk management (USEPA 1988; 1998). However, uncertainty is not a single, generally applicable parameter. Uncertainty surrounding a risk estimate or application has a number of components, including parameter variability, calculation error and simplification, and the underlying reality of exposure assumptions and pathways (USEPA 1988). It is important to understand that uncertainty includes both real variation (reflecting actual, mechanistic biological response ranges and variability in ecosystem conditions) and error (USEPA, 1997). Thus, because biological systems are inherently uncertain and variable, some component of variability in risk estimation is due to a realistic reflection of ecological conditions, while another component is due to error or uncertainty introduced by the overall analytical process. Error is the component to be minimized, because this encompasses undesirable uncertainty that has been introduced by the assessment process. However, it is critically important to understand ecosystem variability because this represents an important component of the ecosystem within which risk management decisions must be made. Substantial differences exist between observations and conclusions made at the individual, population, and community levels of biological organization. For example, effects not manifested at the population or community

levels (e.g., mortality of only a few individuals) may not be observable with the type of studies implemented. The ramifications of this also include an understanding that, because the assessment level endpoints are protective of populations and communities and not individuals, the projected loss of a few individuals may not cause impacts that are important at the levels of assessment where risk management decisions are made.

Due to the multiplicity of potential receptor species and lack of specific knowledge regarding their life cycles, feeding habits, nutritional requirements (*e.g.,* essential elements such as arsenic, trivalent chromium, selenium and zinc), and relative toxicological sensitivity, the uncertainty surrounding estimates of ecological risk may be substantially greater than those associated with human health risk assessment. The generic screening and regulatory criteria used in this assessment are intended to provide conservative benchmarks, but it is important to note that no one approach to criterion derivation is adequate for all sites and all chemicals. The criteria used in this assessment are all chemical-specific and as such cannot address the additive, antagonistic, or synergistic effects of the chemical mixtures typically found in the environment (Swartz *et al.,* 1988). Further, these criteria do not take into account the structure and dynamics of the ecosystem present at the Site, Site-specific conditions regulating chemical contact and bioavailability, the potential toxicity of other constituents that were not quantified, or the pervasive influence of physical stressors associated with the disruption by human activities.

The evaluations presented herein were performed within a range of conditions defined by characteristics of the environment at the time field data were gathered. As such, data obtained and conclusions drawn represent a series of "snap-shots" of Site conditions and, while they can be extrapolated to a broad range of conditions, they are most accurate when Site conditions are most similar to those that existed at the time of sampling. In addition, screening criteria do not necessarily reflect the entire range of possible Site conditions and, as such, the applicability of conclusions is restricted by these simplifications as well (Warren-Hicks and Moore, 1998). Identified contributors to these uncertainties are specified below as it pertains to sampling/analysis, exposure, and bioavailability/bioaccumulation/biomagnification and ecotoxicology.

7.2 UNCERTAINTIES IN THE EXPOSURE ASSESSMENT

Development of accurate and representative CSMs requires a thorough understanding of many elements that are difficult to know with 100% certainty:

- Habitat areas at the site;
- Feeding guilds within each habitat area;
- Representative receptors for each feeding guild;
- Fate and transport processes of each COPEC among environmental media within each AOC;
- Relevant exposure pathways for each receptor/ medium/ habitat area combination; and
- Appropriate assessment and measurement endpoints for each receptor/ medium/ habitat area combination.

As described in detail in the Problem Formulation step in the BERA, these variables have been parameterized following careful consideration and evaluation of conditions at the Site. An understanding of Site conditions derives from many phases of investigation at the Site; literature reviews; and research on many issues and topics. The selection of habitats, feeding guilds and representative receptors, complete exposure pathways, COPECs for quantitative evaluation, and assessment and measurement endpoints was based on this understanding of Site conditions.

7.3 UNCERTAINTIES IN THE EFFECTS ASSESSMENT

This BERA used the hazard quotient method, a common and accepted method to characterize potential risk. Potential HQs were estimated using Site-specific information, information from EPA-recommended sources, and information from the scientific literature. When HQs rely heavily on conservative, non-Site-specific parameter values, there is a high level of confidence that potential risks have not been underestimated (Warren-Hicks and Moore, 1998). For example, the use of maximum concentrations and 95% UCL concentrations as EPCs may overestimate the exposure concentration for the majority of the populations of sessile or minimally mobile receptors such as sediment and soil invertebrates. Because only a portion of the population may be exposed to COPEC concentrations at the level of the EPCs used in this

BERA, the possibility of adverse effects exists only for those portions of the population. Additionally, the exceedance of no-effect TRVs, absent a comparison to low-effect TRVs, does not necessarily suggest that adverse effects may occur, even for these portions of the population. Considering the level of conservatism used in the BERA, such HQs exceeding no-effect TRVs should not be interpreted to suggest that the population of receptors may experience adverse effects.

7.4 UNCERTAINTIES WITH ECOTOXICOLOGY

The following sections outline uncertainties identified relative to ecotoxicological practices.

7.4.1 TOXICITY REFERENCE VALUES

Toxicity reference values were identified for compounds evaluated in this BERA from EPA sources and from an extensive review of the toxicological literature. Identifying appropriate TRVs involves uncertainty for several reasons. In some cases, assumptions must be made in estimating the responses of ecological receptors to low doses of a compound based on information generally gathered from studies that tested the responses of laboratory animals to high doses of the compound (USEPA 1997).

In other cases, multiple toxicity studies have been conducted for a constituent, and the lowest concentration at which no effect was observed in any study is commonly selected as the recommended TRV by EPA sources (e.g., Efroymson *et al*. 1997a and 1997b, NOAA SQuiRTs, EPA Region 3, and Region 5 ESLs). However, this practice may introduce considerable uncertainty into the BERA if the conditions in the selected study are not comparable to the conditions evaluated in the BERA. For example, the recommended TRV may have been based on a study using an especially sensitive species that is not present at the Site.

A common technique for incorporating uncertainty into TRV derivation is the use of uncertainty factors (also referred to as safety factors). These factors are applied to either parameters of a risk model, or to the output of the model to ensure risks are not underestimated (Suter, et al., 2000). As noted on **Table 5-12**, the NOAEL values used to calculate wildlife toxicity benchmarks for some organics and pesticides are divided by a factor of ten if they are based on

subchronic studies or LOAEL values, and by another factor of ten if they are based on interspecies data (e.g., avian TRVs derived from mammalian toxicity benchmarks). The factor of ten is based on scientific judgment that the threshold for chronic toxicity is unlikely to be more than a factor of ten lower than the subchronic threshold, and is unlikely to be more than a factor of ten lower for one species than another (Suter, et al., 2000). Such uncertainty is propagated through the exposure model.

Many of the toxicity values used as benchmarks for benthic invertebrates and fish were highly conservative screening values (e.g., NJDEP ESC, Efroymson *et al*. 1997a and 1997b, NOAA SQuiRTs, EPA Region 3, and Region 5 ESLs). These screening values were developed for the SLERA process, not to indicate that ecological risk is present, but to give investigators a conservative, NOAEL-based screening benchmark in order to focus the later phases of the risk assessment process (USEPA 1997). Representative site-specific toxicity data or literature-based TRVs are intended for risk characterization. However, for certain ecological receptors (birds and mammals), not enough toxicological information is available for certain COPECs (e.g., USEPA EcoSSLs). The resultant toxicity values are likely to overestimate potential risk.

Most of the inorganic COPECs in this BERA were compared to USEPA EcoSSLs (arsenic, barium, chromium, cadmium, lead, nickel, selenium, vanadium, and zinc). The EcoSSL values are calculated by first deriving the TRV, and then back-calculating (using wildlife exposure modeling) to estimate a conservative screening value (USEPA 2003). However, the EcoSSL values for wildlife are lower than the reported range of background soil concentrations in the eastern United States for vanadium, cadmium, and lead (USEPA 2007b).

Figure 9 shows the 95th percentile concentration for vanadium in background soil in the eastern United States is approximately 100 mg/kg, and the maximum background vanadium concentration is listed as approximately 200 mg/kg (USEPA 2007b). EcoSSLs that are below background concentrations are of questionable scientific value and utility. EcoSSLs that are lower than background soil concentrations imply that toxic effects impact wide-ranging species from naturally occurring, routinely detected soil concentrations. EcoSSLs that are lower than background concentrations are ineffective, because they fail to screen out naturally occurring chemicals within the range of background concentrations. Using the avian wildlife EcoSSL for vanadium (7.8 mg/kg) as an example, soil at nearly every site in the eastern United States will

pose ecological risk to birds. This also means that the TRV value (upon which the EcoSSL was based) is overly conservative, and that the HQs derived using the TRV could be significantly overestimated.

Figure 9 also shows the USEPA's 95th percentile background soil concentrations of cadmium (approximately 1.0 mg/kg) is higher than both the mammalian (0.36 mg/kg) and avian (0.77 mg/kg) EcoSSLs. Therefore, the cadmium TRV value (upon which the EcoSSL was based) is also overly conservative, and that the HQs derived using the TRV could be significantly overestimated.

Figure 9 also shows the USEPA's 95th percentile background soil concentration of lead (approximately 40 mg/kg) is higher than the avian (11 mg/kg) but not the mammalian (56 mg/kg) EcoSSLs. However, the maximum background soil lead concentration in the eastern United States is listed as approximately 115 mg/kg, which is significantly higher than both the avian and mammalian EcoSSL screening values. Therefore, the lead TRV value (upon which the EcoSSL was based) is overly conservative, and the HQs derived using the TRV could be significantly overestimated.

7.4.2 AVERAGE DAILY DOSES

Estimation of ADDs for combinations of COPEC/receptor/medium/habitat involves a degree of uncertainty because it requires the selection of parameter values for several variables:

- Receptor biological characteristics, such as body weight and ingestion rates of soil, water, and dietary items;
- Receptor home ranges and seasonal use patterns that determine the fraction of a receptor's foraging that occurs in a habitat;
- EPCs estimated from measured concentrations in media sampled during the Site investigation; and
- EPCs for dietary items modeled from measured concentrations and bioconcentration factors.

Parameter values selected to describe receptor biological parameters, home ranges, and seasonal use patterns were obtained from EPA sources in most cases, and from the scientific literature in a few cases where more appropriate values existed. Because these sources provide peer-reviewed information, little uncertainty is expected to be associated with the use of these values.

All EPCs were developed using all available sediment and surface water analytical data in the evaluated AOCs. Because all available data were used in the BERA, little uncertainty is expected to be associated with the dataset used to estimate potential risks.

EPCs were estimated from measured concentrations as the maximum concentration (in the Forested Wetland with fewer than eight samples) or the lower of the maximum or 95% UCL concentration (in the Swimming River with eight or more samples). This conservative approach may overestimate potential exposures. When calculating the EPCs using USEPA's ProUCL software, the non-detect values are included in a statistically defensible manner. There are two ways to censor the data set; 1) censor at the lowest detection limit; and 2) censor at the lowest detected value. The EPA method censors at the lowest detected value, which is slightly more conservative, but eliminates the potential bias from high detection limits. In the end, the EPC (95% UCL value) is above the mean of the detected values, and below the maximum detected value. Therefore, the 95% UCL is a conservative estimate that assumes sediment concentrations throughout the Swimming River are all higher than the actual mean value (USEPA 2010).

Direct measurement of COPEC concentrations in dietary items is always preferred, because it incorporates all site-specific parameters that may influence the uptake and transfer of COPECs through the food web (Suter, et al., 2000) However, for this BERA, dietary item EPCs were estimated from measured concentrations in environmental media and BCFs. The BCFs for estimating EPCs for dietary items were identified from EPA sources and are considered to be conservative estimates of the extent of bioconcentration (USEPA 1997). While BCFs are simple to use, the uncertainty associated with the estimates they produce may be high. An implicit assumption in the use of uptake factors is that uptake is a simple linear relationship, increasing as the ambient concentration increases (Suter, et al., 2000). Several researchers have shown that bioaccumulation (at least for inorganics) is not linear with respect to soil concentration

(Alsop, et al., 1996; Sample et al., 1998, 1999). Consequently, at sites with sediment or soil inorganics concentrations, the use of uptake factors to estimate biota tissue concentrations may result in gross overestimates (Suter, et al., 2000; Sample, et al., 1998, 1999).

8.0 CONCLUSIONS AND DISCUSSION

This BERA provides an assessment of potential risks to populations of ecological receptors that may be exposed to constituents from the Site. This BERA evaluates the aspects of the Site that could influence potential exposures and risks to ecological receptors, including:

- The environmental setting;
- Potential sources and release mechanisms of constituents to environmental media; and
- Fate and transport processes that may have contributed to existing conditions.

Based on the review of the historical processes and data collected during the RIR, COPECs were identified in each of the environmental media to which ecological receptors could potentially be exposed, including sediment, surface water, and soil.

Using available information about the environmental setting, sources and release mechanisms, fate and transport processes, and the results of investigations, two distinct AOCs were identified as potentially providing habitat to one or more ecological receptors: 1) the Swimming River; and 2) the Forested Wetland.

CSMs were developed for each AOC, describing the potential sources of constituents from the Site, release mechanisms that may have resulted in the presence of Site-related constituents in the AOCs, the environmental media in the AOCs, the feeding guilds and representative receptors, and the complete exposure pathways for each receptor/medium combination.

Seven ecological receptors were identified as potentially present in one or more of the exposure area AOCs. The feeding guilds and the representative receptors for each feeding guild for which potential risks were assessed included:

- Mammals:
    - Omnivores, represented by the raccoon;
    - Invertivores, represented by the short-tailed shrew;

- Birds:
    - Piscivores, represented by the bald eagle and the great blue heron;
    - Omnivores, represented by the mallard duck;
    - Invertivores, represented by the spotted sandpiper and the American robin;

Assessment endpoints and risk questions were developed for each potential ecological receptor in each AOC. The assessment endpoints in this BERA were based on protecting the survival, growth and reproductive success of populations of the selected receptors for each AOC. Risk questions developed from these assessment endpoints were expressed using the general form: "Does exposure to COPECs result in unacceptable adverse effects to the survival, growth and reproductive success of ecological receptors?"

Measurement endpoints were identified for the evaluation of each assessment endpoint. The measurement endpoints selected to answer the risk questions in the BERA were intended to evaluate the health of the population of ecological receptors.

For mammalian and avian receptors selected for quantitative evaluation in the BERA, a food chain exposure model approach was used as the measurement endpoint. Exposure parameter values were obtained from EPA sources and from the scientific literature. The food web models used in the BERA incorporated information about selected biological characteristics and behaviors of receptors at the Site, such as:

- Dietary component and soil/sediment ingestion rates; and
- The size of the receptor's home range relative to the size of the habitat.

The exposure doses estimated using food chain exposure models were compared to NOAEL-based TRVs, considered as having no significant risk of adverse effects to ecological receptors, and to LOAEL-based TRVs, considered as having potential effects to sensitive individuals of the receptor species. TRVs were identified for each COPEC in each exposure medium from EPA sources, from state regulatory agency sources, and from the toxicological literature.

The outcome of the initial measurement endpoint evaluations is a HQ, which is the ratio of an estimated exposure dose or COPEC concentration to a TRV. Hazard Quotients were estimated for each receptor's potential exposure to each COPEC in each relevant exposure medium.

During the course of investigations, samples of sediment and surface water were also collected at an upstream background area. For the purpose of interpreting the potential HQs estimated in the Swimming River, HQs were also estimated for ecological receptors' potential exposure to constituents at background areas.

Estimated HQs for ecological receptors are traditionally interpreted by comparison to a target HQ (HQ=1). This comparison provides one piece of information necessary for risk managers to make decisions regarding the need for and benefits of undertaking corrective measures. However, unlike the comparison of habitat HQs to target HQs, the comparison of habitat HQs to background area HQs provides important perspective about whether constituents in the AOC may be present as a result of naturally-occurring conditions or other conditions that are not related to the Site under investigation. For example, if a receptor's HQ for a COPEC in an AOC exceeds a target HQ but does not exceed the HQ in a background area, then that COPEC is consistent with conditions in the background area, and the exceedance of a target HQ is not likely Site-related. Because the risk characterization information derived from a simple comparison of AOC HQs to target HQs is incomplete, the risk characterization discussions below provide information on the comparison of AOC HQs both to a target HQ of 1 and to background area HQs.

HQs are generally derived from conservative, literature-based TRVs and/or conservative screening values. This BERA used a conservative approach, including the use of maximum COPEC concentrations and 95% UCL concentrations as EPCs along with the screening values. For food chain exposure models, because no site-specific tissue samples had been collected, all prey item tissue concentrations were modeled using conservative literature based BCFs. The exceedance of the target HQ does not necessarily indicate that adverse effects to the population may occur. The EPCs may overestimate exposure concentrations over much of the AOC, such that only a portion of the population would be exposed to these concentrations, while the exposure of the majority of the population would be lower. In summary, the use of several

levels of conservatism in the HQ calculations estimated for this BERA yielded results that may overestimate potential risk.

The following paragraphs present the results of the risk characterization for each habitat:

8.1 SWIMMING RIVER

The CSM for the Swimming River (**Figure 6a**) identified five potential ecological receptors as having complete exposures to COPECs in sediment and surface water. A summary of risk characterization findings for each receptor follows:

8.1.1 SEDIMENT TOXICITY TO BENTHIC INVERTEBRATES

A 10-day acute sediment toxicity study was performed using the euryhaline amphipod, *Leptocheirus plumulosus*. Sediment samples were collected from mid-channel at five locations (**Figure 8**): one upstream reference (UPREF-SED2), three Site-adjacent locations (SED-1C, SED-3C, and SED-5C), and one downstream reference (DNREF-SED2). The full report can be found in **Appendix C**.

Location SED-5C (mid-channel, at the downstream end of the Site) was the only sample to exhibit a significant reduction in survival (76%), as compared to the Reference samples (92% to 95% survival) (**Table 5-11**). Sediment from SED-5C did not have any COPECs that exceeded either the NJDEP ESC, or the concentrations of COPECs in the Reference sediment. Therefore, no relationship can be inferred between observed toxicity and sediment COPEC concentrations. Sediment location SED-5C had the lowest TOC and the coarsest sediment, but the TOC and grain size were within acceptability parameters for *Leptocheirus* survival (ASTM 2008).

The toxicity observed in the SED-5C sediment sample does not appear to be related to COPEC concentrations, and can't be defensibly explained by the TOC or grain size. Though the toxic sample was collected from mid-channel at the downstream end of the Site, it is unknown whether the observed toxicity was Site-related.

8.1.2 ESTIMATED RISK TO RECEPTORS

Benthic Invertebrates and Fish – Because food chain exposure models are not possible for benthic invertebrates and fish, one line of evidence for determining potential risk is through direct comparison of maximum sediment COPEC concentrations to the highly conservative NJDEP ESC, or other suitable screening benchmarks. For this BERA, such comparisons were performed for: 1) Site-adjacent sediment; 2) upstream reference sediment; and 3) downstream reference sediment. The upstream location was above the influence of the Site, and is considered to be representative of background. The downstream location was selected to determine whether potentially adverse impacts from the Site were also impacting the downstream portion of the Swimming River.

Maximum Site sediment COPEC concentrations yielded HQs equal to or greater than 1 for six SVOCs, nine pesticides, three PCBs, and six metals (**Table 6-1**). Three of the SVOCs (2,4-dinitrophenol, 4-nitrophenol, and benzo(g,h,i)perylene) were also found at the upstream reference location, indicating that they are from an off-Site source. Two of them (2,4-dinitrophenol and benzo(g,h,i)perylene) were also found at the downstream location, at lower concentrations than at the upstream reference, indicating that they are background, and not Site-related. However, the concentrations of all three coincident SVOCs were higher adjacent to the Site. The other three SVOCs (acenaphthene, fluorine, and phenanthrene) only slightly exceeded the ESC (HQs of 1.6, 1.5, and 1.1, respectively), and are not likely to impact invertebrates and fish by themselves.

The nine pesticides (4,4'-DDD, 4,4'-DDE, 4,4'-DDT, aldrin, dieldrin, endrin, heptachlor, heptachlor epoxide, and toxaphene) did not exceed the ESC in the upstream or downstream samples (except toxaphene). Three of the pesticides (4,4'-DDT HQ=10, endrin HQ=15.8, and toxaphene HQ=27.9) had significant exceedances of the ESC. However the others (4,4'-DDD, 4,4'-DDE, aldrin, dieldrin, heptachlor, and heptachlor epoxide) only slightly exceeded the ESC (all HQs ≤2), and are not likely to impact invertebrates and fish by themselves. Toxaphene was found at the same maximum concentration in both the upstream and downstream sampling locations, indicating that it is a background contaminant.

The PCBs (Aroclor 1254, Aroclor 1260, and Total PCBs) exceeded the NJDEP ESC adjacent to the Site, but not at the upstream of downstream sample locations.

The metals (arsenic, chromium, copper, lead, nickel, and zinc) exceeded the NJDEP ESC adjacent to the Site. Only arsenic exceeded ESC in the upstream and downstream locations, indicating that arsenic is a background contaminant (though it was higher adjacent to the Site). The metals HQs were all relatively low (HQs ≤6), except for lead, which had a maximum HQ=41.7.

The maximum concentrations of COPECs in both the upstream and downstream sediment in the Swimming River also pose potential risk to benthic invertebrates and fish. However, the downstream HQs are lower for each of the COPECs that exceed ESC than the Site HQs, and are equal or lower than the upstream reference locations (except for benzo(g,h,i)perylene). This indicates that the elevated COPECs detected in sediment adjacent to the Site are not being transported downstream.

The maximum concentrations of COPECs in Site sediment in the Swimming River pose potential risk to benthic invertebrates and fish. However, the maximum concentrations of COPECs are each only found at one location, while the average exposure over the length of the Swimming River adjacent to the Site is significantly lower. **Table 5-3** lists the sediment analytical results for all sample locations, with COPECs in excess of NJDEP ESC and the background concentrations highlighted. **Figure 8** also highlights the COPECs by sample location. The sample locations closest to the shoreline border of the Site (SED-1A, SED-3A, SED-3B, SED-4A, SED-5A, and SED-5B) show the most exceedances, with the highest COPEC concentrations. However, two locations on the opposite shore of the Swimming River (SED-1D and SED-3D) also yielded exceedances of NJDEP ESC.

Bald Eagle – Exposure modeling using maximum sediment concentrations yielded a NOAEL-based lead HQ=5.8. No other COPEC HQs were equal to or greater than 1 (**Table 6-2**). The maximum concentration of lead detected in the sediment of the Swimming River (1,960 mg/kg from Location SED-5B) poses potential risk to bald eagles.

Because the maximum sediment concentrations are each reflective of only a single sampling location, the exposure models that indicated potential exposure risk to receptors were re-calculated using the 95% UCL of all Site sediment concentrations. Additional exposure modeling with the 95% UCL sediment concentrations yielded a NOAEL-based lead HQ=1.6 (**Table 6-7**). The 95% UCL concentration of lead detected in the sediment of the Swimming River (556 mg/kg) may pose potential risk to bald eagles.

However, the lead concentrations in sediment only exceeded the ESC in three locations: SED-1A at 57.1 mg/kg; SED-5A at 284 mg/kg; and SED-5B at 1,960 mg/kg. Therefore, the 95% UCL for lead (556 mg/kg) is nearly double the second highest lead concentration (284 mg/kg). The 95% UCL calculation for lead was skewed by a single value, and is not representative of the Site. Therefore, the Site-adjacent Swimming River sediment does not pose risk to bald eagles feeding near the Site.

For the upstream and downstream sampling locations, no COPEC HQs were equal to or greater than 1 (**Tables 6-10** and **6-15**). The maximum sediment concentrations of COPECs in the upstream and downstream reaches of the Swimming River do not pose risk to the bald eagle.

Great Blue Heron – No COPEC HQs were equal to or greater than 1 (**Table 6-3**). The maximum concentrations of COPECs in Swimming River sediment do not pose risk to the great blue heron.

Mallard – Exposure modeling yielded a NOAEL-based lead HQ=1.6. No other COPEC HQs were equal to or greater than 1 (**Table 6-4**). The maximum concentration of lead detected in the sediment of the Swimming River (1,960 mg/kg from Location SED-5B) poses potential risk to omnivorous birds.

Because the maximum sediment concentrations are each reflective of only a single sampling location, the exposure models that indicated potential exposure risk to receptors were re-calculated using the 95% UCL of all Site sediment concentrations. Additional Exposure modeling with the 95% UCL sediment concentrations yielded no HQs equal to or greater than 1 (**Table 6-8**). The 95% UCL concentrations of COPECs detected in the sediment of the Swimming River do not pose risk to omnivorous birds.

For the upstream and downstream sampling locations, no COPEC HQs were equal to or greater than 1 (**Table 6-12** and **6-17**). The maximum sediment concentrations of COPECs in the upstream and downstream reaches of the Swimming River do not pose risk to omnivorous birds.

Spotted Sandpiper – Food chain exposure modeling yielded NOAEL-based HQs in excess of 1 for five COPECs: endrin HQ=3.5, arsenic HQ=1.3, chromium HQ=1.5, lead HQ=55, and the vanadium HQ=2.6. No other COPEC HQs were equal to or greater than 1 (**Table 6-5**). The maximum concentrations of these COPECs in the sediment of the Swimming River pose potential risk to aquatic invertivorous birds.

Because the maximum sediment concentrations are each reflective of only a single sampling location, the exposure models that indicated potential exposure risk to receptors were re-calculated using the 95% UCL of all Site sediment concentrations. Additional exposure modeling with 95% UCL sediment concentrations yielded NOAEL-based HQs in excess of 1 for three COPECs: endrin HQ=2, lead HQ=16, and vanadium HQ=1.3. No other COPEC HQs were equal to or greater than 1 (**Table 6-9**). The 95% UCL concentrations of these COPECs in the sediment of the Swimming River may pose potential risk to aquatic invertivorous birds.

However, the lead concentrations in sediment only exceeded the ESC in three locations: SED-1A at 57.1 mg/kg; SED-5A at 284 mg/kg; and SED-5B at 1,960 mg/kg. Therefore, the 95% UCL for lead (556 mg/kg) is nearly double the second highest lead concentration (284 mg/kg). The 95% UCL calculation for lead was skewed by a single value, and is not representative of the Site. Therefore, lead in Site-adjacent Swimming River sediment does not pose risk to aquatic invertivorous birds feeding near the Site.

The endrin concentration in sediment only exceeded the ESC in one location: SED-5B at 0.035 mg/kg. Therefore, the 95% UCL for endrin (0.0196 mg/kg) is nearly double the second highest endrin concentration (0.002 mg/kg at location SED-5A). The 95% UCL calculation for endrin was skewed by a single value, and is not representative of the Site. Therefore, endrin in Site-adjacent Swimming River sediment does not pose risk to aquatic invertivorous birds feeding near the Site.

The 95% UCL vanadium concentration in sediment yielded a HQ=1.3, which when rounded to a whole number is HQ=1, and by itself would not pose a risk to invertivorous birds. Therefore, vanadium in Site-adjacent Swimming River sediment does not pose risk to aquatic invertivorous birds feeding near the Site.

Overall, the Site-adjacent sediment in the Swimming River does not pose significant risk to aquatic invertivorous birds.

For the upstream and downstream sampling locations, no COPEC HQs were equal to or greater than 1 (**Tables 6-13** and **6-18**). The maximum sediment concentrations of COPECs in the upstream and downstream reaches of the Swimming River do not pose risk to aquatic invertivorous birds.

Raccoon – No COPEC HQs were equal to or greater than 1 (**Table 6-6**). The maximum concentrations of COPECs in Swimming River sediment do not pose risk to omnivorous mammals.

8.1.3 SWIMMING RIVER CONCLUSIONS

Food chain exposure modeling showed no potential risk to aquatic-feeding receptor species in the vicinity of the Site.

However, sediment toxicity was observed in a sample collected from mid-channel, at the downstream end of the Site. While none of the chemical analyses performed on the toxic sample showed exceedance of NJDEP ESC, and no relationship could be established between observed toxicity and Site-related COPECs, the sample was acutely toxic to amphipods.

The maximum concentrations of COPECs in Site sediment in the Swimming River pose potential risk to benthic invertebrates and fish. However, the maximum concentrations of COPECs are each only found at one location, while the average exposure over the length of the Swimming River adjacent to the Site is significantly lower. **Table 5-3** and **Figure 8** highlight the sample locations with COPECs in excess of ESC. The sample locations closest to the shoreline

border of the Site (SED-1A, SED-3A, SED-3B, SED-4A, SED-5A, and SED-5B) show the most exceedances, with the highest COPEC concentrations.

8.2 FORESTED WETLAND

The CSM for the Forested Wetland (**Figure 6b**) identified three potential ecological receptors as having complete exposures to COPECs in soil. For understanding the soil assessment performed for this BERA, it is critically important to understand that no background soil samples were collected with which to compare the Site soils. In many areas of New Jersey, the natural background concentrations of metals in soil are significantly higher than the ESC. The NJDEP's *Characterization of Ambient Levels of Selected Metals and Other Analytes in New Jersey Urban and Coastal Plain Region Soils* (NJDEP 1998) lists the following background concentrations for the metals selected as COPECs for the Forested Wetland.

COPEC	NJ Coastal Plain Background			Site	
	Mean (mg/kg)	95% UCL (mg/kg)	Max (mg/kg)	Mean (mg/kg)	Max (mg/kg)
Antimony	6,734	7,526	23,100	1.2	1.8
Cadmium	0.36	0.43	2.7	1.0	1.5
Chromium	18.7	23.7	171	94.2	178
Copper	15.0	18.1	93	15.1	48.1
Lead	59.7	72.0	344	96.7	209
Mercury	0.18	0.31	6.1	0.13	0.19
Thallium	0.67	0.72	1.7	1.9	4.8
Vanadium	21.1	25.7	202	164.3	334
Zinc	53.4	62.7	259	155.5	218

Based on this table, antimony is orders of magnitude below background. Therefore, antimony can be eliminated from further consideration in this BERA. Copper and mercury concentrations in the Forested Wetland are at average background concentrations. Therefore, they can be eliminated from consideration as COPECs for this BERA. The maximum values for cadmium, lead, and zinc are well below the maximum background concentrations for those metals. Therefore, they can be eliminated from consideration as COPECs for this BERA. The mean

and maximum values for chromium, thallium, and vanadium are higher than those listed for background, so those three metals will be considered for further assessment.

A summary of risk characterization findings for each receptor follows:

American Robin - Food chain exposure modeling yielded NOAEL-based HQs that exceeded 1 for eight metals (cadmium, chromium, copper, lead, mercury, thallium, vanadium, and zinc) for the robin (**Table 6-20**). No other COPEC HQs were equal to or greater than 1. The maximum concentrations of these COPECs in the soil of the Forested Wetland pose potential risk to omnivorous birds.

Because no biota tissue was collected from the Site, all bioaccumulation data was modeled using BCFs, as detailed in Section 7, using BCFs for metals accumulation can lead to grossly overestimated exposures. For cadmium, 94% of the robin's dose came from modeled tissue data; for mercury, 78% of the dose came from tissue; for thallium, 72% of the dose came from tissue; and for zinc, 81% of the robin's dose came from tissue. It is likely that analysis of actual biota tissue (earthworms) would yield significantly lower metals.

Using the NJDEP background metals concentrations from the table above, consideration will be given to chromium, thallium, and vanadium. The Site maximum concentration of chromium (178 mg/kg) yielded a NOAEL-based HQ=7.9. Using the Site average chromium concentration (94.2 mg/kg), the HQ would drop to HQ=5.5. The Site maximum concentration of thallium (4.8 mg/kg) yielded a NOAEL-based HQ=3.7. Using the Site average thallium concentration (1.9 mg/kg), the HQ would drop to HQ=3.1. The Site maximum concentration of vanadium (334 mg/kg) yielded a NOAEL-based HQ=78. Using the Site average vanadium (164.3 mg/kg) the HQ would drop to HQ=41.

The Site soil concentrations of chromium, thallium, and vanadium may pose a potential risk to invertivorous birds.

Raccoon - No COPEC HQs were equal to or greater than 1 (**Table 6-21**). The maximum concentrations of COPECs in the soil of the Forested Wetland do not pose any risk to omnivorous mammals.

Short-tailed Shrew – Food chain exposure modeling yielded NOAEL-based HQs that exceeded 1 for on pesticide (dieldrin), two PCBs (aroclor 1254 and total PCBs), and nine metals (antimony, cadmium, chromium, lead, mercury, selenium, thallium, vanadium, and zinc) for the shrew (**Table 6-20**). No other COPEC HQs were equal to or greater than 1. The maximum concentrations of these COPECs in the soil of the Forested Wetland pose potential risk to invertivorous mammals.

Because no biota tissue was collected from the Site, all bioaccumulation data was modeled using BCFs, as detailed in Section 7, using BCFs for metals accumulation can lead to grossly overestimated exposures. For antimony, 97% of the shrew's dose came from modeled tissue data; for cadmium, 100% of the shrew's dose came from modeled tissue data; for chromium, 95% of the dose came from tissue; for lead, 89% of the dose came from tissue; for mercury, 99% of the dose came from tissue; for selenium, 96% of the dose came from tissue; for thallium, 100% of the dose came from tissue; and for zinc, 99% of the shrew's dose came from tissue. It is likely that analysis of actual biota tissue (earthworms) would yield significantly lower metals.

Using the NJDEP background metals concentrations from the table above, consideration will be given to chromium, thallium, and vanadium. The Site maximum concentration of chromium (178 mg/kg) yielded a NOAEL-based HQ=5.2. Using the Site average chromium concentration (94.2 mg/kg), the HQ would drop to HQ=5.0. The Site maximum concentration of thallium (4.8 mg/kg) yielded a NOAEL-based HQ=190. Using the Site average thallium concentration (1.9 mg/kg), the HQ would drop to HQ=188. The Site maximum concentration of vanadium (334 mg/kg) yielded a NOAEL-based HQ=1.2. Using the Site average vanadium (164.3 mg/kg) the HQ would drop to HQ=1.

The Site soil concentrations of dieldrin, PCBs, chromium and thallium may pose a potential risk to invertivorous mammals. However, collection of Site-specific biota tissue data would likely drop the estimated HQs significantly.

Forested Wetland Area Risk Conclusions – The Site soil concentrations of dieldrin, PCBs, chromium, thallium, and vanadium may pose risk to invertivorous birds and mammals. It is noted that the potential risks to wildlife in this BERA are based on the use of literature-based

BAFs. As such, there is the potential that these risks are overestimated and could ultimately be refined through the collection of site-related tissue residue data.

8.3 OVERALL CONCLUSIONS

Elevated HQs were related to: 1) the concentrations of COPECs in soil and sediment; and 2) the assumptions utilized in the BERA (NOAEL-based TRVs, literature-based BAFs, 95% UCL COPEC concentrations, and model estimates of tissue concentrations). However, the elevated HQs were not spread throughout the AOCs, but were instead localized at a few sample collection locations.

While some estimated risk to wildlife receptors for certain COPECs may still persist, the use of Site-specific biota tissue data (e.g., soil invertebrates, small mammals, plants) would be expected to reduce the calculated HQs and potentially eliminate the calculated risk for some receptors.

Food chain exposure modeling showed no potential risk to aquatic-feeding receptor species in the vicinity of the Site.

Sediment toxicity was observed in a sample collected from mid-channel, at the downstream end of the Site. The maximum concentrations of COPECs in Site sediment in the Swimming River pose potential risk to benthic invertebrates and fish. However, the maximum concentrations of COPECs are each only found at the sample locations closest to the shoreline border of the Site (SED-3A, SED-3B, SED-5A, and SED-5B). Further field evaluation would be required to refine the BERA and to determine the extent of the impacted areas.

9.0 REFERENCES

Alsop, W.R., E.T. Hawkins, M.E. Stelljes, and W. Collins. 1996. Comparison of Modeled and Measured Tissue Concentrations for Ecological Receptors. Human and Ecological Risk Assessment. Volume 2, pp 539-557.

ASTM (American Society for Testing and Materials). 2008. Standard Test Method for Measuring the Toxicity of Sediment-Associated Contaminants with Estuarine and Marine Invertebrates. E1367-03(2008). ASTM, West Conshohocken, PA.

Barnthouse, L.W. and G.W. Suter, II. 1986. User's Manual for Ecological Risk Assessment. ORNL-6251. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Beyer, W.N., E. Conner, and S. Gerould. 1994. Estimates of Soil Ingestion by Wildlife. Journal of Wildlife Management. 58:375-382.

Efroymson, R. A., M.E. Will, G. W. Suter II, A.C. Wooten. 1997a. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. ES/ER/TH-85/R3.

Efroymson, R. A., M.E. Will, G. W. Suter II. 1997b. Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision. ES/ER/TM-126/R2.

Hamelink, J.L., P.F. Landrum, H.L. Bergman, and W.H. Benson. 1994. Bioavailability: Physical, Chemical, and Biological Interactions. CRC Press, Boca Raton, FL.

Long, E.R., D.D. MacDonald, S.L. Smith, and F.D. Calder, 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. *Env. Manage*. 19:81-97.

Long, E.R. and L.G. Morgan. 1990. The potential for biological effects of sediment-sorbed contaminants tested in the national status and trends program. National Oceanic and Atmospheric Administration (NOAA) Technical Memorandum NOS OMA 52.

MacDonald, D. D., Ingersoll, C. G., Berger, T. A. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Arch. Environ. Contam. Toxicol. 39:20-31.

NJDEP (New Jersey Department of Environmental Protection). Characterization of Ambient Levels of Selected Metals and Other Analytes in New Jersey Urban Coastal Plain Region Soils, Volume I, Final Report. Prepared by BEM Systems, Inc. October 1998.

NJDEP (New Jersey Department of Environmental Protection). 2006. Surface Water Quality Standards. N.J.A.C. 7:9B.

NJDEP (New Jersey Department of Environmental Protection), 2009. NJDEP Ecological Screening Criteria. Available at: http://www.state.nj.us/dep/srp/guidance/ecoscreening/.

NJDEP (New Jersey Department of Environmental Protection). 2012. Ecological Evaluation Technical Guidance, Version 1.2, 8/29/12.

NJGS (New Jersey Geological Survey), 2003. Physiographic Provinces of New Jersey. Information Circular.

NOAA (National Oceanic and Atmospheric Administration). 2007. Screening Quick Reference Tables (SQuiRTs).

Newman, M.C. 2001. Fundamentals of Ecotoxicology. Lewis Publishers, Boca Raton, FL.

Sample, B.E. and G.W. Suter. 1994. Estimating Exposure of Terrestrial Wildlife to Contaminants.

Sample, B.E., D.M. Opresko, G.W. Suter II. 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. ES/ER/TM-86/R3.

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

Sample, B.E., G.W. Suter II, J.J. Beauchamp, and R.A. Efroymson. 1999. Literature-derived bioaccumulation models for earthworms: development and validation. Environmental Toxicology and Chemistry. Volume 18, pp 2110-2120.

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

Suter, G. W. 1996. Toxicological benchmarks for screening contaminants of potential concern for effects on freshwater biota. Environ. Toxicol. Chem. 15(7), 1232-1241.

Suter, G.W and C.L. Tsao. 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision. ES/ER/TM-96/R2.

Suter, G.W., R.A. Efroymson, B.E. Sample, D.S., Jones, 2000. Ecological Risk Assessment for Contaminated Sites. Lewis Publishers, Boca Raton, FL.

Swartz, R.C., P.F. Kemp, D.W. Schults, and J.O. Lamberson. 1988. Effects of mixtures of sediment contaminants on the marine infaunal amphipod *Rhepoxinius abronius*. Environmental Toxicology and Chemistry 7**:**1013-1020.

USDA (United States Department of Agriculture), 2013. Custom Soil Resource Report for Monmouth County, New Jersey. Obtained from the USDA Web Soil Survey website: http://websoilsurvey.nrcs.usda.gov/app/.

USEPA (United States Environmental Protection Agency). 1988. Review of Ecological Risk Assessment Methods. EPA/230-10-88-041. Office of Planning and Evaluation, Washington, D.C.

USEPA (United States Environmental Protection Agency). 1989. Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual, Interim Final. EPA/540/1-89/001.

U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC.

USEPA (United States Environmental Protection Agency). 1992. Framework for Ecological Risk Assessment. EPA/630/R-92/001, Risk Assessment Forum, U.S. Environmental Protection Agency, Washington, D.C.

USEPA (United States Environmental Protection Agency). 1993. Wildlife Exposure Factors Handbook. EPA/600/R-93/187.

USEPA (United States Environmental Protection Agency). 1994. Using Toxicity Tests in Ecological Risk Assessment. ECO Update, Volume 2(1), March 1994. Publication 9345.0-051, OSWER, USEPA.

USEPA (United States Environmental Protection Agency). 1997. Ecological Risk Assessment Guidance for Superfund. Interim Final. EPA 540-R-97-006.

USEPA (United States Environmental Protection Agency), 1998. Guidelines for Ecological Risk Assessment. EPA/630/R-95/002F.

USEPA (United States Environmental Protection Agency). 1999. Fast Track Dredged Material Decontamination Demonstration for the Port of New York and New Jersey. Report to Congress on the Water Resources and Development Acts of 1990 (Section 412), 1992 (Section 405C), and 1996 (Section 226). Submitted by USEPA Region 2, United States Army Corps of Engineers New York District, and United States Department of Energy Brookhaven National Laboratory. EPA 000-0-99000, December 1999.

USEPA (United States Environmental Protection Agency). 1999b. Protocol for Screening Level Ecological Risk Assessment at Hazardous Waste Combustion Facilities, Vol. 1, 2, & 3. Peer Review Draft. August 1999. EPA530-D-99-001A, EPA530-D-99-001B, and EPA530-D-99-001C. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response.

USEPA (United States Environmental Protection Agency). 2000a. USEPA Ecological Soil Screening Levels (Eco-SSLs).

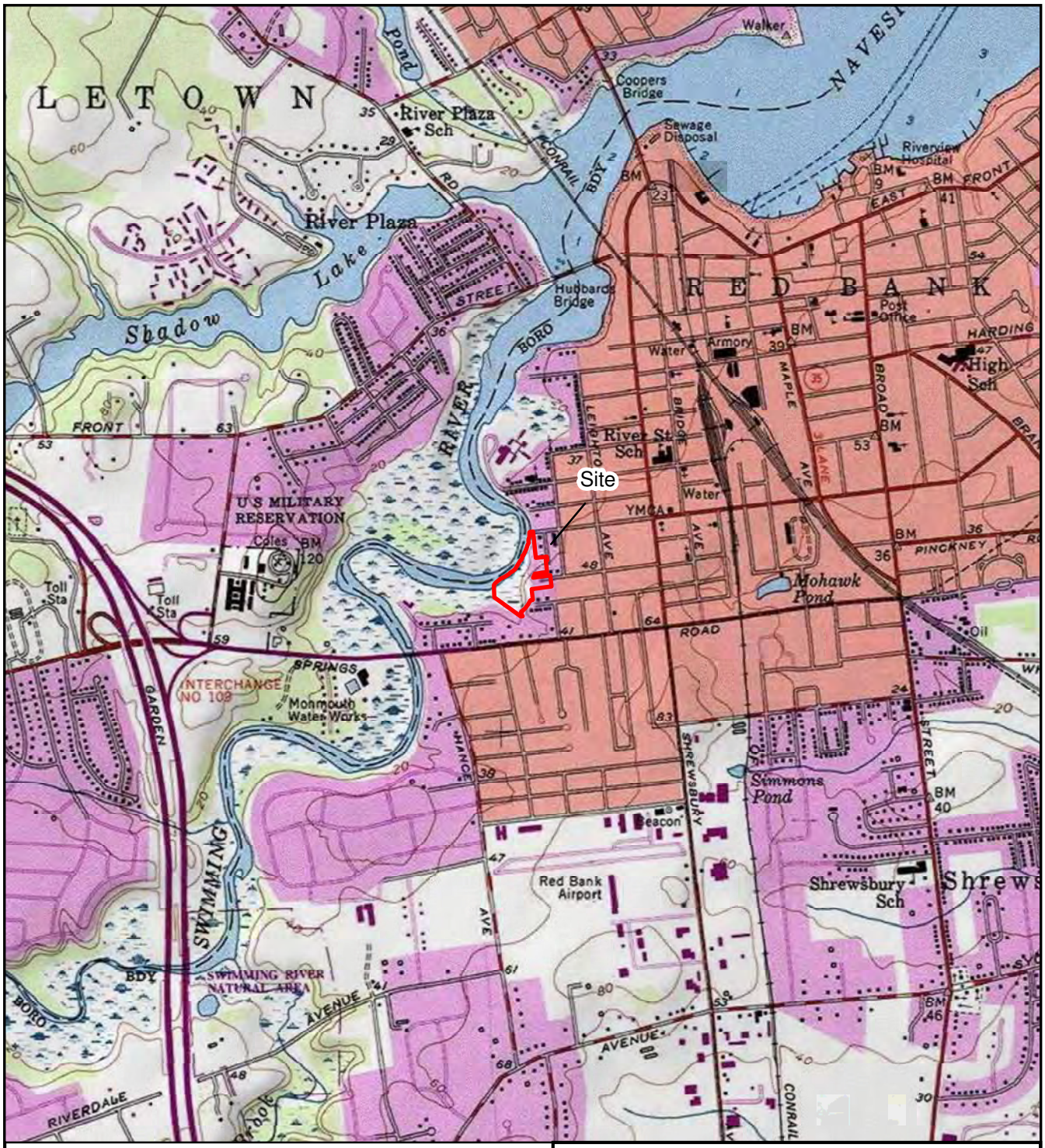
USEPA (United States Environmental Protection Agency). 2007a. Guidance for Developing Ecological Soil Screening Levels (EcoSSLs). Attachment 4-1. Exposure Factors and Bioaccumulation Models for Derivation of Wildlife EcoSSLs.

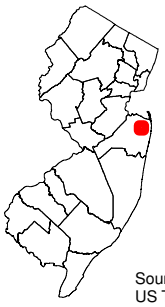
USEPA (United States Environmental Protection Agency). 2007b. Guidance for Developing Ecological Soil Screening Levels (EcoSSLs). Attachment 1-4. Review of Background Concentrations for Metals. http://www.epa.gov/ecotox/ecossl/

USEPA (United States Environmental Protection Agency). 2010. ProUCL Version 4.00.05 Technical Guidance. EPA/600/R-07/041. May 2010.

Warren-Hicks W.J., and D.R.J. Moore. 1998. Uncertainty Analysis in Ecological Risk Assessment. Proceedings from the Pellston Workshop on Uncertainty Analysis in Ecological Risk Assessment. 23-28 August 1995, Pellston, Michigan. Society of Environmental Toxicology and Chemistry (SETAC), Pensacola, FL.

FIGURES





LEGEND

Approximate Site Boundary

N W E S

0 1,000 2,000 4,000 Feet

Source:
US Topo Maps; Digital USGS Seamless Maps; ESRI Map Server. 2012

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Figure 1
Site Location Map
Red Bank Landfill Site
Red Bank, New Jersey

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LEGEND

Approximate Site Boundary

Sediment Sample Location

Soil Sample Location

Source:
US Topo Maps; Digital USGS Seamless Maps; ESRI Map Server. 2012

0 190 380 Feet

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Figure 2
Site Map
Red Bank Landfill Site
Red Bank, New Jersey

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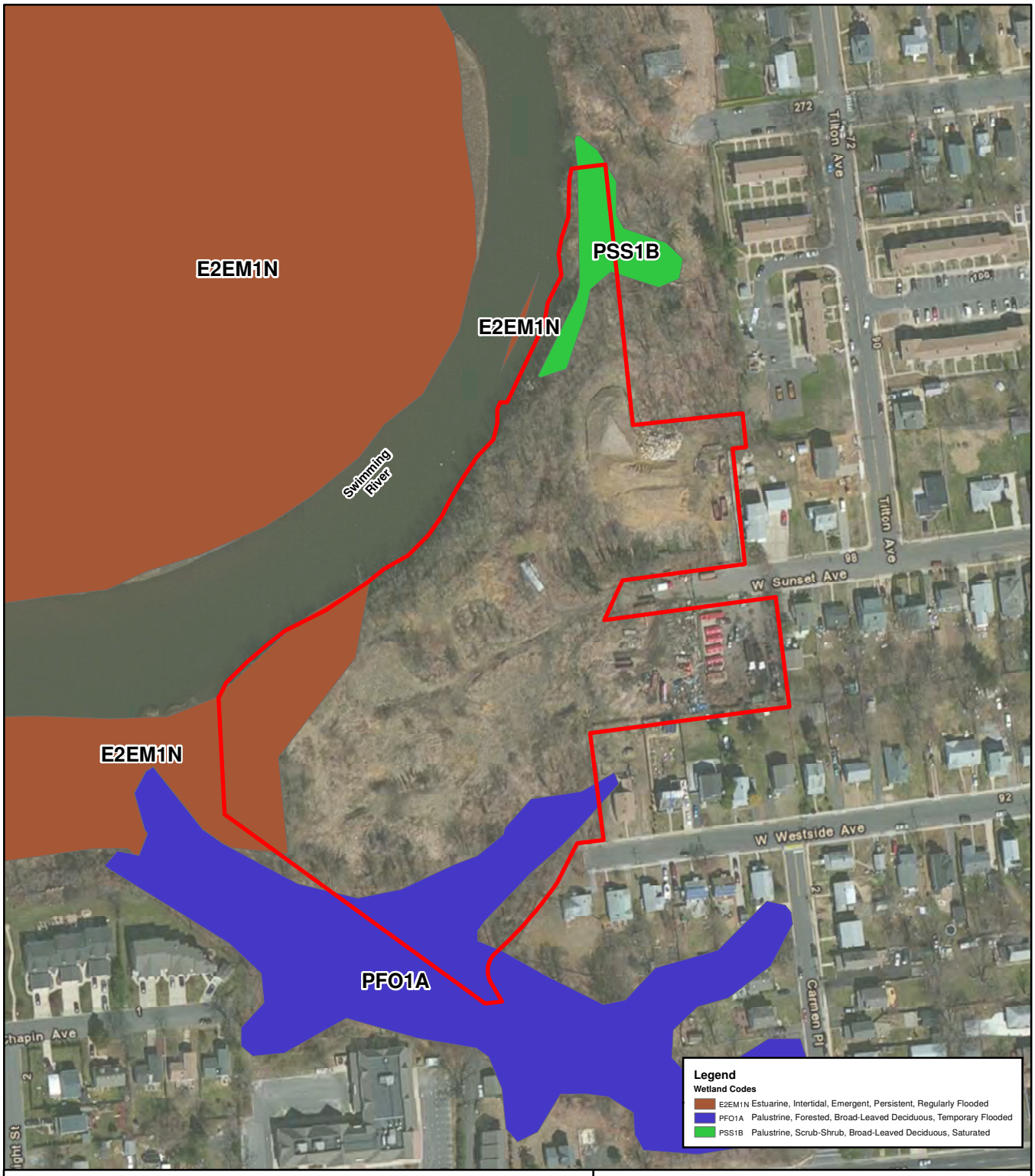

LEGEND

Approximate Site Boundary

N W E S

0 100 200 400 Feet

Source:
US Topo Maps; Digital USGS Seamless Maps; ESRI Map Server. 2012

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Figure 3
New Jersey Freshwater Wetlands Map
Red Bank Landfill Site
Red Bank, New Jersey

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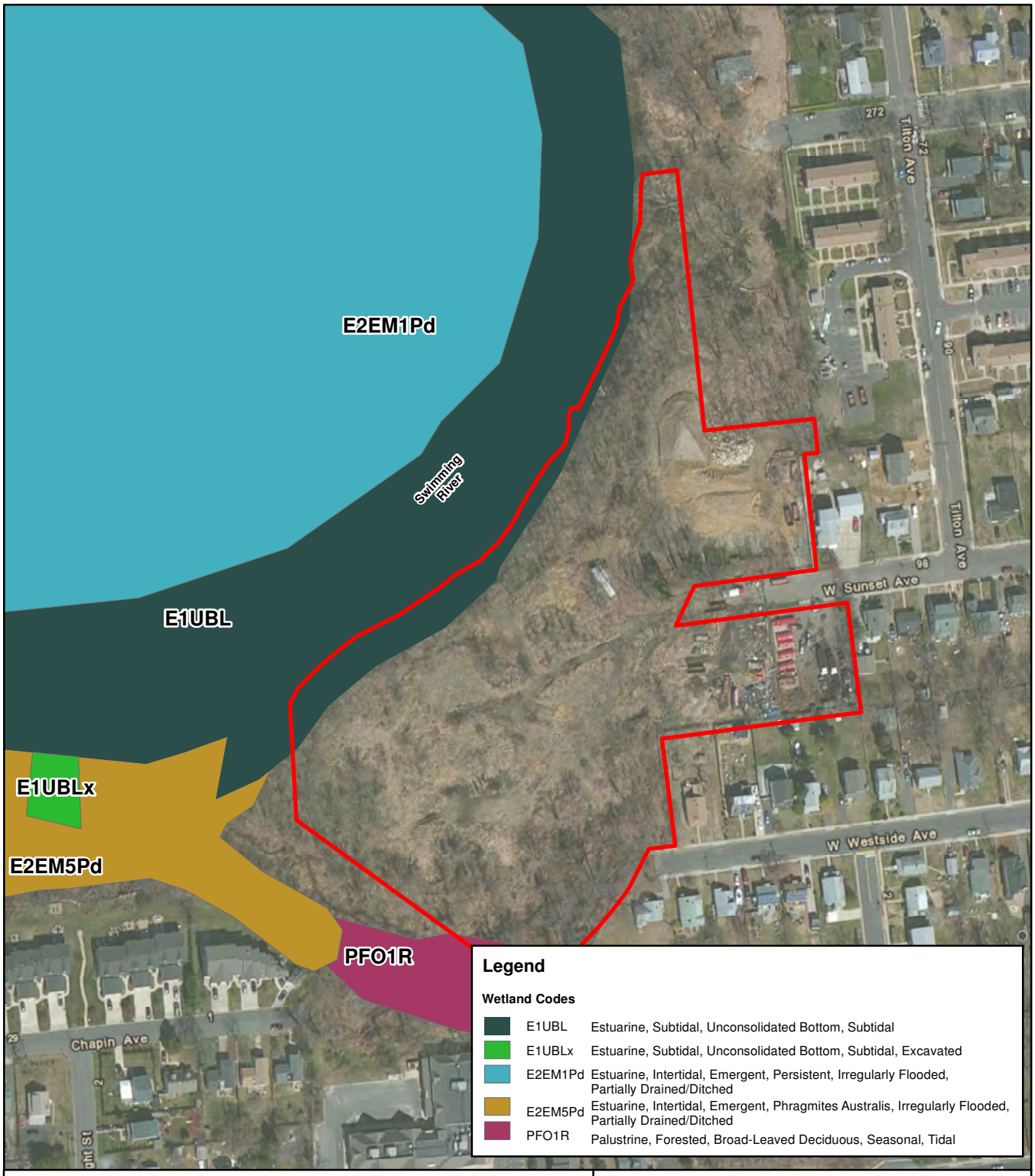

LEGEND

Approximate Site Boundary

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0 100 200 400 Feet

Source:
US Topo Maps; Digital USGS Seamless Maps; ESRI Map Server. 2012

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Figure 4
National Wetlands Inventory Map
Red Bank Landfill Site
Red Bank, New Jersey

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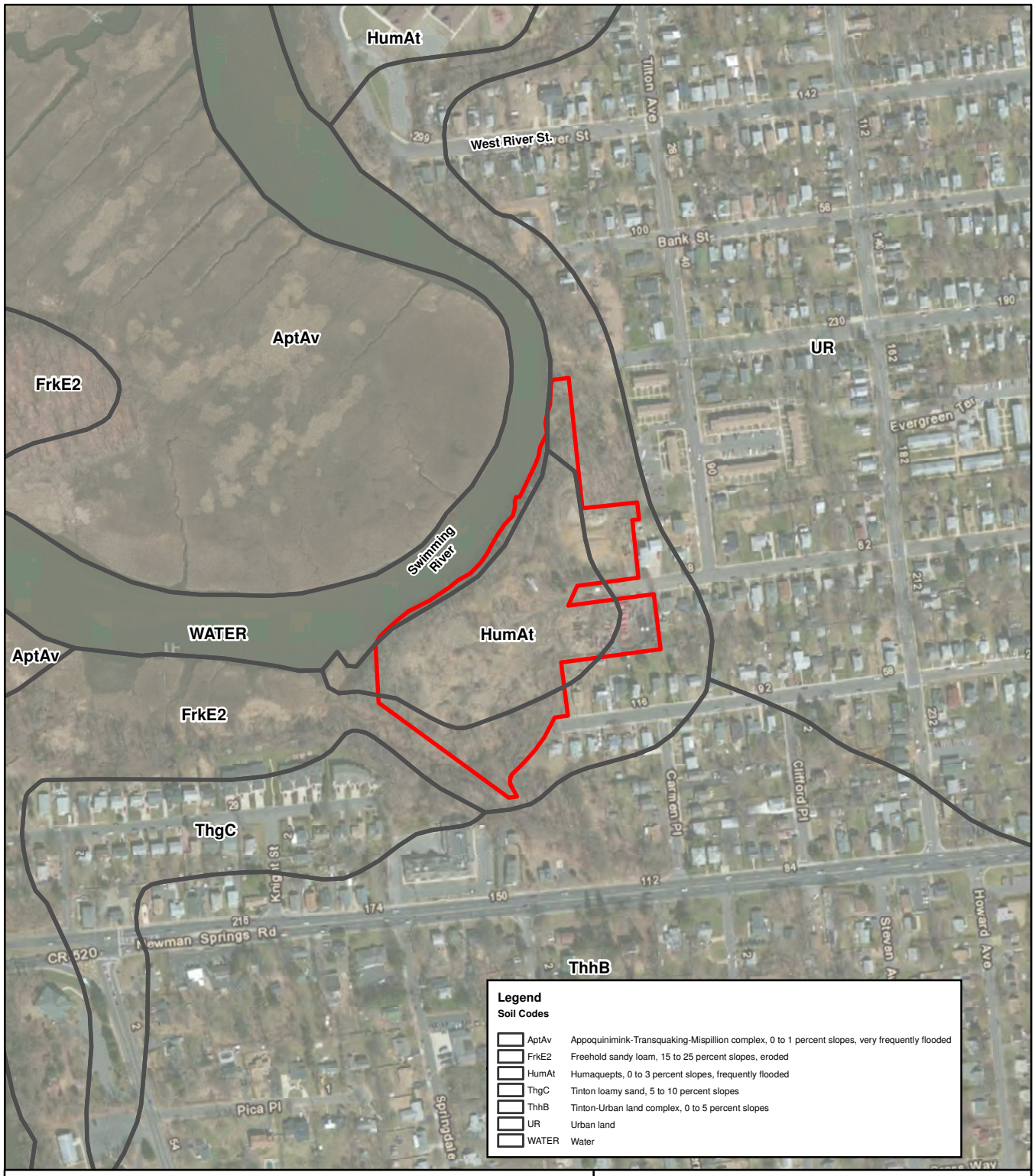

LEGEND

Approximate Site Boundary

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Source:
US Topo Maps; Digital USGS Seamless Maps; ESRI Map Server. 2012

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Figure 5
National Resources Conservation Service Soils Map
Red Bank Landfill Site
Red Bank, New Jersey

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Figure 6a
Conceptual Site Model for the Aquatic Assessment
Red Bank Landfill Site
Red Bank, New Jersey

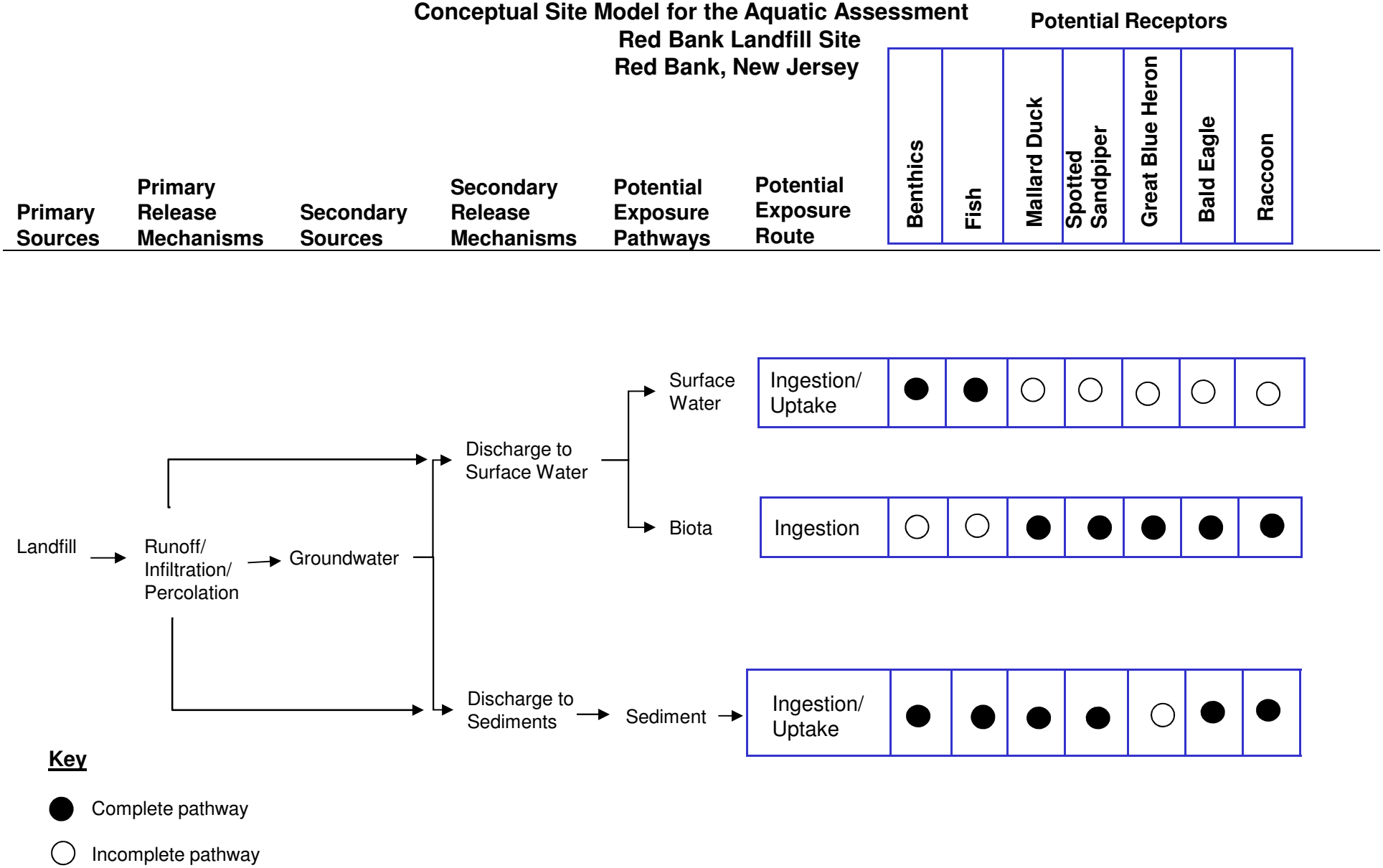
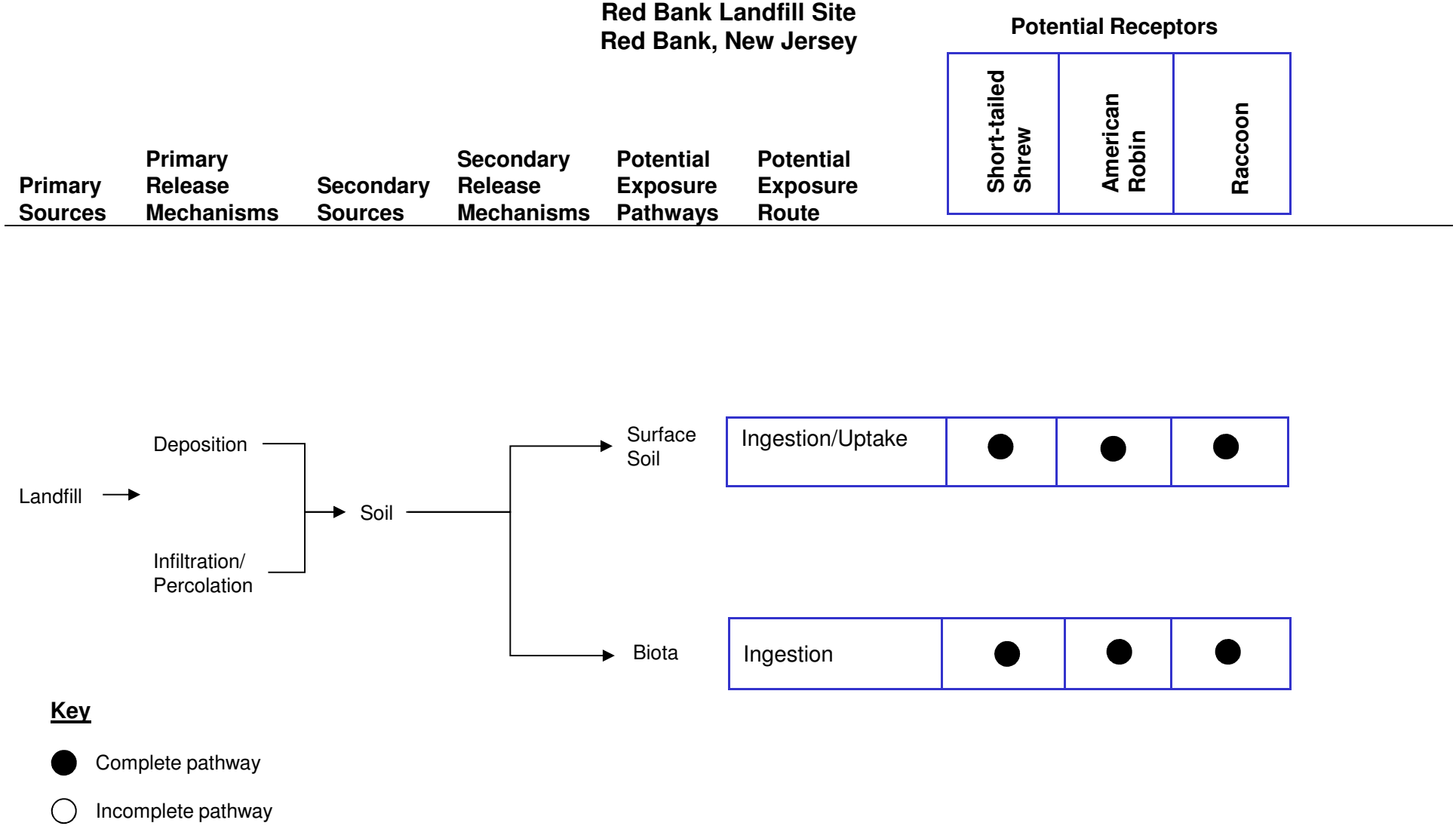
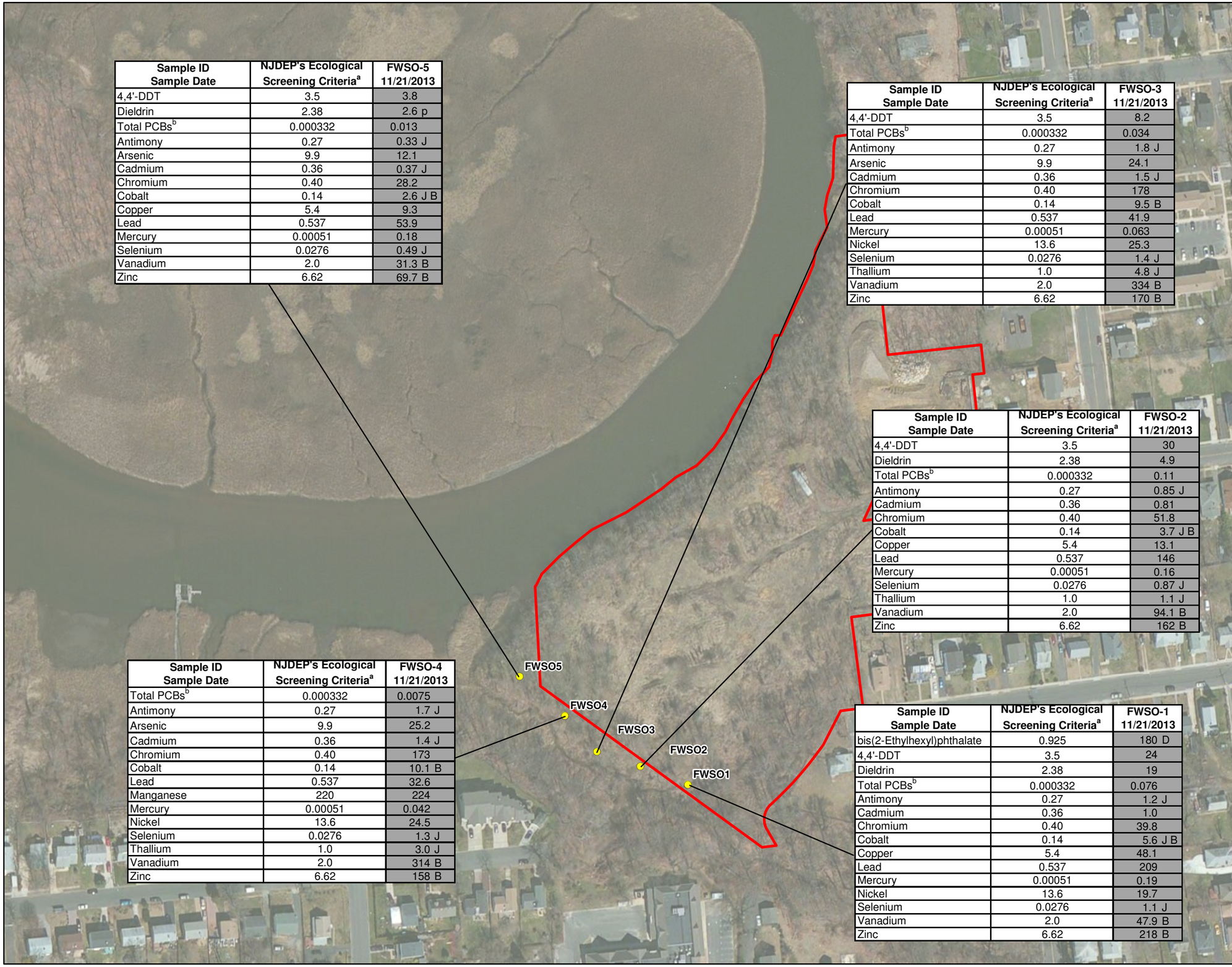


Figure 6b
Conceptual Site Model for the Forested Wetland Assessment
Red Bank Landfill Site
Red Bank, New Jersey





Sample ID Sample Date	NJDEP's Ecological Screening Criteria[a]	FWSO-5 11/21/2013
4,4'-DDT	3.5	3.8
Dieldrin	2.38	2.6 p
Total PCBs[b]	0.000332	0.013
Antimony	0.27	0.33 J
Arsenic	9.9	12.1
Cadmium	0.36	0.37 J
Chromium	0.40	28.2
Cobalt	0.14	2.6 J B
Copper	5.4	9.3
Lead	0.537	53.9
Mercury	0.00051	0.18
Selenium	0.0276	0.49 J
Vanadium	2.0	31.3 B
Zinc	6.62	69.7 B

Sample ID Sample Date	NJDEP's Ecological Screening Criteria[a]	FWSO-3 11/21/2013
4,4'-DDT	3.5	8.2
Total PCBs[b]	0.000332	0.034
Antimony	0.27	1.8 J
Arsenic	9.9	24.1
Cadmium	0.36	1.5 J
Chromium	0.40	178
Cobalt	0.14	9.5 B
Lead	0.537	41.9
Mercury	0.00051	0.063
Nickel	13.6	25.3
Selenium	0.0276	1.4 J
Thallium	1.0	4.8 J
Vanadium	2.0	334 B
Zinc	6.62	170 B

Sample ID Sample Date	NJDEP's Ecological Screening Criteria[a]	FWSO-2 11/21/2013
4,4'-DDT	3.5	30
Dieldrin	2.38	4.9
Total PCBs[b]	0.000332	0.11
Antimony	0.27	0.85 J
Cadmium	0.36	0.81
Chromium	0.40	51.8
Cobalt	0.14	3.7 J B
Copper	5.4	13.1
Lead	0.537	146
Mercury	0.00051	0.16
Selenium	0.0276	0.87 J
Thallium	1.0	1.1 J
Vanadium	2.0	94.1 B
Zinc	6.62	162 B

Sample ID Sample Date	NJDEP's Ecological Screening Criteria[a]	FWSO-4 11/21/2013
Total PCBs[b]	0.000332	0.0075
Antimony	0.27	1.7 J
Arsenic	9.9	25.2
Cadmium	0.36	1.4 J
Chromium	0.40	173
Cobalt	0.14	10.1 B
Lead	0.537	32.6
Manganese	220	224
Mercury	0.00051	0.042
Nickel	13.6	24.5
Selenium	0.0276	1.3 J
Thallium	1.0	3.0 J
Vanadium	2.0	314 B
Zinc	6.62	158 B

Sample ID Sample Date	NJDEP's Ecological Screening Criteria[a]	FWSO-1 11/21/2013
bis(2-Ethylhexyl)phthalate	0.925	180 D
4,4'-DDT	3.5	24
Dieldrin	2.38	19
Total PCBs[b]	0.000332	0.076
Antimony	0.27	1.2 J
Cadmium	0.36	1.0
Chromium	0.40	39.8
Cobalt	0.14	5.6 J B
Copper	5.4	48.1
Lead	0.537	209
Mercury	0.00051	0.19
Nickel	13.6	19.7
Selenium	0.0276	1.1 J
Vanadium	2.0	47.9 B
Zinc	6.62	218 B

N
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Legend

Approximate Site Boundary

Soil Sample Location

Notes:
a - New Jersey Department of Environmental Protection (NJDEP). Ecological Screening Criteria (2009). Most conservative soil criteria used.
J - Result is less than the Reporting Limit (RL) but greater than or equal to the MDL and the concentration is an approximate value.
B - Compound was found in the blank and sample.
p - The %RPD between the primary and confirmation column/detector is >40%. The lower value has been reported.
U - Indicates the analyte was analyzed for but not detected.
D - Sample results are obtained from a dilution; the surrogate or matrix spike recoveries reported are calculated from diluted samples.
Highlighted = Compounds detected equal to or above the Ecological Screening Criteria.

0 50 100 200 Feet

Source:
US Topo Maps; Digital USGS Seamless Maps; ESRI Map Server. 2012

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Figure 7
Surface Soil Screening Benchmark Exceedances
Red Bank Landfill Site
Red Bank, New Jersey

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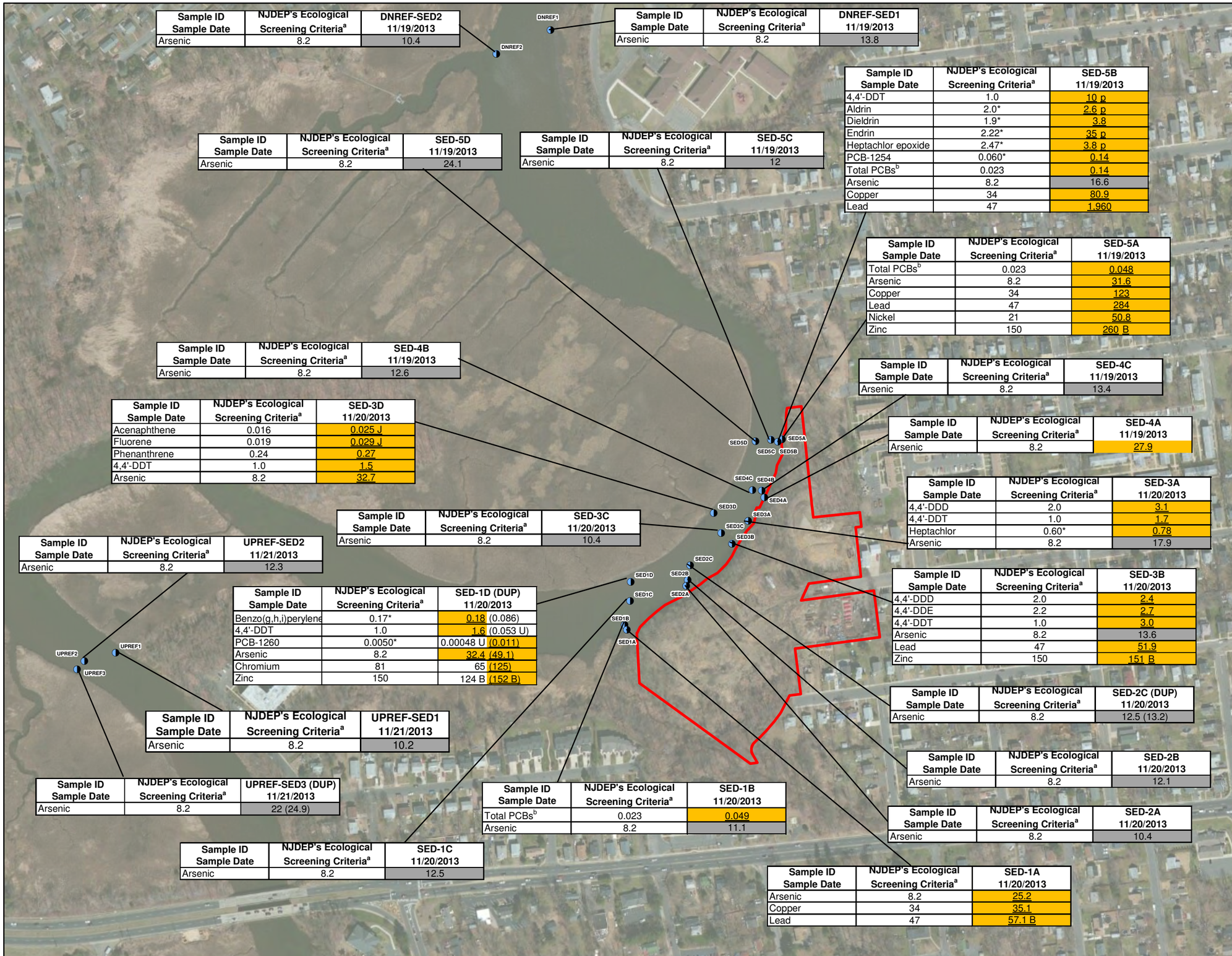

Sample ID Sample Date	NJDEP's Ecological Screening Criteria[a]	DNREF-SED2 11/19/2013
Arsenic	8.2	10.4

Sample ID Sample Date	NJDEP's Ecological Screening Criteria[a]	DNREF-SED1 11/19/2013
Arsenic	8.2	13.8

Sample ID Sample Date	NJDEP's Ecological Screening Criteria[a]	SED-5B 11/19/2013
4,4'-DDT	1.0	10 p
Aldrin	2.0*	2.6 p
Dieldrin	1.9*	3.8
Endrin	2.22*	35 p
Heptachlor epoxide	2.47*	3.8 p
PCB-1254	0.060*	0.14
Total PCBs[b]	0.023	0.14
Arsenic	8.2	16.6
Copper	34	80.9
Lead	47	1,960

Sample ID Sample Date	NJDEP's Ecological Screening Criteria[a]	SED-5D 11/19/2013
Arsenic	8.2	24.1

Sample ID Sample Date	NJDEP's Ecological Screening Criteria[a]	SED-5C 11/19/2013
Arsenic	8.2	12

Sample ID Sample Date	NJDEP's Ecological Screening Criteria[a]	SED-5A 11/19/2013
Total PCBs[b]	0.023	0.048
Arsenic	8.2	31.6
Copper	34	123
Lead	47	284
Nickel	21	50.8
Zinc	150	260 B

Sample ID Sample Date	NJDEP's Ecological Screening Criteria[a]	SED-4B 11/19/2013
Arsenic	8.2	12.6

Sample ID Sample Date	NJDEP's Ecological Screening Criteria[a]	SED-4C 11/19/2013
Arsenic	8.2	13.4

Sample ID Sample Date	NJDEP's Ecological Screening Criteria[a]	SED-3D 11/20/2013
Acenaphthene	0.016	0.025 J
Fluorene	0.019	0.029 J
Phenanthrene	0.24	0.27
4,4'-DDT	1.0	1.5
Arsenic	8.2	32.7

Sample ID Sample Date	NJDEP's Ecological Screening Criteria[a]	SED-4A 11/19/2013
Arsenic	8.2	27.9

Sample ID Sample Date	NJDEP's Ecological Screening Criteria[a]	SED-3A 11/20/2013
4,4'-DDD	2.0	3.1
4,4'-DDT	1.0	1.7
Heptachlor	0.60*	0.78
Arsenic	8.2	17.9

Sample ID Sample Date	NJDEP's Ecological Screening Criteria[a]	SED-3C 11/20/2013
Arsenic	8.2	10.4

Sample ID Sample Date	NJDEP's Ecological Screening Criteria[a]	UPREF-SED2 11/21/2013
Arsenic	8.2	12.3

Sample ID Sample Date	NJDEP's Ecological Screening Criteria[a]	SED-3B 11/20/2013
4,4'-DDD	2.0	2.4
4,4'-DDE	2.2	2.7
4,4'-DDT	1.0	3.0
Arsenic	8.2	13.6
Lead	47	51.9
Zinc	150	151 B

Sample ID Sample Date	NJDEP's Ecological Screening Criteria[a]	SED-1D (DUP) 11/20/2013
Benzo(g,h,i)perylene	0.17*	0.18 (0.086)
4,4'-DDT	1.0	1.6 (0.053 U)
PCB-1260	0.0050*	0.00048 U (0.011)
Arsenic	8.2	32.4 (49.1)
Chromium	81	65 (125)
Zinc	150	124 B (152 B)

Sample ID Sample Date	NJDEP's Ecological Screening Criteria[a]	SED-2C (DUP) 11/20/2013
Arsenic	8.2	12.5 (13.2)

Sample ID Sample Date	NJDEP's Ecological Screening Criteria[a]	UPREF-SED1 11/21/2013
Arsenic	8.2	10.2

Sample ID Sample Date	NJDEP's Ecological Screening Criteria[a]	SED-2B 11/20/2013
Arsenic	8.2	12.1

Sample ID Sample Date	NJDEP's Ecological Screening Criteria[a]	UPREF-SED3 (DUP) 11/21/2013
Arsenic	8.2	22 (24.9)

Sample ID Sample Date	NJDEP's Ecological Screening Criteria[a]	SED-1B 11/20/2013
Total PCBs[b]	0.023	0.049
Arsenic	8.2	11.1

Sample ID Sample Date	NJDEP's Ecological Screening Criteria[a]	SED-2A 11/20/2013
Arsenic	8.2	10.4

Sample ID Sample Date	NJDEP's Ecological Screening Criteria[a]	SED-1C 11/20/2013
Arsenic	8.2	12.5

Sample ID Sample Date	NJDEP's Ecological Screening Criteria[a]	SED-1A 11/20/2013
Arsenic	8.2	25.2
Copper	34	35.1
Lead	47	57.1 B

N
W E
S

Legend

Approximate Site Boundary

Sediment Sample Location

Notes:

a - New Jersey Department of Environmental Protection (NJDEP). Ecological Screening Criteria (2009). Saline water Effects Range Low (ERL) criteria used.

b - Total PCBs were not analyzed. Result is the total of all detected concentrations or the highest non-detect Method Detection Limit (MDL).
J - Result is less than the Reporting Limit (RL) but greater than or equal to the MDL and the concentration is an approximate value.
B - Compound was found in the blank and sample
p - The %RPD between the primary and confirmation column/detector is >40%. The lower value has been reported.
U - Indicates the analyte was analyzed for but not detected.
* - Ecological Screening Criteria based on a chronic freshwater sediment value, as a saline criterion was not available.
Values in parentheses represent duplicate sample.
Highlighted = Compounds detected equal to or above the Ecological Screening Criteria.
Highlighted and Underlined = Site compounds detected equal to or above the Ecological Screening Criteria and above reference concentrations.

0 150 300 600 Feet

Source:
US Topo Maps; Digital USGS Seamless Maps; ESRI Map Server. 2012

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Figure 8
Sediment Screening Benchmark/Background Exceedances Map
Red Bank Landfill Site
Red Bank, New Jersey

Rev. By: CB	3481130017	February 2014

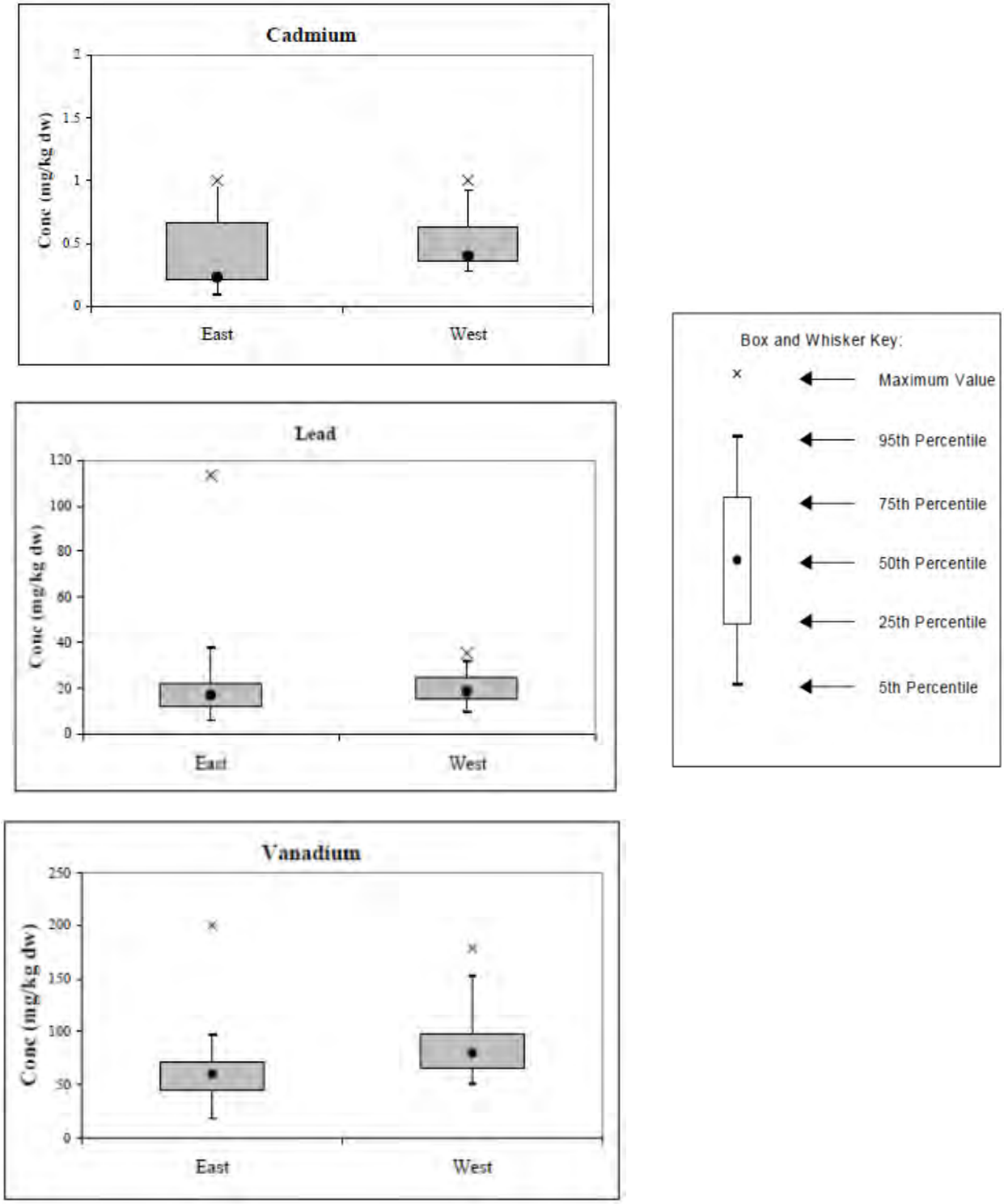

Figure 9. USEPA Ecological Soil Screening Level (EcoSSL) Background Metal Concentrations

Source: USEPA (United States Environmental Protection Agency). 2007. Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs); Attachment 1-4, Review of Background Concentrations for Metals.

TABLES

Table 5-1
Sediment COPECs and Maximum Concentrations
Red Bank Landfill Site
Red Bank, New Jersey

Sediment COPECs	Site Maximum Concentration (mg/kg)	Location	COPEC Reason
SVOCs			
2,4-Dinitrophenol	0.17	SED-3D	a
4-Nitrophenol	0.050	SED-3D	a
Acenaphthene	0.025	SED-3D	c
Acetophenone	0.021	SED-1A	b
Benzaldehyde	0.21	SED-5A	b
Benzo(g,h,i)perylene	0.18	SED-1D	c
Carbazole	0.028	SED-3D	b
Fluorene	0.029	SED-3D	c
Phenanthrene	0.27	SED-3D	c
Pesticides			
4,4'-DDD	0.0031	SED-3A	c
4,4'-DDE	0.0027	SED-3B	c
4,4'-DDT	0.010	SED-5B	c
Aldrin	0.0026	SED-5B	c
alpha-Chlordane	0.0030	SED-3A	b
delta-BHC	0.0012	SED-5B	b
Dieldrin	0.0038	SED-5B	c
Endosulfan I	0.0024	SED-5B	b
Endosulfan II	0.00053	SED-5B	b
Endrin	0.035	SED-5B	c
Endrin Ketone	0.0001	SED-1A	b
gamma-Chlordane	0.017	SED-5B	b
Hepatachlor	0.00078	SED-3A	c
Hepatachlor epoxide	0.0038	SED-5B	c
Toxaphene	0.00215	SED-5A	a
PCBs			
PCB-1254	0.14	SED-5B	c
PCB-1260	0.011	SED-1DDUP	c
Total PCBs	0.14	SED-5B	c
Metals*			
Antimony	4.3	SED-5A	b
Arsenic	49.1	SED-1DDUP	c
Barium	96.4	SED-3A	b
Beryllium	1.4	SED-1DDUP	b
Chromium	125	SED-1DDUP	c
Copper	123	SED-5A	c
Lead	1,960	SED-5B	c
Nickel	50.8	SED-5A	c
Selenium	2.6	SED-1DDUP	b
Thallium	3.4	SED-1DDUP	b
Vanadium	84.4	SED-1DDUP	b
Zinc	260	SED-5A	c

Notes:
a = 1/2 the detection limit exceeded the Ecological Screening Criteria for a non-detected result.
b = Detected concentration with no associated Ecological Screening Criteria with which to compare.
c = Detected concentration equal to or above the Ecological Screening Criteria.
* = Calcium, Iron, Magnesium, Potassium and Sodium were not included as COPECs as they are considered to be essential nutrients.

Table 5-2
Soil COPECs and Maximum Concentrations
Red Bank Landfill Site
Red Bank, New Jersey

Soil COPECs	Site Maximum Concentration (mg/kg)	Location	COPEC Reason
SVOCs			
2,4-Dimethylphenol	0.075	FWSO-1	a
2,4-Dinitrophenol	0.55	FWSO-1	a
Acetophenone	0.012	FWSO-5	b
Benzaldehyde	0.19	FWSO-2	b
Carbazole	0.081	FWSO-1	b
Dibenzofuran	0.01	FWSO-5	b
Pesticides			
4,4'-DDT	0.030	FWSO-2	c
alpha-Chlordane	0.037	FWSO-1	b
delta-BHC	0.00027	FWSO-2	b
Dieldrin	0.019	FWSO-1	c
Endosulfan II	0.0013	FWSO-2	b
Endrin ketone	0.00028	FWSO-3	b
gamma-Chlordane	0.051	FWSO-1	b
PCBs			
PCB-1254	0.11	FWSO-2	b
Total PCBs	0.11	FWSO-2	c
Metals*			
Antimony	1.8	FWSO-3	c
Arsenic	25.2	FWSO-4	c
Cadmium	1.5	FWSO-3	c
Chromium	178	FWSO-3	c
Cobalt	10.1	FWSO-4	c
Copper	48.1	FWSO-1	c
Lead	209	FWSO-1	c
Manganese	224	FWSO-4	c
Mercury	0.19	FWSO-1	c
Nickel	25.3	FWSO-3	c
Selenium	1.4	FWSO-3	c
Thallium	4.8	FWSO-3	c
Vanadium	334	FWSO-3	c
Zinc	218	FWSO-1	c

Notes:
a = 1/2 the detection limit exceeded the Ecological Screening Criteria for a non-detected result.
b = Detected concentration with no associated Ecological Screening Criteria with which to compare.
c = Detected concentration equal to or above the Ecological Screening Criteria.
* = Calcium, Iron, Magnesium, Potassium and Sodium were not included as COPECs as they are considered to be essential nutrients.

Table 5-3
Sediment Analyte Concentrations
Red Bank Landfill Site
Red Bank, New Jersey

		REFERENCE LOCATIONS						SITE
Sample ID	**NJDEP's Ecological Screening Criteria[a]**	**UPREF-SED1**	**UPREF-SED2**	**UPREF-SED3**	**UPREF-SED3DUP**	**DNREF-SED1**	**DNREF-SED2**	**SED-1A**
Lab Sample ID		**460-67151-11**	**460-67151-12**	**460-67151-13**	**460-67151-14**	**460-67000-16**	**460-67000-24**	**460-67074-30**
Sample Date		**11/21/2013**	**11/21/2013**	**11/21/2013**	**11/21/2013**	**11/19/2013**	**11/19/2013**	**11/20/2013**
Semi-Volatile Organic Compounds (SVOCs) (mg/kg)								
1,1'-Biphenyl	NC	0.0090 U	0.0096 U	0.010 U	0.011 U	0.0097 U	0.0042 U	0.013 U
1,2,4,5-Tetrachlorobenzene	1.252*	0.0077 U	0.0082 U	0.0085 U	0.0095 U	0.0082 U	0.0036 U	0.011 U
2,2'-Oxybis(1-chloropropane)	NC	0.0022 U	0.0023 U	0.0024 U	0.0027 U	0.0023 U	0.0010 U	0.0030 U
2,3,4,6-Tetrachlorophenol	NC	0.0065 U	0.0069 U	0.0072 U	0.0081 U	0.0070 U	0.0030 U	0.0091 U
2,4,5-Trichlorophenol	NC	0.011 U	0.011 U	0.012 U	0.013 U	0.012 U	0.0051 U	0.015 U
2,4,6-Trichlorophenol	0.208*	0.015 U	0.016 U	0.017 U	0.019 U	0.016 U	0.0071 U	0.021 U
2,4-Dichlorophenol	0.0817*	0.0020 U	0.0022 U	0.0022 U	0.0025 U	0.0022 U	0.00095 U	0.0028 U
2,4-Dimethylphenol	0.304*	0.016 U	0.017 U	0.018 U	0.020 U	0.017 U	0.0074 U	0.022 U
2,4-Dinitrophenol	0.00621*	**0.12 U**	**0.13 U**	**0.13 U**	**0.15 U**	**0.13 U**	**0.056 U**	**0.17 U**
2,4-Dinitrotoluene	0.0144*	0.0082 U	0.0087 U	0.0090 U	0.010 U	0.0088 U	0.0038 U	0.011 U
2,6-Dinitrotoluene	NC	0.010 U	0.011 U	0.012 U	0.013 U	0.011 U	0.0049 U	0.015 U
2-Chloronaphthalene	0.417*	0.0021 U	0.0022 U	0.0023 U	0.0026 U	0.0023 U	0.00099 U	0.0029 U
2-Chlorophenol	0.0319*	0.0083 U	0.0088 U	0.0092 U	0.010 U	0.0089 U	0.0039 U	0.012 U
2-Methylnaphthalene	0.070	0.0018 U	0.0019 U	0.0020 U	0.0023 U	0.0020 U	0.00085 U	0.0025 U
2-Methylphenol (o-Cresol)	NC	0.0071 U	0.0075 U	0.0078 U	0.0088 U	0.0076 U	0.0033 U	0.0099 U
2-Nitroaniline	NC	0.045 U	0.048 U	0.050 U	0.056 U	0.049 U	0.021 U	0.063 U
2-Nitrophenol	NC	0.011 U	0.012 U	0.012 U	0.014 U	0.012 U	0.0052 U	0.016 U
3,3'-Dichlorobenzidine	0.127*	0.011 U	0.011 U	0.012 U	0.013 U	0.011 U	0.0050 U	0.015 U
3-Nitroaniline	NC	0.042 U	0.044 U	0.046 U	0.052 U	0.045 U	0.019 U	0.058 U
4,6-Dinitro-2-methylphenol	NC	0.041 U	0.043 U	0.045 U	0.050 U	0.044 U	0.019 U	0.057 U
4-Bromophenyl phenyl ether	NC	0.0088 U	0.0094 U	0.0097 U	0.011 U	0.0095 U	0.0041 U	0.012 U
4-Chloro-3-methylphenol	NC	0.0093 U	0.0099 U	0.010 U	0.012 U	0.010 U	0.0044 U	0.013 U
4-Chloroaniline	NC	0.0081 U	0.0086 U	0.0090 U	0.010 U	0.0087 U	0.0038 U	0.011 U
4-Chlorophenyl phenyl ether	NC	0.011 U	0.012 U	0.012 U	0.014 U	0.012 U	0.0053 U	0.016 U
4-Nitroaniline	NC	0.041 U	0.044 U	0.045 U	0.051 U	0.044 U	0.019 U	0.057 U
4-Nitrophenol	0.0133*	**0.037 U**	**0.039 U**	**0.041 U**	**0.046 U**	**0.040 U**	0.017 U	**0.051 U**
Acenaphthene	0.016	0.0019 U	0.0021 U	0.0022 U	0.0024 U	0.0061 J	0.00091 U	0.0027 U
Acenaphthylene	0.044	0.0023 U	0.0025 U	0.0026 U	0.0029 U	0.0091 J	0.0011 U	0.0032 U
Acetophenone	NC	0.0083 U	0.0088 U	0.0092 U	0.010 U	0.0089 U	*0.0039 J*	*0.021 J*
Anthracene	0.085	0.0020 U	0.0072 J	0.0066 J	0.0070 J	0.056	0.00093 U	0.0043 J
Atrazine	NC	0.0099 U	0.010 U	0.011 U	0.012 U	0.011 U	0.0046 U	0.014 U
Benzaldehyde	NC	0.015 U x	0.016 U x	0.017 U x	0.019 U x	0.016 U	0.0071 U	*0.12 J*
Benzo(a)anthracene	0.261	0.0033 J	0.013 J	0.020 J	0.024 J	0.12	0.0031 J	0.016 J
Benzo(a)pyrene	0.43	0.0036 J	0.015 J	0.023	0.029	0.11	0.0042 J	0.017 J
Benzo(b)fluoranthene	10.4*	0.0047 J	0.019 J	0.031	0.035	0.12	0.0067 J	0.025 J
Benzo(g,h,i)perylene	0.17*	0.0031 J	0.0096 J	0.014 J	0.018 J	0.079	0.0043 J	0.022 J
Benzo(k)fluoranthene	0.24*	0.0041 U	0.0073 J	0.013 J	0.016 J	0.047	0.0025 J	0.0078 J
bis(2-Chloroethoxy)methane	NC	0.0067 U	0.0071 U	0.0074 U	0.0083 U	0.0072 U	0.0031 U	0.0093 U
bis(2-Chloroethyl)ether	3.52*	0.0027 U	0.0029 U	0.0030 U	0.0034 U	0.0029 U	0.0013 U	0.0038 U
bis(2-Ethylhexyl)phthalate	0.18216	0.016 U	0.017 U	0.018 U	0.020 U	0.036 J	0.012 J	0.041 J
Butyl benzyl phthalate	1.97*	0.014 U	0.015 U	0.015 U	0.017 U	0.015 U	0.0065 U	0.019 U
Caprolactam	NC	0.077 U	0.081 U	0.085 U	0.095 U	0.082 U	0.036 U	0.11 U
Carbazole	NC	0.0019 U	*0.0031 J*	*0.0042 J*	*0.0028 J*	0.0020 U	0.00087 U	0.0026 U
Chrysene	0.384	0.0039 J	0.021 J	0.029	0.032	0.11	0.0048 J	0.020 J
Dibenzo(a,h)anthracene	0.063	0.0023 U	0.0027 J	0.0040 J	0.0045 J	0.022	0.0011 U	0.0031 U
Dibenzofuran	NC	0.010 U	0.011 U	0.011 U	0.012 U	0.011 U	0.0047 U	0.014 U
Diethyl phthalate	0.295*	0.012 J	0.012 U	0.031 J	0.030 J	0.012 U	0.014 J B	0.015 J B
Dimethyl phthalate	NC	0.011 U	0.012 U	0.012 U	0.014 U	0.012 U	0.0052 U	0.015 U
Di-n-butylphthalate	1.114*	0.013 U	0.013 U	0.014 U	0.016 U	0.014 U	0.0059 U	0.018 U
Di-n-octylphthalate	NC	0.011 U	0.011 U	0.012 U	0.013 U	0.011 U	0.0050 U	0.015 U
Fluoranthene	0.60	0.0065 J	0.053	0.068	0.065	0.29	0.0077 J	0.031
Fluorene	0.019	0.0027 U	0.0038 J	0.0036 J	0.0033 U	0.011 J	0.0012 U	0.0037 U
Hexachlorobenzene	0.020*	0.0022 U	0.0023 U	0.0024 U	0.0027 U	0.0023 U	0.0010 U	0.0030 U
Hexachlorobutadiene	0.0265*	0.0023 U	0.0024 U	0.0025 U	0.0028 U	0.0024 U	0.0011 U	0.0032 U
Hexachlorocyclopentadiene	0.901*	0.011 U	0.012 U	0.012 U	0.014 U	0.012 U	0.0051 U	0.015 U
Hexachloroethane	0.584*	0.0073 U	0.0077 U	0.0081 U	0.0090 U	0.0078 U	0.0034 U	0.010 U
Indeno(1,2,3-cd)pyrene	0.20*	0.0027 J	0.0083 J	0.014 J	0.017 J	0.061	0.0033 J	0.016 J
Isophorone	0.432*	0.0076 U	0.0081 U	0.0084 U	0.0095 U	0.0082 U	0.0036 U	0.011 U
Methylphenol, 3 & 4	NC	0.0099 U	0.011 U	0.011 U	0.012 U	0.011 U	0.0046 U	0.014 U
Naphthalene	0.16	0.0017 U	0.0019 U	0.0019 U	0.0022 U	0.0019 U	0.00082 U	0.0024 U
Nitrobenzene	0.145*	0.0084 U	0.0090 U	0.0093 U	0.010 U	0.0091 U	0.0039 U	0.012 U
N-Nitroso-di-n-propylamine	NC	0.0024 U	0.0025 U	0.0026 U	0.0029 U	0.0025 U	0.0011 U	0.0033 U
N-Nitrosodiphenylamine	NC	0.0094 U	0.010 U	0.010 U	0.012 U	0.010 U	0.0044 U	0.013 U
Pentachlorophenol	23*	0.0091 U	0.0096 U	0.010 U	0.011 U	0.0097 U	0.0042 U	0.013 U
Phenanthrene	0.24	0.0032 U	0.035	0.033	0.018 J	0.13	0.0031 J	0.012 J
Phenol	0.0491*	0.0024 U	0.0025 U	0.0026 U	0.0030 U	0.0026 U	0.0011 U	0.038
Pyrene	0.665	0.0041 J	0.030	0.035	0.036	0.22	0.0068 J	0.027 J

Notes:
a - New Jersey Department of Environmental Protection (NJDEP). Ecological Screening Criteria (2009). Saline water Effects Range Low (ERL) criteria used.
b - Total PCBs were not analyzed. Result is the total of all detected concentrations or the highest non-detect Method Detection Limit (MDL).
* - Ecological Screening Criteria based on a chronic freshwater sediment value as a saline criterion was not available.
J - Result is less than the Reporting Limit (RL) but greater than or equal to the MDL and the concentration is an approximate value.
B - Compound was found in the blank and sample.
p - The %RPD between the primary and confirmation column/detector is >40%. The lower value has been reported.
U - Indicates the analyte was analyzed for but not detected.
x - Recovery or RPD exceeds control limits.
H - Sample was prepped or analyzed beyond the specified holding time.
mg/kg - Milligrams per kilogram.
ug/kg - Micrograms per kilogram.
NC - No criterion.

Italics = Compounds detected with no associated Ecological Screening Criteria with which to compare.
Underlined and Italics = Site compound detected above reference concentrations with no associated Ecological Screening Criteria with which to compare.
Bold = 1/2 the detection limit exceeds the Ecological Screening Criteria for a non-detected result.
Highlighted = Compounds detected equal to or above the Ecological Screening Criteria.
Highlighted and Underlined = Site compounds detected equal to or above the Ecological Screening Criteria and above reference concentrations.

Table 5-3
Sediment Analyte Concentrations
Red Bank Landfill Site
Red Bank, New Jersey

		REFERENCE LOCATIONS						SITE
Sample ID	**NJDEP's Ecological Screening Criteria[a]**	**UPREF-SED1**	**UPREF-SED2**	**UPREF-SED3**	**UPREF-SED3DUP**	**DNREF-SED1**	**DNREF-SED2**	**SED-1A**
Lab Sample ID		**460-67151-11**	**460-67151-12**	**460-67151-13**	**460-67151-14**	**460-67000-16**	**460-67000-24**	**460-67074-30**
Sample Date		**11/21/2013**	**11/21/2013**	**11/21/2013**	**11/21/2013**	**11/19/2013**	**11/19/2013**	**11/20/2013**
Pesticides (ug/kg)								
4,4'-DDD	2.0	0.033 U	0.035 U	0.037 U	0.041 U	0.34	0.22 J	1.1
4,4'-DDE	2.2	0.17 J	0.16 J	0.21 J	0.25 J	0.38	0.21 J	0.32 J p
4,4'-DDT	1.0	0.12 J p B	0.10 J p B	0.15 J p B	0.18 J p B	0.041 U	0.044 U	0.52 J p
Aldrin	2.0*	0.045 U	0.048 U	0.050 U	0.056 U	0.048 U	0.053 U	0.11 U
alpha-BHC	6.0*	0.041 U	0.044 U	0.046 U	0.051 U	0.044 U	0.048 U	0.096 U
alpha-Chlordane	NC	*0.55*	*0.19 J*	*0.19 J*	*0.25 J p*	*0.35*	*0.15 J*	*0.21 J*
beta-BHC	5.0*	0.065 U	0.070 U	0.073 U	0.081 U	0.070 U	0.076 U	0.15 U
delta-BHC	NC	0.039 U	0.041 U	0.043 U	0.048 U	0.042 U	0.045 U	0.090 U
Dieldrin	1.9*	0.11 J	0.073 J p	0.074 J p	0.10 J p	0.13 J	0.077 J	0.15 J p
Endosulfan I	NC	0.048 U	0.051 U	0.053 U	0.059 U	0.051 U	0.056 U	0.11 U
Endosulfan II	NC	0.045 U	0.048 U	0.049 U	0.055 U	0.048 U	0.052 U	0.10 U
Endosulfan sulfate	34.6*	0.026 U	0.028 U	0.029 U	0.033 U	0.037 J	0.031 U	0.061 U
Endrin	2.22*	0.049 U	0.057 J p	0.054 U	0.087 J p	0.18 J	0.093 J	0.13 J p
Endrin aldehyde	480*	0.049 U	0.052 U	0.054 U	0.061 U	0.070 J p	0.057 U	0.15 J p
Endrin ketone	NC	0.039 U	0.042 U	0.044 U	0.049 U	0.042 U	0.046 U	*0.10 J p*
gamma-BHC (Lindane)	3.0*	0.044 U	0.096 J p	0.076 J	0.055 U	0.047 U	0.052 U	0.10 U
gamma-Chlordane	NC	*0.61*	*0.21 J*	*0.18 J*	*0.41*	*0.46*	*0.17 J*	*0.29 J*
Heptachlor	0.60*	0.089 J p	0.060 U	0.062 U	0.069 U	0.060 U	0.065 U	0.13 U
Heptachlor epoxide	2.47*	0.049 U	0.052 U	0.054 U	0.061 U	0.066 J p	0.057 U	0.11 U
Methoxychlor	13.6*	0.053 U	0.056 U	0.18 J p	0.18 J p	0.15 J p	0.20 J p	0.12 U
Toxaphene	0.077*	**1.7 U**	**1.8 U**	**1.9 U**	**2.1 U**	**1.8 U**	**2.0 U**	**3.9 U**
Polychlorinated Biphenyls (PCBs) (mg/kg)								
PCB-1016	0.0070*	0.00037 U	0.00040 U	0.00042 U	0.00046 U	0.00040 U	0.00044 U	0.00087 U
PCB-1221	NC	0.00048 U	0.00051 U	0.00053 U	0.00060 U	0.00052 U	0.00056 U	0.0011 U
PCB-1232	NC	0.00043 U	0.00046 U	0.00048 U	0.00053 U	0.00046 U	0.00051 U	0.0010 U
PCB-1242	NC	0.00041 U	0.00044 U	0.00046 U	0.00051 U	0.00044 U	0.00048 U	0.00096 U
PCB-1248	0.030*	0.00024 U	0.00025 U	0.00026 U	0.00030 U	0.00026 U	0.00028 U	0.00056 U
PCB-1254	0.060*	0.00036 U	0.00038 U	0.00040 U	0.00044 U	0.0056	0.0023 J	0.0087
PCB-1260	0.0050*	0.00036 U	0.00038 U	0.00040 U	0.0039	0.00039 U	0.00042 U	0.00084 U
Total PCBs[b]	0.023	0.00048 U	0.00051 U	0.00053 U	0.0039	0.0056	0.0023 J	0.0087
Metals (mg/kg)								
Aluminum	25,500*	1,470 B	1,950 B	2,920 B	3,060 B	2,590	2,010	10,700 B
Antimony	NC	*0.18 J*	*0.18 J*	0.22 U	0.24 U	*0.32 J*	0.11 U	0.23 U
Arsenic	8.2	10.2	12.3	22	24.9	13.8	10.4	25.2
Barium	NC	*10.3 J B*	*5.2 J B*	*12 J B*	*12.3 J B*	*5.5 J B*	*4.5 J B*	*43.9 B*
Beryllium	NC	*0.41*	*0.37*	*0.47*	*0.50*	*0.48 B*	*0.36 B*	*1.0*
Cadmium	1.2	0.048 J	0.033 J	0.11 J	0.10 J	0.18 J	0.13 J	0.19 J
Calcium	NC	*321 B*	*407 B*	*681 B*	*755 B*	*611 B*	*466 B*	*3,320 B*
Chromium	81	22.8	16	19.9	20.6	22.3	15.8	50.4
Cobalt	50*	2.7 J B	3.0 J B	2.3 J B	2.4 J B	2.1 J	1.8 J	7.3 B
Copper	34	1.5	3.2	5.6	6.0	7.0	4.9	35.1
Iron	NC	*24,300 B*	*23,800 B*	*38,300 B*	*39,200 B*	*26,300*	*18,900*	*62,700 B*
Lead	47	5.5 B	7.4 B	12.4 B	13.2 B	21.1	11	57.1 B
Magnesium	NC	*499 B*	*591 B*	*833 B*	*954 B*	*960 B*	*889 B*	*5,410 B*
Manganese	630*	157 B	176 B	50.3 B	51.1 B	47.7	42.5	276 B
Mercury	0.15	0.0065 U	0.0075 U	0.015 J	0.016 J	0.025	0.018 J	0.090
Nickel	21	5.7	5.8	6.2	6.3	6.3	4.7	20.3
Potassium	NC	*518*	*558*	*939*	*1,100*	*899*	*772*	*3,270*
Selenium	NC	*0.72 B*	*0.6 J B*	*0.81 J B*	*0.82 J B*	*0.31 J*	*0.24 J*	*2.2 B*
Silver	1.0	0.035 U	0.037 U	0.039 U	0.043 U	0.038 U	0.040 U	0.082 U
Sodium	NC	*1,120*	*1,240*	*1,200*	*1,750*	*2,200*	*2,990*	*8,970*
Thallium	NC	*0.8 J*	*0.83 J*	*1.7 J*	*1.2 J*	*0.86 J*	*0.61 J*	*1.6 J*
Vanadium	NC	*21.9*	*21.9*	*26.8*	*27.5*	*24.4*	*19.3*	*52.3*
Zinc	150	41.5 B	53 B	61.7 B	63 B	70.8 B	47.9 B	126 B

Notes:
a - New Jersey Department of Environmental Protection (NJDEP). Ecological Screening Criteria (2009). Saline water Effects Range Low (ERL) criteria used.
b - Total PCBs were not analyzed. Result is the total of all detected concentrations or the highest non-detect Method Detection Limit (MDL).
* - Ecological Screening Criteria based on a chronic freshwater sediment value as a saline criterion was not available.
J - Result is less than the Reporting Limit (RL) but greater than or equal to the MDL and the concentration is an approximate value.
B - Compound was found in the blank and sample.
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mg/kg - Milligrams per kilogram.
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NC - No criterion.

Italics = Compounds detected with no associated Ecological Screening Criteria with which to compare.
Underlined and Italics = Site compound detected above reference concentrations with no associated Ecological Screening Criteria with which to compare.
Bold = 1/2 the detection limit exceeds the Ecological Screening Criteria for a non-detected result.
Highlighted = Compounds detected equal to or above the Ecological Screening Criteria.
Highlighted and Underlined = Site compounds detected equal to or above the Ecological Screening Criteria and above reference concentrations.

Table 5-3
Sediment Analyte Concentrations
Red Bank Landfill Site
Red Bank, New Jersey

		REFERENCE LOCATIONS						SITE
Sample ID	**NJDEP's Ecological Screening Criteria[a]**	**UPREF-SED1**	**UPREF-SED2**	**UPREF-SED3**	**UPREF-SED3DUP**	**DNREF-SED1**	**DNREF-SED2**	**SED-1A**
Lab Sample ID		**460-67151-11**	**460-67151-12**	**460-67151-13**	**460-67151-14**	**460-67000-16**	**460-67000-24**	**460-67074-30**
Sample Date		**11/21/2013**	**11/21/2013**	**11/21/2013**	**11/21/2013**	**11/19/2013**	**11/19/2013**	**11/20/2013**
Wet Chemistry (Units)								
pH	NC	7.56 H	7.36 H	7.12 H	7.11 H	6.92 H	7.0 H	7.08 H
Percent Moisture	NC	17.8	22.7	25.5	33.5	23.3	29.5	64.6
Total Organic Carbon (TOC) (mg/kg)								
TOC	NC	2,620	2,990	6,930	5,660	6,160	3,540	39,200
Geotechnical (%)								
Coarse Sand	NC	4.8	0.0	0.0	0.1	0.6	0.0	1.8
Fine Sand	NC	34.1	90.2	94.4	98.7	52.4	93.3	20.1
Fines	NC	3.3	2.0	4.7	0.1	4.3	1.8	63.1
Gravel	NC	1.0	0.0	0.0	0.0	0.4	0.0	4.0
Medium Sand	NC	56.8	7.8	0.9	1.1	42.3	4.9	11.0
Sand	NC	95.7	98.0	95.3	99.9	95.3	98.2	32.9
Sieve Size #10	NC	4.8	0.0	0.0	0.1	0.6	0.0	1.8
Sieve Size #100	NC	0.2	0.7	6.7	5.4	0.4	0.9	1.1
Sieve Size #20	NC	14.7	0.6	0.1	0.2	3.5	0.1	3.2
Sieve Size #200	NC	0.2	0.4	2.3	2.4	0.5	0.5	3.0
Sieve Size #4	NC	1.0	0.0	0.0	0.0	0.4	0.0	4.0
Sieve Size #40	NC	42.1	7.2	0.8	0.9	38.8	4.8	7.8
Sieve Size #60	NC	31.3	75.4	44.4	45.8	47.8	79.7	11.9
Sieve Size #80	NC	2.4	13.7	41.0	45.1	3.7	12.1	4.1
Sieve Size 0.375 inch	NC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sieve Size 0.75 inch	NC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sieve Size 1 inch	NC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sieve Size 1.5 inch	NC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sieve Size 2 inch	NC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sieve Size 3 inch	NC	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Notes:
a - New Jersey Department of Environmental Protection (NJDEP). Ecological Screening Criteria (2009). Saline water Effects Range Low (ERL) criteria used.
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mg/kg - Milligrams per kilogram.
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Italics = Compounds detected with no associated Ecological Screening Criteria with which to compare.
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Table 5-3
Sediment Analyte Concentrations
Red Bank Landfill Site
Red Bank, New Jersey

		SITE						
Sample ID	**NJDEP's Ecological Screening Criteria[a]**	**SED-1B**	**SED-1C**	**SED-1D**	**SED-1DDUP**	**SED-2A**	**SED-2B**	**SED-2C**
Lab Sample ID		**460-67074-29**	**460-67074-28**	**460-67074-27**	**460-67074-31**	**460-67074-26**	**460-67074-25**	**460-67074-24**
Sample Date		**11/20/2013**	**11/20/2013**	**11/20/2013**	**11/20/2013**	**11/20/2013**	**11/20/2013**	**11/20/2013**
Semi-Volatile Organic Compounds (SVOCs) (mg/kg)								
1,1'-Biphenyl	NC	0.0062 U	0.0037 U	0.024 U	0.013 U	0.0055 U	0.0056 U	0.0055 U
1,2,4,5-Tetrachlorobenzene	1.252*	0.0053 U	0.0031 U	0.021 U	0.011 U	0.0047 U	0.0047 U	0.0047 U
2,2'-Oxybis(1-chloropropane)	NC	0.0015 U	0.00088 U	0.0059 U	0.0030 U	0.0013 U	0.0014 U	0.0013 U
2,3,4,6-Tetrachlorophenol	NC	0.0045 U	0.0026 U	0.017 U	0.0090 U	0.0040 U	0.0040 U	0.0039 U
2,4,5-Trichlorophenol	NC	0.0074 U	0.0044 U	0.029 U	0.015 U	0.0066 U	0.0067 U	0.0066 U
2,4,6-Trichlorophenol	0.208*	0.010 U	0.0061 U	0.041 U	0.021 U	0.0093 U	0.0094 U	0.0092 U
2,4-Dichlorophenol	0.0817*	0.0014 U	0.00082 U	0.0054 U	0.0028 U	0.0012 U	0.0013 U	0.0012 U
2,4-Dimethylphenol	0.304*	0.011 U	0.0064 U	0.042 U	0.022 U	0.010 U	0.010 U	0.010 U
2,4-Dinitrophenol	0.00621*	**0.083 U**	**0.049 U**	**0.32 U**	**0.17 U**	**0.074 U**	**0.074 U**	**0.073 U**
2,4-Dinitrotoluene	0.0144*	0.0056 U	0.0033 U	0.022 U	0.011 U	0.0050 U	0.0050 U	0.0050 U
2,6-Dinitrotoluene	NC	0.0072 U	0.0042 U	0.028 U	0.014 U	0.0064 U	0.0065 U	0.0063 U
2-Chloronaphthalene	0.417*	0.0015 U	0.00085 U	0.0057 U	0.0029 U	0.0013 U	0.0013 U	0.0013 U
2-Chlorophenol	0.0319*	0.0057 U	0.0033 U	0.022 U	0.011 U	0.0051 U	0.0051 U	0.0050 U
2-Methylnaphthalene	0.070	0.0013 U	0.00074 U	0.0049 U	0.011 J	0.0011 U	0.0011 U	0.0011 U
2-Methylphenol (o-Cresol)	NC	0.0049 U	0.0029 U	0.019 U	0.0098 U	0.0043 U	0.0044 U	0.0043 U
2-Nitroaniline	NC	0.031 U	0.018 U	0.12 U	0.063 U	0.028 U	0.028 U	0.027 U
2-Nitrophenol	NC	0.0077 U	0.0045 U	0.030 U	0.015 U	0.0068 U	0.0069 U	0.0068 U
3,3'-Dichlorobenzidine	0.127*	0.0074 U	0.0043 U	0.029 U	0.015 U	0.0065 U	0.0066 U	0.0065 U
3-Nitroaniline	NC	0.029 U	0.017 U	0.11 U	0.058 U	0.025 U	0.026 U	0.025 U
4,6-Dinitro-2-methylphenol	NC	0.028 U	0.016 U	0.11 U	0.056 U	0.025 U	0.025 U	0.025 U
4-Bromophenyl phenyl ether	NC	0.0061 U	0.0036 U	0.024 U	0.012 U	0.0054 U	0.0054 U	0.0053 U
4-Chloro-3-methylphenol	NC	0.0064 U	0.0038 U	0.025 U	0.013 U	0.0057 U	0.0058 U	0.0057 U
4-Chloroaniline	NC	0.0056 U	0.0033 U	0.022 U	0.011 U	0.0050 U	0.0050 U	0.0049 U
4-Chlorophenyl phenyl ether	NC	0.0077 U	0.0046 U	0.030 U	0.016 U	0.0069 U	0.0070 U	0.0068 U
4-Nitroaniline	NC	0.028 U	0.017 U	0.11 U	0.057 U	0.025 U	0.025 U	0.025 U
4-Nitrophenol	0.0133*	0.025 U	0.015 U	**0.099 U**	**0.051 U**	0.023 U	0.023 U	0.022 U
Acenaphthene	0.016	0.0013 U	0.0010 J	0.0096 J	0.0048 J	0.0033 J	0.0012 U	0.0012 U
Acenaphthylene	0.044	0.0016 U	0.0024 J	0.021 J	0.0078 J	0.0024 J	0.0015 J	0.0014 U
Acetophenone	NC	*0.0070* J	*0.0054* J	0.022 U	0.012 U	0.0051 U	0.0051 U	0.0050 U
Anthracene	0.085	0.0030 J	0.0033 J	0.048 J	0.015 J	0.013	0.0025 J	0.0026 J
Atrazine	NC	0.0068 U	0.0040 U	0.026 U	0.014 U	0.0060 U	0.0061 U	0.0060 U
Benzaldehyde	NC	*0.052* J	0.0061 U	0.041 U	*0.11* J	0.0093 U	0.0094 U	0.0092 U
Benzo(a)anthracene	0.261	0.010 J	0.016	0.16	0.069	0.056	0.012 J	0.017
Benzo(a)pyrene	0.43	0.011 J	0.018	0.17	0.084	0.048	0.012 J	0.018
Benzo(b)fluoranthene	10.4*	0.012 J	0.024	0.24	0.11	0.067	0.020	0.024
Benzo(g,h,i)perylene	0.17*	0.012 J	0.018	0.18	0.086	0.046	0.015	0.018
Benzo(k)fluoranthene	0.24*	0.0079 J	0.0096	0.093	0.064	0.024	0.0065 J	0.0096 J
bis(2-Chloroethoxy)methane	NC	0.0046 U	0.0027 U	0.018 U	0.0092 U	0.0041 U	0.0041 U	0.0040 U
bis(2-Chloroethyl)ether	3.52*	0.0019 U	0.0011 U	0.0073 U	0.0038 U	0.0017 U	0.0017 U	0.0016 U
bis(2-Ethylhexyl)phthalate	0.18216	0.015 J	0.0066 U	0.044 U	0.026 J	0.010 U	0.013 J	0.015 J
Butyl benzyl phthalate	1.97*	0.0095 U	0.0056 U	0.037 U	0.019 U	0.0085 U	0.0085 U	0.0084 U
Caprolactam	NC	0.053 U	0.031 U	0.21 U	0.11 U	0.047 U	0.047 U	0.046 U
Carbazole	NC	0.0013 U	0.00075 U	*0.017* J	*0.0080* J	*0.0095* J	0.0012 U	0.0011 U
Chrysene	0.384	0.013 J	0.021	0.20	0.10	0.064	0.016	0.021
Dibenzo(a,h)anthracene	0.063	0.0015 U	0.0051 J	0.050 J	0.018 J	0.012	0.0038 J	0.0014 U
Dibenzofuran	NC	0.0069 U	0.0040 U	0.027 U	0.014 U	0.0061 U	0.0062 U	0.0060 U
Diethyl phthalate	0.295*	0.0090 J B	0.010 J B	0.049 J B	0.016 J B	0.0068 U	0.0073 J B	0.0067 U
Dimethyl phthalate	NC	0.0076 U	0.0045 U	0.030 U	0.015 U	0.0067 U	0.0068 U	0.0067 U
Di-n-butylphthalate	1.114*	0.0087 U	0.0051 U	0.034 U	0.018 U	0.0079 J	0.0078 U	0.0077 U
Di-n-octylphthalate	NC	0.0073 U	0.0043 U	0.029 U	0.015 U	0.0065 U	0.0066 U	0.0065 U
Fluoranthene	0.60	0.021	0.037	0.37	0.16	0.14	0.025	0.030
Fluorene	0.019	0.0018 U	0.0011 U	0.0072 U	0.0037 U	0.0036 J	0.0016 U	0.0016 U
Hexachlorobenzene	0.020*	0.0015 U	0.00087 U	0.0058 U	0.0030 U	0.0013 U	0.0013 U	0.0013 U
Hexachlorobutadiene	0.0265*	0.0016 U	0.00092 U	0.0061 U	0.0031 U	0.0014 U	0.0014 U	0.0014 U
Hexachlorocyclopentadiene	0.901*	0.0075 U	0.0044 U	0.029 U	0.015 U	0.0067 U	0.0067 U	0.0066 U
Hexachloroethane	0.584*	0.0050 U	0.0029 U	0.020 U	0.010 U	0.0044 U	0.0045 U	0.0044 U
Indeno(1,2,3-cd)pyrene	0.20*	0.010 J	0.014	0.15	0.067	0.038	0.011 J	0.014
Isophorone	0.432*	0.0052 U	0.0031 U	0.020 U	0.011 U	0.0047 U	0.0047 U	0.0046 U
Methylphenol, 3 & 4	NC	0.0068 U	0.0040 U	0.027 U	0.014 U	0.0061 U	0.0061 U	0.0060 U
Naphthalene	0.16	0.0012 U	0.00071 U	0.0047 U	0.0024 U	0.0011 U	0.0011 U	0.0011 U
Nitrobenzene	0.145*	0.0058 U	0.0034 U	0.023 U	0.012 U	0.0051 U	0.0052 U	0.0051 U
N-Nitroso-di-n-propylamine	NC	0.0016 U	0.00096 U	0.0064 U	0.0033 U	0.0015 U	0.0015 U	0.0014 U
N-Nitrosodiphenylamine	NC	0.0064 U	0.0038 U	0.025 U	0.013 U	0.0057 U	0.0058 U	0.0057 U
Pentachlorophenol	23*	0.0062 U	0.0037 U	0.024 U	0.013 U	0.0055 U	0.0056 U	0.0055 U
Phenanthrene	0.24	0.0085 J	0.016	0.15	0.056	0.073	0.011 J	0.0091 J
Phenol	0.0491*	0.010 J	0.0010 U	0.0064 U	0.0033 U	0.0015 U	0.0015 U	0.0015 U
Pyrene	0.665	0.017	0.031	0.29	0.14	0.11	0.020	0.027

Notes:
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Table 5-3
Sediment Analyte Concentrations
Red Bank Landfill Site
Red Bank, New Jersey

		SITE						
Sample ID	**NJDEP's Ecological Screening Criteria[a]**	**SED-1B**	**SED-1C**	**SED-1D**	**SED-1DDUP**	**SED-2A**	**SED-2B**	**SED-2C**
Lab Sample ID		**460-67074-29**	**460-67074-28**	**460-67074-27**	**460-67074-31**	**460-67074-26**	**460-67074-25**	**460-67074-24**
Sample Date		**11/20/2013**	**11/20/2013**	**11/20/2013**	**11/20/2013**	**11/20/2013**	**11/20/2013**	**11/20/2013**
Pesticides (ug/kg)								
4,4'-DDD	2.0	0.29	0.12 J	1.8	1.2 B	0.23 J	0.17 J	0.15 J
4,4'-DDE	2.2	0.18 J	0.096 J	1.5	1.2	0.14 J	0.088 J	0.10 J
4,4'-DDT	1.0	0.043 U	0.039 U	1.6	0.053 U	0.039 U	0.039 U	0.038 U
Aldrin	2.0*	0.052 U	0.046 U	0.11 J p	0.089 J	0.046 U	0.047 U	0.046 U
alpha-BHC	6.0*	0.047 U	0.042 U	0.055 U	0.057 U	0.042 U	0.042 U	0.042 U
alpha-Chlordane	NC	*0.41*	*0.051 J p*	*0.60 p*	*0.58 p*	*0.28 p*	*0.095 J p*	*0.080 J*
beta-BHC	5.0*	0.075 U	0.067 U	0.088 U	0.091 U	0.067 U	0.067 U	0.066 U
delta-BHC	NC	0.045 U	0.040 U	*0.057 J p*	0.054 U	0.039 U	0.040 U	0.039 U
Dieldrin	1.9*	0.15 J	0.074 J	0.31 J p	0.35 p	0.12 J p	0.065 J	0.063 J p
Endosulfan I	NC	0.055 U	0.048 U	0.064 U	0.066 U	0.048 U	0.049 U	0.048 U
Endosulfan II	NC	0.051 U	0.045 U	*0.081 J p*	0.062 U	0.045 U	0.046 U	0.045 U
Endosulfan sulfate	34.6*	0.030 U	0.027 U	0.035 U	0.082 J	0.027 U	0.027 U	0.027 U
Endrin	2.22*	0.056 U	0.050 U	0.46 p	0.38	0.050 U	0.051 U	0.051 J p
Endrin aldehyde	480*	0.056 U	0.050 U	0.15 J p	0.068 U	0.050 U	0.051 U	0.050 U
Endrin ketone	NC	0.045 U	0.040 U	0.053 U	0.055 U	0.040 U	0.041 U	0.040 U
gamma-BHC (Lindane)	3.0*	0.051 U	0.045 U	0.059 U	0.080 J	0.045 J p	0.046 U	0.17 J
gamma-Chlordane	NC	*0.47*	*0.089 J p*	*1.1*	*1.1*	*0.44*	*0.16 J*	*0.089 J p*
Heptachlor	0.60*	0.064 U	0.057 U	0.075 U	0.078 U	0.057 U	0.058 U	0.057 U
Heptachlor epoxide	2.47*	0.056 U	0.050 U	0.16 J p	0.12 J p	0.050 U	0.051 U	0.050 U
Methoxychlor	13.6*	0.061 U	0.054 U	0.23 J p	0.22 J p	0.30 J p	0.054 U	0.053 U
Toxaphene	0.077*	**1.9 U**	**1.7 U**	**2.3 U**	**2.3 U**	**1.7 U**	**1.7 U**	**1.7 U**
Polychlorinated Biphenyls (PCBs) (mg/kg)								
PCB-1016	0.0070*	0.0053	0.00038 U	0.00050 U	0.00052 U	0.00038 U	0.00039 U	0.00038 U
PCB-1221	NC	0.00055 U	0.00049 U	0.00065 U	0.00067 U	0.00049 U	0.00050 U	0.00049 U
PCB-1232	NC	0.00050 U	0.00044 U	0.00058 U	0.00060 U	0.00044 U	0.00045 U	0.00044 U
PCB-1242	NC	0.00047 U	0.00042 U	0.00055 U	0.00057 U	0.00042 U	0.00042 U	0.00042 U
PCB-1248	0.030*	0.00027 U	0.00024 U	0.00032 U	0.00033 U	0.00024 U	0.00025 U	0.00024 U
PCB-1254	0.060*	0.044	0.0021 J	0.012	0.00050 U	0.0016 J	0.0011 J	0.00036 U
PCB-1260	0.0050*	0.00041 U	0.00037 U	0.00048 U	0.011	0.00037 U	0.00037 U	0.00036 U
Total PCBs[b]	0.023	0.049	0.0021 J	0.012	0.011	0.0016 J	0.0011 J	0.00049 U
Metals (mg/kg)								
Aluminum	25,500*	2,670 B	1,840 B	5,970 B	6,990 B	1,840 B	1,970 B	1,780
Antimony	NC	0.11 U	*0.13 J*	*0.42 J*	*0.92 J*	*0.16 J*	*0.20 J*	*0.19 J*
Arsenic	8.2	11.1	12.5	32.4	49.1	10.4	12.1	12.5
Barium	NC	*7.9 J B*	*5.9 J B*	*20.1 B*	*22.9 B*	*4.7 J B*	*4.7 J B*	*5.5 J B*
Beryllium	NC	*0.39*	*0.37*	*0.88*	*1.4*	*0.33*	*0.40*	*0.41 B*
Cadmium	1.2	0.028 J	0.028 J	0.22 J	0.20 J	0.019 J	0.028 J	0.15 J
Calcium	NC	*531 B*	*397 B*	*1,330 B*	*1,420 B*	*382 B*	*369 B*	*338 B*
Chromium	81	17.6	21.9	65	125	15.5	20.5	18.5
Cobalt	50*	2.5 J B	4.0 B	4.4 B	4.7 B	3.2 B	3.2 B	4.2
Copper	34	4.5	2.8	24.7	23.3	4.0	3.0	2.4
Iron	NC	*23,800 B*	*23,800 B*	*62,500 B*	*98,500 B*	*20,700 B*	*24,600 B*	*23,100*
Lead	47	9.0 B	8.6 B	35.6 B	40.5 B	11.8 B	10.4 B	10
Magnesium	NC	*1,080 B*	*594 B*	*2,110 B*	*2,140 B*	*628 B*	*673 B*	*595 B*
Manganese	630*	79.1 B	321 B	129 B	148 B	179 B	146 B	364
Mercury	0.15	0.012 J	0.0068 J	0.12	0.11	0.0088 J	0.0090 J	0.0059 U
Nickel	21	6.0	6.3	12.5	14	5.4	6.4	6.6
Potassium	NC	*891*	*605*	*1,800*	*1,760*	*600*	*634*	*554*
Selenium	NC	*0.71 B*	*0.74 B*	*1.5 J B*	*2.6 J B*	*0.55 J B*	*0.84 B*	0.13 U
Silver	1.0	0.040 U	0.035 U	0.11 J	0.097 J	0.035 U	0.036 U	0.035 U
Sodium	NC	*2,030*	*1,300*	*4,250*	*4,810*	*1,540*	*1,790*	*1,620*
Thallium	NC	*0.83 J*	*0.87 J*	*1.9 J*	*3.4 J*	*0.74 J*	*0.93 J*	*0.71 J*
Vanadium	NC	*20.5*	*23.2*	*56.9*	*84.4*	*20.6*	*24.4*	*22.8*
Zinc	150	47.9 B	55.3 B	124 B	152 B	53.4 B	60.3 B	57.2 B

Notes:
a - New Jersey Department of Environmental Protection (NJDEP). Ecological Screening Criteria (2009). Saline water Effects Range Low (ERL) criteria used.
b - Total PCBs were not analyzed. Result is the total of all detected concentrations or the highest non-detect Method Detection Limit (MDL).
* - Ecological Screening Criteria based on a chronic freshwater sediment value as a saline criterion was not available.
J - Result is less than the Reporting Limit (RL) but greater than or equal to the MDL and the concentration is an approximate value.
B - Compound was found in the blank and sample.
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U - Indicates the analyte was analyzed for but not detected.
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mg/kg - Milligrams per kilogram.
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NC - No criterion.

Italics = Compounds detected with no associated Ecological Screening Criteria with which to compare.
Underlined and Italics = Site compound detected above reference concentrations with no associated Ecological Screening Criteria with which to compare.
Bold = 1/2 the detection limit exceeds the Ecological Screening Criteria for a non-detected result.
Highlighted = Compounds detected equal to or above the Ecological Screening Criteria.
Highlighted and Underlined = Site compounds detected equal to or above the Ecological Screening Criteria and above reference concentrations.

Table 5-3
Sediment Analyte Concentrations
Red Bank Landfill Site
Red Bank, New Jersey

		SITE						
Sample ID	**NJDEP's Ecological Screening Criteria[a]**	**SED-1B**	**SED-1C**	**SED-1D**	**SED-1DDUP**	**SED-2A**	**SED-2B**	**SED-2C**
Lab Sample ID		**460-67074-29**	**460-67074-28**	**460-67074-27**	**460-67074-31**	**460-67074-26**	**460-67074-25**	**460-67074-24**
Sample Date		**11/20/2013**	**11/20/2013**	**11/20/2013**	**11/20/2013**	**11/20/2013**	**11/20/2013**	**11/20/2013**
Wet Chemistry (Units)								
pH	NC	7.02 H	6.98 H	6.74 H	6.94 H	7.04 H	7.07 H	7.05 H
Percent Moisture	NC	28.2	19.1	38.6	40.8	19.1	20.3	18.5
Total Organic Carbon (TOC) (mg/kg)								
TOC	NC	7,250	2,570	23,800	19,700	2,810	3,250	3,080
Geotechnical (%)								
Coarse Sand	NC	0.5	0.4	5.8	4.0	0.2	1.5	0.7
Fine Sand	NC	85.7	65.8	48.1	54	83.2	72.3	63.1
Fines	NC	1.4	0.003	9.7	0.6	1.9	1.4	0.7
Gravel	NC	0.0	0.0	0.6	1.6	0.0	0.2	0.0
Medium Sand	NC	12.4	33.8	35.8	39.8	14.7	24.6	35.5
Sand	NC	98.6	100	89.7	97.8	98.1	98.4	99.3
Sieve Size #10	NC	0.5	0.4	5.8	4.0	0.2	1.5	0.7
Sieve Size #100	NC	0.8	0.6	2.8	3.2	0.4	0.5	0.6
Sieve Size #20	NC	2.1	7.0	11.6	10.9	2.3	5.0	6.7
Sieve Size #200	NC	0.6	0.3	4.2	4.9	0.1	0.2	0.3
Sieve Size #4	NC	0.0	0.0	0.6	1.6	0.0	0.2	0.0
Sieve Size #40	NC	10.3	26.8	24.2	28.9	12.4	19.6	28.8
Sieve Size #60	NC	71.2	58.4	33.7	38.5	70.8	60.3	55.4
Sieve Size #80	NC	13.1	6.5	7.4	7.4	11.9	11.3	6.8
Sieve Size 0.375 inch	NC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sieve Size 0.75 inch	NC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sieve Size 1 inch	NC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sieve Size 1.5 inch	NC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sieve Size 2 inch	NC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sieve Size 3 inch	NC	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Notes:
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U - Indicates the analyte was analyzed for but not detected.
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mg/kg - Milligrams per kilogram.
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Highlighted = Compounds detected equal to or above the Ecological Screening Criteria.
Highlighted and Underlined = Site compounds detected equal to or above the Ecological Screening Criteria and above reference concentrations.

Table 5-3
Sediment Analyte Concentrations
Red Bank Landfill Site
Red Bank, New Jersey

		SITE						
Sample ID	**NJDEP's Ecological Screening Criteria[a]**	**SED-2CDUP**	**SED-3A**	**SED-3B**	**SED-3C**	**SED-3D**	**SED-4A**	**SED-4B**
Lab Sample ID		**460-67074-32**	**460-67074-23**	**460-67074-22**	**460-67074-21**	**460-67074-20**	**460-67000-21**	**460-67000-22**
Sample Date		**11/20/2013**	**11/20/2013**	**11/20/2013**	**11/20/2013**	**11/20/2013**	**11/19/2013**	**11/19/2013**
Semi-Volatile Organic Compounds (SVOCs) (mg/kg)								
1,1'-Biphenyl	NC	0.0037 U	0.022 U	0.019 U	0.0036 U	0.026 U	0.019 U	0.0098 U
1,2,4,5-Tetrachlorobenzene	1.252*	0.0032 U	0.019 U	0.016 U	0.0031 U	0.022 U	0.016 U	0.0083 U
2,2'-Oxybis(1-chloropropane)	NC	0.00090 U	0.0054 U	0.0045 U	0.00088 U	0.0062 U	0.0046 U	0.0024 U
2,3,4,6-Tetrachlorophenol	NC	0.0027 U	0.016 U	0.013 U	0.0026 U	0.018 U	0.014 U	0.0070 U
2,4,5-Trichlorophenol	NC	0.0044 U	0.027 U	0.022 U	0.0043 U	0.031 U	0.023 U	0.012 U
2,4,6-Trichlorophenol	0.208*	0.0062 U	0.038 U	0.031 U	0.0061 U	0.043 U	0.032 U	0.016 U
2,4-Dichlorophenol	0.0817*	0.00083 U	0.0050 U	0.0042 U	0.00081 U	0.0058 U	0.0042 U	0.0022 U
2,4-Dimethylphenol	0.304*	0.0065 U	0.039 U	0.033 U	0.0063 U	0.045 U	0.033 U	0.017 U
2,4-Dinitrophenol	0.00621*	**0.050 U**	**0.30 U**	**0.25 U**	**0.048 U**	**0.34 U**	**0.25 U**	**0.13 U**
2,4-Dinitrotoluene	0.0144*	0.0034 U	0.020 U	0.017 U	0.0033 U	0.023 U	0.017 U	0.0088 U
2,6-Dinitrotoluene	NC	0.0043 U	0.026 U	0.022 U	0.0042 U	0.030 U	0.022 U	0.011 U
2-Chloronaphthalene	0.417*	0.00087 U	0.0052 U	0.0044 U	0.00085 U	0.0060 U	0.0044 U	0.0023 U
2-Chlorophenol	0.0319*	0.0034 U	0.021 U	0.017 U	0.0033 U	0.024 U	0.017 U	0.0089 U
2-Methylnaphthalene	0.070	0.00075 U	0.0045 U	0.0037 U	0.00073 U	0.0065 J	0.0038 U	0.0020 U
2-Methylphenol (o-Cresol)	NC	0.0029 U	0.018 U	0.015 U	0.0028 U	0.020 U	0.015 U	0.0076 U
2-Nitroaniline	NC	0.019 U	0.11 U	0.093 U	0.018 U	0.13 U	0.094 U	0.049 U
2-Nitrophenol	NC	0.0046 U	0.028 U	0.023 U	0.0045 U	0.032 U	0.023 U	0.012 U
3,3'-Dichlorobenzidine	0.127*	0.0044 U	0.027 U	0.022 U	0.0043 U	0.030 U	0.022 U	0.012 U
3-Nitroaniline	NC	0.017 U	0.10 U	0.086 U	0.017 U	0.12 U	0.087 U	0.045 U
4,6-Dinitro-2-methylphenol	NC	0.017 U	0.10 U	0.084 U	0.016 U	0.12 U	0.085 U	0.044 U
4-Bromophenyl phenyl ether	NC	0.0036 U	0.022 U	0.018 U	0.0035 U	0.025 U	0.018 U	0.0095 U
4-Chloro-3-methylphenol	NC	0.0038 U	0.023 U	0.019 U	0.0037 U	0.026 U	0.019 U	0.010 U
4-Chloroaniline	NC	0.0033 U	0.020 U	0.017 U	0.0032 U	0.023 U	0.017 U	0.0088 U
4-Chlorophenyl phenyl ether	NC	0.0046 U	0.028 U	0.023 U	0.0045 U	0.032 U	0.023 U	0.012 U
4-Nitroaniline	NC	0.017 U	0.10 U	0.084 U	0.016 U	0.12 U	0.085 U	0.044 U
4-Nitrophenol	0.0133*	0.015 U	**0.092 U**	**0.076 U**	0.015 U	**0.10 U**	**0.077 U**	**0.040 U**
Acenaphthene	0.016	0.00080 U	0.0055 J	0.0040 U	0.00078 U	0.025 J	0.0041 U	0.0021 U
Acenaphthylene	0.044	0.0010 U	0.0058 U	0.0048 U	0.00093 U	0.018 J	0.0048 U	0.0025 U
Acetophenone	NC	*0.0044 J*	0.021 U	0.017 U	0.0033 U	0.024 U	0.017 U	0.0090 U
Anthracene	0.085	0.0019 J	0.020 J	0.0083 J	0.0011 J	0.052 J	0.0074 J	0.0028 J
Atrazine	NC	0.0040 U	0.024 U	0.020 U	0.0039 U	0.028 U	0.021 U	0.011 U
Benzaldehyde	NC	0.0062 U	*0.19 J*	0.031 U	0.0061 U	0.043 U	*0.15 J*	0.016 U
Benzo(a)anthracene	0.261	0.018	0.066	0.026 J	0.0038 J	0.15	0.028 J	0.011 J
Benzo(a)pyrene	0.43	0.038	0.072	0.028 J	0.0038 J	0.17	0.026 J	0.0022 U
Benzo(b)fluoranthene	10.4*	0.043	0.097	0.038 J	0.0050 J	0.24	0.034 J	0.0034 U
Benzo(g,h,i)perylene	0.17*	0.038	0.074	0.032 J	0.0033 J	0.16	0.028 J	0.0022 U
Benzo(k)fluoranthene	0.24*	0.011	0.049 J	0.013 J	0.0023 J	0.097	0.020 J	0.0044 U
bis(2-Chloroethoxy)methane	NC	0.0027 U	0.017 U	0.014 U	0.0027 U	0.019 U	0.014 U	0.0072 U
bis(2-Chloroethyl)ether	3.52*	0.0011 U	0.0067 U	0.0056 U	0.0011 U	0.0077 U	0.0057 U	0.0029 U
bis(2-Ethylhexyl)phthalate	0.18216	0.0067 U	0.041 U	0.034 U	0.0066 U	0.046 U	0.034 U	0.018 U
Butyl benzyl phthalate	1.97*	0.0057 U	0.034 U	0.028 U	0.0055 U	0.039 U	0.029 U	0.015 U
Caprolactam	NC	0.031 U	0.19 U	0.16 U	0.031 U	0.22 U	0.16 U	0.083 U
Carbazole	NC	0.00077 U	*0.0084 J*	0.0038 U	0.00075 U	*0.028 J*	0.0039 U	0.0020 U
Chrysene	0.384	0.018	0.088	0.030 J	0.0048 J	0.21	0.034 J	0.016 J
Dibenzo(a,h)anthracene	0.063	0.0070 J	0.022 J	0.0086 J	0.00090 U	0.042 J	0.0047 U	0.0024 U
Dibenzofuran	NC	0.0041 U	0.025 U	0.021 U	0.0040 U	0.028 U	0.021 U	0.011 U
Diethyl phthalate	0.295*	0.0072 J B	0.029 J B	0.023 U	0.015 J B	0.078 J B	0.043 J B	0.021 J B
Dimethyl phthalate	NC	0.0045 U	0.027 U	0.023 U	0.0044 U	0.031 U	0.023 U	0.012 U
Di-n-butylphthalate	1.114*	0.0052 U	0.031 U	0.026 U	0.0051 U	0.036 U	0.026 U	0.014 U
Di-n-octylphthalate	NC	0.0044 U	0.026 U	0.022 U	0.0043 U	0.030 U	0.022 U	0.012 U
Fluoranthene	0.60	0.020	0.15	0.043	0.0069 J	0.42	0.057	0.025
Fluorene	0.019	0.0011 U	0.0066 U	0.0055 U	0.0011 U	0.029 J	0.0056 U	0.0029 U
Hexachlorobenzene	0.020*	0.00089 U	0.0054 U	0.0044 U	0.00086 U	0.0061 U	0.0045 U	0.0023 U
Hexachlorobutadiene	0.0265*	0.00093 U	0.0056 U	0.0047 U	0.00091 U	0.0064 U	0.0047 U	0.0024 U
Hexachlorocyclopentadiene	0.901*	0.0045 U	0.027 U	0.022 U	0.0044 U	0.031 U	0.023 U	0.012 U
Hexachloroethane	0.584*	0.0030 U	0.018 U	0.015 U	0.0029 U	0.021 U	0.015 U	0.0079 U
Indeno(1,2,3-cd)pyrene	0.20*	0.032	0.066	0.024 J	0.0027 J	0.13	0.022 J	0.0023 U
Isophorone	0.432*	0.0031 U	0.019 U	0.016 U	0.0031 U	0.022 U	0.016 U	0.0082 U
Methylphenol, 3 & 4	NC	0.0041 U	0.025 U	0.020 U	0.0040 U	0.028 U	0.021 U	0.011 U
Naphthalene	0.16	0.00072 U	0.0043 U	0.0036 U	0.00070 U	0.0050 U	0.0036 U	0.0019 U
Nitrobenzene	0.145*	0.0035 U	0.021 U	0.017 U	0.0034 U	0.024 U	0.018 U	0.0091 U
N-Nitroso-di-n-propylamine	NC	0.00098 U	0.0059 U	0.0049 U	0.00095 U	0.0067 U	0.0049 U	0.0026 U
N-Nitrosodiphenylamine	NC	0.0038 U	0.023 U	0.019 U	0.0038 U	0.027 U	0.020 U	0.010 U
Pentachlorophenol	23*	0.0037 U	0.022 U	0.019 U	0.0036 U	0.026 U	0.019 U	0.0098 U
Phenanthrene	0.24	0.0069 J	0.057	0.019 J	0.0022 J	0.27	0.017 J	0.013 J
Phenol	0.0491*	0.0010 U	0.0059 U	0.0049 U	0.0010 U	0.0068 U	0.0050 U	0.0026 U
Pyrene	0.665	0.019	0.130	0.041 J	0.0072 J	0.35	0.051	0.023

Notes:
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Table 5-3
Sediment Analyte Concentrations
Red Bank Landfill Site
Red Bank, New Jersey

		SITE						
Sample ID	**NJDEP's Ecological Screening Criteria[a]**	**SED-2CDUP**	**SED-3A**	**SED-3B**	**SED-3C**	**SED-3D**	**SED-4A**	**SED-4B**
Lab Sample ID		**460-67074-32**	**460-67074-23**	**460-67074-22**	**460-67074-21**	**460-67074-20**	**460-67000-21**	**460-67000-22**
Sample Date		**11/20/2013**	**11/20/2013**	**11/20/2013**	**11/20/2013**	**11/20/2013**	**11/19/2013**	**11/19/2013**
Pesticides (ug/kg)								
4,4'-DDD	2.0	0.33 B	3.1	2.4	0.098 J	1.4	1.5	1.2
4,4'-DDE	2.2	0.15 J	1.9	2.7	0.060 J	1.4	0.86	0.60
4,4'-DDT	1.0	0.27 p	1.7	3.0	0.038 U	1.5	0.82 p	0.44 p
Aldrin	2.0*	0.047 U	0.18 J p	1.1 p	0.045 U	0.11 J	0.13 J	0.049 U
alpha-BHC	6.0*	0.043 U	0.051 U	0.043 U	0.041 U	0.059 U	0.086 U	0.045 U
alpha-Chlordane	NC	*0.088 J p*	*3.0 p*	*2.7*	0.050 U	*0.93*	*0.87*	*0.36*
beta-BHC	5.0*	0.068 U	0.081 U	0.068 U	0.066 U	0.093 U	0.14 U	0.071 U
delta-BHC	NC	*0.041 J p*	*0.19 J p*	*0.98 p*	0.039 U	0.055 U	0.081 U	0.042 U
Dieldrin	1.9*	0.14 J	0.34 p	1.0	0.042 U	0.30 J p	0.29 J p	0.12 J p
Endosulfan I	NC	0.049 U	0.059 U	*0.11 J p*	0.048 U	0.068 U	0.099 U	0.052 U
Endosulfan II	NC	0.046 U	*0.058 J p*	*0.074 J p*	0.045 U	0.063 U	0.093 U	0.048 U
Endosulfan sulfate	34.6*	0.052 J p	0.15 J	0.31	0.026 U	0.12 J	0.15 J	0.057 J
Endrin	2.22*	0.051 U	0.73	0.75 p	0.049 U	0.56	0.41 J	0.14 J
Endrin aldehyde	480*	0.20 J p	0.061 U	0.29	0.049 U	0.070 U	0.10 U	0.053 U
Endrin ketone	NC	*0.062 J p*	0.049 U	0.041 U	0.040 U	0.056 U	0.082 U	0.043 U
gamma-BHC (Lindane)	3.0*	0.046 U	0.094 J p	0.046 U	0.044 U	0.063 U	0.092 U	0.048 U
gamma-Chlordane	NC	*0.37*	*4.7*	*3.1*	*0.072 J*	*1.1*	*0.91*	*0.38*
Heptachlor	0.60*	0.058 U	0.78	0.058 U	0.056 U	0.080 U	0.12 U	0.061 U
Heptachlor epoxide	2.47*	0.051 U	0.21 J p	1.8 p	0.049 U	0.17 J p	0.17 J p	0.056 J p
Methoxychlor	13.6*	0.21 J p	2.4	0.054 U	0.053 U	1.7 p	1.9 p	0.44 J p
Toxaphene	0.077*	**1.7 U**	**2.1 U**	**1.7 U**	**1.7 U**	**2.4 U**	**3.5 U**	**1.8 U**
Polychlorinated Biphenyls (PCBs) (mg/kg)								
PCB-1016	0.0070*	0.00039 U	0.0039	0.0050	0.00038 U	0.0066	0.00078 U	0.00040 U
PCB-1221	NC	0.00050 U	0.00060 U	0.00050 U	0.00048 U	0.00068 U	0.0010 U	0.00052 U
PCB-1232	NC	0.00045 U	0.00054 U	0.00045 U	0.00043 U	0.00061 U	0.00090 U	0.00047 U
PCB-1242	NC	0.00042 U	0.00051 U	0.00043 U	0.00041 U	0.00058 U	0.00086 U	0.00044 U
PCB-1248	0.030*	0.00025 U	0.00030 U	0.00025 U	0.00024 U	0.00034 U	0.00050 U	0.00026 U
PCB-1254	0.060*	0.00037 U	0.011	0.012	0.00036 U	0.014	0.0071	0.0023 J
PCB-1260	0.0050*	0.00037 U	0.00045 U	0.00037 U	0.00036 U	0.00051 U	0.00075 U	0.00039 U
Total PCBs[b]	0.023	0.00050 U	0.015	0.017	0.00048 U	0.021	0.0071	0.0023 J
Metals (mg/kg)								
Aluminum	25,500*	1,770 B	3,890	1,810	1,560	7,520	5,890	1,830
Antimony	NC	*0.15 J*	*0.33 J*	*0.52 J*	*0.17 J*	*0.38 J*	*0.25 J*	*0.21 J*
Arsenic	8.2	13.2	17.9	13.6	10.4	32.7	27.9	12.6
Barium	NC	*5.5 J B*	*96.4 B*	*93.4 B*	*4.0 J B*	*20.4 B*	*19.4 J B*	*14.1 B*
Beryllium	NC	*0.41*	*0.63 B*	*0.42 B*	*0.36 B*	*1.1 B*	*0.86 B*	*0.40 B*
Cadmium	1.2	0.043 J	0.34 J	0.30 J	0.13 J	0.47 J	0.37 J	0.15 J
Calcium	NC	*371 B*	*1,360 B*	*1,210 B*	*264 J B*	*1,610 B*	*1,310 B*	*508 B*
Chromium	81	20.4	41.5	27.4	17.8	49.5	40.2	18.9
Cobalt	50*	4.5 B	3.5 J	2.7 J	3.2	5.1	6.1 J	3.0 J
Copper	34	2.3	17	16.8	1.7	31.6	12.7	3.5
Iron	NC	*26,200 B*	*39,300*	*32,200*	*19,900*	*61,000*	*48,400*	*24,500*
Lead	47	8.4 B	28.6	51.9	7.1	44.7	33.8	11.7
Magnesium	NC	*615 B*	*1,690 B*	*801 B*	*485 B*	*2,850 B*	*2,670 B*	*662 B*
Manganese	630*	372 B	126	91.3	208	136	275	153
Mercury	0.15	0.0072 U	0.068	0.041	0.0065 U	0.13	0.035 J	0.0083 J
Nickel	21	6.9	10.1	8.4	5.8	14.9	14.6	6.1
Potassium	NC	*540*	*1,080*	*448*	*478*	*2,820*	*1,910*	*562*
Selenium	NC	*0.56 J B*	*0.40 J*	*0.54 J*	*0.22 J*	*0.74 J*	*0.80 J*	0.13 U
Silver	1.0	0.036 U	0.097 J	0.036 U	0.035 U	0.13 J	0.073 U	0.038 U
Sodium	NC	*1,710*	*3,250*	*1,700*	*1,360*	*5,320*	*4,370*	*1,420*
Thallium	NC	*0.84 J*	*1.5 J*	*1.1 J*	*0.64 J*	*2.0 J*	*1.3 J*	*0.97 J*
Vanadium	NC	*25*	*35.9*	*26.7*	*20.2*	*56.3*	*46.1*	*22.7*
Zinc	150	60.5 B	86.9 B	151 B	49.2 B	146 B	101 B	58.8 B

Notes:
a - New Jersey Department of Environmental Protection (NJDEP). Ecological Screening Criteria (2009). Saline water Effects Range Low (ERL) criteria used.
b - Total PCBs were not analyzed. Result is the total of all detected concentrations or the highest non-detect Method Detection Limit (MDL).
* - Ecological Screening Criteria based on a chronic freshwater sediment value as a saline criterion was not available.
J - Result is less than the Reporting Limit (RL) but greater than or equal to the MDL and the concentration is an approximate value.
B - Compound was found in the blank and sample.
p - The %RPD between the primary and confirmation column/detector is >40%. The lower value has been reported.
U - Indicates the analyte was analyzed for but not detected.
x - Recovery or RPD exceeds control limits.
H - Sample was prepped or analyzed beyond the specified holding time.
mg/kg - Milligrams per kilogram.
ug/kg - Micrograms per kilogram.
NC - No criterion.

Italics = Compounds detected with no associated Ecological Screening Criteria with which to compare.
Underlined and Italics = Site compound detected above reference concentrations with no associated Ecological Screening Criteria with which to compare.
Bold = 1/2 the detection limit exceeds the Ecological Screening Criteria for a non-detected result.
Highlighted = Compounds detected equal to or above the Ecological Screening Criteria.
Highlighted and Underlined = Site compounds detected equal to or above the Ecological Screening Criteria and above reference concentrations.

Table 5-3
Sediment Analyte Concentrations
Red Bank Landfill Site
Red Bank, New Jersey

		SITE						
Sample ID	**NJDEP's Ecological Screening Criteria[a]**	**SED-2CDUP**	**SED-3A**	**SED-3B**	**SED-3C**	**SED-3D**	**SED-4A**	**SED-4B**
Lab Sample ID		**460-67074-32**	**460-67074-23**	**460-67074-22**	**460-67074-21**	**460-67074-20**	**460-67000-21**	**460-67000-22**
Sample Date		**11/20/2013**	**11/20/2013**	**11/20/2013**	**11/20/2013**	**11/20/2013**	**11/19/2013**	**11/19/2013**
Wet Chemistry (Units)								
pH	NC	6.99 H	6.86 H	7.12 H	7.18 H	7.07 H	6.98 H	7.0 H
Percent Moisture	NC	20	33.9	20.3	17.8	42	60.5	24
Total Organic Carbon (TOC) (mg/kg)								
TOC	NC	2,430	16,400	6,700	2,640	26,700	28,300	3,920
Geotechnical (%)								
Coarse Sand	NC	0.5	1.4	6.2	1.7	0.5	2.6	3.5
Fine Sand	NC	58.8	42.5	37	67.2	74.8	39.3	54.6
Fines	NC	2.7	28.6	3.1	0.5	19.2	15.9	4.2
Gravel	NC	0.0	0.0	1.5	0.0	0.0	0.0	3.4
Medium Sand	NC	38	27.5	52.2	30.6	5.5	42.2	34.3
Sand	NC	97.3	71.4	95.4	99.5	80.8	84.1	92.4
Sieve Size #10	NC	0.5	1.4	6.2	1.7	0.5	2.6	3.5
Sieve Size #100	NC	0.5	1.1	0.5	0.2	8.8	0.6	0.2
Sieve Size #20	NC	8.0	6.5	15.2	4.4	1.0	10.3	6.8
Sieve Size #200	NC	0.3	1.9	0.4	0.1	8.3	0.9	0.1
Sieve Size #4	NC	0.0	0.0	1.5	0.0	0.0	0.0	2.0
Sieve Size #40	NC	30	21	37	26.2	4.5	31.9	27.5
Sieve Size #60	NC	52.1	36.5	32.9	62.7	38	35.3	52.7
Sieve Size #80	NC	5.9	3.0	3.2	4.2	19.7	2.5	1.5
Sieve Size 0.375 inch	NC	0.0	0.0	0.0	0.0	0.0	0.0	1.4
Sieve Size 0.75 inch	NC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sieve Size 1 inch	NC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sieve Size 1.5 inch	NC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sieve Size 2 inch	NC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sieve Size 3 inch	NC	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Notes:
a - New Jersey Department of Environmental Protection (NJDEP). Ecological Screening Criteria (2009). Saline water Effects Range Low (ERL) criteria used.
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Table 5-3
Sediment Analyte Concentrations
Red Bank Landfill Site
Red Bank, New Jersey

		SITE				
Sample ID	**NJDEP's Ecological Screening Criteria[a]**	**SED-4C**	**SED-5A**	**SED-5B**	**SED-5C**	**SED-5D**
Lab Sample ID		**460-67000-23**	**460-67000-17**	**460-67000-18**	**460-67000-19**	**460-67000-20**
Sample Date		**11/19/2013**	**11/19/2013**	**11/19/2013**	**11/19/2013**	**11/19/2013**
Semi-Volatile Organic Compounds (SVOCs) (mg/kg)						
1,1'-Biphenyl	NC	0.0039 U	0.023 U	0.0091 U	0.0098 U	0.012 U
1,2,4,5-Tetrachlorobenzene	1.252*	0.0033 U	0.020 U	0.0077 U	0.0083 U	0.010 U
2,2'-Oxybis(1-chloropropane)	NC	0.00093 U	0.0056 U	0.0022 U	0.0024 U	0.0028 U
2,3,4,6-Tetrachlorophenol	NC	0.0028 U	0.017 U	0.0065 U	0.0070 U	0.0085 U
2,4,5-Trichlorophenol	NC	0.0046 U	0.027 U	0.011 U	0.012 U	0.014 U
2,4,6-Trichlorophenol	0.208*	0.0065 U	0.039 U	0.015 U	0.016 U	0.020 U
2,4-Dichlorophenol	0.0817*	0.00087 U	0.0052 U	0.0020 U	0.0022 U	0.0026 U
2,4-Dimethylphenol	0.304*	0.0068 U	0.040 U	0.016 U	0.017 U	0.021 U
2,4-Dinitrophenol	0.00621*	**0.051 U**	**0.31 U**	**0.12 U**	**0.13 U**	**0.16 U**
2,4-Dinitrotoluene	0.0144*	0.0035 U	0.021 U	0.0082 U	0.0089 U	0.011 U
2,6-Dinitrotoluene	NC	0.0045 U	0.027 U	0.010 U	0.011 U	0.014 U
2-Chloronaphthalene	0.417*	0.00090 U	0.0054 U	0.0021 U	0.0023 U	0.0028 U
2-Chlorophenol	0.0319*	0.0035 U	0.021 U	0.0083 U	0.0090 U	0.011 U
2-Methylnaphthalene	0.070	0.00078 U	0.0046 U	0.0018 U	0.0020 U	0.0024 U
2-Methylphenol (o-Cresol)	NC	0.0030 U	0.018 U	0.0071 U	0.0077 U	0.0092 U
2-Nitroaniline	NC	0.019 U	0.12 U	0.046 U	0.049 U	0.059 U
2-Nitrophenol	NC	0.0048 U	0.028 U	0.011 U	0.012 U	0.015 U
3,3'-Dichlorobenzidine	0.127*	0.0046 U	0.027 U	0.011 U	0.012 U	0.014 U
3-Nitroaniline	NC	0.018 U	0.11 U	0.042 U	0.045 U	0.054 U
4,6-Dinitro-2-methylphenol	NC	0.017 U	0.10 U	0.041 U	0.044 U	0.053 U
4-Bromophenyl phenyl ether	NC	0.0038 U	0.022 U	0.0089 U	0.0095 U	0.011 U
4-Chloro-3-methylphenol	NC	0.0040 U	0.024 U	0.0094 U	0.010 U	0.012 U
4-Chloroaniline	NC	0.0035 U	0.021 U	0.0081 U	0.0088 U	0.011 U
4-Chlorophenyl phenyl ether	NC	0.0048 U	0.029 U	0.011 U	0.012 U	0.015 U
4-Nitroaniline	NC	0.018 U	0.10 U	0.041 U	0.044 U	0.053 U
4-Nitrophenol	0.0133*	0.016 U	**0.094 U**	**0.037 U**	**0.040 U**	**0.048 U**
Acenaphthene	0.016	0.00083 U	0.0049 U	0.0020 U	0.0021 U	0.0043 J
Acenaphthylene	0.044	0.00099 U	0.0059 U	0.0023 U	0.0025 U	0.0077 J
Acetophenone	NC	0.0036 U	0.021 U	0.0084 U	0.0090 U	0.011 U
Anthracene	0.085	0.0017 J	0.0070 J	0.0026 J	0.0021 U	0.014 J
Atrazine	NC	0.0042 U	0.025 U	0.0099 U	0.011 U	0.013 U
Benzaldehyde	NC	0.0065 U	*0.21 J*	0.015 U	0.016 U	0.020 U
Benzo(a)anthracene	0.261	0.0078 J	0.023 J	0.011 J	0.0051 J	0.045
Benzo(a)pyrene	0.43	0.0080 J	0.024 J	0.013 J	0.0022 U	0.058
Benzo(b)fluoranthene	10.4*	0.010	0.031 J	0.018 J	0.0034 U	0.088
Benzo(g,h,i)perylene	0.17*	0.0065 J	0.0051 U	0.015 J	0.0022 U	0.063
Benzo(k)fluoranthene	0.24*	0.0054 J	0.028 J	0.0072 J	0.0044 U	0.036
bis(2-Chloroethoxy)methane	NC	0.0028 U	0.017 U	0.0067 U	0.0072 U	0.0087 U
bis(2-Chloroethyl)ether	3.52*	0.0012 U	0.0069 U	0.0027 U	0.0029 U	0.0035 U
bis(2-Ethylhexyl)phthalate	0.18216	0.0070 U	0.077 J	0.016 U	0.018 U	0.024 J
Butyl benzyl phthalate	1.97*	0.0066 J	0.035 U	0.014 U	0.015 U	0.018 U
Caprolactam	NC	0.033 U	0.19 U	0.077 U	0.083 U	0.10 U
Carbazole	NC	0.00080 U	0.0047 U	0.0019 U	0.0020 U	0.0024 U
Chrysene	0.384	0.0098	0.027 J	0.015 J	0.0042 J	0.070
Dibenzo(a,h)anthracene	0.063	0.00096 U	0.0057 U	0.0023 U	0.0024 U	0.017 J
Dibenzofuran	NC	0.0043 U	0.025 U	0.010 U	0.011 U	0.013 U
Diethyl phthalate	0.295*	0.017 J B	0.028 U	0.032 J B	0.024 J B	0.026 J B
Dimethyl phthalate	NC	0.0047 U	0.028 U	0.011 U	0.012 U	0.014 U
Di-n-butylphthalate	1.114*	0.0054 U	0.032 U	0.013 U	0.014 U	0.017 U
Di-n-octylphthalate	NC	0.0046 U	0.027 U	0.011 U	0.012 U	0.014 U
Fluoranthene	0.60	0.017	0.048 J	0.025	0.0075 J	0.11
Fluorene	0.019	0.0011 U	0.0068 U	0.0027 U	0.0029 U	0.0035 U
Hexachlorobenzene	0.020*	0.00092 U	0.0055 U	0.0022 U	0.0023 U	0.0028 U
Hexachlorobutadiene	0.0265*	0.00097 U	0.0058 U	0.0023 U	0.0025 U	0.0030 U
Hexachlorocyclopentadiene	0.901*	0.0047 U	0.028 U	0.011 U	0.012 U	0.014 U
Hexachloroethane	0.584*	0.0031 U	0.019 U	0.0073 U	0.0079 U	0.0095 U
Indeno(1,2,3-cd)pyrene	0.20*	0.0057 J	0.021 J	0.012 J	0.0023 U	0.051
Isophorone	0.432*	0.0033 U	0.019 U	0.0077 U	0.0083 U	0.0099 U
Methylphenol, 3 & 4	NC	0.0042 U	0.025 U	0.010 U	0.011 U	0.013 U
Naphthalene	0.16	0.00075 U	0.0044 U	0.0018 U	0.0019 U	0.0023 U
Nitrobenzene	0.145*	0.0036 U	0.021 U	0.0085 U	0.0091 U	0.011 U
N-Nitroso-di-n-propylamine	NC	0.0010 U	0.006 U	0.0024 U	0.0026 U	0.0031 U
N-Nitrosodiphenylamine	NC	0.0040 U	0.024 U	0.0094 U	0.010 U	0.012 U
Pentachlorophenol	23*	0.0039 U	0.023 U	0.0091 U	0.0098 U	0.012 U
Phenanthrene	0.24	0.0075 J	0.031 J	0.0092 J	0.0035 U	0.041
Phenol	0.0491*	0.0010 U	0.036 J	0.015 J	0.0026 U	0.0031 U
Pyrene	0.665	0.014	0.034 J	0.019 J	0.0064 J	0.082

Notes:
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Table 5-3
Sediment Analyte Concentrations
Red Bank Landfill Site
Red Bank, New Jersey

		SITE				
Sample ID	**NJDEP's Ecological Screening Criteria[a]**	**SED-4C**	**SED-5A**	**SED-5B**	**SED-5C**	**SED-5D**
Lab Sample ID		**460-67000-23**	**460-67000-17**	**460-67000-18**	**460-67000-19**	**460-67000-20**
Sample Date		**11/19/2013**	**11/19/2013**	**11/19/2013**	**11/19/2013**	**11/19/2013**
Pesticides (ug/kg)						
4,4'-DDD	2.0	0.14 J	0.27 J p	0.80 p	0.19 J	1.2
4,4'-DDE	2.2	0.099 J	0.28 J p	0.039 U	0.13 J	1.0
4,4'-DDT	1.0	0.074 J p	0.096 U	10 p	0.20 J p	0.70 p
Aldrin	2.0*	0.048 U	0.11 U	2.6 p	0.049 U	0.094 J
alpha-BHC	6.0*	0.044 U	0.10 U	0.042 U	0.045 U	0.054 U
alpha-Chlordane	NC	*0.080 J*	*0.43 J*	*1.6 p*	*0.11 J*	*0.65*
beta-BHC	5.0*	0.070 U	0.17 U	0.95 p	0.071 U	0.085 U
delta-BHC	NC	0.041 U	*0.13 J p*	*1.2 p*	0.042 U	0.051 U
Dieldrin	1.9*	0.075 J	0.35 J	3.8	0.046 U	0.21 J p
Endosulfan I	NC	0.051 U	0.12 U	*2.4*	0.052 U	0.062 U
Endosulfan II	NC	0.048 U	0.11 U	*0.53 p*	0.048 U	0.058 U
Endosulfan sulfate	34.6*	0.028 U	0.13 J p	1.9 p	0.029 U	0.059 J
Endrin	2.22*	0.052 U	2.0	35 p	0.082 J	0.40
Endrin aldehyde	480*	0.052 U	0.22 J	0.050 U	0.053 U	0.077 J p
Endrin ketone	NC	0.042 U	0.10 U	0.040 U	0.043 U	0.051 U
gamma-BHC (Lindane)	3.0*	0.047 U	0.11 U	0.093 J p	0.048 U	0.058 U
gamma-Chlordane	NC	*0.076 J*	*1.3*	*17*	*0.14 J*	*0.72*
Heptachlor	0.60*	0.060 U	0.14 U	0.057 U	0.061 U	0.075 J p
Heptachlor epoxide	2.47*	0.052 U	0.22 J p	3.8 p	0.053 U	0.14 J p
Methoxychlor	13.6*	0.056 U	2.0 p	7.3 p	0.057 U	1.1 p
Toxaphene	0.077*	**1.8 U**	**4.3 U**	**1.7 U**	**1.8 U**	**2.2 U**
Polychlorinated Biphenyls (PCBs) (mg/kg)						
PCB-1016	0.0070*	0.00040 U	0.00096 U	0.00038 U	0.00041 U	0.0018 J
PCB-1221	NC	0.00052 U	0.0012 U	0.00049 U	0.00052 U	0.00063 U
PCB-1232	NC	0.00046 U	0.0011 U	0.00044 U	0.00047 U	0.00056 U
PCB-1242	NC	0.00044 U	0.0011 U	0.00042 U	0.00045 U	0.00054 U
PCB-1248	0.030*	0.00026 U	0.00061 U	0.00024 U	0.00026 U	0.00031 U
PCB-1254	0.060*	0.0011 J	0.048	0.14	0.0012 J	0.0087
PCB-1260	0.0050*	0.00038 U	0.00092 U	0.00036 U	0.00039 U	0.00047 U
Total PCBs[b]	0.023	0.0011 J	0.048	0.14	0.0012 J	0.011
Metals (mg/kg)						
Aluminum	25,500*	1,740	11,400	2,510	1,690	5,310
Antimony	NC	*0.16 J*	*4.3*	*0.96 J*	*0.20 J*	0.25 U
Arsenic	8.2	13.4	31.6	16.6	12	24.1
Barium	NC	*5.1 J B*	*45.2 B*	*21.4 B*	*4.0 J B*	*11.6 J B*
Beryllium	NC	*0.45 B*	*1.1 B*	*0.50 B*	*0.40 B*	*0.84 B*
Cadmium	1.2	0.15 J	1.0 J	0.36 J	0.12 J	0.35 J
Calcium	NC	*344 B*	*3,150 B*	*2,390 B*	*340 B*	*1,020 B*
Chromium	81	22.8	68.4	31.2	19.5	35.5
Cobalt	50*	3.4	7.8	4.2	2.6 J	3.7 J
Copper	34	1.8	123	80.9	2.1	14.5
Iron	NC	*25,500*	*90,200*	*48,900*	*21,700*	*46,700*
Lead	47	10.3	284	1,960	9.0	25.7
Magnesium	NC	*523 B*	*5,580 B*	*982 B*	*580 B*	*1,890 B*
Manganese	630*	266	250	194	103	83.8
Mercury	0.15	0.0069 U	0.053	0.030	0.050	0.059
Nickel	21	6.5	50.8	17	5.7	10
Potassium	NC	*533*	*3,350*	*657*	*583*	*2,380*
Selenium	NC	*0.26 J*	*2.2 J*	*0.39 J*	*0.23 J*	*0.44 J*
Silver	1.0	0.037 U	0.47 J	0.55	0.038 U	0.045 U
Sodium	NC	*1,030*	*13,700*	*1,350*	*1,650*	*3,820*
Thallium	NC	*0.88 J*	*3.0 J*	*1.7 J*	*0.88 J*	*2.0 J*
Vanadium	NC	*25.8*	*53.1*	*30*	*22*	*43.1*
Zinc	150	59.5 B	260 B	147 B	51.2 B	100 B

Notes:
a - New Jersey Department of Environmental Protection (NJDEP). Ecological Screening Criteria (2009). Saline water Effects Range Low (ERL) criteria used.
b - Total PCBs were not analyzed. Result is the total of all detected concentrations or the highest non-detect Method Detection Limit (MDL).
* - Ecological Screening Criteria based on a chronic freshwater sediment value as a saline criterion was not available.
J - Result is less than the Reporting Limit (RL) but greater than or equal to the MDL and the concentration is an approximate value.
B - Compound was found in the blank and sample.
p - The %RPD between the primary and confirmation column/detector is >40%. The lower value has been reported.
U - Indicates the analyte was analyzed for but not detected.
x - Recovery or RPD exceeds control limits.
H - Sample was prepped or analyzed beyond the specified holding time.
mg/kg - Milligrams per kilogram.
ug/kg - Micrograms per kilogram.
NC - No criterion.

Italics = Compounds detected with no associated Ecological Screening Criteria with which to compare.
Underlined and Italics = Site compound detected above reference concentrations with no associated Ecological Screening Criteria with which to compare.
Bold = 1/2 the detection limit exceeds the Ecological Screening Criteria for a non-detected result.
Highlighted = Compounds detected equal to or above the Ecological Screening Criteria.
Highlighted and Underlined = Site compounds detected equal to or above the Ecological Screening Criteria and above reference concentrations.

Table 5-3
Sediment Analyte Concentrations
Red Bank Landfill Site
Red Bank, New Jersey

		SITE				
Sample ID **Lab Sample ID** **Sample Date**	**NJDEP's Ecological Screening Criteria[a]**	**SED-4C** **460-67000-23** **11/19/2013**	**SED-5A** **460-67000-17** **11/19/2013**	**SED-5B** **460-67000-18** **11/19/2013**	**SED-5C** **460-67000-19** **11/19/2013**	**SED-5D** **460-67000-20** **11/19/2013**
Wet Chemistry (Units)						
pH	NC	7 H	6.87 H	7.27 H	7.12 H	7.05 H
Percent Moisture	NC	22.9	67.7	18.3	24.2	36.8
Total Organic Carbon (TOC) (mg/kg)						
TOC	NC	2,990	52,400	4,030	2,470	13,100
Geotechnical (%)						
Coarse Sand	NC	0.2	2.9	12.9	1.9	0.5
Fine Sand	NC	60.1	21.1	22.7	54.6	95.6
Fines	NC	0.6	62.3	4.2	1.1	1.0
Gravel	NC	0.0	1.8	7.2	0.0	0.0
Medium Sand	NC	39.1	11.9	53	42.4	2.9
Sand	NC	99.4	35.9	88.6	98.9	99
Sieve Size #10	NC	0.2	2.9	12.9	1.9	0.5
Sieve Size #100	NC	0.1	1.9	0.5	0.2	17.1
Sieve Size #20	NC	5.4	4.1	23.4	8.5	0.8
Sieve Size #200	NC	0.06	3.6	0.7	0.1	6.3
Sieve Size #4	NC	0.0	1.8	4.6	0.0	0.0
Sieve Size #40	NC	33.7	7.8	29.6	33.9	2.1
Sieve Size #60	NC	56.1	11.1	19.3	51.2	26.7
Sieve Size #80	NC	3.9	4.5	2.2	3.0	45.5
Sieve Size 0.375 inch	NC	0.0	0.0	2.6	0.0	0.0
Sieve Size 0.75 inch	NC	0.0	0.0	0.0	0.0	0.0
Sieve Size 1 inch	NC	0.0	0.0	0.0	0.0	0.0
Sieve Size 1.5 inch	NC	0.0	0.0	0.0	0.0	0.0
Sieve Size 2 inch	NC	0.0	0.0	0.0	0.0	0.0
Sieve Size 3 inch	NC	0.0	0.0	0.0	0.0	0.0

Notes:
a - New Jersey Department of Environmental Protection (NJDEP). Ecological Screening Criteria (2009). Saline water Effects Range Low (ERL) criteria used.
b - Total PCBs were not analyzed. Result is the total of all detected concentrations or the highest non-detect Method Detection Limit (MDL).
* - Ecological Screening Criteria based on a chronic freshwater sediment value as a saline criterion was not available.
J - Result is less than the Reporting Limit (RL) but greater than or equal to the MDL and the concentration is an approximate value.
B - Compound was found in the blank and sample.
p - The %RPD between the primary and confirmation column/detector is >40%. The lower value has been reported.
U - Indicates the analyte was analyzed for but not detected.
x - Recovery or RPD exceeds control limits.
H - Sample was prepped or analyzed beyond the specified holding time.
mg/kg - Milligrams per kilogram.
ug/kg - Micrograms per kilogram.
NC - No criterion.

Italics = Compounds detected with no associated Ecological Screening Criteria with which to compare.
Underlined and Italics = Site compound detected above reference concentrations with no associated Ecological Screening Criteria with which to compare.
Bold = 1/2 the detection limit exceeds the Ecological Screening Criteria for a non-detected result.
Highlighted = Compounds detected equal to or above the Ecological Screening Criteria.
Highlighted and Underlined = Site compounds detected equal to or above the Ecological Screening Criteria and above reference concentrations.

Table 5-4
Surface Water Analyte Concentrations
Red Bank Landfill Site
Red Bank, New Jersey

		REFERENCE LOCATIONS				SITE							
Sample ID		**UPREF-SW2**	**UPREF-SW3**	**DNREF-SW1**	**DNREF-SW2**	**SW-1C**	**SW-2C**	**SW-2CDUP**	**SW-3C**	**SW-4C**	**SW-5A**	**SW-5C**	**SW-5D**
Lab Sample ID	**NJDEP's Ecological Screening Criteria[a]**	**460-67151-10**	**460-67074-18**	**460-67000-3**	**460-67000-1**	**460-67074-15**	**460-67074-13**	**460-67074-14**	**460-67074-12**	**460-67000-15**	**460-67000-6**	**460-67000-9**	**460-67000-10**
Sample Date		**11/21/2013**	**11/20/2013**	**11/19/2013**	**11/19/2013**	**11/20/2013**	**11/20/2013**	**11/20/2013**	**11/20/2013**	**11/19/2013**	**11/19/2013**	**11/19/2013**	**11/19/2013**
Metals (ug/L)													
Aluminum	NC	*145 J*	*139 J*	*133 J*	*204*	*179 J*	*149 J*	*142 J*	*146 J*	*101 J*	*104 J*	*136 J*	*135 J*
Antimony	80*	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
Arsenic	36	4.9 J	3.0 J	5.2 J	4.8 J	4.3 J	3.1 J	3.9 J	3.7 J	3.6 J	5.0 J	3.8 J	4.4 J
Barium	220*	27.3 J	31.9 J	21.2 J	21.3 J	27 J	21 J	22.5 J	21.1 J	33.9 J	24.1 J	29.2 J	29.5 J
Beryllium	3.6*	0.23 U	0.23 U	0.23 U	0.23 U	0.23 U	0.23 U	0.23 U	0.23 U	0.23 U	0.23 U	0.23 U	0.23 U
Cadmium	8.8	0.13 U	0.13 U	0.13 U	0.20 J	0.13 U	0.13 U	0.13 U	0.13 U	0.13 U	0.13 U	0.17 J	0.13 U
Calcium	NC	*184,000*	*141,000*	*269,000*	*269,000*	*213,000*	*269,000*	*266,000*	*269,000*	*113,000*	*257,000*	*213,000*	*197,000*
Chromium	42*	0.65 J	0.57 U	0.80 J	0.68 J	0.57 U	0.57 U	0.57 U	0.57 J	0.65 J	0.57 U	0.57 U	0.57 U
Cobalt	24*	2.9 J B	3.5 J B	2.1 J B	2.1 J B	2.5 J B	2.4 J B	3.0 J B	0.40 U	1.90 J B	1.4 J B	3.30 J B	1.70 J B
Copper	3.1	2.7 U	2.7 U	2.7 U	3.2 J	2.7 U	2.7 U	2.7 U	2.9 J	2.7 U	2.7 U	2.7 U	2.7 U
Iron[b]	1000*	652	654	406	644	546	457	392	414	672	387	418	449
Lead	24	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
Magnesium	NC	*587,000*	*428,000*	*914,000*	*920,000*	*678,000*	*899,000*	*875,000*	*902,000*	*330,000*	*877,000*	*705,000*	*641,000*
Manganese[c]	100	49	66.4	22.7	23.9	39.2	22.3	24.5	22.6	78	29.4	42.5	48.1
Mercury	0.94	0.038 U	0.038 U	0.038 U	0.038 U	0.038 U	0.038 U	0.038 U	0.038 U	0.038 U	0.038 U	0.038 U	0.038 U
Nickel	22	2.5 J	2.7 J	1.9 J	1.6 U	2.2 J	1.8 J	2.7 J	1.9 J	2.2 J	2.7 J	2.4 J	2.9 J
Potassium	NC	*274,000*	*194,000*	*404,000*	*406,000*	*330,000*	*400,000*	*389,000*	*404,000*	*147,000*	*386,000*	*332,000*	*296,000*
Selenium	71	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U
Silver	0.12*	0.71 J B	**0.68 U**	**0.68 U**	**0.68 U**	**0.68 U**	**0.68 U**	**0.68 U**	**0.68 U**	**0.68 U**	**0.68 U**	**0.68 U**	**0.68 U**
Sodium	NC	*4,570,000*	*3,290,000*	*7,070,000*	*7,120,000*	*5,290,000*	*6,950,000*	*6,830,000*	*7,020,000*	*2,610,000*	*6,710,000*	*5,410,000*	*4,930,000*
Thallium	10*	2.4 U	2.4 U	2.4 U	2.4 U	2.4 U	2.4 U	2.4 U	2.4 U	2.4 U	2.4 U	2.4 U	2.4 U
Vanadium	12*	6.4 J	7.8 J	8.0 J	8.8 J	9.3 J	10.9 J	8.9 J	6.9 J	6.6 J	9.2 J	7.9 J	7.6 J
Zinc	81	6.9 J	13.6 J	10.2 J	14 J	8.6 J	10.5 J	9.9 J	8.7 J	7.7 J	12.3 J	10.5 J	8.6 J
Wet Chemistry (Units)													
pH	NC	8.52 HF	8.14 HF	8.41 HF	8.43 HF	8.54 HF	8.65 HF	8.6 HF	8.52 HF	7.75 HF	8.59 HF	8.2 HF	8.13 HF
Total Suspended Solids (TSS) (ug/L)													
TSS	NC	14,700	8,530	12,000	11,100	16,400	20,900	20,100	22,600	6,900	10,900	10,300	12,300

Notes:
a - New Jersey Department of Environmental Protection (NJDEP). Ecological Screening Criteria (ESC) (2009). Chronic saline water aquatic criteria used.
b - NJDEP ESC not available. United States Environmental Protection Agency (USEPA). National Recommended Water Quality Criteria. Aquatic Life Criteria Table used. (USEPA, 2014).
Available at: http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm#altable.
c - NJDEP ESC not available. National Oceanic and Atmospheric Administration (NOAA). Screening Quick Reference Tables (SQuiRTs) - marine chronic surface water values used (NOAA, 2008).
* - Ecological Screening Criteria base on a chronic freshwater value as a saline criterion was not available.
J - Result is less than the Reporting Limit (RL) but greater than or equal to the Method Detection Limit (MDL) and the concentration is an approximate value.
B - Compound was found in the blank and sample.
U - Indicates the analyte was analyzed for but not detected.
HF - Field parameter with a holding time of 15 minutes.
ug/L - Micrograms per liter.
NC - No criterion.

Italics = Compounds detected with no associated Ecological Screening Criteria with which to compare.
Underlined and Italics = Site compound detected above reference concentrations with no associated Ecological Screening Criteria with which to compare.
Bold = 1/2 the detection limit exceeds the Ecological Screening Criteria for a non-detected result.
Highlighted = Compounds detected equal to or above the Ecological Screening Criteria.
Bold and Highlighted = Site compounds detected equal to or above the Ecological Screening Criteria and above reference concentrations.

Table 5-5
Soil Analyte Concentrations
Red Bank Landfill Site
Red Bank, New Jersey

Sample ID Lab Sample ID Sample Date	NJDEP's Ecological Screening Criteria[a]	FWSO-1 460-67151-3 11/21/2013	FWSO-2 460-67151-2 11/21/2013	FWSO-3 460-67151-1 11/21/2013	FWSO-4 460-67151-4 11/21/2013	FWSO-5 460-67151-5 11/21/2013
Semi-Volatile Organic Compounds (SVOCs) (mg/kg)						
1,1'-Biphenyl	60	0.086 U	0.020 U	0.0038 U	0.0035 U	0.0064 U
1,2,4,5-Tetrachlorobenzene	2.02	0.073 U	0.017 U	0.0032 U	0.0030 U	0.0055 U
2,2'-Oxybis(1-chloropropane)	NC	0.021 U	0.0048 U	0.00091 U	0.00085 U	0.0016 U
2,3,4,6-Tetrachlorophenol	NC	0.062 U	0.014 U	0.0027 U	0.0025 U	0.0046 U
2,4,5-Trichlorophenol	4.0	0.10 U	0.024 U	0.0045 U	0.0042 U	0.0077 U
2,4,6-Trichlorophenol	4.0	0.14 U	0.033 U	0.0063 U	0.0059 U	0.011 U
2,4-Dichlorophenol	87.5	0.019 U	0.0045 U	0.00084 U	0.00079 U	0.0014 U
2,4-Dimethylphenol	0.010	**0.15 U**	**0.035 U**	0.0066 U	0.0062 U	0.011 U
2,4-Dinitrophenol	0.0609	**1.1 U**	**0.26 U**	0.050 U	0.047 U	0.086 U
2,4-Dinitrotoluene	1.28	0.077 U	0.018 U	0.0034 U	0.0032 U	0.0058 U
2,6-Dinitrotoluene	NC	0.099 U	0.023 U	0.0043 U	0.0041 U	0.0074 U
2-Chloronaphthalene	0.0122	0.020 U	0.0046 U	0.00088 U	0.00082 U	0.0015 U
2-Chlorophenol	0.243	0.078 U	0.018 U	0.0034 U	0.0032 U	0.0059 U
2-Methylnaphthalene	3.24	0.017 U	0.0047 J	0.0014 J	0.0019 J	0.0053 J
2-Methylphenol (o-Cresol)	NC	0.067 U	0.016 U	0.0029 U	0.0028 U	0.0050 U
2-Nitroaniline	NC	0.43 U	0.10 U	0.019 U	0.018 U	0.032 U
2-Nitrophenol	NC	0.11 U	0.025 U	0.0046 U	0.0044 U	0.0079 U
3,3'-Dichlorobenzidine	0.646	0.10 U	0.024 U	0.0045 U	0.0042 U	0.0076 U
3-Nitroaniline	NC	0.40 U	0.092 U	0.017 U	0.016 U	0.030 U
4,6-Dinitro-2-methylphenol	NC	0.39 U	0.089 U	0.017 U	0.016 U	0.029 U
4-Bromophenyl phenyl ether	NC	0.084 U	0.019 U	0.0037 U	0.0034 U	0.0063 U
4-Chloro-3-methylphenol	NC	0.088 U	0.020 U	0.0039 U	0.0036 U	0.0066 U
4-Chloroaniline	NC	0.077 U	0.018 U	0.0034 U	0.0032 U	0.0058 U
4-Chlorophenyl phenyl ether	NC	0.11 U	0.025 U	0.0047 U	0.0044 U	0.0080 U
4-Nitroaniline	NC	0.39 U	0.090 U	0.017 U	0.016 U	0.029 U
4-Nitrophenol	5.12	0.35 U	0.081 U	0.015 U	0.014 U	0.026 U
Acenaphthene	20	0.029 J	0.0083 J	0.0025 J	0.017	0.014
Acenaphthylene	682	0.054 J	0.026 J	0.0057 J	0.0020 J	0.031
Acetophenone	NC	0.079 U	0.018 U	*0.011 J*	*0.010 J*	*0.012 J*
Anthracene	1,480	0.12 J	0.047	0.011	0.017	0.054
Atrazine	NC	0.093 U	0.022 U	0.0041 U	0.0038 U	0.0070 U
Benzaldehyde	NC	0.14 U	*0.19 J*	*0.038 J*	*0.036 J*	*0.063 J*
Benzo(a)anthracene	5.21	0.58	0.22	0.040	0.091	0.21
Benzo(a)pyrene	1.52	0.69	0.23	0.044	0.071	0.21
Benzo(b)fluoranthene	59.8	1.0	0.38	0.086	0.097	0.27
Benzo(g,h,i)perylene	119	0.73	0.18	0.043	0.051	0.17
Benzo(k)fluoranthene	148	0.36	0.16	0.028	0.036	0.10
bis(2-Chloroethoxy)methane	NC	0.063 U	0.015 U	0.0028 U	0.0026 U	0.0047 U
bis(2-Chloroethyl)ether	23.7	0.026 U	0.0060 U	0.0011 U	0.0011 U	0.0019 U
bis(2-Ethylhexyl)phthalate	0.925	180 D	0.36 J	0.038 J	0.018 J	0.026 J
Butyl benzyl phthalate	0.239	0.18 J	0.030 J	0.012 J	0.0091 J	0.010 J
Caprolactam	NC	0.72 U	0.17 U	0.032 U	0.030 U	0.054 U
Carbazole	NC	*0.081 J*	*0.017 J*	*0.0046 J*	*0.0052 J*	*0.014*
Chrysene	4.73	0.96	0.26	0.065	0.090	0.21
Dibenzo(a,h)anthracene	18.4	0.15 J	0.044 J	0.0094	0.012	0.042
Dibenzofuran	NC	0.094 U	0.022 U	0.0041 U	*0.0063 J*	*0.010 J*
Diethyl phthalate	24.8	0.10 U	0.054 J B	0.015 J B	0.0082 J B	0.017 J B
Dimethyl phthalate	NC	0.10 U	0.024 U	0.0046 U	0.0043 U	0.0079 U
Di-n-butylphthalate	0.15	0.12 U	0.028 U	0.0053 U	0.0050 U	0.0090 U
Di-n-octylphthalate	NC	0.10 U	0.023 U	0.0044 U	0.0042 U	0.0076 U
Fluoranthene	122	1.3	0.33	0.070	0.19	0.33
Fluorene	122	0.035 J	0.0095 J	0.0030 J	0.0099	0.012 J
Hexachlorobenzene	0.199	0.020 U	0.0047 U	0.00090 U	0.00084 U	0.0015 U
Hexachlorobutadiene	0.0398	0.021 U	0.0050 U	0.00094 U	0.00088 U	0.0016 U
Hexachlorocyclopentadiene	0.755	0.10 U	0.024 U	0.0045 U	0.0043 U	0.0078 U
Hexachloroethane	0.596	0.069 U	0.016 U	0.0030 U	0.0028 U	0.0052 U
Indeno(1,2,3-cd)pyrene	109	0.58	0.17	0.037	0.047	0.15
Isophorone	139	0.072 U	0.017 U	0.0032 U	0.0030 U	0.0054 U
Methylphenol, 3 & 4	NC	0.094 U	0.022 U	0.0041 U	0.0039 U	0.0071 U
Naphthalene	0.0994	0.017 U	0.0079 J	0.0030 J	0.0014 J	0.016
Nitrobenzene	1.31	0.080 U	0.019 U	0.0035 U	0.0033 U	0.0060 U
N-Nitroso-di-n-propylamine	NC	0.023 U	0.0052 U	0.00099 U	0.00093 U	0.0017 U
N-Nitrosodiphenylamine	0.545	0.089 U	0.021 U	0.0039 U	0.0037 U	0.0067 U
Pentachlorophenol	0.119	0.086 U	0.020 U	0.0038 U	0.0035 U	0.0064 U
Phenanthrene	45.7	0.54	0.11	0.032	0.081	0.15
Phenol	30	0.023 U	0.0053 U	0.0010 U	0.00093 U	0.0017 U
Pyrene	78.5	1.2	0.33	0.074	0.17	0.30

Notes:
a - New Jersey Department of Environmental Protection (NJDEP). Ecological Screening Criteria (2009). Most conservative soil criteria used.
b - Total PCBs were not analyzed. Result is the total of all detected concentrations.
D - Sample results are obtained from a dilution; the surrogate or matrix spike recoveries reported are calculated from diluted samples.
J - Result is less than the Reporting Limit (RL) but greater than or equal to the Method Detection Limit (MDL) and the concentration is an approximate value.
B - Compound was found in the blank and sample.
p - The Relative Percent Difference (%RPD) between the primary and confirmation column/detector is >40%. The lower value has been reported.
U - Indicates the analyte was analyzed for but not detected.
HF - Field parameter with a holding time of 15 minutes.
mg/kg - Milligrams per kilogram.
ug/kg - Micrograms per kilogram.
NC - No criterion.

Italics = Compounds detected with no associated Ecological Screening Criteria with which to compare.
Bold = 1/2 the detection limit exceeds the Ecological Screening Criteria for a non-detected result.
Highlighted = Compounds detected equal to or above the Ecological Screening Criteria.

Table 5-5
Soil Analyte Concentrations
Red Bank Landfill Site
Red Bank, New Jersey

Sample ID Lab Sample ID Sample Date	NJDEP's Ecological Screening Criteria[a]	FWSO-1 460-67151-3 11/21/2013	FWSO-2 460-67151-2 11/21/2013	FWSO-3 460-67151-1 11/21/2013	FWSO-4 460-67151-4 11/21/2013	FWSO-5 460-67151-5 11/21/2013
Pesticides (ug/kg)						
4,4'-DDD	758	6.5 p	3.0 p	0.069 U	0.065 U	0.12 U
4,4'-DDE	596	6.4	9.8	0.39 J p	0.23 J	0.14 U
4,4'-DDT	3.5	24	30	8.2	0.89 p	3.8
Aldrin	3.32	0.58 J p	0.34 J p	0.094 U	0.088 U	0.16 U
alpha-BHC	99.4	0.20 U	0.18 U	0.086 U	0.081 U	0.15 U
alpha-Chlordane	NC	*37 p*	*2.3 p*	*0.55 p*	*0.18 J p*	*0.81 J p*
beta-BHC	3.98	0.32 J p	0.29 U	0.14 U	0.13 U	0.23 U
delta-BHC	NC	0.18 U	*0.27 J p*	0.081 U	*0.24 J p*	*0.18 J p*
Dieldrin	2.38	19	4.9	0.90	0.44 J	2.6 p
Endosulfan I	NC	0.23 U	0.21 U	0.099 U	0.093 U	0.17 U
Endosulfan II	NC	*0.87 J p*	*1.3 p*	*0.12 J p*	0.087 U	0.16 U
Endosulfan sulfate	35.8	0.97 J p	2.9	0.23 J p	0.052 U	0.47 J p
Endrin	10.1	2.5 p	3.9 p	2.2 p	0.20 J p	0.65 J p
Endrin aldehyde	10.5	2.0	0.60 J p	0.37 J	0.096 U	0.18 U
Endrin ketone	NC	0.19 U	0.17 U	*0.28 J p*	0.077 U	0.14 U
gamma-BHC (Lindane)	5.0	0.45 J p	0.31 J	0.092 U	0.086 U	2.0
gamma-Chlordane	NC	*51*	*3.5 p*	*1.3*	*0.26 J p*	*1.7*
Heptachlor	5.98	0.27 U	0.27 J p	0.12 U	0.20 J p	0.20 U
Heptachlor epoxide	152	3.0 p	1.2	0.34 J p	0.096 U	0.18 U
Methoxychlor	19.9	18	4.6 p	3.1 p	1.0 p	4.3
Toxaphene	119	8.0 U	7.4 U	3.5 U	3.3 U	6.0 U
Polychlorinated Biphenyls (PCBs) (mg/kg)						
PCB-1016	NC	0.00089 U	0.00083 U	0.00078 U	0.00073 U	0.00067 U
PCB-1221	NC	0.0011 U	0.0011 U	0.0010 U	0.00094 U	0.00086 U
PCB-1232	NC	0.001 U	0.00095 U	0.00090 U	0.00085 U	0.00077 U
PCB-1242	NC	0.00097 U	0.00091 U	0.00086 U	0.00080 U	0.00073 U
PCB-1248	NC	0.00056 U	0.00053 U	0.00050 U	0.00047 U	0.00043 U
PCB-1254	NC	*0.076*	*0.11*	*0.034*	*0.0075*	*0.013*
PCB-1260	NC	0.00085 U	0.00079 U	0.00075 U	0.00070 U	0.00064 U
Total PCBs[b]	0.000332	0.076	0.11	0.034	0.0075	0.013
Metals (mg/kg)						
Aluminum	50 (if pH is <5.5[c])	5,570 B	7,570 B	14,800 B	15,200 B	4,130 B
Antimony	0.27	1.2 J	0.85 J	1.8 J	1.7 J	0.33 J
Arsenic	9.9	7.8	9.7	24.1	25.2	12.1
Barium	283	43.1 B	60.9 B	69.6 B	57.4 B	29.3 B
Beryllium	10	0.62	0.97	2.2	2.2	0.57
Cadmium	0.36	1.0	0.81	1.5 J	1.4 J	0.37 J
Calcium	NC	*2,830 B*	*3,370 B*	*1,710 B*	*1,650 B*	*968 B*
Chromium	0.40	39.8	51.8	178	173	28.2
Cobalt	0.14	5.6 J B	3.7 J B	9.5 B	10.1 B	2.6 J B
Copper	5.4	48.1	13.1	3.4	1.6 J	9.3
Iron	NC	*22,500 B*	*43,100 B*	*138,000 B*	*136,000 B*	*22,400 B*
Lead	0.537	209	146	41.9	32.6	53.9
Magnesium	NC	*1,640 B*	*1,480 B*	*2,000 B*	*1,940 B*	*1,110 B*
Manganese	220	143	162	219	224	87.9
Mercury	0.00051	0.19	0.16	0.063	0.042	0.18
Nickel	13.6	19.7	11.1	25.3	24.5	6.6
Potassium	NC	*1,290*	*1,770*	*4,290*	*4,470*	*1,910*
Selenium	0.0276	1.1 J	0.87 J	1.4 J	1.3 J	0.49 J
Silver	2.0	0.24 J	0.077 U	0.072 U	0.13 U	0.49 J
Sodium	NC	*210 J*	10.9 U	51.3 U	47.7 U	*81.4 J*
Thallium	1.0	0.3 U	1.1 J	4.8 J	3.0 J	0.37 J
Vanadium	2.0	47.9 B	94.1 B	334 B	314 B	31.3 B
Zinc	6.62	218 B	162 B	170 B	158 B	69.7 B

Notes:
a - New Jersey Department of Environmental Protection (NJDEP). Ecological Screening Criteria (2009). Most conservative soil criteria used.
b - Total PCBs were not analyzed. Result is the total of all detected concentrations.
c - Potential ecological risks associated with aluminum in soils is identified based on the measured soil pH. Aluminum is identified as a Contaminant of Potential Ecological Concern (COPEC) only for those soils with a soil pH less than 5.5. The technical basis for this procedure is that the soluble and toxic forms of aluminum are only present in soil under soil pH values of less than 5.5 (USEPA, 2003 - Ecological Soil Screening Level for Aluminum - Interim Final).
D - Sample results are obtained from a dilution; the surrogate or matrix spike recoveries reported are calculated from diluted samples.
J - Result is less than the Reporting Limit (RL) but greater than or equal to the Method Detection Limit (MDL) and the concentration is an approximate value.
B - Compound was found in the blank and sample.
p - The Relative Percent Difference (%RPD) between the primary and confirmation column/detector is >40%. The lower value has been reported.
U - Indicates the analyte was analyzed for but not detected.
HF - Field parameter with a holding time of 15 minutes.
mg/kg - Milligrams per kilogram.
ug/kg - Micrograms per kilogram.
NC - No criterion.

Italics = Compounds detected with no associated Ecological Screening Criteria with which to compare.
Bold = 1/2 the detection limit exceeds the Ecological Screening Criteria for a non-detected result.
Highlighted = Compounds detected equal to or above the Ecological Screening Criteria.

Table 5-5
Soil Analyte Concentrations
Red Bank Landfill Site
Red Bank, New Jersey

Sample ID Lab Sample ID Sample Date	NJDEP's Ecological Screening Criteria[a]	FWSO-1 460-67151-3 11/21/2013	FWSO-2 460-67151-2 11/21/2013	FWSO-3 460-67151-1 11/21/2013	FWSO-4 460-67151-4 11/21/2013	FWSO-5 460-67151-5 11/21/2013
Wet Chemistry (Units)						
pH	NC	6.5 HF	6.36 HF	6.32 HF	5.67 HF	6.53 HF
Percent Moisture	NC	30.9	25	20.8	15.6	7.5
Total Organic Carbon (TOC) (mg/kg)						
TOC	NC	71,200	76,000	27,500	25,000	14,700
Geotechnical (%)						
Coarse Sand	NC	1.0	1.2	4.8	4.7	3.7
Fine Sand	NC	58.2	54.5	26.5	27.9	60.4
Fines	NC	19.7	18.8	22.5	26.9	11.9
Gravel	NC	0.80	0.0	1.6	3.8	3.9
Medium Sand	NC	20.3	25.5	44.6	36.7	20.1
Sand	NC	79.5	81.2	75.9	69.3	84.2
Sieve Size #10	NC	1.0	1.2	4.8	4.7	3.7
Sieve Size #100	NC	4.5	2.6	1.7	1.8	4.4
Sieve Size #20	NC	2.7	3.7	21.4	13.5	5.8
Sieve Size #200	NC	6.2	3.7	3.6	3.7	4.5
Sieve Size #4	NC	0.80	0.0	1.6	2.2	3.9
Sieve Size #40	NC	17.6	21.8	23.2	23.2	14.3
Sieve Size #60	NC	35	38	16.8	17.8	37.1
Sieve Size #80	NC	12.5	10.2	4.4	4.6	14.4
Sieve Size 0.375 inch	NC	0.0	0.0	0.0	1.6	0.0
Sieve Size 0.75 inch	NC	0.0	0.0	0.0	0.0	0.0
Sieve Size 1 inch	NC	0.0	0.0	0.0	0.0	0.0
Sieve Size 1.5 inch	NC	0.0	0.0	0.0	0.0	0.0
Sieve Size 2 inch	NC	0.0	0.0	0.0	0.0	0.0
Sieve Size 3 inch	NC	0.0	0.0	0.0	0.0	0.0

Notes:
a - New Jersey Department of Environmental Protection (NJDEP). Ecological Screening Criteria (2009). Most conservative soil criteria used.
b - Total PCBs were not analyzed. Result is the total of all detected concentrations.
c - Potential ecological risks associated with aluminum in soils is identified based on the measured soil pH. Aluminum is identified as a Contaminant of Potential Ecological Concern (COPEC) only for those soils with a soil pH less than 5.5. The technical basis for this procedure is that the soluble and toxic forms of aluminum are only present in soil under soil pH values of less than 5.5 (USEPA, 2003 - Ecological Soil Screening Level for Aluminum - Interim Final).
D - Sample results are obtained from a dilution; the surrogate or matrix spike recoveries reported are calculated from diluted samples.
J - Result is less than the Reporting Limit (RL) but greater than or equal to the Method Detection Limit (MDL) and the concentration is an approximate value.
B - Compound was found in the blank and sample.
p - The Relative Percent Difference (%RPD) between the primary and confirmation column/detector is >40%. The lower value has been reported.
U - Indicates the analyte was analyzed for but not detected.
HF - Field parameter with a holding time of 15 minutes.
mg/kg - Milligrams per kilogram.
ug/kg - Micrograms per kilogram.
NC - No criterion.

Italics = Compounds detected with no associated Ecological Screening Criteria with which to compare.
Bold = 1/2 the detection limit exceeds the Ecological Screening Criteria for a non-detected result.
Highlighted = Compounds detected equal to or above the Ecological Screening Criteria.

Table 5-6
Estimated COPEC Concentrations in Benthic Invertebrates and Fish (Site Sediment - Maximum Concentrations)
Red Bank Landfill Site
Red Bank, New Jersey

Analyte	Sediment Maximum Value (mg COPEC/kg sediment dw)	Sediment to Benthic Invertebrate/Fish BSAF (mg COPEC/kg tissue ww)/ (mg COPEC/kg sediment dw)[a]	BSAF Reference	log K_{ow}	log K_{ow} Reference	Calculated Concentration of Analyte in Benthic Invertebrates/Fish (mg COPEC/kg tissue ww)
SVOCs						
2,4-Dinitrophenol	**0.17**	log=0.819*log(Kow)-1.146	1a	1.52	1	1.9E-01
4-Nitrophenol	**0.050**	log=0.819*log(Kow)-1.146	1a	1.91	1	7.6E-02
Acenaphthene	0.025	0.00411	2	NA	NA	1.0E-04
Acetophenone	*0.021*	log=0.819*log(Kow)-1.146	1a	1.64	1	2.6E-02
Benzaldehyde	*0.21*	log=0.819*log(Kow)-1.146	1a	1.48	1	2.2E-01
Benzo(g,h,i)perylene	0.18	0.0164	2	NA	NA	3.0E-03
Carbazole	*0.028*	log=0.819*log(Kow)-1.146	1a	3.29	5	1.3E-01
Fluorene	0.029	0.0040	2	NA	NA	1.2E-04
Phenanthrene	0.27	0.0039	2	NA	NA	1.1E-03
Pesticides						
4,4'-DDD	0.0031	log=0.819*log(Kow)-1.146	1a	6.12	1	1.5E-01
4,4'-DDE	0.0027	0.95	1b	NA	NA	2.6E-03
4,4'-DDT	0.010	log=0.819*log(Kow)-1.146	1a	6.07	1	4.6E-01
Aldrin	0.0026	log=0.819*log(Kow)-1.146	1a	6.18	1	1.3E-01
alpha-Chlordane	*0.0030*	log=0.819*log(Kow)-1.146	1a	6.32	3	1.7E-01
delta-BHC	*0.0012*	log=0.819*log(Kow)-1.146	1a	4.14	4	1.1E-02
Dieldrin	0.0038	log=0.819*log(Kow)-1.146	1a	5.27	1	9.0E-02
Endosulfan I	*0.0024*	log=0.819*log(Kow)-1.146	1a	3.48	1	1.3E-02
Endosulfan II	*0.00053*	log=0.819*log(Kow)-1.146	1a	3.62	4	3.3E-03
Endrin	0.035	log=0.819*log(Kow)-1.146	1a	4.89	1	6.1E-01
Endrin Ketone	*0.0001*	log=0.819*log(Kow)-1.146	1a	4.99	4	1.9E-03
gamma-Chlordane	*0.017*	log=0.819*log(Kow)-1.146	1a	6.32	3	9.6E-01
Hepatachlor	0.00078	1.67	1b	NA	NA	1.3E-03
Hepatachlor epoxide	0.0038	log=0.819*log(Kow)-1.146	1a	4.75	1	5.9E-02
Toxaphene	**0.00215**	log=0.819*log(Kow)-1.146	1a	5.50	3	6.2E-02
PCBs						
Aroclor 1254	0.14	0.53	1b	NA	NA	7.4E-02
Aroclor 1260	0.011	log=0.819*log(Kow)-1.146	1a	6.80	4.00	9.2E-01
Total PCBs	0.14	0.0327	2	NA	NA	4.6E-03
Metals						
Antimony	*4.3*	0.90	1b	NA	NA	3.9E+00
Arsenic	49.1	0.90	1b	NA	NA	4.4E+01
Barium	*96.4*	0.90	1b	NA	NA	8.7E+01
Beryllium	*1.4*	0.90	1b	NA	NA	1.3E+00
Chromium	125	0.39	1b	NA	NA	4.9E+01
Copper	123	0.30	1b	NA	NA	3.7E+01
Lead	1,960	0.63	1b	NA	NA	1.2E+03
Nickel	50.8	0.90	1b	NA	NA	4.6E+01
Selenium	*2.6*	0.90	1b	NA	NA	2.3E+00
Thallium	*3.4*	0.90	1b	NA	NA	3.1E+00
Vanadium	*84.4*	0.0148	2	NA	NA	1.2E+00
Zinc	260	0.57	1b	NA	NA	1.5E+02

NOTES:
BAF = Bioaccumulation factor.
COPEC = Contaminant of Potential Ecological Concern.
mg/kg = milligrams per kilogram
dw = Dry weight.
ww = Wet weight.
a = Sediment to fish BSAFs were not available so sediment to benthic invertebrate BSAFs were used as surrogate values in order to be conservative.
1 = Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities. USEPA, 1999.
(a) Equation C-1-9.
(b) Sediment-to-benthic invertebrate bioconcentration factors
2 = Site Specific Human Health and Ecological Risk Assessment - Technical Study Report. Durham/York Residual Waste Study Report No. 1009497. July 31, 2009.
3 = Final Remedial Investigation Report Area of Concern (AOC) H Former Naval Ammunition Support Detachment, Vieques Island, Puerto Rico. CH2M Hill, July 2007.
4 = Toxicological Profiles. Agency for Toxic Substances and Disease Registry (ATSDR) Website. Available at: http://www.atsdr.cdc.gov/toxprofiles/index.asp.
5 = ChemSpider profile for carbazole. Royal Society of Chemistry Website.
Available at: http://www.chemspider.com/Chemical-Structure.6593.html?rid=2a400d19-83d6-4673-8dd8-1faec982e01e.

BOLD = Based entirely on 1/2 the detection limit exceeding the Ecological Screening Criteria for non-detected results.
Italics = Based on detected compounds with no associated Ecological Screening Criteria with which to compare.
Highlighted = Based on compounds detected equal to or above the Ecological Screening Criteria.

Table 5-7
Estimated COPEC Concentrations in Benthic Invertebrates and Fish (Upstream Sediment - Maximum Concentrations)
Red Bank Landfill Site
Red Bank, New Jersey

Analyte	Sediment Maximum Value (mg COPEC/kg sediment dw)	Sediment to Benthic Invertebrate/Fish BSAF (mg COPEC/kg tissue ww)/ (mg COPEC/kg sediment dw)[a]	BSAF Reference	log K_{ow}	log K_{ow} Reference	Calculated Concentration of Analyte in Benthic Invertebrates/Fish (mg COPEC/kg tissue ww)
SVOCs						
2,4-Dinitrophenol	**0.075**	log=0.819*log(Kow)-1.146	1a	1.52	1	8.3E-02
4-Nitrophenol	**0.023**	log=0.819*log(Kow)-1.146	1a	1.91	1	3.5E-02
Acenaphthene	**0.0012**	0.00411	2	NA	NA	4.9E-06
Acetophenone	**0.0050**	log=0.819*log(Kow)-1.146	1a	1.64	1	6.1E-03
Benzaldehyde	**0.0095**	log=0.819*log(Kow)-1.146	1a	1.48	1	1.0E-02
Benzo(g,h,i)perylene	0.018	0.0164	2	NA	NA	3.0E-04
Carbazole	*0.0042*	log=0.819*log(Kow)-1.146	1a	3.29	5	2.0E-02
Fluorene	0.0038	0.0040	2	NA	NA	1.5E-05
Phenanthrene	0.035	0.0039	2	NA	NA	1.4E-04
Pesticides						
4,4'-DDD	**0.000021**	log=0.819*log(Kow)-1.146	1a	6.12	1	9.8E-04
4,4'-DDE	0.00025	0.95	1b	NA	NA	2.4E-04
4,4'-DDT	0.00018	log=0.819*log(Kow)-1.146	1a	6.07	1	8.2E-03
Aldrin	**0.000028**	log=0.819*log(Kow)-1.146	1a	6.18	1	1.4E-03
alpha-Chlordane	*0.00055*	log=0.819*log(Kow)-1.146	1a	6.32	3	3.1E-02
delta-BHC	**0.000024**	log=0.819*log(Kow)-1.146	1a	4.14	4	2.3E-04
Dieldrin	0.00011	log=0.819*log(Kow)-1.146	1a	5.27	1	2.6E-03
Endosulfan I	**0.000030**	log=0.819*log(Kow)-1.146	1a	3.48	1	1.6E-04
Endosulfan II	**0.000028**	log=0.819*log(Kow)-1.146	1a	3.62	4	1.7E-04
Endrin	0.000087	log=0.819*log(Kow)-1.146	1a	4.89	1	1.5E-03
Endrin Ketone	**0.000025**	log=0.819*log(Kow)-1.146	1a	4.99	4	4.6E-04
gamma-Chlordane	*0.00041*	log=0.819*log(Kow)-1.146	1a	6.32	3	2.3E-02
Hepatachlor	0.000089	1.67	1b	NA	NA	1.5E-04
Hepatachlor epoxide	**0.000031**	log=0.819*log(Kow)-1.146	1a	4.75	1	4.7E-04
Toxaphene	**0.0011**	log=0.819*log(Kow)-1.146	1a	5.50	3	3.0E-02
PCBs						
Aroclor 1254	**0.00022**	0.53	1b	NA	NA	1.2E-04
Aroclor 1260	0.0039	log=0.819*log(Kow)-1.146	1a	6.80	4.00	3.3E-01
Total PCBs	0.0039	0.0327	2	NA	NA	1.3E-04
Metals						
Antimony	*0.18*	0.90	1b	NA	NA	1.6E-01
Arsenic	24.9	0.90	1b	NA	NA	2.2E+01
Barium	*12.3*	0.90	1b	NA	NA	1.1E+01
Beryllium	*0.50*	0.90	1b	NA	NA	4.5E-01
Chromium	22.8	0.39	1b	NA	NA	8.9E+00
Copper	6.0	0.30	1b	NA	NA	1.8E+00
Lead	13.2	0.63	1b	NA	NA	8.3E+00
Nickel	6.3	0.90	1b	NA	NA	5.7E+00
Selenium	*0.82*	0.90	1b	NA	NA	7.4E-01
Thallium	*1.7*	0.90	1b	NA	NA	1.5E+00
Vanadium	*27.5*	0.0148	2	NA	NA	4.1E-01
Zinc	63	0.57	1b	NA	NA	3.6E+01

NOTES:
BSAF = Biota-Sediment Accumulation Factor.
COPEC = Contaminant of Potential Ecological Concern.
mg/kg = milligrams per kilogram
dw = Dry weight.
ww = Wet weight.
a = Sediment to fish BSAFs were not available so sediment to benthic invertebrate BSAFs were used as surrogate values in order to be conservative.
1 = Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities. USEPA, 1999.
(a) Equation C-1-9.
(b) Sediment-to-benthic invertebrate bioconcentration factors
2 = Site Specific Human Health and Ecological Risk Assessment - Technical Study Report. Durham/York Residual Waste Study Report No. 1009497. July 31, 2009.
3 = Final Remedial Investigation Report Area of Concern (AOC) H Former Naval Ammunition Support Detachment, Vieques Island, Puerto Rico. CH2M Hill, July 2007.
4 = Toxicological Profiles. Agency for Toxic Substances and Disease Registry (ATSDR) Website. Available at: http://www.atsdr.cdc.gov/toxprofiles/index.asp.
5 = ChemSpider profile for carbazole. Royal Society of Chemisty Website.
Available at: http://www.chemspider.com/Chemical-Structure.6593.html?rid=2a400d19-83d6-4673-8dd8-1faec982e01e.

Italics = Based on a detected concentration with no associated Ecological Screening Criteria with which to compare.
Bold = Based on 1/2 the detection limit for a non-detected concentration.
Underlined = Based on a detected concentration below the associated Ecological Screening Criteria.
Highlighted = Based on a detected concentration equal to or above the Ecological Screening Criteria.

Table 5-8
Estimated COPEC Concentrations in Benthic Invertebrates and Fish (Downstream Sediment - Maximum Concentrations)
Red Bank Landfill Site
Red Bank, New Jersey

Analyte	Sediment Maximum Value (mg COPEC/kg sediment dw)	Sediment to Benthic Invertebrate/Fish BSAF (mg COPEC/kg tissue ww)/ (mg COPEC/kg sediment dw)[a]	BSAF Reference	log K_{ow}	log K_{ow} Reference	Calculated Concentration of Analyte in Benthic Invertebrates/Fish (mg COPEC/kg tissue ww)
SVOCs						
2,4-Dinitrophenol	**0.065**	log=0.819*log(Kow)-1.146	1a	1.52	1	7.2E-02
4-Nitrophenol	**0.020**	log=0.819*log(Kow)-1.146	1a	1.91	1	3.0E-02
Acenaphthene	0.0061	0.00411	2	NA	NA	2.5E-05
Acetophenone	*0.0039*	log=0.819*log(Kow)-1.146	1a	1.64	1	4.8E-03
Benzaldehyde	**0.0080**	log=0.819*log(Kow)-1.146	1a	1.48	1	8.5E-03
Benzo(g,h,i)perylene	0.079	0.0164	2	NA	NA	1.3E-03
Carbazole	**0.0010**	log=0.819*log(Kow)-1.146	1a	3.29	5	4.7E-03
Fluorene	0.011	0.0040	2	NA	NA	4.4E-05
Phenanthrene	0.13	0.0039	2	NA	NA	5.1E-04
Pesticides						
4,4'-DDD	0.00034	log=0.819*log(Kow)-1.146	1a	6.12	1	1.6E-02
4,4'-DDE	0.00038	0.95	1b	NA	NA	3.6E-04
4,4'-DDT	**0.000022**	log=0.819*log(Kow)-1.146	1a	6.07	1	1.0E-03
Aldrin	**0.000027**	log=0.819*log(Kow)-1.146	1a	6.18	1	1.3E-03
alpha-Chlordane	*0.00035*	log=0.819*log(Kow)-1.146	1a	6.32	3	2.0E-02
delta-BHC	**0.000023**	log=0.819*log(Kow)-1.146	1a	4.14	4	2.1E-04
Dieldrin	0.00013	log=0.819*log(Kow)-1.146	1a	5.27	1	3.1E-03
Endosulfan I	**0.000028**	log=0.819*log(Kow)-1.146	1a	3.48	1	1.5E-04
Endosulfan II	**0.000026**	log=0.819*log(Kow)-1.146	1a	3.62	4	1.6E-04
Endrin	0.00018	log=0.819*log(Kow)-1.146	1a	4.89	1	3.1E-03
Endrin Ketone	**0.000023**	log=0.819*log(Kow)-1.146	1a	4.99	4	4.4E-04
gamma-Chlordane	*0.00046*	log=0.819*log(Kow)-1.146	1a	6.32	3	2.6E-02
Hepatachlor	**0.000033**	1.67	1b	NA	NA	5.4E-05
Hepatachlor epoxide	0.000066	log=0.819*log(Kow)-1.146	1a	4.75	1	1.0E-03
Toxaphene	**0.0010**	log=0.819*log(Kow)-1.146	1a	5.50	3	2.9E-02
PCBs						
Aroclor 1254	0.0056	0.53	1b	NA	NA	3.0E-03
Aroclor 1260	**0.00021**	log=0.819*log(Kow)-1.146	1a	6.80	4.00	1.8E-02
Total PCBs	0.0056	0.0327	2	NA	NA	1.8E-04
Metals						
Antimony	*0.32*	0.90	1b	NA	NA	2.9E-01
Arsenic	13.8	0.90	1b	NA	NA	1.2E+01
Barium	*5.5*	0.90	1b	NA	NA	5.0E+00
Beryllium	*0.48*	0.90	1b	NA	NA	4.3E-01
Chromium	22.3	0.39	1b	NA	NA	8.7E+00
Copper	7.0	0.30	1b	NA	NA	2.1E+00
Lead	21.1	0.63	1b	NA	NA	1.3E+01
Nickel	6.3	0.90	1b	NA	NA	5.7E+00
Selenium	*0.31*	0.90	1b	NA	NA	2.8E-01
Thallium	*0.86*	0.90	1b	NA	NA	7.7E-01
Vanadium	*24.4*	0.0148	2	NA	NA	3.6E-01
Zinc	70.8	0.57	1b	NA	NA	4.0E+01

NOTES:
BSAF = Biota-Sediment Accumulation Factor.
COPEC = Contaminant of Potential Ecological Concern.
mg/kg = milligrams per kilogram
dw = Dry weight.
ww = Wet weight.
a = Sediment to fish BSAFs were not available so sediment to benthic invertebrate BSAFs were used as surrogate values in order to be conservative.
1 = Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities. USEPA, 1999.
(a) Equation C-1-9.
(b) Sediment-to-benthic invertebrate bioconcentration factors
2 = Site Specific Human Health and Ecological Risk Assessment - Technical Study Report. Durham/York Residual Waste Study Report No. 1009497. July 31, 2009.
3 = Final Remedial Investigation Report Area of Concern (AOC) H Former Naval Ammunition Support Detachment, Vieques Island, Puerto Rico. CH2M Hill, July 2007.
4 = Toxicological Profiles. Agency for Toxic Substances and Disease Registry (ATSDR) Website. Available at: http://www.atsdr.cdc.gov/toxprofiles/index.asp.
5 = ChemSpider profile for carbazole. Royal Society of Chemisty Website.
Available at: http://www.chemspider.com/Chemical-Structure.6593.html?rid=2a400d19-83d6-4673-8dd8-1faec982e01e.

Italics = Based on a detected concentration with no associated Ecological Screening Criteria with which to compare.
Bold = Based on 1/2 the detection limit for a non-detected concentration.
Underlined = Based on a detected concentration below the associated Ecological Screening Criteria.
Highlighted = Based on a detected concentration equal to or above the Ecological Screening Criteria.

Table 5-9
Estimated COPEC Concentrations in Earthworm Tissue (Site Soil - Maximum Concentrations)
Red Bank Landfill Site
Red Bank, New Jersey

Analyte	Soil Maximum Value (mg COPEC/kg soil dw)	Soil to Invertebrate BAF (mg COPEC/kg tissue)/ (mg COPEC/kg soil dw)	BAF Reference	Calculated Concentration of Analyte in Soil Invertebrate (mg COPEC/kg tissue dw)	Dry Weight to Wet Weight Conversion[c]	Calculated Concentration of Analyte in Soil Invertebrate (mg COPEC/kg tissue ww)
SVOCs						
2,4-Dimethylphenol	**0.075**	1.0	3	NA	NA	0.075
2,4-Dinitrophenol	**0.55**	1.0	3	NA	NA	0.55
Acetophenone	*0.012*	1.0	3	NA	NA	0.012
Benzaldehyde	*0.19*	1.0	3	NA	NA	0.19
Carbazole	*0.081*	1.0	3	NA	NA	0.081
Dibenzofuran	*0.01*	1.0	3	NA	NA	0.010
Pesticides						
4,4'-DDT	0.030	11.2	1b	0.34	=(0.34 x 16)/100	0.054
alpha-Chlordane	*0.037*	1.0	3	NA	NA	0.037
delta-BHC	*0.00027*	1.0	3	NA	NA	0.00027
Dieldrin	0.019	14.7	1b	0.28	=(0.28 x 16)/100	0.045
Endosulfan II	*0.0013*	1.0	3	NA	NA	0.0013
Endrin Ketone	*0.00028*	1.0	3	NA	NA	0.00028
gamma-Chlordane	*0.051*	1.0	3	NA	NA	0.051
PCBs						
Aroclor 1254	*0.11*	1.13	2	NA	NA	0.12
Total PCBs	0.11	1.0	3	NA	NA	0.11
Metals						
Antimony	1.8	1.0	1b	1.8	=(1.8 x 16)/100	0.29
Arsenic	25.2	ln=0.706*ln(Cs)-1.421	1b	2.4	=(2.4 x 16)/100	0.38
Cadmium	1.5	ln=0.795*ln(Cs)+2.114	1b	11	=(11 x 16)/100	1.8
Chromium	178	0.306	1b	54	=(54 x 16)/100	8.7
Cobalt	10.1	0.122	1b	1.2	=(1.2 x 16)/100	0.20
Copper	48.1	0.515	1b	25	=(25 x 16)/100	4.0
Lead	209	ln=0.807*ln(Cs)-0.218	1b	60	=(60 x 16)/100	9.6
Manganese	224	ln=0.682*ln(Cs)-0.809	1b	18	=(18 x 16)/100	2.9
Mercury[a]	0.19	(8.5*3%Cs) + (0.04*97%Cs)	2	NA	NA	0.056
Nickel	25.3	0.020	2	NA	NA	0.51
Selenium	1.4	ln=0.733*ln(Cs)-0.075	1b	1.2	=(1.2 x 16)/100	0.19
Thallium	4.8	0.22	2	NA	NA	1.1
Vanadium	334	0.042	1b	14	=(14 x 16)/100	2.2
Zinc	218	ln=0.328*ln(Cs)+4.449	1b	500	=(500 x 16)/100	80

NOTES:
BAF = Bioaccumulation factor.
ln = Natural log.
Cs = Concentration in soil.
COPEC = Contaminant of Potential Ecological Concern.
a = Based on 97% inorganic mercury compounds and 3% methyl mercury in soil as per USEPA Mercury Study Report to Congress, Volume III: Fate and Transport of Mercury in the Environment. USEPA, 1997.
b = BAF based on milligrams (mg) of COPEC per kilogram (kg) of dry weight of an earthworm. Earthworms are considered to be made up of 84% water (USEPA, 2007).
c = The calculation used for conversion of the concentration of a COPEC in earthworms based on a dry weight to a concentration based on a wet weight was:

$Cs_{ww} = (Cs_{dw} * \%\ solids)/100$

Where: Cs = Concentration in soil
dw = Dry weight
ww = Wet weight
% solids = 100 - % water makeup of earthworms (e.g. 100 - 84 = 16)

1 = United States Environmental Protection Agency (USEPA) Ecological Soil Screening Levels (Eco-SSLs). Guidance for Developing EcoSSLs. Attachment 4-1. Exposure Factors and Bioaccumulation Models for Derivation of Wildlife EcoSSLs. USEPA. 2007.
2 = Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities. Soil-to-soil invertebrate bioconcentration factors. USEPA 1999.
3 = Default value of 1 used because no data were identified in the literature.

BOLD = Based entirely on 1/2 the detection limit exceeding the Ecological Screening Criteria for non-detected results.
Italics = Based on detected compounds with no associated Ecological Screening Criteria with which to compare.
Highlighted = Based on compounds detected equal to or above the Ecological Screening Criteria.

Table 5-10
Estimated COPEC Concentrations in White-Footed Mice (Site Soil - Maximum Concentrations)
Red Bank Landfill Site
Red Bank, New Jersey

Analyte	Soil Maximum Value (mg COPEC/kg soil dw)	Soil to WFM BCF (mg COPEC/kg tissue ww)/ (mg COPEC/kg soil dw)	BAF Reference	Calculated Concentration of Analyte in WFM (mg COPEC/kg tissue ww)
SVOCs				
2,4-Dimethylphenol	**0.075**	1.0	2	0.075
2,4-Dinitrophenol	**0.55**	1.0	2	0.55
Acetophenone	*0.012*	1.0	2	0.012
Benzaldehyde	*0.19*	1.0	2	0.19
Carbazole	*0.081*	1.0	2	0.081
Dibenzofuran	*0.01*	1.0	2	0.010
Pesticides				
4,4'-DDT	0.030	0.000122	1b	0.0000037
alpha-Chlordane	*0.037*	1.0	2	0.037
delta-BHC	*0.00027*	1.0	2	0.00027
Dieldrin	0.019	1.0	2	0.019
Endosulfan II	*0.0013*	1.0	2	0.001
Endrin Ketone	*0.00028*	1.0	2	0.000
gamma-Chlordane	*0.051*	1.0	2	0.051
PCBs				
Aroclor 1254	*0.11*	0.000109	1	0.000012
Total PCBs	0.11	0.000109	1c	0.11
Metals				
Antimony	1.8	0.0000027	1	0.0000049
Arsenic	25.2	0.0000054	1	0.00014
Cadmium	1.5	0.000000324	1	0.00000049
Chromium	178	0.0000149	1	0.0027
Cobalt	10.1	1.0	2	10
Copper	48.1	1.0	2	48
Lead	209	0.000000811	1	0.00017
Manganese	224	1.0	2	224
Mercury[a]	0.19	(0.00000211*3%Cs) + (0.0000141*97%Cs)	1	0.0000026
Nickel	25.3	0.0000162	1	0.00041
Selenium	1.4	0.00000613	1	0.0000086
Thallium	4.8	0.000108	1	0.00052
Vanadium	334	1.0	2	334
Zinc	218	0.000000243	1	0.000053

NOTES:
BAF = Bioaccumulation factor.
WFM = White footed mouse.
COPEC = Contaminant of Potential Ecological Concern.
dw = Dry weight.
ww = Wet weight.
mg/kg = Milligrams per kilogram.
Cs = Concentration in soil.
a = Based on 97% inorganic mercury compounds and 3% methyl mercury in soil as per USEPA Mercury Study Report to Congress, Volume III: Fate and Transport of Mercury in the Environment. USEPA, 1997.
b = Based 4,4-DDE.
c = Based on Aroclor 1254.
1 = Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities.
Soil-to-soil invertebrate bioconcentration factors. USEPA 1999.
2 = Default value of 1 used because no data were identified in the literature.

BOLD = Based entirely on 1/2 the detection limit exceeding the Ecological Screening Criteria for non-detected results.
Italics = Based on detected compounds with no associated Ecological Screening Criteria with which to compare.
Highlighted = Based on compounds detected equal to or above the Ecological Screening Criteria.

Table 5-11. *Leptocheirus plumulosus* Toxicity Test Results
Red Bank Landfill Site
Red Bank, New Jersey

	Mean Survival (%)	Significantly Different from Laboratory Control	Significantly Different from UPREF-SED2	Significantly Different from DNREF-SED2
Lab Control	98	NA	NO	NO
UPREF-SED2	92	NO	NA	NO
DNREF-SED2	95	NO	NO	NA
SED-1C	99	NO	NO	NO
SED-3C	98	NO	NO	NO
SED-5C	76	YES	YES	YES

Light gray shaded cells were not included in comparisons for that column
Light yellow shaded cells indicate significant difference from lab control and reference locations
% = percent

Table 5-12
Mammalian and Avian NOAEL TRVs
Red Bank Landfill Site
Red Bank, New Jersey

					Derived NOAEL						Derived NOAEL				
Chemical	Mammalian Test Species	Test Species Chronic NOAEL (mg/kg-d)	Note	Uncertainty Factor (o)	Short Tailed Shrew NOAEL (mg/kg-d)	Raccoon NOAEL (mg/kg-d)	AvianTest Species	Test Species Chronic NOAEL (mg/kg-d)	Note	Uncertainty Factor (o)	Bald Eagle NOAEL (mg/kg-d)	Great Blue Heron NOAEL (mg/kg-d)	Spotted Sandpiper NOAEL (mg/kg-d)	Mallard NOAEL (mg/kg-d)	American Robin NOAEL (mg/kg-d)
Semi-Volatile Organic Compounds (SVOCs)															
2,4-Dimethylphenol	Mouse	50	k, l	10	5.0	5.0	Various	1.6	z		1.6	1.6	1.6	1.6	1.6
2,4-Dinitrophenol	Rat	20	n, o		20	20	Various	1.6	z		1.6	1.6	1.6	1.6	1.6
4-Nitrophenol	Various	118.02	n, g, l	10	12	12	Quail	159	w, l	10	16	16	16	16	16
Acenaphthene	Rat	66	a, c		66	66	Quail	19	v		19	19	19	19	19
Acetophenone	Rat	423	k, l	10	42	42	Various	1.6	z		1.6	1.6	1.6	1.6	1.6
Benzaldehyde	Rat	143	k, l	10	14	14	Various	1.6	z		1.6	1.6	1.6	1.6	1.6
Benzo(ghi)perylene	Mouse	0.62	a, d		0.62	0.62	Chicken egg	2.0	w, l	10	0.20	0.20	0.20	0.20	0.20
Carbazole	Rat	500	t, l, u	100	5.0	5.0	Various	1.6	z		1.6	1.6	1.6	1.6	1.6
Dibenzofuran	Dog	2.0	k		2.0	2.0	Blackbird	6.3	v		6.3	6.3	6.3	6.3	6.3
Fluorene	Rat	66	a, c		66	66	Chicken egg	2.0	w, l	10	0.20	0.20	0.20	0.20	0.20
Phenanthrene	Rat	66	a, c		66	66	Chicken egg	2.0	w, l	10	0.20	0.20	0.20	0.20	0.20
Pesticides															
4,4'-DDD	Rat	0.15	a		0.15	0.15	Chicken	0.23	a		0.23	0.23	0.23	0.23	0.23
4,4'-DDE	Rat	0.15	a		0.15	0.15	Chicken	0.23	a		0.23	0.23	0.23	0.23	0.23
4,4'-DDT	Rat	0.15	a		0.15	0.15	Chicken	0.23	a		0.23	0.23	0.23	0.23	0.23
Aldrin	Rat	0.20	e		0.20	0.20	Mallard	5.0	w, l, u	100	0.050	0.050	0.050	0.050	0.050
alpha-Chlordane	Mouse	4.6	e, i		4.6	4.6	Blackbird	2.1	e, i		2.1	2.1	2.1	2.1	2.1
delta-BHC	Various	0.15	e, g, h		0.15	0.15	Quail	0.56	e		0.56	0.56	0.56	0.56	0.56
Dieldrin	Rat	0.015	a		0.015	0.015	Mallard	0.071	a		0.071	0.071	0.071	0.071	0.071
Endosulfan-I	Rat	0.15	e, j		0.15	0.15	Partridge	10	e, j		10	10	10	10	10
Endosulfan-II	Rat	0.15	e, j		0.15	0.15	Partridge	10	e, j		10	10	10	10	10
Endrin	Mouse	0.092	e		0.092	0.092	Owl	0.010	e		0.010	0.010	0.010	0.010	0.010
Endrin Ketone	Mouse	0.092	e, r		0.092	0.092	Owl	0.010	e, r		0.010	0.010	0.010	0.010	0.010
gamma-Chlordane	Mouse	4.6	e, i		4.6	4.6	Blackbird	2.1	e, i		2.1	2.1	2.1	2.1	2.1
Heptachlor	Mink	0.10	e		0.10	0.10	Quail	65	m		65	65	65	65	65
Heptachlor epoxide	Mink	0.10	e, p		0.10	0.10	Quail	65	m, y		65	65	65	65	65
Toxaphene	Rat	8.0	e		8.0	8.0	Various	0.68	aa		0.68	0.68	0.68	0.68	0.68
Polychlorinated Biphenyls (PCBs)															
Aroclor 1254	Various	0.098	e, g		0.098	0.098	Pheasant	0.18	e		0.18	0.18	0.18	0.18	0.18
Aroclor 1260	Rat	5.0	n, q		5.0	5.0	Pheasant	0.18	e, s		0.18	0.18	0.18	0.18	0.18
Total PCBs	Various	0.098	e, s		0.098	0.098	Pheasant	0.18	e, s		0.18	0.18	0.18	0.18	0.18
Metals															
Antimony	Rat	0.059	a		0.059	0.059	Quail	490	v		490	490	490	490	490
Arsenic	Dog	1.0	a		1.0	1.0	Chicken	2.2	a		2.2	2.2	2.2	2.2	2.2
Barium	Various	52	a		52	52	One day old chick	21	m		21	21	21	21	21
Beryllium	Rat	0.53	a		0.53	0.53	Various	3.9	bb		3.9	3.9	3.9	3.9	3.9
Cadmium	Rat	0.77	a		0.77	0.77	Various	1.5	a		1.5	1.5	1.5	1.5	1.5
Chromium	Various	2.4	a, b		2.4	2.4	Various	2.7	a, b		2.7	2.7	2.7	2.7	2.7
Cobalt	Various	7.3	a		7.3	7.3	Various	7.6	a		7.6	7.6	7.6	7.6	7.6
Copper	Pig	5.6	a		5.6	5.6	Chicken	4.1	a		4.1	4.1	4.1	4.1	4.1
Lead	Rat	4.7	a		4.7	4.7	Chicken	1.6	a		1.6	1.6	1.6	1.6	1.6
Manganese	Various	52	a		52	52	Various	179	a		179	179	179	179	179
Mercury	Mink	0.015	e, f		0.015	0.015	Various	0.054	e, g		0.054	0.054	0.054	0.054	0.054
Nickel	Mouse	1.7	a		1.7	1.7	Various	6.7	a		6.7	6.7	6.7	6.7	6.7
Selenium	Pig	0.14	a		0.14	0.14	Chicken	0.29	a		0.29	0.29	0.29	0.29	0.29
Thallium	Rat	0.0074	e		0.0074	0.0074	Starling	0.35	m		0.35	0.35	0.35	0.35	0.35
Vanadium	Mouse	4.2	a		4.2	4.2	Chicken	0.34	a		0.34	0.34	0.34	0.34	0.34
Zinc	Various	75	a		75	75	Various	66	a		66	66	66	66	66

NOTES:
(a) - USEPA, 2010.
(b) - Based on trivalent chromium.
(c) - Based on low molecular weight polycyclic aromatic hydrocarbons (PAHs).
(d) - Based on high molecular weight PAHs.
(e) - Sample *et al.,* 1996.
(f) - Based on highest bounded NOAEL lower than the lowest bounded LOAEL.
(g) - Based on geometric mean of NOAELs.
(h) - Based on BHC-mixed isomers.
(i) - Based on chlordane.
(j) - Based on endosulfan.
(k) - USEPA, 2014a.
(l) - Chronic value based on a subchronic/acute study divided by an uncertainty factor of 10.
(m) - USEPA, 1999.
(n) - ATSDR, 2012.
(o) - Based on dinitrophenols bounded chronic NOAEL.
(p) - Based on heptachlor.
(q) - Based on average of male and female NOAEL results for reproductive study.
(r) - Based on endrin.
(s) - Based on Aroclor 1254.
(t) - SCB, 2008.
(u) - NOAEL based on a LOAEL divided by an uncertainty factor of 10.
(v) - SAIC, 2001.
(w) - USEPA, 2014b.
(x) - Based on the lowest bounded NOEL.
(y) - Based on heptachlor.
(z) - Based on geometric mean of SVOC NOAELs.
(aa) - Based on geometric mean of pesticide NOAELs.
(bb) - Based on geometric mean of metal NOAELs.

Table 5-13
Mammalian and Avian LOAEL TRVs
Red Bank Landfill Site
Red Bank, New Jersey

					Derived LOAEL						Derived LOAEL				
Chemical	Mammalian Test Species	Test Species Chronic LOAEL (mg/kg-d)	Note	Uncertainty Factor (o)	Short Tailed Shrew LOAEL (mg/kg-d)	Raccoon LOAEL (mg/kg-d)	AvianTest Species	Test Species Chronic LOAEL (mg/kg-d)	Note	Uncertainty Factor (o)	Bald Eagle LOAEL (mg/kg-d)	Great Blue Heron LOAEL (mg/kg-d)	Spotted Sandpiper LOAEL (mg/kg-d)	Mallard LOAEL (mg/kg-d)	American Robin LOAEL (mg/kg-d)
Semi-Volatile Organic Compounds (SVOCs)															
2,4-Dimethylphenol	Mouse	250	l, m	10	25	25	Various	16	y		16	16	16	16	16
2,4-Dinitrophenol	Rat	30	p, q		30	30	Various	16	y		16	16	16	16	16
4-Nitrophenol	Various	284	p, g, m	10	28.41	28.41	Quail	159	w, m, k	10, 10	159	159	159	159	159
Acenaphthene	Various	356	a, c		356	356	Quail	19	v, k		194	194	194	194	194
Acetophenone	Rat	423	l, m, k	10, 10	423	423	Various	16	y		16	16	16	16	16
Benzaldehyde	Rat	400	l, m	10	40	40	Various	16	y		16	16	16	16	16
Benzo(ghi)perylene	Various	38	a, d		38	38	Chicken egg	2.0	w, m, k	10, 10	2.0	2.0	2.0	2.0	2.0
Carbazole	Rat	500	u, m	10	50	50	Various	16	y		16	16	16	16	16
Dibenzofuran	Dog	10	l		10	10	Blackbird	6.3	v, k	10, 10	63	63	63	63	63
Fluorene	Various	356	a, c		356	356	Chicken egg	2.0	w, m, k	10, 10	2.0	2.0	2.0	2.0	2.0
Phenanthrene	Various	356	a, c		356	356	Chicken egg	2.0	w, m, k	10, 10	2.0	2.0	2.0	2.0	2.0
Pesticides															
4,4'-DDD	Various	5.6	a		5.6	5.6	Various	2.7	a		2.7	2.7	2.7	2.7	2.7
4,4'-DDE	Various	5.6	a		5.6	5.6	Various	2.7	a		2.7	2.7	2.7	2.7	2.7
4,4'-DDT	Various	5.6	a		5.6	5.6	Various	2.7	a		2.7	2.7	2.7	2.7	2.7
Aldrin	Rat	1.0	e		1.0	1.0	Mallard	5.0	w, m	10	0.50	0.50	0.50	0.50	0.50
alpha-Chlordane	Mouse	9.2	e, i		9.2	9.2	Blackbird	11	e, i		11	11	11	11	11
delta-BHC	Various	0.67	e, g, h		0.67	0.67	Quail	2.3	e		2.3	2.3	2.3	2.3	2.3
Dieldrin	Various	1.3	a		1.3	1.3	Various	0.80	a		0.80	0.80	0.80	0.80	0.80
Endosulfan-I	Rat	0.15	e, j, k	10	1.5	1.5	Partridge	100	e, j, k	10	100	100	100	100	100
Endosulfan-II	Rat	0.15	e, j, k	10	1.5	1.5	Partridge	100	e, j, k	10	100	100	100	100	100
Endrin	Mouse	0.92	e		0.92	0.92	Owl	0.10	e		0.10	0.10	0.10	0.10	0.10
Endrin Ketone	Mouse	0.92	e, s		0.92	0.92	Owl	0.10	e, s		0.10	0.10	0.10	0.10	0.10
gamma-Chlordane	Mouse	9.2	e, i		9.2	9.2	Blackbird	11	e, i		11	11	11	11	11
Heptachlor	Mink	1.0	e		1.0	1.0	Quail	65	n, k	10	650	650	650	650	650
Heptachlor epoxide	Mink	1.0	e, r		1.0	1.0	Quail	65	n, k, x	10	650	650	650	650	650
Toxaphene	Rat	8.0	e, k	10	80	80	Various	6.0	z		6.0	6.0	6.0	6.0	6.0
Polychlorinated Biphenyls (PCBs)															
Aroclor 1254	Various	0.68	e, g		0.68	0.68	Pheasant	1.8	e		1.8	1.8	1.8	1.8	1.8
Aroclor 1260	Rat	5.0	p, k		50	50	Pheasant	1.8	e, t		1.8	1.8	1.8	1.8	1.8
Total PCBs	Various	0.68	e, t		0.68	0.68	Pheasant	1.8	e, t		1.8	1.8	1.8	1.8	1.8
Metals															
Antimony	Various	2.8	a		2.8	2.8	Quail	490	v, k	10	4,900	4,900	4,900	4,900	4,900
Arsenic	Various	5.7	a		5.7	5.7	Various	4.5	a		4.5	4.5	4.5	4.5	4.5
Barium	Various	83	a		83	83	One day old chick	21	n, k	10	208	208	208	208	208
Beryllium	Various	0.67	a		0.67	0.67	Various	19	aa		19	19	19	19	19
Cadmium	Various	6.9	a		6.9	6.9	Various	6.3	a		6.3	6.3	6.3	6.3	6.3
Chromium	Various	58	a, b		58	58	Various	16	a, b		16	16	16	16	16
Cobalt	Various	19	a		19	19	Various	18	a		18	18	18	18	18
Copper	Various	83	a		83	83	Various	35	a		35	35	35	35	35
Lead	Various	186	a		186	186	Various	45	a		45	45	45	45	45
Manganese	Various	146	a		146	146	Various	377	a		377	377	377	377	377
Mercury	Rat	0.16	e, f		0.16	0.16	Various	0.24	e, g		0.24	0.24	0.24	0.24	0.24
Nickel	Various	15	a		15	15	Various	19	a		19	19	19	19	19
Selenium	Various	0.66	a		0.66	0.66	Various	0.82	a		0.82	0.82	0.82	0.82	0.82
Thallium	Rat	0.074	e		0.074	0.074	Starling	0.35	n, k	10	3.5	3.5	3.5	3.5	3.5
Vanadium	Various	9.4	a		9.4	9.4	Various	1.7	a		1.7	1.7	1.7	1.7	1.7
Zinc	Various	298	a		298	298	Various	171	a		171	171	171	171	171

NOTES:
(a) - USEPA, 2010 (Geometric mean of growth and reproduction LOAELs)
(b) - Based on trivalent chromium.
(c) - Based on low molecular weight polycyclic aromatic hydrocarbons (PAHs).
(d) - Based on high molecular weight PAHs.
(e) - Sample *et al.,* 1996.
(f) - Based on lowest bounded LOAEL higher than the derived NOAEL.
(g) - Based on geometric mean of LOAELs.
(h) - Based on BHC-mixed isomers.
(i) - Based on chlordane.
(j) - Based on endosulfan.
(k) - LOAEL based on a NOAEL multiplied by an uncertainty factor of 10.
(l) - USEPA, 2014a.
(m) - Chronic value based on a subchronic/acute study divided by an uncertainty factor of 10.
(n) - USEPA, 1999.
(o) - SRSERD, 1999
(p) - ATSDR, 2012.
(q) - Based on dinitrophenols bounded chronic LOAEL.
(r) - Based on heptachlor.
(s) - Based on endrin.
(t) - Based on Aroclor 1254.
(u) - SCB, 2008.
(v) - SAIC, 2001.
(w) - USEPA, 2014b.
(x) - Based on heptachlor.
(y) - Based on geometric mean of SVOC LOAELs.
(z) - Based on geometric mean of pesticide LOAELs.
(aa) - Based on geometric mean of metal LOAELs.

Table 6-1
Sediment Maximum Concentrations - Site versus Upstream Benthic Invertebrate and Fish HQs
Red Bank Landfill Site
Red Bank, New Jersey

Sediment COPECs	NJDEP Saline Sediment ESC: Effects Range - Low	Site Maximum Concentration (mg/kg)	Location	Site Maximum HQ	Upstream Maximum Concentration (mg/kg)	Location	Upstream Maximum HQ	Downstream Maximum Concentration (mg/kg)	Location	Downstream Maximum HQ
SVOCs										
2,4-Dinitrophenol	0.00621**	0.17	SED-3D	27.4	0.075	UPREF-SED3	12.1	0.065	DNREF-SED1	10.5
4-Nitrophenol	0.0133**	0.050	SED-3D	3.8	0.023	UPREF-SED3	1.7	0.006	DNREF-SED1	0.45
Acenaphthene	0.016	0.025	SED-3D	1.6	0.0012	UPREF-SED3	0.08	0.003	DNREF-SED1	0.19
Acetophenone	NC	0.021	SED-1A	NA	0.005	UPREF-SED3	NA	0.0039	DNREF-SED1	NA
Benzaldehyde	NC	0.21	SED-5A	NA	NA	NA	NA	0.008	DNREF-SED1	NA
Benzo(g,h,i)perylene	0.017**	0.18	SED-1D	10.6	0.018	UPREF-SED3	1	0.079	DNREF-SED1	2.9
Carbazole	NC	0.028	SED-3D	NA	0.0042	UPREF-SED3	NA	0.001	DNREF-SED1	NA
Fluorene	0.019	0.029	SED-3D	1.5	0.0038	UPREF-SED2	0.2	0.011	DNREF-SED1	0.6
Phenanthrene	0.24	0.27	SED-3D	1.1	0.035	UPREF-SED2	0.1	0.13	DNREF-SED1	0.5
Pesticides										
4,4'-DDD	0.002	0.0031	SED-3A	1.5	0.00002	UPREF-SED3	0.01	0.00034	DNREF-SED1	0.17
4,4'-DDE	0.0022	0.0027	SED-3B	1.2	0.00025	UPREF-SED3	0.1	0.00038	DNREF-SED1	0.17
4,4'-DDT	0.001	0.010	SED-5B	10	0.00018	UPREF-SED3	0.2	0.000022	DNREF-SED2	0.02
Aldrin	0.002**	0.0026	SED-5B	1.3	0.000025	UPREF-SED3	0.01	0.000026	DNREF-SED2	0.01
alpha-Chlordane	NC	0.0030	SED-3A	NA	0.00025	UPREF-SED3	NA	0.00035	DNREF-SED1	NA
delta-BHC	NC	0.0012	SED-5B	NA	0.000024	UPREF-SED3	NA	0.000023	DNREF-SED2	NA
Dieldrin	0.0019**	0.0038	SED-5B	2	0.0001	UPREF-SED3	0.05	0.00013	DNREF-SED1	0.06
Endosulfan I	NC	0.0024	SED-5B	NA	0.000029	UPREF-SED3	NA	0.000026	DNREF-SED2	NA
Endosulfan II	NC	0.00053	SED-5B	NA	0.000023	UPREF-SED3	NA	0.000026	DNREF-SED2	NA
Endrin	0.00222**	0.035	SED-5B	15.8	0.000087	UPREF-SED3	0.04	0.00018	DNREF-SED1	0.08
Endrin Ketone	NC	0.0001	SED-1A	NA	0.000025	UPREF-SED3	NA	0.000023	DNREF-SED2	NA
gamma-Chlordane	NC	0.017	SED-5B	NA	0.00061	UPREF-SED1	NA	0.00046	DNREF-SED1	NA
Hepatachlor	0.0006**	0.00078	SED-3A	1.3	0.000045	UPREF-SED1	0.08	0.000033	DNREF-SED2	0.05
Hepatachlor epoxide	0.00247**	0.0038	SED-5B	1.5	0.00003	UPREF-SED3	0.01	0.000066	DNREF-SED1	0.02
Toxaphene	0.000077**	0.00215	SED-5A	27.9	0.001	UPREF-SED3	13	0.001	DNREF-SED2	13
PCBs										
PCB-1254	0.06**	0.14	SED-5B	2.3	0.00022	UPREF-SED3	0.003	0.0056	DNREF-SED1	0.09
PCB-1260	0.005**	0.011	SED-1DDUP	2.2	0.0039	UPREF-SED3	0.8	0.00021	DNREF-SED2	0.04
Total PCBs	0.023	0.14	SED-5B	6.1	0.0039	UPREF-SED3	0.2	0.0056	DNREF-SED1	0.2
Metals*										
Antimony	NC	4.3	SED-5A	NA	0.18	UPREF-SED1	NA	0.32	DNREF-SED1	NA
Arsenic	8.2	49.1	SED-1DDUP	6	24.9	UPREF-SED3	3	13.8	DNREF-SED1	1.7
Barium	NC	96.4	SED-3A	NA	12.3	UPREF-SED3	NA	5.5	DNREF-SED1	NA
Beryllium	NC	1.4	SED-1DDUP	NA	0.5	UPREF-SED3	NA	0.48	DNREF-SED1	NA
Chromium	81	125	SED-1DDUP	1.5	22.8	UPREF-SED1	0.3	22.3	DNREF-SED1	0.3
Copper	34	123	SED-5A	3.6	6	UPREF-SED3	0.2	7	DNREF-SED1	0.2
Lead	47	1,960	SED-5B	41.7	13.2	UPREF-SED3	0.3	21.1	DNREF-SED1	0.4
Nickel	21	50.8	SED-5A	2.4	6.3	UPREF-SED3	0.3	6.3	DNREF-SED1	0.3
Selenium	NC	2.6	SED-1DDUP	NA	0.82	UPREF-SED3	NA	0.31	DNREF-SED1	NA
Thallium	NC	3.4	SED-1DDUP	NA	1.7	UPREF-SED3	NA	0.86	DNREF-SED1	NA
Vanadium	NC	84.4	SED-1DDUP	NA	27.5	UPREF-SED3	NA	24.4	DNREF-SED1	NA
Zinc	150	260	SED-5A	1.7	63	UPREF-SED3	0.4	70.8	DNREF-SED1	0.4

Notes:
NC = no screening criteria available
NA = not applicable because no screening criteria availble

* = Calcium, Iron, Magnesium, Potassium and Sodium were not included as COPECs as they are considered to be essential nutrients
** = NJDEP ESC based on Freshwater screening value because no saline value was available
Yellow highlighted cells HQ = or >1

Table 6-2
Hazard Quotients for Ingestion of Fish - Bald Eagle (Site Maximum Concentrations)
Red Bank Landfill Site
Red Bank, New Jersey

Analyte	Maximum Concentration of Contaminant in Sediment (mg/kg_{dw})	Sediment Ingestion Rate (a) (d) (kg_{dw}/day)	Area Use Factor (a)	Dose from Sediment (mg/kg_{bw}/day)	Dietary Ingestion Rate (a) (kg_{ww}/day)	Sediment to Fish Biota-Sediment Accumulation Factors (BSAFs) (b)	Concentration of Contaminant in Fish (mg/kg_{ww}) (b)	Dietary Percentage of Fish (a)	Dose from Fish (mg/kg_{bw}/day)	Average Body Weight (a) (kg)	Seasonal Use Factor (a)	Average Daily Dose (mg/kg_{bw}/day)	Toxicity Reference Values (TRVs) (c)		Hazard Quotient	
SVOCs													NOAEL	LOAEL	NOAEL HQ	LOAEL HQ
2,4-Dinitrophenol	**0.17**	0.018	0.060	0.000049	0.45	log=0.819*log(Kow)-1.146	0.19	1.0	0.0013	3.75	1.0	0.0014	1.6	16	0.00088	0.000088
4-Nitrophenol	**0.050**	0.018	0.060	0.000014	0.45	log=0.819*log(Kow)-1.146	0.076	1.0	0.00055	3.75	1.0	0.00056	16	159	0.000035	0.0000035
Acenaphthene	0.025	0.018	0.060	0.0000072	0.45	0.00411	0.00010	1.0	0.00000074	3.75	1.0	0.0000079	19	194	0.00000041	0.000000041
Acetophenone	*0.021*	0.018	0.060	0.0000061	0.45	log=0.819*log(Kow)-1.146	0.026	1.0	0.00018	3.75	1.0	0.00019	1.6	16	0.00012	0.000012
Benzaldehyde	*0.21*	0.018	0.060	0.000061	0.45	log=0.819*log(Kow)-1.146	0.22	1.0	0.0016	3.75	1.0	0.0017	1.6	16	0.0011	0.00011
Benzo(g,h,i)perylene	0.18	0.018	0.060	0.000052	0.45	0.0164	0.0030	1.0	0.000021	3.75	1.0	0.000073	0.20	2.0	0.00037	0.000037
Carbazole	*0.028*	0.018	0.060	0.0000081	0.45	log=0.819*log(Kow)-1.146	0.13	1.0	0.00095	3.75	1.0	0.00096	1.6	16	0.00061	0.000061
Fluorene	0.029	0.018	0.060	0.0000084	0.45	0.0040	0.00012	1.0	0.00000084	3.75	1.0	0.0000092	0.20	2.0	0.000046	0.0000046
Phenanthrene	0.27	0.018	0.060	0.000078	0.45	0.0039	0.0011	1.0	0.0000076	3.75	1.0	0.000085	0.20	2.0	0.00043	0.000043
Pesticides																
4,4'-DDD	0.0031	0.018	0.060	0.00000089	0.45	log=0.819*log(Kow)-1.146	0.15	1.0	0.0011	3.75	1.0	0.0011	0.23	2.7	0.0047	0.00040
4,4'-DDE	0.0027	0.018	0.060	0.00000078	0.45	0.95	0.0026	1.0	0.000018	3.75	1.0	0.000019	0.23	2.7	0.000085	0.0000071
4,4'-DDT	0.010	0.018	0.060	0.0000029	0.45	log=0.819*log(Kow)-1.146	0.46	1.0	0.0033	3.75	1.0	0.0033	0.23	2.7	0.015	0.0012
Aldrin	0.0026	0.018	0.060	0.00000075	0.45	log=0.819*log(Kow)-1.146	0.13	1.0	0.00094	3.75	1.0	0.00094	0.050	0.50	0.019	0.0019
alpha-Chlordane	*0.0030*	0.018	0.060	0.00000086	0.45	log=0.819*log(Kow)-1.146	0.17	1.0	0.0012	3.75	1.0	0.0012	2.1	11	0.00057	0.00011
delta-BHC	*0.0012*	0.018	0.060	0.00000035	0.45	log=0.819*log(Kow)-1.146	0.011	1.0	0.000082	3.75	1.0	0.000082	0.56	2.3	0.00015	0.000036
Dieldrin	0.0038	0.018	0.060	0.0000011	0.45	log=0.819*log(Kow)-1.146	0.090	1.0	0.00065	3.75	1.0	0.00065	0.071	0.80	0.0092	0.00081
Endosulfan I	*0.0024*	0.018	0.060	0.00000069	0.45	log=0.819*log(Kow)-1.146	0.013	1.0	0.000095	3.75	1.0	0.000096	10	100	0.0000096	0.00000096
Endosulfan II	*0.00053*	0.018	0.060	0.00000015	0.45	log=0.819*log(Kow)-1.146	0.0033	1.0	0.000024	3.75	1.0	0.000024	10	100	0.0000024	0.00000024
Endrin	0.035	0.018	0.060	0.000010	0.45	log=0.819*log(Kow)-1.146	0.61	1.0	0.0044	3.75	1.0	0.0044	0.010	0.10	0.44	0.044
Endrin Ketone	*0.0001*	0.018	0.060	0.000000029	0.45	log=0.819*log(Kow)-1.146	0.0019	1.0	0.000014	3.75	1.0	0.000014	0.010	0.10	0.0014	0.00014
gamma-Chlordane	*0.017*	0.018	0.060	0.0000049	0.45	log=0.819*log(Kow)-1.146	0.96	1.0	0.0069	3.75	1.0	0.0069	2.1	11	0.0032	0.00064
Hepatachlor	0.00078	0.018	0.060	0.00000022	0.45	1.67	0.0013	1.0	0.0000094	3.75	1.0	0.0000096	65	650	0.00000015	0.000000015
Hepatachlor epoxide	0.0038	0.018	0.060	0.0000011	0.45	log=0.819*log(Kow)-1.146	0.059	1.0	0.00043	3.75	1.0	0.00043	65	650	0.0000066	0.00000066
Toxaphene	**0.00215**	0.018	0.060	0.00000062	0.45	log=0.819*log(Kow)-1.146	0.062	1.0	0.00044	3.75	1.0	0.00045	0.68	6.0	0.00066	0.000074
PCBs																
PCB-1254	0.14	0.018	0.060	0.000040	0.45	0.53	0.074	1.0	0.00053	3.75	1.0	0.00057	0.18	1.8	0.0032	0.00032
PCB-1260	0.011	0.018	0.060	0.0000032	0.45	log=0.819*log(Kow)-1.146	0.92	1.0	0.0066	3.75	1.0	0.0066	0.18	1.8	0.037	0.0037
Total PCBs	0.14	0.018	0.060	0.000040	0.45	0.0327	0.0046	1.0	0.000033	3.75	1.0	0.000073	0.18	1.8	0.00041	0.000041
Metals*																
Antimony	*4.3*	0.018	0.060	0.0012	0.45	0.90	3.9	1.0	0.028	3.75	1.0	0.029	490	4,900	0.000059	0.0000059
Arsenic	49.1	0.018	0.060	0.014	0.45	0.90	44	1.0	0.32	3.75	1.0	0.33	2.2	4.5	0.15	0.074
Barium	*96.4*	0.018	0.060	0.028	0.45	0.90	87	1.0	0.62	3.75	1.0	0.65	21	208	0.031	0.0031
Beryllium	*1.4*	0.018	0.060	0.00040	0.45	0.90	1.3	1.0	0.0091	3.75	1.0	0.0095	3.9	19	0.0024	0.00049
Chromium	125	0.018	0.060	0.036	0.45	0.39	49	1.0	0.35	3.75	1.0	0.39	2.7	16	0.15	0.025
Copper	123	0.018	0.060	0.035	0.45	0.30	37	1.0	0.27	3.75	1.0	0.30	4.1	35	0.074	0.0086
Lead	1,960	0.018	0.060	0.56	0.45	0.63	1235	1.0	8.9	3.75	1.0	9.5	1.6	45	5.8	0.21
Nickel	50.8	0.018	0.060	0.015	0.45	0.90	46	1.0	0.33	3.75	1.0	0.34	6.7	19	0.051	0.019
Selenium	*2.6*	0.018	0.060	0.00075	0.45	0.90	2.3	1.0	0.017	3.75	1.0	0.018	0.29	0.82	0.061	0.021
Thallium	*3.4*	0.018	0.060	0.00098	0.45	0.90	3.1	1.0	0.022	3.75	1.0	0.023	0.35	3.5	0.066	0.0066
Vanadium	*84.4*	0.018	0.060	0.024	0.45	0.0148	1.2	1.0	0.0090	3.75	1.0	0.033	0.34	1.7	0.097	0.020
Zinc	260	0.018	0.060	0.075	0.45	0.57	148	1.0	1.1	3.75	1.0	1.1	66	171	0.017	0.0067

NOTES:
(a) - Values and references for these variables are presented in Section 5.5.1 of the Risk Assessment Workplan.
(b) - See table XXX for BSAFs and concentration calculations.
(c) - See Table XXX for TRV derivations.
(d) - Sediment consumption rate was converted from kg wet weight (ww) per day to kg dry weight (dw) per day by using the equation from United States Environmental Protection Agency (USEPA) Exposure Factors Handbook (USEPA, 2011):

IRdw = (IRww * % solids)/100
Where: IR = Ingestion rate
% solids = 100 - average % water makeup of sediment (e.g. 100 - 32.15 = 67.85)

* Calcium, Iron, Magnesium, Potassium and Sodium were not included in the model equations as they are considered to be essential nutrients.
mg/kg - milligrams per kilogram
kg/day - kilograms per day
mg/kg/day - milligrams per kilogram per day
kg - kilograms
$_{ww}$ - wet weight
$_{dw}$ - dry weight
$_{bw}$ - body weight
NOAEL - No Observable Adverse Effects Level.
LOAEL - Lowest Observable Adverse Effects Level.
HQ - Hazard Quotient.

Bolded values indicate a concentration based on 1/2 the maximum detection limit for a non-detected value.
Italicized values indicate a maximum detected concentration with no associated Ecological Screening Value.
Shaded cells indicated HQs equal to or greater than 1.0.

Table 6-3
Hazard Quotients for Ingestion of Fish - Great Blue Heron (Site Maximum Concentrations)
Red Bank Landfill Site
Red Bank, New Jersey

Analyte	Maximum Concentration of Contaminant in Sediment (mg/kg_{dw})	Sediment Ingestion Rate (a) (kg_{dw}/day)	Area Use Factor (a)	Dose from Sediment (mg/kg_{bw}/day)	Dietary Ingestion Rate (a) (kg_{ww}/day)	Sediment to Fish Biota-Sediment Accumulation Factors (BSAFs) (b)	Concentration of Contaminant in Fish (mg/kg_{ww}) (b)	Dietary Percentage of Fish (a)	Dose from Fish (mg/kg_{bw}/day)	Average Body Weight (a) (kg)	Seasonal Use Factor (a)	Average Daily Dose (mg/kg_{bw}/day)	Toxicity Reference Values (TRVs) (c)		Hazard Quotient	
SVOCs													NOAEL	LOAEL	NOAEL HQ	LOAEL HQ
2,4-Dinitrophenol	**0.17**	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.19	1.0	0.000013	2.39	1.0	0.000013	1.6	16	0.0000081	0.00000081
4-Nitrophenol	**0.050**	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.076	1.0	0.0000052	2.39	1.0	0.0000052	16	159	0.00000033	0.000000033
Acenaphthene	0.025	0.0	0.00039	0.0	0.42	0.00411	0.00010	1.0	0.0000000070	2.39	1.0	0.0000000070	19	194	0.00000000036	0.000000000036
Acetophenone	*0.021*	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.026	1.0	0.0000018	2.39	1.0	0.0000018	1.6	16	0.0000011	0.00000011
Benzaldehyde	*0.21*	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.22	1.0	0.000015	2.39	1.0	0.000015	1.6	16	0.0000097	0.00000097
Benzo(g,h,i)perylene	0.18	0.0	0.00039	0.0	0.42	0.0164	0.0030	1.0	0.00000020	2.39	1.0	0.00000020	0.20	2.0	0.0000010	0.00000010
Carbazole	*0.028*	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.13	1.0	0.0000090	2.39	1.0	0.0000090	1.6	16	0.0000057	0.00000057
Fluorene	0.029	0.0	0.00039	0.0	0.42	0.0040	0.00012	1.0	0.0000000080	2.39	1.0	0.0000000080	0.20	2.0	0.000000040	0.0000000040
Phenanthrene	0.27	0.0	0.00039	0.0	0.42	0.0039	0.0011	1.0	0.000000072	2.39	1.0	0.000000072	0.20	2.0	0.00000036	0.000000036
Pesticides																
4,4'-DDD	0.0031	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.15	1.0	0.000010	2.39	1.0	0.000010	0.23	2.7	0.000045	0.0000038
4,4'-DDE	0.0027	0.0	0.00039	0.0	0.42	0.95	0.0026	1.0	0.00000018	2.39	1.0	0.00000018	0.23	2.7	0.00000077	0.000000065
4,4'-DDT	0.010	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.46	1.0	0.000031	2.39	1.0	0.000031	0.23	2.7	0.00014	0.000012
Aldrin	0.0026	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.13	1.0	0.0000089	2.39	1.0	0.0000089	0.050	0.50	0.00018	0.000018
alpha-Chlordane	*0.0030*	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.17	1.0	0.000012	2.39	1.0	0.000012	2.1	11	0.0000054	0.0000011
delta-BHC	*0.0012*	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.011	1.0	0.00000078	2.39	1.0	0.00000078	0.56	2.3	0.0000014	0.00000034
Dieldrin	0.0038	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.090	1.0	0.0000062	2.39	1.0	0.0000062	0.071	0.80	0.000087	0.0000077
Endosulfan I	*0.0024*	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.013	1.0	0.00000090	2.39	1.0	0.00000090	10	100	0.000000090	0.0000000090
Endosulfan II	*0.00053*	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.0033	1.0	0.00000022	2.39	1.0	0.00000022	10	100	0.000000022	0.0000000022
Endrin	0.035	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.61	1.0	0.000042	2.39	1.0	0.000042	0.010	0.10	0.0042	0.00042
Endrin Ketone	*0.0001*	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.0019	1.0	0.00000013	2.39	1.0	0.00000013	0.010	0.10	0.000013	0.0000013
gamma-Chlordane	*0.017*	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.96	1.0	0.000066	2.39	1.0	0.000066	2.1	11	0.000031	0.0000061
Hepatachlor	0.00078	0.0	0.00039	0.0	0.42	1.67	0.0013	1.0	0.000000089	2.39	1.0	0.000000089	65	650	0.0000000014	0.00000000014
Hepatachlor epoxide	0.0038	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.059	1.0	0.0000040	2.39	1.0	0.0000040	65	650	0.000000062	0.0000000062
Toxaphene	**0.00215**	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.062	1.0	0.0000042	2.39	1.0	0.0000042	0.68	6.0	0.0000062	0.00000070
PCBs																
PCB-1254	0.14	0.0	0.00039	0.0	0.42	0.53	0.074	1.0	0.0000051	2.39	1.0	0.0000051	0.18	1.8	0.000028	0.0000028
PCB-1260	0.011	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.92	1.0	0.000063	2.39	1.0	0.000063	0.18	1.8	0.00035	0.000035
Total PCBs	0.14	0.0	0.00039	0.0	0.42	0.0327	0.0046	1.0	0.00000031	2.39	1.0	0.00000031	0.18	1.8	0.0000017	0.00000017
Metals*																
Antimony	*4.3*	0.0	0.00039	0.0	0.42	0.90	3.9	1.0	0.00027	2.39	1.0	0.00027	490	4,900	0.00000054	0.000000054
Arsenic	49.1	0.0	0.00039	0.0	0.42	0.90	44	1.0	0.0030	2.39	1.0	0.0030	2.2	4.5	0.0014	0.00067
Barium	*96.4*	0.0	0.00039	0.0	0.42	0.90	87	1.0	0.0059	2.39	1.0	0.0059	21	208	0.00029	0.000029
Beryllium	*1.4*	0.0	0.00039	0.0	0.42	0.90	1.3	1.0	0.000086	2.39	1.0	0.000086	3.9	19	0.000022	0.0000045
Chromium	125	0.0	0.00039	0.0	0.42	0.39	49	1.0	0.0033	2.39	1.0	0.0033	2.7	16	0.0013	0.00021
Copper	123	0.0	0.00039	0.0	0.42	0.30	37	1.0	0.0025	2.39	1.0	0.0025	4.1	35	0.00062	0.000073
Lead	1,960	0.0	0.00039	0.0	0.42	0.63	1235	1.0	0.085	2.39	1.0	0.085	1.6	45	0.052	0.0019
Nickel	50.8	0.0	0.00039	0.0	0.42	0.90	46	1.0	0.0031	2.39	1.0	0.0031	6.7	19	0.00047	0.00017
Selenium	*2.6*	0.0	0.00039	0.0	0.42	0.90	2.3	1.0	0.00016	2.39	1.0	0.00016	0.29	0.82	0.00055	0.00020
Thallium	*3.4*	0.0	0.00039	0.0	0.42	0.90	3.1	1.0	0.00021	2.39	1.0	0.00021	0.35	3.5	0.00060	0.000060
Vanadium	*84.4*	0.0	0.00039	0.0	0.42	0.0148	1.2	1.0	0.000086	2.39	1.0	0.000086	0.34	1.7	0.00025	0.000050
Zinc	260	0.0	0.00039	0.0	0.42	0.57	148	1.0	0.010	2.39	1.0	0.010	66	171	0.00015	0.000059

NOTES:
(a) - Values and references for these variables are presented in Section 5.5.1 of the Risk Assessment Workplan.
(b) - See table XXX for BSAFs and concentration calculations.
(c) - See Table XXX for TRV derivations.
* Calcium, Iron, Magnesium, Potassium and Sodium were not included in the model equations as they are considered to be essential nutrients.
mg/kg - milligrams per kilogram
kg/day - kilograms per day
mg/kg/day - milligrams per kilogram per day
kg - kilograms
$_{ww}$ - wet weight
$_{dw}$ - dry weight
$_{bw}$ - body weight
NOAEL - No Observable Adverse Effects Level.
LOAEL - Lowest Observable Adverse Effects Level.
HQ - Hazard Quotient.

Bolded values indicate a concentration based on 1/2 the maximum detection limit for a non-detected value.
Italicized values indicate a maximum detected concentration with no associated Ecological Screening Value.
Shaded cells indicated HQs equal to or greater than 1.0.

Table 6-4
Hazard Quotients for Ingestion of Benthic Invertebrates - Mallard Duck (Site Maximum Concentrations)
Red Bank Landfill Site
Red Bank, New Jersey

Analyte	Maximum Concentration of Contaminant in Sediment (mg/kg_{dw})	Sediment Ingestion Rate (a) (d) (kg_{dw}/day)	Area Use Factor (a)	Dose from Sediment (mg/kg_{bw}/day)	Dietary Ingestion Rate (a) (kg_{ww}/day)	Sediment to Benthic Invertebrate Bioaccumulation Factors (BAFs) (b)	Concentration of Contaminant in Benthic Invertebrates (mg/kg_{ww}) (b)	Dietary Percentage of Benthic Invertebrates (a)	Dose from Benthic Invertebrates (mg/kg_{bw}/day)	Average Body Weight (a) (kg)	Seasonal Use Factor (a)	Average Daily Dose (mg/kg_{bw}/day)	Toxicity Reference Values (TRVs) (c)		Hazard Quotient	
													NOAEL	LOAEL	NOAEL HQ	LOAEL HQ
SVOCs																
2,4-Dinitrophenol	**0.17**	0.00668	0.0079	0.0000077	0.298	log=0.819*log(Kow)-1.146	0.19	1.0	0.00038	1.162	1.0	0.00039	1.6	16	0.00025	0.000025
4-Nitrophenol	**0.050**	0.00668	0.0079	0.0000023	0.298	log=0.819*log(Kow)-1.146	0.076	1.0	0.00015	1.162	1.0	0.00016	16	159	0.0000098	0.00000098
Acenaphthene	0.025	0.00668	0.0079	0.0000011	0.298	0.00411	0.00010	1.0	0.00000021	1.162	1.0	0.0000013	19	194	0.000000069	0.0000000069
Acetophenone	*0.021*	0.00668	0.0079	0.00000095	0.298	log=0.819*log(Kow)-1.146	0.026	1.0	0.000052	1.162	1.0	0.000053	1.6	16	0.000033	0.0000033
Benzaldehyde	*0.21*	0.00668	0.0079	0.0000095	0.298	log=0.819*log(Kow)-1.146	0.22	1.0	0.00045	1.162	1.0	0.00046	1.6	16	0.00029	0.000029
Benzo(g,h,i)perylene	0.18	0.00668	0.0079	0.0000082	0.298	0.0164	0.0030	1.0	0.0000060	1.162	1.0	0.000014	0.20	2.0	0.000071	0.0000071
Carbazole	*0.028*	0.00668	0.0079	0.0000013	0.298	log=0.819*log(Kow)-1.146	0.13	1.0	0.00027	1.162	1.0	0.00027	1.6	16	0.00017	0.000017
Fluorene	0.029	0.00668	0.0079	0.0000013	0.298	0.0040	0.00012	1.0	0.00000024	1.162	1.0	0.0000016	0.20	2.0	0.0000078	0.00000078
Phenanthrene	0.27	0.00668	0.0079	0.000012	0.298	0.0039	0.0011	1.0	0.0000021	1.162	1.0	0.000014	0.20	2.0	0.000072	0.0000072
Pesticides																
4,4'-DDD	0.0031	0.00668	0.0079	0.00000014	0.298	log=0.819*log(Kow)-1.146	0.15	1.0	0.00030	1.162	1.0	0.00030	0.23	2.7	0.0013	0.00011
4,4'-DDE	0.0027	0.00668	0.0079	0.00000012	0.298	0.95	0.0026	1.0	0.0000052	1.162	1.0	0.0000053	0.23	2.7	0.000023	0.0000020
4,4'-DDT	0.010	0.00668	0.0079	0.00000045	0.298	log=0.819*log(Kow)-1.146	0.46	1.0	0.00093	1.162	1.0	0.00093	0.23	2.7	0.0041	0.00034
Aldrin	0.0026	0.00668	0.0079	0.00000012	0.298	log=0.819*log(Kow)-1.146	0.13	1.0	0.00026	1.162	1.0	0.00026	0.050	0.50	0.0053	0.00053
alpha-Chlordane	*0.0030*	0.00668	0.0079	0.00000014	0.298	log=0.819*log(Kow)-1.146	0.17	1.0	0.00034	1.162	1.0	0.00034	2.1	11	0.00016	0.000032
delta-BHC	*0.0012*	0.00668	0.0079	0.000000055	0.298	log=0.819*log(Kow)-1.146	0.011	1.0	0.000023	1.162	1.0	0.000023	0.56	2.3	0.000041	0.000010
Dieldrin	0.0038	0.00668	0.0079	0.00000017	0.298	log=0.819*log(Kow)-1.146	0.090	1.0	0.00018	1.162	1.0	0.00018	0.071	0.80	0.0026	0.00023
Endosulfan I	*0.0024*	0.00668	0.0079	0.00000011	0.298	log=0.819*log(Kow)-1.146	0.013	1.0	0.000027	1.162	1.0	0.000027	10	100	0.0000027	0.00000027
Endosulfan II	*0.00053*	0.00668	0.0079	0.000000024	0.298	log=0.819*log(Kow)-1.146	0.0033	1.0	0.0000066	1.162	1.0	0.0000066	10	100	0.00000066	0.000000066
Endrin	0.035	0.00668	0.0079	0.0000016	0.298	log=0.819*log(Kow)-1.146	0.61	1.0	0.0012	1.162	1.0	0.0012	0.010	0.10	0.12	0.012
Endrin Ketone	*0.0001*	0.00668	0.0079	0.0000000045	0.298	log=0.819*log(Kow)-1.146	0.0019	1.0	0.0000038	1.162	1.0	0.0000038	0.010	0.10	0.00038	0.000038
gamma-Chlordane	*0.017*	0.00668	0.0079	0.00000077	0.298	log=0.819*log(Kow)-1.146	0.96	1.0	0.0019	1.162	1.0	0.0019	2.1	11	0.00091	0.00018
Hepatachlor	0.00078	0.00668	0.0079	0.000000035	0.298	1.67	0.0013	1.0	0.0000026	1.162	1.0	0.0000027	65	650	0.000000041	0.0000000041
Hepatachlor epoxide	0.0038	0.00668	0.0079	0.00000017	0.298	log=0.819*log(Kow)-1.146	0.059	1.0	0.00012	1.162	1.0	0.00012	65	650	0.0000018	0.00000018
Toxaphene	**0.00215**	0.00668	0.0079	0.000000098	0.298	log=0.819*log(Kow)-1.146	0.062	1.0	0.00013	1.162	1.0	0.00013	0.68	6.0	0.00018	0.000021
PCBs																
PCB-1254	0.14	0.00668	0.0079	0.0000064	0.298	0.53	0.074	1.0	0.00015	1.162	1.0	0.00016	0.18	1.8	0.00087	0.000087
PCB-1260	0.011	0.00668	0.0079	0.00000050	0.298	log=0.819*log(Kow)-1.146	0.92	1.0	0.0019	1.162	1.0	0.0019	0.18	1.8	0.010	0.0010
Total PCBs	0.14	0.00668	0.0079	0.0000064	0.298	0.0327	0.0046	1.0	0.0000093	1.162	1.0	0.000016	0.18	1.8	0.000087	0.0000087
Metals*																
Antimony	*4.3*	0.00668	0.0079	0.00020	0.298	0.90	3.9	1.0	0.0078	1.162	1.0	0.0080	490	4,900	0.000016	0.0000016
Arsenic	49.1	0.00668	0.0079	0.0022	0.298	0.90	44	1.0	0.090	1.162	1.0	0.092	2.2	4.5	0.041	0.020
Barium	*96.4*	0.00668	0.0079	0.0044	0.298	0.90	87	1.0	0.18	1.162	1.0	0.18	21	208	0.0087	0.00087
Beryllium	*1.4*	0.00668	0.0079	0.000064	0.298	0.90	1.3	1.0	0.0026	1.162	1.0	0.0026	3.9	19	0.00068	0.00014
Chromium	125	0.00668	0.0079	0.0057	0.298	0.39	49	1.0	0.099	1.162	1.0	0.10	2.7	16	0.039	0.0067
Copper	123	0.00668	0.0079	0.0056	0.298	0.30	37	1.0	0.075	1.162	1.0	0.080	4.1	35	0.020	0.0023
Lead	1,960	0.00668	0.0079	0.089	0.298	0.63	1235	1.0	2.5	1.162	1.0	2.6	1.6	45	1.6	0.058
Nickel	50.8	0.00668	0.0079	0.0023	0.298	0.90	46	1.0	0.093	1.162	1.0	0.095	6.7	19	0.014	0.0051
Selenium	*2.6*	0.00668	0.0079	0.00012	0.298	0.90	2.3	1.0	0.0047	1.162	1.0	0.0049	0.29	0.82	0.017	0.0059
Thallium	*3.4*	0.00668	0.0079	0.00015	0.298	0.90	3.1	1.0	0.0062	1.162	1.0	0.0064	0.35	3.5	0.018	0.0018
Vanadium	*84.4*	0.00668	0.0079	0.0038	0.298	0.0148	1.2	1.0	0.0025	1.162	1.0	0.0064	0.34	1.7	0.019	0.0037
Zinc	260	0.00668	0.0079	0.012	0.298	0.57	148	1.0	0.30	1.162	1.0	0.31	66	171	0.0047	0.0018

NOTES:
(a) - Values and references for these variables are presented in Section 5.5.1 of the Risk Assessment Workplan.
(b) - See table XXX for BAFs and concentration calculations.
(c) - See Table XXX for TRV derivations.
(d) - Sediment consumption rate was converted from kg wet weight (ww) per day to kg dry weight (dw) per day by using the equation from United States Environmental Protection Agency (USEPA) Exposure Factors Handbook (USEPA, 2011):
IRdw = (IRww * % solids)/100
Where: IR = Ingestion rate
% solids = 100 - average % water makeup of sediment (e.g. 100 - 32.15 = 67.85)
* Calcium, Iron, Magnesium, Potassium and Sodium were not included in the model equations as they are considered to be essential nutrients.
mg/kg - milligrams per kilogram
kg/day - kilograms per day
mg/kg/day - milligrams per kilogram per day
kg - kilograms
$_{ww}$ - wet weight
$_{dw}$ - dry weight
$_{bw}$ - body weight
NOAEL - No Observable Adverse Effects Level.
LOAEL - Lowest Observable Adverse Effects Level.
HQ - Hazard Quotient.

Bolded values indicate a concentration based on 1/2 the maximum detection limit for a non-detected value.
Italicized values indicate a maximum detected concentration with no associated Ecological Screening Value.
Shaded cells indicated HQs equal to or greater than 1.0.

Table 6-5
Hazard Quotients for Ingestion of Benthic Invertebrates - Spotted Sandpiper (Site Maximum Concentrations)
Red Bank Landfill Site
Red Bank, New Jersey

Analyte	Maximum Concentration of Contaminant in Sediment (mg/kg_{dw})	Sediment Ingestion Rate (a) (kg_{dw}/day)	Area Use Factor (a)	Dose from Sediment (mg/kg_{bw}/day)	Dietary Ingestion Rate (a) (d) (kg_{ww}/day)	Sediment to Benthic Invertebrate Bioaccumulation Factors (BAFs) (b)	Concentration of Contaminant in Benthic Invertebrates (mg/kg_{ww}) (b)	Dietary Percentage of Benthic Invertebrates (a)	Dose from Benthic Invertebrates (mg/kg_{bw}/day)	Average Body Weight (a) (kg)	Seasonal Use Factor (a)	Average Daily Dose (mg/kg_{bw}/day)	Toxicity Reference Values (TRVs) (c)		Hazard Quotient	
													NOAEL	LOAEL	NOAEL HQ	LOAEL HQ
SVOCs																
2,4-Dinitrophenol	**0.17**	0.0085	0.070	0.0025	0.049	log=0.819*log(Kow)-1.146	0.19	1.0	0.016	0.040	0.66	0.012	1.6	16	0.0078	0.00078
4-Nitrophenol	**0.050**	0.0085	0.070	0.00074	0.049	log=0.819*log(Kow)-1.146	0.076	1.0	0.0066	0.040	0.66	0.0048	16	159	0.00030	0.000030
Acenaphthene	0.025	0.0085	0.070	0.00037	0.049	0.00411	0.00010	1.0	0.0000089	0.040	0.66	0.00025	19	194	0.000013	0.0000013
Acetophenone	*0.021*	0.0085	0.070	0.00031	0.049	log=0.819*log(Kow)-1.146	0.026	1.0	0.0022	0.040	0.66	0.0017	1.6	16	0.0011	0.00011
Benzaldehyde	*0.21*	0.0085	0.070	0.0031	0.049	log=0.819*log(Kow)-1.146	0.22	1.0	0.019	0.040	0.66	0.015	1.6	16	0.0094	0.00094
Benzo(g,h,i)perylene	0.18	0.0085	0.070	0.0027	0.049	0.0164	0.0030	1.0	0.00026	0.040	0.66	0.0019	0.20	2.0	0.0097	0.00097
Carbazole	*0.028*	0.0085	0.070	0.00042	0.049	log=0.819*log(Kow)-1.146	0.13	1.0	0.011	0.040	0.66	0.0078	1.6	16	0.0049	0.00049
Fluorene	0.029	0.0085	0.070	0.00043	0.049	0.0040	0.00012	1.0	0.000010	0.040	0.66	0.00029	0.20	2.0	0.0015	0.00015
Phenanthrene	0.27	0.0085	0.070	0.0040	0.049	0.0039	0.0011	1.0	0.000091	0.040	0.66	0.0027	0.20	2.0	0.014	0.0014
Pesticides																
4,4'-DDD	0.0031	0.0085	0.070	0.000046	0.049	log=0.819*log(Kow)-1.146	0.15	1.0	0.013	0.040	0.66	0.0085	0.23	2.7	0.037	0.0031
4,4'-DDE	0.0027	0.0085	0.070	0.000040	0.049	0.95	0.0026	1.0	0.00022	0.040	0.66	0.00017	0.23	2.7	0.00076	0.000064
4,4'-DDT	0.010	0.0085	0.070	0.00015	0.049	log=0.819*log(Kow)-1.146	0.46	1.0	0.040	0.040	0.66	0.026	0.23	2.7	0.12	0.0097
Aldrin	0.0026	0.0085	0.070	0.000039	0.049	log=0.819*log(Kow)-1.146	0.13	1.0	0.011	0.040	0.66	0.0075	0.050	0.50	0.15	0.015
alpha-Chlordane	*0.0030*	0.0085	0.070	0.000045	0.049	log=0.819*log(Kow)-1.146	0.17	1.0	0.015	0.040	0.66	0.0097	2.1	11	0.0045	0.00090
delta-BHC	*0.0012*	0.0085	0.070	0.000018	0.049	log=0.819*log(Kow)-1.146	0.011	1.0	0.0010	0.040	0.66	0.00066	0.56	2.3	0.0012	0.00029
Dieldrin	0.0038	0.0085	0.070	0.000057	0.049	log=0.819*log(Kow)-1.146	0.090	1.0	0.0078	0.040	0.66	0.0052	0.071	0.80	0.073	0.0065
Endosulfan I	*0.0024*	0.0085	0.070	0.000036	0.049	log=0.819*log(Kow)-1.146	0.013	1.0	0.0011	0.040	0.66	0.00078	10	100	0.000078	0.0000078
Endosulfan II	*0.00053*	0.0085	0.070	0.0000079	0.049	log=0.819*log(Kow)-1.146	0.0033	1.0	0.00028	0.040	0.66	0.00019	10	100	0.000019	0.0000019
Endrin	0.035	0.0085	0.070	0.00052	0.049	log=0.819*log(Kow)-1.146	0.61	1.0	0.053	0.040	0.66	0.035	0.010	0.10	3.5	0.35
Endrin Ketone	*0.0001*	0.0085	0.070	0.0000015	0.049	log=0.819*log(Kow)-1.146	0.0019	1.0	0.00016	0.040	0.66	0.00011	0.010	0.10	0.011	0.0011
gamma-Chlordane	*0.017*	0.0085	0.070	0.00025	0.049	log=0.819*log(Kow)-1.146	0.96	1.0	0.083	0.040	0.66	0.055	2.1	11	0.026	0.0051
Hepatachlor	0.00078	0.0085	0.070	0.000012	0.049	1.67	0.0013	1.0	0.00011	0.040	0.66	0.000082	65	650	0.0000013	0.00000013
Hepatachlor epoxide	0.0038	0.0085	0.070	0.000057	0.049	log=0.819*log(Kow)-1.146	0.059	1.0	0.0051	0.040	0.66	0.0034	65	650	0.000052	0.0000052
Toxaphene	**0.00215**	0.0085	0.070	0.000032	0.049	log=0.819*log(Kow)-1.146	0.062	1.0	0.0053	0.040	0.66	0.0036	0.68	6.0	0.0052	0.00059
PCBs																
PCB-1254	0.14	0.0085	0.070	0.0021	0.049	0.53	0.074	1.0	0.0064	0.040	0.66	0.0056	0.18	1.8	0.031	0.0031
PCB-1260	0.011	0.0085	0.070	0.00016	0.049	log=0.819*log(Kow)-1.146	0.92	1.0	0.079	0.040	0.66	0.052	0.18	1.8	0.29	0.029
Total PCBs	0.14	0.0085	0.070	0.0021	0.049	0.0327	0.0046	1.0	0.00040	0.040	0.66	0.0016	0.18	1.8	0.0091	0.00091
Metals*																
Antimony	*4.3*	0.0085	0.070	0.064	0.049	0.90	3.9	1.0	0.33	0.040	0.66	0.26	490	4,900	0.00054	0.000054
Arsenic	49.1	0.0085	0.070	0.73	0.049	0.90	44	1.0	3.8	0.040	0.66	3.0	2.2	4.5	1.3	0.67
Barium	*96.4*	0.0085	0.070	1.4	0.049	0.90	87	1.0	7.5	0.040	0.66	5.9	21	208	0.28	0.028
Beryllium	*1.4*	0.0085	0.070	0.021	0.049	0.90	1.3	1.0	0.11	0.040	0.66	0.086	4	19	0.022	0.0045
Chromium	125	0.0085	0.070	1.9	0.049	0.39	49	1.0	4.2	0.040	0.66	4.0	2.7	16	1.5	0.26
Copper	123	0.0085	0.070	1.8	0.049	0.30	37	1.0	3.2	0.040	0.66	3.3	4.1	35	0.82	0.095
Lead	1,960	0.0085	0.070	29	0.049	0.63	1235	1.0	107	0.040	0.66	90	1.6	45	55	2.0
Nickel	50.8	0.0085	0.070	0.76	0.049	0.90	46	1.0	4.0	0.040	0.66	3.1	6.7	19	0.46	0.17
Selenium	*2.6*	0.0085	0.070	0.039	0.049	0.90	2.3	1.0	0.20	0.040	0.66	0.16	0.29	0.82	0.55	0.19
Thallium	*3.4*	0.0085	0.070	0.051	0.049	0.90	3.1	1.0	0.26	0.040	0.66	0.21	0.35	3.5	0.59	0.059
Vanadium	*84.4*	0.0085	0.070	1.3	0.049	0.0148	1.2	1.0	0.11	0.040	0.66	0.90	0.34	1.7	2.6	0.53
Zinc	260	0.0085	0.070	3.9	0.049	0.57	148	1.0	13	0.040	0.66	11	66	171	0.17	0.064

NOTES:
(a) - Values and references for these variables are presented in Section 5.5.1 of the Risk Assessment Workplan.
(b) - See table XXX for BAFs and concentration calculations.
(c) - See Table XXX for TRV derivations.
(d) - Food consumption rate was converted from kg dry weight (dw) per day to kg wet weight (ww) per day by using the equation from United States Environmental Protection Agency (USEPA) Exposure Factors Handbook (USEPA, 2011):
IRww = (IRdw * 100)/% solids
Where: IR = Ingestion rate
% solids = 100 - % water makeup of benthic invertebrates (e.g. 100 - 84 = 16) (USEPA, 2007)
* Calcium, Iron, Magnesium, Potassium and Sodium were not included in the model equations as they are considered to be essential nutrients.
mg/kg - milligrams per kilogram
kg/day - kilograms per day
mg/kg/day - milligrams per kilogram per day
kg - kilograms
$_{ww}$ - wet weight
$_{dw}$ - dry weight
$_{bw}$ - body weight
NOAEL - No Observable Adverse Effects Level.
LOAEL - Lowest Observable Adverse Effects Level.
HQ - Hazard Quotient.

Bolded values indicate a concentration based on 1/2 the maximum detection limit for a non-detected value.
Italicized values indicate a maximum detected concentration with no associated Ecological Screening Value.
Shaded cells indicated HQs equal to or greater than 1.0.

Table 6-6
Hazard Quotients for Ingestion of Fish and Benthic Invertebrates - Raccoon (Site Maximum Concentrations)
Red Bank Landfill Site
Red Bank, New Jersey

Analyte	Maximum Concentration of Contaminant in Sediment (mg/kg_{dw})	Sediment Ingestion Rate (a) (d) (kg_{dw}/day)	Area Use Factor (a)	Dose from Sediment (mg/kg_{bw}/day)	Dietary Ingestion Rate (a) (kg_{ww}/day)	Sediment to Benthic Invertebrate Biota-Sediment Accumulation Factors (BSAFs) (b)	Concentration of Contaminant in Benthic Invertebrates (mg/kg_{ww}) (b)	Dietary Percentage of Benthic Invertebrates (a)	Dose from Benthic Invertebrates (mg/kg_{bw}/day)	Sediment to Fish Biota-Sediment Accumulation Factors (BSAFs) (b)	Concentration of Contaminant in Fish (mg/kg_{ww}) (b)	Dietary Percentage of Fish (a)	Dose from Fish (mg/kg_{bw}/day)	Average Body Weight (a) (kg)	Seasonal Use Factor (a)	Average Daily Dose (mg/kg_{bw}/day)	Toxicity Reference Values (TRVs) (c)		Hazard Quotient	
																	NOAEL	LOAEL	NOAEL HQ	LOAEL HQ
SVOCs																				
2,4-Dinitrophenol	**0.17**	0.080	0.0054	0.000013	1.26	log=0.819*log(Kow)-1.146	0.19	0.50	0.00011	log=0.819*log(Kow)-1.146	0.19	0.50	0.00011	5.78	1.0	0.00023	20	30	0.000012	0.0000078
4-Nitrophenol	**0.050**	0.080	0.0054	0.0000038	1.26	log=0.819*log(Kow)-1.146	0.076	0.50	0.000045	log=0.819*log(Kow)-1.146	0.076	0.50	0.000045	5.78	1.0	0.000093	12	28	0.0000079	0.0000033
Acenaphthene	0.025	0.080	0.0054	0.0000019	1.26	0.00411	0.00010	0.50	0.000000060	0.00411	0.00010	0.50	0.000000060	5.78	1.0	0.0000020	66	356	0.000000030	0.0000000056
Acetophenone	*0.021*	0.080	0.0054	0.0000016	1.26	log=0.819*log(Kow)-1.146	0.026	0.50	0.000015	log=0.819*log(Kow)-1.146	0.026	0.50	0.000015	5.78	1.0	0.000032	42	423	0.00000075	0.000000075
Benzaldehyde	*0.21*	0.080	0.0054	0.000016	1.26	log=0.819*log(Kow)-1.146	0.22	0.50	0.00013	log=0.819*log(Kow)-1.146	0.22	0.50	0.00013	5.78	1.0	0.00028	14	40	0.000020	0.0000070
Benzo(g,h,i)perylene	0.18	0.080	0.0054	0.000014	1.26	0.0164	0.0030	0.50	0.0000017	0.0164	0.0030	0.50	0.0000017	5.78	1.0	0.000017	0.62	38	0.000028	0.00000044
Carbazole	*0.028*	0.080	0.0054	0.0000021	1.26	log=0.819*log(Kow)-1.146	0.13	0.50	0.000078	log=0.819*log(Kow)-1.146	0.13	0.50	0.000078	5.78	1.0	0.00016	5.0	50	0.000031	0.0000031
Fluorene	0.029	0.080	0.0054	0.0000022	1.26	0.0040	0.00012	0.50	0.000000068	0.0040	0.00012	0.50	0.000000068	5.78	1.0	0.0000023	66	356	0.000000035	0.0000000065
Phenanthrene	0.27	0.080	0.0054	0.000020	1.26	0.0039	0.0011	0.50	0.00000062	0.0039	0.0011	0.50	0.00000062	5.78	1.0	0.000022	66	356	0.00000033	0.000000060
Pesticides																				
4,4'-DDD	0.0031	0.080	0.0054	0.00000023	1.26	log=0.819*log(Kow)-1.146	0.15	0.50	0.000087	log=0.819*log(Kow)-1.146	0.15	0.50	0.000087	5.78	1.0	0.00017	0.15	5.6	0.0012	0.000031
4,4'-DDE	0.0027	0.080	0.0054	0.00000020	1.26	0.95	0.0026	0.50	0.0000015	0.95	0.0026	0.50	0.0000015	5.78	1.0	0.0000032	0.15	5.6	0.000022	0.00000058
4,4'-DDT	0.010	0.080	0.0054	0.00000075	1.26	log=0.819*log(Kow)-1.146	0.46	0.50	0.00027	log=0.819*log(Kow)-1.146	0.46	0.50	0.00027	5.78	1.0	0.00054	0.15	5.6	0.0037	0.000097
Aldrin	0.0026	0.080	0.0054	0.00000020	1.26	log=0.819*log(Kow)-1.146	0.13	0.50	0.000077	log=0.819*log(Kow)-1.146	0.13	0.50	0.000077	5.78	1.0	0.00015	0.20	1.0	0.00077	0.00015
alpha-Chlordane	*0.0030*	0.080	0.0054	0.00000023	1.26	log=0.819*log(Kow)-1.146	0.17	0.50	0.000099	log=0.819*log(Kow)-1.146	0.17	0.50	0.000099	5.78	1.0	0.00020	4.6	9.2	0.000043	0.000022
delta-BHC	*0.0012*	0.080	0.0054	0.000000090	1.26	log=0.819*log(Kow)-1.146	0.011	0.50	0.0000067	log=0.819*log(Kow)-1.146	0.011	0.50	0.0000067	5.78	1.0	0.000013	0.15	0.67	0.000090	0.000020
Dieldrin	0.0038	0.080	0.0054	0.00000029	1.26	log=0.819*log(Kow)-1.146	0.090	0.50	0.000053	log=0.819*log(Kow)-1.146	0.090	0.50	0.000053	5.78	1.0	0.00011	0.015	1.3	0.0071	0.000084
Endosulfan I	*0.0024*	0.080	0.0054	0.00000018	1.26	log=0.819*log(Kow)-1.146	0.013	0.50	0.0000078	log=0.819*log(Kow)-1.146	0.013	0.50	0.0000078	5.78	1.0	0.000016	0.15	1.5	0.00010	0.000010
Endosulfan II	*0.00053*	0.080	0.0054	0.000000040	1.26	log=0.819*log(Kow)-1.146	0.0033	0.50	0.0000019	log=0.819*log(Kow)-1.146	0.0033	0.50	0.0000019	5.78	1.0	0.0000039	0.15	1.5	0.000026	0.0000026
Endrin	0.035	0.080	0.0054	0.0000026	1.26	log=0.819*log(Kow)-1.146	0.61	0.50	0.00036	log=0.819*log(Kow)-1.146	0.61	0.50	0.00036	5.78	1.0	0.00072	0.092	0.92	0.0078	0.00078
Endrin Ketone	*0.0001*	0.080	0.0054	0.0000000075	1.26	log=0.819*log(Kow)-1.146	0.0019	0.50	0.0000011	log=0.819*log(Kow)-1.146	0.0019	0.50	0.0000011	5.78	1.0	0.0000022	0.092	0.92	0.000024	0.0000024
gamma-Chlordane	*0.017*	0.080	0.0054	0.0000013	1.26	log=0.819*log(Kow)-1.146	0.96	0.50	0.00056	log=0.819*log(Kow)-1.146	0.96	0.50	0.00056	5.78	1.0	0.0011	4.6	9.2	0.00025	0.00012
Hepatachlor	0.00078	0.080	0.0054	0.000000059	1.26	1.67	0.0013	0.50	0.00000077	1.67	0.0013	0.50	0.00000077	5.78	1.0	0.0000016	0.10	1.0	0.000016	0.0000016
Hepatachlor epoxide	0.0038	0.080	0.0054	0.00000029	1.26	log=0.819*log(Kow)-1.146	0.059	0.50	0.000035	log=0.819*log(Kow)-1.146	0.059	0.50	0.000035	5.78	1.0	0.000070	0.10	1.0	0.00070	0.000070
Toxaphene	**0.00215**	0.080	0.0054	0.00000016	1.26	log=0.819*log(Kow)-1.146	0.062	0.50	0.000036	log=0.819*log(Kow)-1.146	0.062	0.50	0.000036	5.78	1.0	0.000073	8.0	80	0.0000091	0.00000091
PCBs																				
PCB-1254	0.14	0.080	0.0054	0.000011	1.26	0.53	0.074	0.50	0.000044	0.53	0.074	0.50	0.000044	5.78	1.0	0.000098	0.098	0.68	0.0010	0.00014
PCB-1260	0.011	0.080	0.0054	0.00000083	1.26	log=0.819*log(Kow)-1.146	0.92	0.50	0.00054	log=0.819*log(Kow)-1.146	0.92	0.50	0.00054	5.78	1.0	0.0011	5.0	50	0.00022	0.000022
Total PCBs	0.14	0.080	0.0054	0.000011	1.26	0.0327	0.0046	0.50	0.0000027	0.0327	0.0046	0.50	0.0000027	5.78	1.0	0.000016	0.098	0.68	0.00016	0.000023
Metals*																				
Antimony	*4.3*	0.080	0.0054	0.00032	1.26	0.90	3.9	0.50	0.0023	0.90	3.9	0.50	0.0023	5.78	1.0	0.0049	0.059	2.8	0.083	0.0018
Arsenic	49.1	0.080	0.0054	0.0037	1.26	0.90	44	0.50	0.026	0.90	44	0.50	0.026	5.78	1.0	0.056	1.0	5.7	0.054	0.0098
Barium	*96.4*	0.080	0.0054	0.0072	1.26	0.90	87	0.50	0.051	0.90	87	0.50	0.051	5.78	1.0	0.11	52	83	0.0021	0.0013
Beryllium	*1.4*	0.080	0.0054	0.00011	1.26	0.90	1.3	0.50	0.00074	0.90	1.3	0.50	0.00074	5.78	1.0	0.0016	0.53	0.67	0.0030	0.0024
Chromium	125	0.080	0.0054	0.0094	1.26	0.39	49	0.50	0.029	0.39	49	0.50	0.029	5.78	1.0	0.067	2.4	58	0.028	0.0011
Copper	123	0.080	0.0054	0.0092	1.26	0.30	37	0.50	0.022	0.30	37	0.50	0.022	5.78	1.0	0.053	5.6	83	0.0094	0.00064
Lead	1,960	0.080	0.0054	0.15	1.26	0.63	1235	0.50	0.73	0.63	1235	0.50	0.73	5.78	1.0	1.6	4.7	186	0.34	0.0086
Nickel	50.8	0.080	0.0054	0.0038	1.26	0.90	46	0.50	0.027	0.90	46	0.50	0.027	5.78	1.0	0.058	1.7	15	0.034	0.0039
Selenium	*2.6*	0.080	0.0054	0.00020	1.26	0.90	2.3	0.50	0.0014	0.90	2.3	0.50	0.0014	5.78	1.0	0.0029	0.14	0.66	0.021	0.0045
Thallium	*3.4*	0.080	0.0054	0.00026	1.26	0.90	3.1	0.50	0.0018	0.90	3.1	0.50	0.0018	5.78	1.0	0.0039	0.0074	0.074	0.52	0.052
Vanadium	*84.4*	0.080	0.0054	0.0063	1.26	0.0148	1.2	0.50	0.00074	0.0148	1.2	0.50	0.00074	5.78	1.0	0.0078	4.2	9.4	0.0019	0.00083
Zinc	260	0.080	0.0054	0.020	1.26	0.57	148	0.50	0.087	0.57	148	0.50	0.087	5.78	1.0	0.19	75	298	0.0026	0.00065

NOTES:
(a) - Values and references for these variables are presented in Section 5.5.1 of the Risk Assessment Workplan.
(b) - See table XXX for BSAFs and concentration calculations.
(c) - See Table XXX for TRV derivations.
(d) - Sediment consumption rate was converted from kg wet weight (ww) per day to kg dry weight (dw) per day by using the equation from United States Environmental Protection Agency (USEPA) Exposure Factors Handbook (USEPA, 2011):
IRdw = (IRww * % solids)/100
Where: IR = Ingestion rate
% solids = 100 - average % water makeup of sediment (e.g. 100 - 32.15 = 67.85)
* Calcium, Iron, Magnesium, Potassium and Sodium were not included in the model equations as they are considered to be essential nutrients.
mg/kg - milligrams per kilogram
kg/day - kilograms per day
mg/kg/day - milligrams per kilogram per day
kg - kilograms
$_{ww}$ - wet weight
$_{dw}$ - dry weight
$_{bw}$ - body weight
NOAEL - No Observable Adverse Effects Level.
LOAEL - Lowest Observable Adverse Effects Level.
HQ - Hazard Quotient.

Bolded values indicate a concentration based on 1/2 the maximum detection limit for a non-detected value.
Italicized values indicate a maximum detected concentration with no associated Ecological Screening Value.
Shaded cells indicated HQs equal to or greater than 1.0.

Table 6-7
Hazard Quotients for Ingestion of Fish - Bald Eagle (95% UCL Site Concentrations)
Red Bank Landfill Site
Red Bank, New Jersey

Analyte	95% UCL Concentration of Contaminant in Sediment (mg/kg_{dw})	Sediment Ingestion Rate (a) (d) (kg_{dw}/day)	Area Use Factor (a)	Dose from Sediment (mg/kg_{bw}/day)	Dietary Ingestion Rate (a) (kg_{ww}/day)	Sediment to Fish Biota-Sediment Accumulation Factors (BSAFs) (b)	Concentration of Contaminant in Fish (mg/kg_{ww}) (b)	Dietary Percentage of Fish (a)	Dose from Fish (mg/kg_{bw}/day)	Average Body Weight (a) (kg)	Seasonal Use Factor (a)	Average Daily Dose (mg/kg_{bw}/day)	Toxicity Reference Values (TRVs) (c)		Hazard Quotient	
Pesticides																
Endrin	0.0196	0.018	0.060	0.0000056	0.45	log=0.819*log(Kow)-1.146	0.34	1.0	0.0025	3.75	1.0	0.0025	0.010	0.10	0.25	0.025
Metals*																
Arsenic	23.63	0.018	0.060	0.0068	0.45	0.90	21	1.0	0.15	3.75	1.0	0.16	2.2	4.5	0.071	0.035
Chromium	62.03	0.018	0.060	0.018	0.45	0.39	24	1.0	0.17	3.75	1.0	0.19	2.7	16	0.072	0.012
Lead	556	0.018	0.060	0.16	0.45	0.63	350	1.0	2.5	3.75	1.0	2.7	1.6	45	1.6	0.060
Vanadium	42.37	0.018	0.060	0.012	0.45	0.0148	0.63	1.0	0.0045	3.75	1.0	0.017	0.34	1.7	0.049	0.0098

NOTES:
(a) - Values and references for these variables are presented in Section 5.5.1 of the Risk Assessment Workplan.
(b) - See table XXX for BSAFs and concentration calculations.
(c) - See Table XXX for TRV derivations.
(d) - Sediment consumption rate was converted from kg wet weight (ww) per day to kg dry weight (dw) per day by using the equation from United States Environmental Protection Agency (USEPA) Exposure Factors Handbook (USEPA, 2011):
IRdw = (IRww * % solids)/100
Where: IR = Ingestion rate
% solids = 100 - average % water makeup of sediment (e.g. 100 - 32.15 = 67.85)
* Calcium, Iron, Magnesium, Potassium and Sodium were not included in the model equations as they are considered to be essential nutrients.
mg/kg - milligrams per kilogram
kg/day - kilograms per day
mg/kg/day - milligrams per kilogram per day
kg - kilograms
$_{ww}$ - wet weight
$_{dw}$ - dry weight
$_{bw}$ - body weight
UCL - Upper Confidence Limit.
NOAEL - No Observable Adverse Effects Level.
LOAEL - Lowest Observable Adverse Effects Level.
HQ - Hazard Quotient.

Shaded cells indicated HQs equal to or greater than 1.0.

Table 6-8
Hazard Quotients for Ingestion of Benthic Invertebrates - Mallard Duck (95% UCL Site Concentrations)
Red Bank Landfill Site
Red Bank, New Jersey

Analyte	95% UCL Concentration of Contaminant in Sediment (mg/kg_{dw})	Sediment Ingestion Rate (a) (d) (kg_{dw}/day)	Area Use Factor (a)	Dose from Sediment (mg/kg_{bw}/day)	Dietary Ingestion Rate (a) (kg_{ww}/day)	Sediment to Benthic Invertebrate Bioaccumulation Factors (BAFs) (b)	Concentration of Contaminant in Benthic Invertebrates (mg/kg_{ww}) (b)	Dietary Percentage of Benthic Invertebrates (a)	Dose from Benthic Invertebrates (mg/kg_{bw}/day)	Average Body Weight (a) (kg)	Seasonal Use Factor (a)	Average Daily Dose (mg/kg_{bw}/day)	Toxicity Reference Values (TRVs) (c)		Hazard Quotient	
Pesticides																
Endrin	0.0196	0.00668	0.0079	0.00000089	0.298	log=0.819*log(Kow)-1.146	0.34	1.0	0.0007	1.162	1.0	0.0007	0.010	0.10	0.07	0.007
Metals*																
Arsenic	23.63	0.00668	0.0079	0.0011	0.298	0.90	21	1.0	0.043	1.162	1.0	0.044	2.2	4.5	0.020	0.0098
Chromium	62.03	0.00668	0.0079	0.0028	0.298	0.39	24	1.0	0.049	1.162	1.0	0.052	2.7	16	0.019	0.0033
Lead	556	0.00668	0.0079	0.025	0.298	0.63	350	1.0	0.71	1.162	1.0	0.74	1.6	45	0.45	0.016
Vanadium	42.37	0.00668	0.0079	0.0019	0.298	0.0148	0.63	1.0	0.0013	1.162	1.0	0.0032	0.34	1.7	0.0093	0.0019

NOTES:
(a) - Values and references for these variables are presented in Section 5.5.1 of the Risk Assessment Workplan.
(b) - See table XXX for BAFs and concentration calculations.
(c) - See Table XXX for TRV derivations.
(d) - Sediment consumption rate was converted from kg wet weight (ww) per day to kg dry weight (dw) per day by using the equation from United States Environmental Protection Agency (USEPA) Exposure Factors Handbook (USEPA, 2011):
IRdw = (IRww * % solids)/100
Where: IR = Ingestion rate
% solids = 100 - average % water makeup of sediment (e.g. 100 - 32.15 = 67.85)
mg/kg - milligrams per kilogram
kg/day - kilograms per day
mg/kg/day - milligrams per kilogram per day
kg - kilograms
$_{ww}$ - wet weight
$_{dw}$ - dry weight
$_{bw}$ - body weight
UCL - Upper Confidence Limit.
NOAEL - No Observable Adverse Effects Level.
LOAEL - Lowest Observable Adverse Effects Level.
HQ - Hazard Quotient.

Shaded cells indicated HQs equal to or greater than 1.0.

Table 6-9
Hazard Quotients for Ingestion of Benthic Invertebrates - Spotted Sandpiper (95% UCL Site Concentrations)
Red Bank Landfill Site
Red Bank, New Jersey

Analyte	95% UCL Concentration of Contaminant in Sediment (mg/kg_{dw})	Sediment Ingestion Rate (a) (kg_{dw}/day)	Area Use Factor (a)	Dose from Sediment (mg/kg_{bw}/day)	Dietary Ingestion Rate (a) (d) (kg_{ww}/day)	Sediment to Benthic Invertebrate Bioaccumulation Factors (BAFs) (b)	Concentration of Contaminant in Benthic Invertebrates (mg/kg_{ww}) (b)	Dietary Percentage of Benthic Invertebrates (a)	Dose from Benthic Invertebrates (mg/kg_{bw}/day)	Average Body Weight (a) (kg)	Seasonal Use Factor (a)	Average Daily Dose (mg/kg_{bw}/day)	Toxicity Reference Values (TRVs) (c)		Hazard Quotient	
Pesticides																
Endrin	0.0196	0.0085	0.070	0.00029	0.049	log=0.819*log(Kow)-1.146	0.34	1.0	0.030	0.040	0.66	0.020	0.010	0.10	2.0	0.20
Metals*																
Arsenic	23.63	0.0085	0.070	0.35	0.049	0.90	21	1.0	1.8	0.040	0.66	1.4	2.2	4.5	0.65	0.32
Chromium	62.03	0.0085	0.070	0.92	0.049	0.39	24	1.0	2.1	0.040	0.66	2.0	2.7	16	0.75	0.13
Lead	556	0.0085	0.070	8.3	0.049	0.63	350	1.0	30	0.040	0.66	25	1.6	45	16	0.57
Vanadium	42.37	0.0085	0.070	0.63	0.049	0.0148	0.63	1.0	0.054	0.040	0.66	0.45	0.34	1.7	1.3	0.27

NOTES:
(a) - Values and references for these variables are presented in Section 5.5.1 of the Risk Assessment Workplan.
(b) - See table XXX for BAFs and concentration calculations.
(c) - See Table XXX for TRV derivations.
(d) - Food consumption rate was converted from kg dry weight (dw) per day to kg wet weight (ww) per day by using the equation from United States Environmental Protection Agency (USEPA) Exposure Factors Handbook (USEPA, 2011):
IRww = (IRdw * 100)/% solids
Where: IR = Ingestion rate
% solids = 100 - % water makeup of benthic invertebrates (e.g. 100 - 84 = 16) (USEPA, 2007)
mg/kg - milligrams per kilogram
kg/day - kilograms per day
mg/kg/day - milligrams per kilogram per day
kg - kilograms
$_{ww}$ - wet weight
$_{dw}$ - dry weight
$_{bw}$ - body weight
UCL - Upper Confidence Limit.
NOAEL - No Observable Adverse Effects Level.
LOAEL - Lowest Observable Adverse Effects Level.
HQ - Hazard Quotient.

Shaded cells indicated HQs equal to or greater than 1.0.

Table 6-10
Hazard Quotients for Ingestion of Fish - Bald Eagle (Upstream Maximum Concentrations)
Red Bank Landfill Site
Red Bank, New Jersey

Analyte	Maximum Concentration of Contaminant in Sediment (mg/kg_{dw})	Sediment Ingestion Rate (a) (d) (kg_{dw}/day)	Area Use Factor (a)	Dose from Sediment (mg/kg_{bw}/day)	Dietary Ingestion Rate (a) (kg_{ww}/day)	Sediment to Fish Biota-Sediment Accumulation Factors (BSAFs) (b)	Concentration of Contaminant in Fish (mg/kg_{ww}) (b)	Dietary Percentage of Fish (a)	Dose from Fish (mg/kg_{bw}/day)	Average Body Weight (a) (kg)	Seasonal Use Factor (a)	Average Daily Dose (mg/kg_{bw}/day)	Toxicity Reference Values (TRVs) (c)		Hazard Quotient	
SVOCs													NOAEL	LOAEL	NOAEL HQ	LOAEL HQ
2,4-Dinitrophenol	**0.075**	0.018	0.060	0.000022	0.45	log=0.819*log(Kow)-1.146	0.083	1.0	0.00060	3.75	1.0	0.00062	1.6	16	0.00039	0.000039
4-Nitrophenol	**0.023**	0.018	0.060	0.0000066	0.45	log=0.819*log(Kow)-1.146	0.035	1.0	0.00025	3.75	1.0	0.00026	16	159	0.000016	0.0000016
Acenaphthene	**0.0012**	0.018	0.060	0.00000035	0.45	0.00411	0.0000049	1.0	0.000000036	3.75	1.0	0.00000038	19	194	0.000000020	0.0000000020
Acetophenone	**0.0050**	0.018	0.060	0.0000014	0.45	log=0.819*log(Kow)-1.146	0.0061	1.0	0.000044	3.75	1.0	0.000045	1.6	16	0.000029	0.0000029
Benzaldehyde	**0.0095**	0.018	0.060	0.0000027	0.45	log=0.819*log(Kow)-1.146	0.010	1.0	0.000073	3.75	1.0	0.000076	1.6	16	0.000048	0.0000048
Benzo(g,h,i)perylene	0.018	0.018	0.060	0.0000052	0.45	0.0164	0.00030	1.0	0.0000021	3.75	1.0	0.0000073	0.20	2.0	0.000037	0.0000037
Carbazole	*0.0042*	0.018	0.060	0.0000012	0.45	log=0.819*log(Kow)-1.146	0.020	1.0	0.00014	3.75	1.0	0.00014	1.6	16	0.000091	0.0000091
Fluorene	0.0038	0.018	0.060	0.0000011	0.45	0.0040	0.000015	1.0	0.00000011	3.75	1.0	0.0000012	0.20	2.0	0.0000060	0.00000060
Phenanthrene	0.035	0.018	0.060	0.000010	0.45	0.0039	0.00014	1.0	0.00000098	3.75	1.0	0.000011	0.20	2.0	0.000055	0.0000055
Pesticides																
4,4'-DDD	**0.000021**	0.018	0.060	0.0000000059	0.45	log=0.819*log(Kow)-1.146	0.00098	1.0	0.0000071	3.75	1.0	0.0000071	0.23	2.7	0.000031	0.0000026
4,4'-DDE	0.00025	0.018	0.060	0.000000072	0.45	0.95	0.00024	1.0	0.0000017	3.75	1.0	0.0000018	0.23	2.7	0.0000079	0.00000066
4,4'-DDT	0.00018	0.018	0.060	0.000000052	0.45	log=0.819*log(Kow)-1.146	0.0082	1.0	0.000059	3.75	1.0	0.000059	0.23	2.7	0.00026	0.000022
Aldrin	**0.000028**	0.018	0.060	0.0000000081	0.45	log=0.819*log(Kow)-1.146	0.0014	1.0	0.000010	3.75	1.0	0.000010	0.050	0.50	0.00020	0.000020
alpha-Chlordane	*0.00055*	0.018	0.060	0.00000016	0.45	log=0.819*log(Kow)-1.146	0.031	1.0	0.00022	3.75	1.0	0.00022	2.1	11	0.00010	0.000021
delta-BHC	**0.000024**	0.018	0.060	0.0000000069	0.45	log=0.819*log(Kow)-1.146	0.00023	1.0	0.0000016	3.75	1.0	0.0000016	0.56	2.3	0.0000029	0.00000073
Dieldrin	0.00011	0.018	0.060	0.000000032	0.45	log=0.819*log(Kow)-1.146	0.0026	1.0	0.000019	3.75	1.0	0.000019	0.071	0.80	0.00027	0.000024
Endosulfan I	**0.000030**	0.018	0.060	0.0000000085	0.45	log=0.819*log(Kow)-1.146	0.00016	1.0	0.0000012	3.75	1.0	0.0000012	10	100	0.00000012	0.000000012
Endosulfan II	**0.000028**	0.018	0.060	0.0000000079	0.45	log=0.819*log(Kow)-1.146	0.00017	1.0	0.0000012	3.75	1.0	0.0000012	10	100	0.00000012	0.000000012
Endrin	0.000087	0.018	0.060	0.000000025	0.45	log=0.819*log(Kow)-1.146	0.0015	1.0	0.000011	3.75	1.0	0.000011	0.010	0.10	0.0011	0.00011
Endrin Ketone	**0.000025**	0.018	0.060	0.0000000071	0.45	log=0.819*log(Kow)-1.146	0.00046	1.0	0.0000033	3.75	1.0	0.0000033	0.010	0.10	0.00033	0.000033
gamma-Chlordane	*0.00041*	0.018	0.060	0.00000012	0.45	log=0.819*log(Kow)-1.146	0.023	1.0	0.00017	3.75	1.0	0.00017	2.1	11	0.000078	0.000016
Hepatachlor	0.000089	0.018	0.060	0.000000026	0.45	1.67	0.00015	1.0	0.0000011	3.75	1.0	0.0000011	65	650	0.000000017	0.0000000017
Hepatachlor epoxide	**0.000031**	0.018	0.060	0.0000000088	0.45	log=0.819*log(Kow)-1.146	0.00047	1.0	0.0000034	3.75	1.0	0.0000034	65	650	0.000000053	0.0000000053
Toxaphene	**0.0011**	0.018	0.060	0.00000030	0.45	log=0.819*log(Kow)-1.146	0.030	1.0	0.00022	3.75	1.0	0.00022	0.68	6.0	0.00032	0.000036
PCBs																
PCB-1254	**0.00022**	0.018	0.060	0.000000063	0.45	0.53	0.00012	1.0	0.00000084	3.75	1.0	0.00000090	0.18	1.8	0.0000050	0.00000050
PCB-1260	0.0039	0.018	0.060	0.0000011	0.45	log=0.819*log(Kow)-1.146	0.33	1.0	0.0023	3.75	1.0	0.0023	0.18	1.8	0.013	0.0013
Total PCBs	0.0039	0.018	0.060	0.0000011	0.45	0.0327	0.00013	1.0	0.00000092	3.75	1.0	0.0000020	0.18	1.8	0.000011	0.0000011
Metals*																
Antimony	*0.18*	0.018	0.060	0.000052	0.45	0.90	0.16	1.0	0.0012	3.75	1.0	0.0012	490	4,900	0.0000025	0.00000025
Arsenic	24.9	0.018	0.060	0.0072	0.45	0.90	22	1.0	0.16	3.75	1.0	0.17	2.2	4.5	0.075	0.037
Barium	*12.3*	0.018	0.060	0.0035	0.45	0.90	11	1.0	0.080	3.75	1.0	0.083	21	208	0.0040	0.00040
Beryllium	*0.50*	0.018	0.060	0.00014	0.45	0.90	0.45	1.0	0.0032	3.75	1.0	0.0034	3.9	19	0.00087	0.00018
Chromium	22.8	0.018	0.060	0.0066	0.45	0.39	8.9	1.0	0.064	3.75	1.0	0.071	2.7	16	0.027	0.0045
Copper	6.0	0.018	0.060	0.0017	0.45	0.30	1.8	1.0	0.013	3.75	1.0	0.015	4.1	35	0.0036	0.00042
Lead	13.2	0.018	0.060	0.0038	0.45	0.63	8.3	1.0	0.060	3.75	1.0	0.064	1.6	45	0.039	0.0014
Nickel	6.3	0.018	0.060	0.0018	0.45	0.90	5.7	1.0	0.041	3.75	1.0	0.043	6.7	19	0.0064	0.0023
Selenium	*0.82*	0.018	0.060	0.00024	0.45	0.90	0.74	1.0	0.0053	3.75	1.0	0.0055	0.29	0.82	0.019	0.0068
Thallium	*1.7*	0.018	0.060	0.00049	0.45	0.90	1.5	1.0	0.011	3.75	1.0	0.012	0.35	3.5	0.033	0.0033
Vanadium	*27.5*	0.018	0.060	0.0079	0.45	0.0148	0.41	1.0	0.0029	3.75	1.0	0.011	0.34	1.7	0.032	0.0064
Zinc	63	0.018	0.060	0.018	0.45	0.57	36	1.0	0.26	3.75	1.0	0.28	66	171	0.0042	0.0016

NOTES:
(a) - Values and references for these variables are presented in Section 5.5.1 of the Risk Assessment Workplan.
(b) - See table XXX for BSAFs and concentration calculations.
(c) - See Table XXX for TRV derivations.
(d) - Sediment consumption rate was converted from kg wet weight (ww) per day to kg dry weight (dw) per day by using the equation from United States Environmental Protection Agency (USEPA) Exposure Factors Handbook (USEPA, 2011):
IRdw = (IRww * % solids)/100
Where: IR = Ingestion rate
% solids = 100 - average % water makeup of sediment (e.g. 100 - 32.15 = 67.85)
* Calcium, Iron, Magnesium, Potassium and Sodium were not included in the model equations as they are considered to be essential nutrients.
mg/kg - milligrams per kilogram
kg/day - kilograms per day
mg/kg/day - milligrams per kilogram per day
kg - kilograms
$_{ww}$ - wet weight
$_{dw}$ - dry weight
$_{bw}$ - body weight
NOAEL - No Observable Adverse Effects Level.
LOAEL - Lowest Observable Adverse Effects Level.
HQ - Hazard Quotient.

Bolded values indicate a concentration based on 1/2 the maximum detection limit for a non-detected value.
Italicized values indicate a maximum detected concentration with no associated Ecological Screening Value.
Shaded cells indicated HQs equal to or greater than 1.0.

Table 6-11
Hazard Quotients for Ingestion of Fish - Great Blue Heron (Upstream Maximum Concentrations)
Red Bank Landfill Site
Red Bank, New Jersey

Analyte	Maximum Concentration of Contaminant in Sediment (mg/kg_{dw})	Sediment Ingestion Rate (a) (kg_{dw}/day)	Area Use Factor (a)	Dose from Sediment (mg/kg_{bw}/day)	Dietary Ingestion Rate (a) (kg_{ww}/day)	Sediment to Fish Biota-Sediment Accumulation Factors (BSAFs) (b)	Concentration of Contaminant in Fish (mg/kg_{ww}) (b)	Dietary Percentage of Fish (a)	Dose from Fish (mg/kg_{bw}/day)	Average Body Weight (a) (kg)	Seasonal Use Factor (a)	Average Daily Dose (mg/kg_{bw}/day)	Toxicity Reference Values (TRVs) (c)		Hazard Quotient	
SVOCs													NOAEL	LOAEL	NOAEL HQ	LOAEL HQ
2,4-Dinitrophenol	**0.075**	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.083	1.0	0.0000057	2.39	1.0	0.0000057	1.6	16	0.0000036	0.00000036
4-Nitrophenol	**0.023**	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.035	1.0	0.0000024	2.39	1.0	0.0000024	16	159	0.00000015	0.000000015
Acenaphthene	**0.0012**	0.0	0.00039	0.0	0.42	0.00411	0.0000049	1.0	0.00000000034	2.39	1.0	0.00000000034	19	194	0.000000000017	0.00000000000017
Acetophenone	**0.0050**	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.0061	1.0	0.00000042	2.39	1.0	0.00000042	1.6	16	0.00000026	0.000000026
Benzaldehyde	**0.0095**	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.010	1.0	0.00000069	2.39	1.0	0.00000069	1.6	16	0.00000044	0.000000044
Benzo(g,h,i)perylene	0.018	0.0	0.00039	0.0	0.42	0.0164	0.00030	1.0	0.000000020	2.39	1.0	0.000000020	0.20	2.0	0.00000010	0.000000010
Carbazole	*0.0042*	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.020	1.0	0.0000014	2.39	1.0	0.0000014	1.6	16	0.00000086	0.000000086
Fluorene	0.0038	0.0	0.00039	0.0	0.42	0.0040	0.000015	1.0	0.0000000010	2.39	1.0	0.0000000010	0.20	2.0	0.0000000052	0.00000000052
Phenanthrene	0.035	0.0	0.00039	0.0	0.42	0.0039	0.00014	1.0	0.0000000094	2.39	1.0	0.0000000094	0.20	2.0	0.000000047	0.0000000047
Pesticides																
4,4'-DDD	**0.000021**	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.00098	1.0	0.000000067	2.39	1.0	0.000000067	0.23	2.7	0.00000030	0.000000025
4,4'-DDE	0.00025	0.0	0.00039	0.0	0.42	0.95	0.00024	1.0	0.000000016	2.39	1.0	0.000000016	0.23	2.7	0.000000072	0.0000000060
4,4'-DDT	0.00018	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.0082	1.0	0.00000056	2.39	1.0	0.00000056	0.23	2.7	0.0000025	0.00000021
Aldrin	**0.000028**	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.0014	1.0	0.000000096	2.39	1.0	0.000000096	0.050	0.50	0.0000019	0.00000019
alpha-Chlordane	*0.00055*	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.031	1.0	0.0000021	2.39	1.0	0.0000021	2.1	11	0.0000010	0.00000020
delta-BHC	**0.000024**	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.00023	1.0	0.000000016	2.39	1.0	0.000000016	0.56	2.3	0.000000028	0.0000000069
Dieldrin	0.00011	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.0026	1.0	0.00000018	2.39	1.0	0.00000018	0.071	0.80	0.0000025	0.00000022
Endosulfan I	**0.000030**	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.00016	1.0	0.000000011	2.39	1.0	0.000000011	10	100	0.0000000011	0.00000000011
Endosulfan II	**0.000028**	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.00017	1.0	0.000000012	2.39	1.0	0.000000012	10	100	0.0000000012	0.00000000012
Endrin	0.000087	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.0015	1.0	0.00000010	2.39	1.0	0.00000010	0.010	0.10	0.000010	0.0000010
Endrin Ketone	**0.000025**	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.00046	1.0	0.000000032	2.39	1.0	0.000000032	0.010	0.10	0.0000032	0.00000032
gamma-Chlordane	*0.00041*	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.023	1.0	0.0000016	2.39	1.0	0.0000016	2.1	11	0.00000074	0.00000015
Hepatachlor	0.000089	0.0	0.00039	0.0	0.42	1.67	0.00015	1.0	0.000000010	2.39	1.0	0.000000010	65	650	0.00000000016	0.000000000016
Hepatachlor epoxide	**0.000031**	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.00047	1.0	0.000000033	2.39	1.0	0.000000033	65	650	0.00000000050	0.000000000050
Toxaphene	**0.0011**	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.030	1.0	0.0000021	2.39	1.0	0.0000021	0.68	6.0	0.0000030	0.00000034
PCBs																
PCB-1254	**0.00022**	0.0	0.00039	0.0	0.42	0.53	0.00012	1.0	0.0000000080	2.39	1.0	0.0000000080	0.18	1.8	0.000000044	0.0000000044
PCB-1260	0.0039	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.33	1.0	0.000022	2.39	1.0	0.000022	0.18	1.8	0.00012	0.000012
Total PCBs	0.0039	0.0	0.00039	0.0	0.42	0.0327	0.00013	1.0	0.0000000087	2.39	1.0	0.0000000087	0.18	1.8	0.000000049	0.0000000049
Metals*																
Antimony	*0.18*	0.0	0.00039	0.0	0.42	0.90	0.16	1.0	0.000011	2.39	1.0	0.000011	490	4,900	0.000000023	0.0000000023
Arsenic	24.9	0.0	0.00039	0.0	0.42	0.90	22	1.0	0.0015	2.39	1.0	0.0015	2.2	4.5	0.00069	0.00034
Barium	*12.3*	0.0	0.00039	0.0	0.42	0.90	11	1.0	0.00076	2.39	1.0	0.00076	21	208	0.000036	0.0000036
Beryllium	*0.50*	0.0	0.00039	0.0	0.42	0.90	0.45	1.0	0.000031	2.39	1.0	0.000031	3.9	19	0.0000080	0.0000016
Chromium	22.8	0.0	0.00039	0.0	0.42	0.39	8.9	1.0	0.00061	2.39	1.0	0.00061	2.7	16	0.00023	0.000039
Copper	6.0	0.0	0.00039	0.0	0.42	0.30	1.8	1.0	0.00012	2.39	1.0	0.00012	4.1	35	0.000030	0.0000035
Lead	13.2	0.0	0.00039	0.0	0.42	0.63	8.3	1.0	0.00057	2.39	1.0	0.00057	1.6	45	0.00035	0.000013
Nickel	6.3	0.0	0.00039	0.0	0.42	0.90	5.7	1.0	0.00039	2.39	1.0	0.00039	6.7	19	0.000058	0.000021
Selenium	*0.82*	0.0	0.00039	0.0	0.42	0.90	0.74	1.0	0.000051	2.39	1.0	0.000051	0.29	0.82	0.00017	0.000062
Thallium	*1.7*	0.0	0.00039	0.0	0.42	0.90	1.5	1.0	0.00010	2.39	1.0	0.00010	0.35	3.5	0.00030	0.000030
Vanadium	*27.5*	0.0	0.00039	0.0	0.42	0.0148	0.41	1.0	0.000028	2.39	1.0	0.000028	0.34	1.7	0.000081	0.000016
Zinc	63	0.0	0.00039	0.0	0.42	0.57	36	1.0	0.0025	2.39	1.0	0.0025	66	171	0.000037	0.000014

NOTES:
(a) - Values and references for these variables are presented in Section 5.5.1 of the Risk Assessment Workplan.
(b) - See table XXX for BSAFs and concentration calculations.
(c) - See Table XXX for TRV derivations.
* Calcium, Iron, Magnesium, Potassium and Sodium were not included in the model equations as they are considered to be essential nutrients.
mg/kg - milligrams per kilogram
kg/day - kilograms per day
mg/kg/day - milligrams per kilogram per day
kg - kilograms
$_{ww}$ - wet weight
$_{dw}$ - dry weight
$_{bw}$ - body weight
NOAEL - No Observable Adverse Effects Level.
LOAEL - Lowest Observable Adverse Effects Level.
HQ - Hazard Quotient.

Bolded values indicate a concentration based on 1/2 the maximum detection limit for a non-detected value.
Italicized values indicate a maximum detected concentration with no associated Ecological Screening Value.
Shaded cells indicated HQs equal to or greater than 1.0.

Table 6-12
Hazard Quotients for Ingestion of Benthic Invertebrates - Mallard Duck (Upstream Maximum Concentrations)
Red Bank Landfill Site
Red Bank, New Jersey

Analyte	Maximum Concentration of Contaminant in Sediment (mg/kg_{dw})	Sediment Ingestion Rate (a) (d) (kg_{dw}/day)	Area Use Factor (a)	Dose from Sediment (mg/kg_{bw}/day)	Dietary Ingestion Rate (a) (kg_{ww}/day)	Sediment to Benthic Invertebrate Bioaccumulation Factors (BAFs) (b)	Concentration of Contaminant in Benthic Invertebrates (mg/kg_{ww}) (b)	Dietary Percentage of Benthic Invertebrates (a)	Dose from Benthic Invertebrates (mg/kg_{bw}/day)	Average Body Weight (a) (kg)	Seasonal Use Factor (a)	Average Daily Dose (mg/kg_{bw}/day)	Toxicity Reference Values (TRVs) (c)		Hazard Quotient	
SVOCs													NOAEL	LOAEL	NOAEL HQ	LOAEL HQ
2,4-Dinitrophenol	**0.075**	0.00668	0.0079	0.0000034	0.298	log=0.819*log(Kow)-1.146	0.083	1.0	0.00017	1.162	1.0	0.00017	1.6	16	0.00011	0.000011
4-Nitrophenol	**0.023**	0.00668	0.0079	0.0000010	0.298	log=0.819*log(Kow)-1.146	0.035	1.0	0.000071	1.162	1.0	0.000072	16	159	0.0000045	0.00000045
Acenaphthene	**0.0012**	0.00668	0.0079	0.000000055	0.298	0.00411	0.0000049	1.0	0.000000010	1.162	1.0	0.000000065	19	194	0.0000000033	0.00000000033
Acetophenone	**0.0050**	0.00668	0.0079	0.00000023	0.298	log=0.819*log(Kow)-1.146	0.0061	1.0	0.000012	1.162	1.0	0.000013	1.6	16	0.0000080	0.00000080
Benzaldehyde	**0.0095**	0.00668	0.0079	0.00000043	0.298	log=0.819*log(Kow)-1.146	0.010	1.0	0.000021	1.162	1.0	0.000021	1.6	16	0.000013	0.0000013
Benzo(g,h,i)perylene	0.018	0.00668	0.0079	0.00000082	0.298	0.0164	0.00030	1.0	0.00000060	1.162	1.0	0.0000014	0.20	2.0	0.0000071	0.00000071
Carbazole	*0.0042*	0.00668	0.0079	0.00000019	0.298	log=0.819*log(Kow)-1.146	0.020	1.0	0.000040	1.162	1.0	0.000040	1.6	16	0.000025	0.0000025
Fluorene	0.0038	0.00668	0.0079	0.00000017	0.298	0.0040	0.000015	1.0	0.000000031	1.162	1.0	0.00000020	0.20	2.0	0.0000010	0.00000010
Phenanthrene	0.035	0.00668	0.0079	0.0000016	0.298	0.0039	0.00014	1.0	0.00000028	1.162	1.0	0.0000019	0.20	2.0	0.0000093	0.00000093
Pesticides																
4,4'-DDD	**0.000021**	0.00668	0.0079	0.00000000093	0.298	log=0.819*log(Kow)-1.146	0.00098	1.0	0.0000020	1.162	1.0	0.0000020	0.23	2.7	0.0000087	0.00000074
4,4'-DDE	0.00025	0.00668	0.0079	0.000000011	0.298	0.95	0.00024	1.0	0.00000048	1.162	1.0	0.00000049	0.23	2.7	0.0000022	0.00000018
4,4'-DDT	0.00018	0.00668	0.0079	0.0000000082	0.298	log=0.819*log(Kow)-1.146	0.0082	1.0	0.000017	1.162	1.0	0.000017	0.23	2.7	0.000074	0.0000062
Aldrin	**0.000028**	0.00668	0.0079	0.0000000013	0.298	log=0.819*log(Kow)-1.146	0.0014	1.0	0.0000028	1.162	1.0	0.0000028	0.050	0.50	0.000057	0.0000057
alpha-Chlordane	*0.00055*	0.00668	0.0079	0.000000025	0.298	log=0.819*log(Kow)-1.146	0.031	1.0	0.000063	1.162	1.0	0.000063	2.1	11	0.000029	0.0000059
delta-BHC	**0.000024**	0.00668	0.0079	0.0000000011	0.298	log=0.819*log(Kow)-1.146	0.00023	1.0	0.00000046	1.162	1.0	0.00000046	0.56	2.3	0.00000082	0.00000020
Dieldrin	0.00011	0.00668	0.0079	0.0000000050	0.298	log=0.819*log(Kow)-1.146	0.0026	1.0	0.0000053	1.162	1.0	0.0000053	0.071	0.80	0.000075	0.0000066
Endosulfan I	**0.000030**	0.00668	0.0079	0.0000000013	0.298	log=0.819*log(Kow)-1.146	0.00016	1.0	0.00000033	1.162	1.0	0.00000033	10	100	0.000000033	0.0000000033
Endosulfan II	**0.000028**	0.00668	0.0079	0.0000000012	0.298	log=0.819*log(Kow)-1.146	0.00017	1.0	0.00000034	1.162	1.0	0.00000034	10	100	0.000000034	0.0000000034
Endrin	0.000087	0.00668	0.0079	0.0000000040	0.298	log=0.819*log(Kow)-1.146	0.0015	1.0	0.0000031	1.162	1.0	0.0000031	0.010	0.10	0.00031	0.000031
Endrin Ketone	**0.000025**	0.00668	0.0079	0.0000000011	0.298	log=0.819*log(Kow)-1.146	0.00046	1.0	0.00000094	1.162	1.0	0.00000094	0.010	0.10	0.000094	0.0000094
gamma-Chlordane	*0.00041*	0.00668	0.0079	0.000000019	0.298	log=0.819*log(Kow)-1.146	0.023	1.0	0.000047	1.162	1.0	0.000047	2.1	11	0.000022	0.0000044
Hepatachlor	0.000089	0.00668	0.0079	0.0000000040	0.298	1.67	0.00015	1.0	0.00000030	1.162	1.0	0.00000031	65	650	0.0000000047	0.00000000047
Hepatachlor epoxide	**0.000031**	0.00668	0.0079	0.0000000014	0.298	log=0.819*log(Kow)-1.146	0.00047	1.0	0.00000096	1.162	1.0	0.00000096	65	650	0.000000015	0.0000000015
Toxaphene	**0.0011**	0.00668	0.0079	0.000000048	0.298	log=0.819*log(Kow)-1.146	0.030	1.0	0.000061	1.162	1.0	0.000061	0.68	6.0	0.000090	0.000010
PCBs																
PCB-1254	**0.00022**	0.00668	0.0079	0.000000010	0.298	0.53	0.00012	1.0	0.00000024	1.162	1.0	0.00000025	0.18	1.8	0.0000014	0.00000014
PCB-1260	0.0039	0.00668	0.0079	0.00000018	0.298	log=0.819*log(Kow)-1.146	0.33	1.0	0.00066	1.162	1.0	0.00066	0.18	1.8	0.0037	0.00037
Total PCBs	0.0039	0.00668	0.0079	0.00000018	0.298	0.0327	0.00013	1.0	0.00000026	1.162	1.0	0.00000044	0.18	1.8	0.0000024	0.00000024
Metals*																
Antimony	*0.18*	0.00668	0.0079	0.0000082	0.298	0.90	0.16	1.0	0.00033	1.162	1.0	0.00034	490	4,900	0.00000069	0.000000069
Arsenic	24.9	0.00668	0.0079	0.0011	0.298	0.90	22	1.0	0.045	1.162	1.0	0.047	2.2	4.5	0.021	0.010
Barium	*12.3*	0.00668	0.0079	0.00056	0.298	0.90	11	1.0	0.022	1.162	1.0	0.023	21	208	0.0011	0.00011
Beryllium	*0.50*	0.00668	0.0079	0.000023	0.298	0.90	0.45	1.0	0.00091	1.162	1.0	0.00093	3.9	19	0.00024	0.000049
Chromium	22.8	0.00668	0.0079	0.0010	0.298	0.39	8.9	1.0	0.018	1.162	1.0	0.019	2.7	16	0.0072	0.0012
Copper	6.0	0.00668	0.0079	0.00027	0.298	0.30	1.8	1.0	0.0036	1.162	1.0	0.0039	4.1	35	0.00097	0.00011
Lead	13.2	0.00668	0.0079	0.00060	0.298	0.63	8.3	1.0	0.017	1.162	1.0	0.017	1.6	45	0.011	0.00039
Nickel	6.3	0.00668	0.0079	0.00029	0.298	0.90	5.7	1.0	0.011	1.162	1.0	0.012	6.7	19	0.0018	0.00063
Selenium	*0.82*	0.00668	0.0079	0.000037	0.298	0.90	0.74	1.0	0.0015	1.162	1.0	0.0015	0.29	0.82	0.0053	0.0019
Thallium	*1.7*	0.00668	0.0079	0.000077	0.298	0.90	1.5	1.0	0.0031	1.162	1.0	0.0032	0.35	3.5	0.0091	0.00091
Vanadium	*27.5*	0.00668	0.0079	0.0012	0.298	0.0148	0.41	1.0	0.00082	1.162	1.0	0.0021	0.34	1.7	0.0060	0.0012
Zinc	63	0.00668	0.0079	0.0029	0.298	0.57	36	1.0	0.073	1.162	1.0	0.076	66	171	0.0011	0.00044

NOTES:
(a) - Values and references for these variables are presented in Section 5.5.1 of the Risk Assessment Workplan.
(b) - See table XXX for BAFs and concentration calculations.
(c) - See Table XXX for TRV derivations.
(d) - Sediment consumption rate was converted from kg wet weight (ww) per day to kg dry weight (dw) per day by using the equation from United States Environmental Protection Agency (USEPA) Exposure Factors Handbook (USEPA, 2011):
IRdw = (IRww * % solids)/100
Where: IR = Ingestion rate
% solids = 100 - average % water makeup of sediment (e.g. 100 - 32.15 = 67.85)
* Calcium, Iron, Magnesium, Potassium and Sodium were not included in the model equations as they are considered to be essential nutrients.
mg/kg - milligrams per kilogram
kg/day - kilograms per day
mg/kg/day - milligrams per kilogram per day
kg - kilograms
$_{ww}$ - wet weight
$_{dw}$ - dry weight
$_{bw}$ - body weight
NOAEL - No Observable Adverse Effects Level.
LOAEL - Lowest Observable Adverse Effects Level.
HQ - Hazard Quotient.

Bolded values indicate a concentration based on 1/2 the maximum detection limit for a non-detected value.
Italicized values indicate a maximum detected concentration with no associated Ecological Screening Value.
Shaded cells indicated HQs equal to or greater than 1.0.

Table 6-13
Hazard Quotients for Ingestion of Benthic Invertebrates - Spotted Sandpiper (Upstream Maximum Concentrations)
Red Bank Landfill Site
Red Bank, New Jersey

Analyte	Maximum Concentration of Contaminant in Sediment (mg/kg_{dw})	Sediment Ingestion Rate (a) (kg_{dw}/day)	Area Use Factor (a)	Dose from Sediment (mg/kg_{bw}/day)	Dietary Ingestion Rate (a) (d) (kg_{ww}/day)	Sediment to Benthic Invertebrate Bioaccumulation Factors (BAFs) (b)	Concentration of Contaminant in Benthic Invertebrates (mg/kg_{ww}) (b)	Dietary Percentage of Benthic Invertebrates (a)	Dose from Benthic Invertebrates (mg/kg_{bw}/day)	Average Body Weight (a) (kg)	Seasonal Use Factor (a)	Average Daily Dose (mg/kg_{bw}/day)	Toxicity Reference Values (TRVs) (c)		Hazard Quotient	
SVOCs													NOAEL	LOAEL	NOAEL HQ	LOAEL HQ
2,4-Dinitrophenol	**0.075**	0.0085	0.070	0.0011	0.049	log=0.819*log(Kow)-1.146	0.083	1.0	0.0072	0.040	0.66	0.0055	1.6	16	0.0035	0.00035
4-Nitrophenol	**0.023**	0.0085	0.070	0.00034	0.049	log=0.819*log(Kow)-1.146	0.035	1.0	0.0030	0.040	0.66	0.0022	16	159	0.00014	0.000014
Acenaphthene	**0.0012**	0.0085	0.070	0.000018	0.049	0.00411	0.0000049	1.0	0.00000043	0.040	0.66	0.000012	19	194	0.00000062	0.000000062
Acetophenone	**0.0050**	0.0085	0.070	0.000074	0.049	log=0.819*log(Kow)-1.146	0.0061	1.0	0.00053	0.040	0.66	0.00040	1.6	16	0.00025	0.000025
Benzaldehyde	**0.0095**	0.0085	0.070	0.00014	0.049	log=0.819*log(Kow)-1.146	0.010	1.0	0.00088	0.040	0.66	0.00067	1.6	16	0.00042	0.000042
Benzo(g,h,i)perylene	0.018	0.0085	0.070	0.00027	0.049	0.0164	0.00030	1.0	0.000026	0.040	0.66	0.00019	0.20	2.0	0.00097	0.000097
Carbazole	*0.0042*	0.0085	0.070	0.000062	0.049	log=0.819*log(Kow)-1.146	0.020	1.0	0.0017	0.040	0.66	0.0012	1.6	16	0.00074	0.000074
Fluorene	0.0038	0.0085	0.070	0.000057	0.049	0.0040	0.000015	1.0	0.0000013	0.040	0.66	0.000038	0.20	2.0	0.00019	0.000019
Phenanthrene	0.035	0.0085	0.070	0.00052	0.049	0.0039	0.00014	1.0	0.000012	0.040	0.66	0.00035	0.20	2.0	0.0018	0.00018
Pesticides																
4,4'-DDD	**0.000021**	0.0085	0.070	0.00000030	0.049	log=0.819*log(Kow)-1.146	0.00098	1.0	0.000085	0.040	0.66	0.000056	0.23	2.7	0.00025	0.000021
4,4'-DDE	0.00025	0.0085	0.070	0.0000037	0.049	0.95	0.00024	1.0	0.000021	0.040	0.66	0.000016	0.23	2.7	0.000071	0.0000059
4,4'-DDT	0.00018	0.0085	0.070	0.0000027	0.049	log=0.819*log(Kow)-1.146	0.0082	1.0	0.00071	0.040	0.66	0.00047	0.23	2.7	0.0021	0.00017
Aldrin	**0.000028**	0.0085	0.070	0.00000042	0.049	log=0.819*log(Kow)-1.146	0.0014	1.0	0.00012	0.040	0.66	0.000080	0.050	0.50	0.0016	0.00016
alpha-Chlordane	*0.00055*	0.0085	0.070	0.0000082	0.049	log=0.819*log(Kow)-1.146	0.031	1.0	0.0027	0.040	0.66	0.0018	2.1	11	0.00083	0.00017
delta-BHC	**0.000024**	0.0085	0.070	0.00000036	0.049	log=0.819*log(Kow)-1.146	0.00023	1.0	0.000020	0.040	0.66	0.000013	0.56	2.3	0.000024	0.0000059
Dieldrin	0.00011	0.0085	0.070	0.0000016	0.049	log=0.819*log(Kow)-1.146	0.0026	1.0	0.00023	0.040	0.66	0.00015	0.071	0.80	0.0021	0.00019
Endosulfan I	**0.000030**	0.0085	0.070	0.00000044	0.049	log=0.819*log(Kow)-1.146	0.00016	1.0	0.000014	0.040	0.66	0.0000095	10	100	0.00000095	0.000000095
Endosulfan II	**0.000028**	0.0085	0.070	0.00000041	0.049	log=0.819*log(Kow)-1.146	0.00017	1.0	0.000015	0.040	0.66	0.0000099	10	100	0.00000099	0.000000099
Endrin	0.000087	0.0085	0.070	0.0000013	0.049	log=0.819*log(Kow)-1.146	0.0015	1.0	0.00013	0.040	0.66	0.000088	0.010	0.10	0.0088	0.00088
Endrin Ketone	**0.000025**	0.0085	0.070	0.00000036	0.049	log=0.819*log(Kow)-1.146	0.00046	1.0	0.000040	0.040	0.66	0.000027	0.010	0.10	0.0027	0.00027
gamma-Chlordane	*0.00041*	0.0085	0.070	0.0000061	0.049	log=0.819*log(Kow)-1.146	0.023	1.0	0.0020	0.040	0.66	0.0013	2.1	11	0.00062	0.00012
Hepatachlor	0.000089	0.0085	0.070	0.0000013	0.049	1.67	0.00015	1.0	0.000013	0.040	0.66	0.0000094	65	650	0.00000014	0.000000014
Hepatachlor epoxide	**0.000031**	0.0085	0.070	0.00000045	0.049	log=0.819*log(Kow)-1.146	0.00047	1.0	0.000041	0.040	0.66	0.000027	65	650	0.00000042	0.000000042
Toxaphene	**0.0011**	0.0085	0.070	0.000016	0.049	log=0.819*log(Kow)-1.146	0.030	1.0	0.0026	0.040	0.66	0.0017	0.68	6.0	0.0026	0.00029
PCBs																
PCB-1254	**0.00022**	0.0085	0.070	0.0000033	0.049	0.53	0.00012	1.0	0.000010	0.040	0.66	0.0000088	0.18	1.8	0.000049	0.0000049
PCB-1260	0.0039	0.0085	0.070	0.000058	0.049	log=0.819*log(Kow)-1.146	0.33	1.0	0.028	0.040	0.66	0.019	0.18	1.8	0.10	0.010
Total PCBs	0.0039	0.0085	0.070	0.000058	0.049	0.0327	0.00013	1.0	0.000011	0.040	0.66	0.000046	0.18	1.8	0.00025	0.000025
Metals*																
Antimony	*0.18*	0.0085	0.070	0.0027	0.049	0.90	0.16	1.0	0.014	0.040	0.66	0.011	490	4,900	0.000022	0.0000022
Arsenic	24.9	0.0085	0.070	0.37	0.049	0.90	22	1.0	1.9	0.040	0.66	1.5	2.2	4.5	0.68	0.34
Barium	*12.3*	0.0085	0.070	0.18	0.049	0.90	11	1.0	0.96	0.040	0.66	0.75	21	208	0.036	0.0036
Beryllium	*0.50*	0.0085	0.070	0.0074	0.049	0.90	0.45	1.0	0.039	0.040	0.66	0.031	4	19	0.0079	0.0016
Chromium	22.8	0.0085	0.070	0.34	0.049	0.39	8.9	1.0	0.77	0.040	0.66	0.73	2.7	16	0.28	0.047
Copper	6.0	0.0085	0.070	0.089	0.049	0.30	1.8	1.0	0.16	0.040	0.66	0.16	4.1	35	0.040	0.0046
Lead	13.2	0.0085	0.070	0.20	0.049	0.63	8.3	1.0	0.72	0.040	0.66	0.60	1.6	45	0.37	0.014
Nickel	6.3	0.0085	0.070	0.094	0.049	0.90	5.7	1.0	0.49	0.040	0.66	0.39	6.7	19	0.057	0.021
Selenium	*0.82*	0.0085	0.070	0.012	0.049	0.90	0.74	1.0	0.064	0.040	0.66	0.050	0.29	0.82	0.17	0.061
Thallium	*1.7*	0.0085	0.070	0.025	0.049	0.90	1.5	1.0	0.13	0.040	0.66	0.10	0.35	3.5	0.30	0.030
Vanadium	*27.5*	0.0085	0.070	0.41	0.049	0.0148	0.41	1.0	0.035	0.040	0.66	0.29	0.34	1.7	0.85	0.17
Zinc	63	0.0085	0.070	0.94	0.049	0.57	36	1.0	3.1	0.040	0.66	2.7	66	171	0.040	0.016

NOTES:
(a) - Values and references for these variables are presented in Section 5.5.1 of the Risk Assessment Workplan.
(b) - See table XXX for BAFs and concentration calculations.
(c) - See Table XXX for TRV derivations.
(d) - Food consumption rate was converted from kg dry weight (dw) per day to kg wet weight (ww) per day by using the equation from United States Environmental Protection Agency (USEPA) Exposure Factors Handbook (USEPA, 2011):
IRww = (IRdw * 100)/% solids
Where: IR = Ingestion rate
% solids = 100 - % water makeup of benthic invertebrates (e.g. 100 - 84 = 16) (USEPA, 2007)
* Calcium, Iron, Magnesium, Potassium and Sodium were not included in the model equations as they are considered to be essential nutrients.
mg/kg - milligrams per kilogram
kg/day - kilograms per day
mg/kg/day - milligrams per kilogram per day
kg - kilograms
$_{ww}$ - wet weight
$_{dw}$ - dry weight
$_{bw}$ - body weight
NOAEL - No Observable Adverse Effects Level.
LOAEL - Lowest Observable Adverse Effects Level.
HQ - Hazard Quotient.

Bolded values indicate a concentration based on 1/2 the maximum detection limit for a non-detected value.
Italicized values indicate a maximum detected concentration with no associated Ecological Screening Value.
Shaded cells indicated HQs equal to or greater than 1.0.

Table 6-14
Hazard Quotients for Ingestion of Fish and Benthic Invertebrates - Raccoon (Upstream Maximum Concentrations)
Red Bank Landfill Site
Red Bank, New Jersey

Analyte	Maximum Concentration of Contaminant in Sediment (mg/kg_{dw})	Sediment Ingestion Rate (a) (d) (kg_{dw}/day)	Area Use Factor (a)	Dose from Sediment (mg/kg_{bw}/day)	Dietary Ingestion Rate (a) (kg_{ww}/day)	Sediment to Benthic Invertebrate Biota-Sediment Accumulation Factors (BSAFs) (b)	Concentration of Contaminant in Benthic Invertebrates (mg/kg_{ww}) (b)	Dietary Percentage of Benthic Invertebrates (a)	Dose from Benthic Invertebrates (mg/kg_{bw}/day)	Sediment to Fish Biota-Sediment Accumulation Factors (BSAFs) (b)	Concentration of Contaminant in Fish (mg/kg_{ww}) (b)	Dietary Percentage of Fish (a)	Dose from Fish (mg/kg_{bw}/day)	Average Body Weight (a) (kg)	Seasonal Use Factor (a)	Average Daily Dose (mg/kg_{bw}/day)	Toxicity Reference Values (TRVs) (c)		Hazard Quotient	
SVOCs																	NOAEL	LOAEL	NOAEL HQ	LOAEL HQ
2,4-Dinitrophenol	**0.075**	0.080	0.0054	0.0000056	1.26	log=0.819*log(Kow)-1.146	0.083	0.50	0.000049	log=0.819*log(Kow)-1.146	0.083	0.50	0.000049	5.78	1.0	0.00010	20	30	0.0000051	0.0000034
4-Nitrophenol	**0.023**	0.080	0.0054	0.0000017	1.26	log=0.819*log(Kow)-1.146	0.035	0.50	0.000021	log=0.819*log(Kow)-1.146	0.035	0.50	0.000021	5.78	1.0	0.000043	12	28	0.0000036	0.0000015
Acenaphthene	**0.0012**	0.080	0.0054	0.000000090	1.26	0.00411	0.0000049	0.50	0.0000000029	0.00411	0.0000049	0.50	0.0000000029	5.78	1.0	0.000000096	66	356	0.0000000015	0.00000000027
Acetophenone	**0.0050**	0.080	0.0054	0.00000038	1.26	log=0.819*log(Kow)-1.146	0.0061	0.50	0.0000036	log=0.819*log(Kow)-1.146	0.0061	0.50	0.0000036	5.78	1.0	0.0000075	42	423	0.00000018	0.000000018
Benzaldehyde	**0.0095**	0.080	0.0054	0.00000071	1.26	log=0.819*log(Kow)-1.146	0.010	0.50	0.0000060	log=0.819*log(Kow)-1.146	0.010	0.50	0.0000060	5.78	1.0	0.000013	14	40	0.00000088	0.00000032
Benzo(g,h,i)perylene	0.018	0.080	0.0054	0.0000014	1.26	0.0164	0.00030	0.50	0.00000017	0.0164	0.00030	0.50	0.00000017	5.78	1.0	0.0000017	0.62	38	0.0000028	0.000000044
Carbazole	*0.0042*	0.080	0.0054	0.00000032	1.26	log=0.819*log(Kow)-1.146	0.020	0.50	0.000012	log=0.819*log(Kow)-1.146	0.020	0.50	0.000012	5.78	1.0	0.000024	5.0	50	0.0000047	0.00000047
Fluorene	0.0038	0.080	0.0054	0.00000029	1.26	0.0040	0.000015	0.50	0.0000000089	0.0040	0.000015	0.50	0.0000000089	5.78	1.0	0.00000030	66	356	0.0000000046	0.00000000085
Phenanthrene	0.035	0.080	0.0054	0.0000026	1.26	0.0039	0.00014	0.50	0.000000080	0.0039	0.00014	0.50	0.000000080	5.78	1.0	0.0000028	66	356	0.000000043	0.0000000078
Pesticides																				
4,4'-DDD	**0.000021**	0.080	0.0054	0.0000000015	1.26	log=0.819*log(Kow)-1.146	0.00098	0.50	0.00000058	log=0.819*log(Kow)-1.146	0.00098	0.50	0.00000058	5.78	1.0	0.0000012	0.15	5.6	0.0000079	0.00000021
4,4'-DDE	0.00025	0.080	0.0054	0.000000019	1.26	0.95	0.00024	0.50	0.00000014	0.95	0.00024	0.50	0.00000014	5.78	1.0	0.00000030	0.15	5.6	0.0000020	0.000000054
4,4'-DDT	0.00018	0.080	0.0054	0.000000014	1.26	log=0.819*log(Kow)-1.146	0.0082	0.50	0.0000049	log=0.819*log(Kow)-1.146	0.0082	0.50	0.0000049	5.78	1.0	0.0000097	0.15	5.6	0.000066	0.0000017
Aldrin	**0.000028**	0.080	0.0054	0.0000000021	1.26	log=0.819*log(Kow)-1.146	0.0014	0.50	0.00000083	log=0.819*log(Kow)-1.146	0.0014	0.50	0.00000083	5.78	1.0	0.0000017	0.20	1.0	0.0000083	0.0000017
alpha-Chlordane	*0.00055*	0.080	0.0054	0.000000041	1.26	log=0.819*log(Kow)-1.146	0.031	0.50	0.000018	log=0.819*log(Kow)-1.146	0.031	0.50	0.000018	5.78	1.0	0.000036	4.6	9.2	0.0000079	0.0000040
delta-BHC	**0.000024**	0.080	0.0054	0.0000000018	1.26	log=0.819*log(Kow)-1.146	0.00023	0.50	0.00000013	log=0.819*log(Kow)-1.146	0.00023	0.50	0.00000013	5.78	1.0	0.00000027	0.15	0.67	0.0000018	0.00000040
Dieldrin	0.00011	0.080	0.0054	0.0000000083	1.26	log=0.819*log(Kow)-1.146	0.0026	0.50	0.0000015	log=0.819*log(Kow)-1.146	0.0026	0.50	0.0000015	5.78	1.0	0.0000031	0.015	1.3	0.00021	0.0000024
Endosulfan I	**0.000030**	0.080	0.0054	0.0000000022	1.26	log=0.819*log(Kow)-1.146	0.00016	0.50	0.000000095	log=0.819*log(Kow)-1.146	0.00016	0.50	0.000000095	5.78	1.0	0.00000019	0.15	1.5	0.0000013	0.00000013
Endosulfan II	**0.000028**	0.080	0.0054	0.0000000021	1.26	log=0.819*log(Kow)-1.146	0.00017	0.50	0.00000010	log=0.819*log(Kow)-1.146	0.00017	0.50	0.00000010	5.78	1.0	0.00000020	0.15	1.5	0.0000013	0.00000013
Endrin	0.000087	0.080	0.0054	0.0000000065	1.26	log=0.819*log(Kow)-1.146	0.0015	0.50	0.00000089	log=0.819*log(Kow)-1.146	0.0015	0.50	0.00000089	5.78	1.0	0.0000018	0.092	0.92	0.000020	0.0000020
Endrin Ketone	**0.000025**	0.080	0.0054	0.0000000018	1.26	log=0.819*log(Kow)-1.146	0.00046	0.50	0.00000027	log=0.819*log(Kow)-1.146	0.00046	0.50	0.00000027	5.78	1.0	0.00000055	0.092	0.92	0.0000060	0.00000060
gamma-Chlordane	*0.00041*	0.080	0.0054	0.000000031	1.26	log=0.819*log(Kow)-1.146	0.023	0.50	0.000014	log=0.819*log(Kow)-1.146	0.023	0.50	0.000014	5.78	1.0	0.000027	4.6	9.2	0.0000059	0.0000030
Hepatachlor	0.000089	0.080	0.0054	0.0000000067	1.26	1.67	0.00015	0.50	0.000000087	1.67	0.00015	0.50	0.000000087	5.78	1.0	0.00000018	0.10	1.0	0.0000018	0.00000018
Hepatachlor epoxide	**0.000031**	0.080	0.0054	0.0000000023	1.26	log=0.819*log(Kow)-1.146	0.00047	0.50	0.00000028	log=0.819*log(Kow)-1.146	0.00047	0.50	0.00000028	5.78	1.0	0.00000056	0.10	1.0	0.0000056	0.00000056
Toxaphene	**0.0011**	0.080	0.0054	0.000000079	1.26	log=0.819*log(Kow)-1.146	0.030	0.50	0.000018	log=0.819*log(Kow)-1.146	0.030	0.50	0.000018	5.78	1.0	0.000036	8.0	80	0.0000045	0.00000045
PCBs																				
PCB-1254	**0.00022**	0.080	0.0054	0.000000017	1.26	0.53	0.00012	0.50	0.000000069	0.53	0.00012	0.50	0.000000069	5.78	1.0	0.00000015	0.098	0.68	0.0000016	0.00000022
PCB-1260	0.0039	0.080	0.0054	0.00000029	1.26	log=0.819*log(Kow)-1.146	0.33	0.50	0.00019	log=0.819*log(Kow)-1.146	0.33	0.50	0.00019	5.78	1.0	0.00038	5.0	50	0.000077	0.0000077
Total PCBs	0.0039	0.080	0.0054	0.00000029	1.26	0.0327	0.00013	0.50	0.000000075	0.0327	0.00013	0.50	0.000000075	5.78	1.0	0.00000044	0.098	0.68	0.0000045	0.00000065
Metals*																				
Antimony	*0.18*	0.080	0.0054	0.000014	1.26	0.90	0.16	0.50	0.000095	0.90	0.16	0.50	0.000095	5.78	1.0	0.00020	0.059	2.8	0.0035	0.000074
Arsenic	24.9	0.080	0.0054	0.0019	1.26	0.90	22	0.50	0.013	0.90	22	0.50	0.013	5.78	1.0	0.028	1.0	5.7	0.027	0.0050
Barium	*12.3*	0.080	0.0054	0.00092	1.26	0.90	11	0.50	0.0065	0.90	11	0.50	0.0065	5.78	1.0	0.014	52	83	0.00027	0.00017
Beryllium	*0.50*	0.080	0.0054	0.000038	1.26	0.90	0.45	0.50	0.00026	0.90	0.45	0.50	0.00026	5.78	1.0	0.00057	0.53	0.67	0.0011	0.00084
Chromium	22.8	0.080	0.0054	0.0017	1.26	0.39	8.9	0.50	0.0052	0.39	8.9	0.50	0.0052	5.78	1.0	0.012	2.4	58	0.0051	0.00021
Copper	6.0	0.080	0.0054	0.00045	1.26	0.30	1.8	0.50	0.0011	0.30	1.8	0.50	0.0011	5.78	1.0	0.0026	5.6	83	0.00046	0.000031
Lead	13.2	0.080	0.0054	0.00099	1.26	0.63	8.3	0.50	0.0049	0.63	8.3	0.50	0.0049	5.78	1.0	0.011	4.7	186	0.0023	0.000058
Nickel	6.3	0.080	0.0054	0.00047	1.26	0.90	5.7	0.50	0.0033	0.90	5.7	0.50	0.0033	5.78	1.0	0.0071	1.7	15	0.0042	0.00048
Selenium	*0.82*	0.080	0.0054	0.000062	1.26	0.90	0.74	0.50	0.00043	0.90	0.74	0.50	0.00043	5.78	1.0	0.00093	0.14	0.66	0.0065	0.0014
Thallium	*1.7*	0.080	0.0054	0.00013	1.26	0.90	1.5	0.50	0.00090	0.90	1.5	0.50	0.00090	5.78	1.0	0.0019	0.0074	0.074	0.26	0.026
Vanadium	*27.5*	0.080	0.0054	0.0021	1.26	0.0148	0.41	0.50	0.00024	0.0148	0.41	0.50	0.00024	5.78	1.0	0.0025	4.2	9.4	0.00061	0.00027
Zinc	63	0.080	0.0054	0.0047	1.26	0.57	36	0.50	0.021	0.57	36	0.50	0.021	5.78	1.0	0.047	75	298	0.00062	0.00016

NOTES:
(a) - Values and references for these variables are presented in Section 5.5.1 of the Risk Assessment Workplan.
(b) - See table XXX for BSAFs and concentration calculations.
(c) - See Table XXX for TRV derivations.
(d) - Sediment consumption rate was converted from kg wet weight (ww) per day to kg dry weight (dw) per day by using the equation from United States Environmental Protection Agency (USEPA) Exposure Factors Handbook (USEPA, 2011):
IRdw = (IRww * % solids)/100
Where: IR = Ingestion rate
% solids = 100 - average % water makeup of sediment (e.g. 100 - 32.15 = 67.85)
* Calcium, Iron, Magnesium, Potassium and Sodium were not included in the model equations as they are considered to be essential nutrients.
mg/kg - milligrams per kilogram
kg/day - kilograms per day
mg/kg/day - milligrams per kilogram per day
kg - kilograms
$_{ww}$ - wet weight
$_{dw}$ - dry weight
$_{bw}$ - body weight
NOAEL - No Observable Adverse Effects Level.
LOAEL - Lowest Observable Adverse Effects Level.
HQ - Hazard Quotient.

Bolded values indicate a concentration based on 1/2 the maximum detection limit for a non-detected value.
Italicized values indicate a maximum detected concentration with no associated Ecological Screening Value.
Shaded cells indicated HQs equal to or greater than 1.0.

Table 6-15
Hazard Quotients for Ingestion of Fish - Bald Eagle (Downstream Maximum Concentrations)
Red Bank Landfill Site
Red Bank, New Jersey

Analyte	Maximum Concentration of Contaminant in Sediment (mg/kg_{dw})	Sediment Ingestion Rate (a) (d) (kg_{dw}/day)	Area Use Factor (a)	Dose from Sediment (mg/kg_{bw}/day)	Dietary Ingestion Rate (a) (kg_{ww}/day)	Sediment to Fish Biota-Sediment Accumulation Factors (BSAFs) (b)	Concentration of Contaminant in Fish (mg/kg_{ww}) (b)	Dietary Percentage of Fish (a)	Dose from Fish (mg/kg_{bw}/day)	Average Body Weight (a) (kg)	Seasonal Use Factor (a)	Average Daily Dose (mg/kg_{bw}/day)	Toxicity Reference Values (TRVs) (c)		Hazard Quotient	
SVOCs													NOAEL	LOAEL	NOAEL HQ	LOAEL HQ
2,4-Dinitrophenol	**0.065**	0.018	0.060	0.000019	0.45	log=0.819*log(Kow)-1.146	0.072	1.0	0.00052	3.75	1.0	0.00053	1.6	16	0.00034	0.000034
4-Nitrophenol	**0.020**	0.018	0.060	0.0000058	0.45	log=0.819*log(Kow)-1.146	0.030	1.0	0.00022	3.75	1.0	0.00022	16	159	0.000014	0.0000014
Acenaphthene	0.0061	0.018	0.060	0.0000018	0.45	0.00411	0.000025	1.0	0.00000018	3.75	1.0	0.0000019	19	194	0.00000010	0.000000010
Acetophenone	*0.0039*	0.018	0.060	0.0000011	0.45	log=0.819*log(Kow)-1.146	0.0048	1.0	0.000034	3.75	1.0	0.000035	1.6	16	0.000022	0.0000022
Benzaldehyde	**0.0080**	0.018	0.060	0.0000023	0.45	log=0.819*log(Kow)-1.146	0.0085	1.0	0.000061	3.75	1.0	0.000064	1.6	16	0.000040	0.0000040
Benzo(g,h,i)perylene	0.079	0.018	0.060	0.000023	0.45	0.0164	0.0013	1.0	0.0000093	3.75	1.0	0.000032	0.20	2.0	0.00016	0.000016
Carbazole	**0.0010**	0.018	0.060	0.00000029	0.45	log=0.819*log(Kow)-1.146	0.0047	1.0	0.000034	3.75	1.0	0.000034	1.6	16	0.000022	0.0000022
Fluorene	0.011	0.018	0.060	0.0000032	0.45	0.0040	0.000044	1.0	0.00000032	3.75	1.0	0.0000035	0.20	2.0	0.000017	0.0000017
Phenanthrene	0.13	0.018	0.060	0.000037	0.45	0.0039	0.00051	1.0	0.0000037	3.75	1.0	0.000041	0.20	2.0	0.00021	0.000021
Pesticides																
4,4'-DDD	0.00034	0.018	0.060	0.000000098	0.45	log=0.819*log(Kow)-1.146	0.016	1.0	0.00012	3.75	1.0	0.00012	0.23	2.7	0.00052	0.000043
4,4'-DDE	0.00038	0.018	0.060	0.00000011	0.45	0.95	0.00036	1.0	0.0000026	3.75	1.0	0.0000027	0.23	2.7	0.000012	0.0000010
4,4'-DDT	**0.000022**	0.018	0.060	0.0000000063	0.45	log=0.819*log(Kow)-1.146	0.0010	1.0	0.0000073	3.75	1.0	0.0000073	0.23	2.7	0.000032	0.0000027
Aldrin	**0.000027**	0.018	0.060	0.0000000076	0.45	log=0.819*log(Kow)-1.146	0.0013	1.0	0.0000096	3.75	1.0	0.0000096	0.050	0.50	0.00019	0.000019
alpha-Chlordane	*0.00035*	0.018	0.060	0.00000010	0.45	log=0.819*log(Kow)-1.146	0.020	1.0	0.00014	3.75	1.0	0.00014	2.1	11	0.000066	0.000013
delta-BHC	**0.000023**	0.018	0.060	0.0000000065	0.45	log=0.819*log(Kow)-1.146	0.00021	1.0	0.0000015	3.75	1.0	0.0000015	0.56	2.3	0.0000027	0.00000068
Dieldrin	0.00013	0.018	0.060	0.000000037	0.45	log=0.819*log(Kow)-1.146	0.0031	1.0	0.000022	3.75	1.0	0.000022	0.071	0.80	0.00031	0.000028
Endosulfan I	**0.000028**	0.018	0.060	0.0000000081	0.45	log=0.819*log(Kow)-1.146	0.00015	1.0	0.0000011	3.75	1.0	0.0000011	10	100	0.00000011	0.000000011
Endosulfan II	**0.000026**	0.018	0.060	0.0000000075	0.45	log=0.819*log(Kow)-1.146	0.00016	1.0	0.0000012	3.75	1.0	0.0000012	10	100	0.00000012	0.000000012
Endrin	0.00018	0.018	0.060	0.000000052	0.45	log=0.819*log(Kow)-1.146	0.0031	1.0	0.000023	3.75	1.0	0.000023	0.010	0.10	0.0023	0.00023
Endrin Ketone	**0.000023**	0.018	0.060	0.0000000066	0.45	log=0.819*log(Kow)-1.146	0.00044	1.0	0.0000031	3.75	1.0	0.0000031	0.010	0.10	0.00031	0.000031
gamma-Chlordane	*0.00046*	0.018	0.060	0.00000013	0.45	log=0.819*log(Kow)-1.146	0.026	1.0	0.00019	3.75	1.0	0.00019	2.1	11	0.000087	0.000017
Hepatachlor	**0.000033**	0.018	0.060	0.0000000094	0.45	1.67	0.000054	1.0	0.00000039	3.75	1.0	0.00000040	65	650	0.0000000062	0.00000000062
Hepatachlor epoxide	0.000066	0.018	0.060	0.000000019	0.45	log=0.819*log(Kow)-1.146	0.0010	1.0	0.0000074	3.75	1.0	0.0000074	65	650	0.00000011	0.000000011
Toxaphene	**0.0010**	0.018	0.060	0.00000029	0.45	log=0.819*log(Kow)-1.146	0.029	1.0	0.00021	3.75	1.0	0.00021	0.68	6.0	0.00030	0.000034
PCBs																
PCB-1254	0.0056	0.018	0.060	0.0000016	0.45	0.53	0.0030	1.0	0.000021	3.75	1.0	0.000023	0.18	1.8	0.00013	0.000013
PCB-1260	**0.00021**	0.018	0.060	0.000000061	0.45	log=0.819*log(Kow)-1.146	0.018	1.0	0.00013	3.75	1.0	0.00013	0.18	1.8	0.00070	0.000070
Total PCBs	0.0056	0.018	0.060	0.0000016	0.45	0.0327	0.00018	1.0	0.0000013	3.75	1.0	0.0000029	0.18	1.8	0.000016	0.0000016
Metals*																
Antimony	*0.32*	0.018	0.060	0.000092	0.45	0.90	0.29	1.0	0.0021	3.75	1.0	0.0022	490	4,900	0.0000044	0.00000044
Arsenic	13.8	0.018	0.060	0.0040	0.45	0.90	12	1.0	0.089	3.75	1.0	0.093	2.2	4.5	0.042	0.021
Barium	*5.5*	0.018	0.060	0.0016	0.45	0.90	5.0	1.0	0.036	3.75	1.0	0.037	21	208	0.0018	0.00018
Beryllium	*0.48*	0.018	0.060	0.00014	0.45	0.90	0.43	1.0	0.0031	3.75	1.0	0.0032	3.9	19	0.00084	0.00017
Chromium	22.3	0.018	0.060	0.0064	0.45	0.39	8.7	1.0	0.063	3.75	1.0	0.069	2.7	16	0.026	0.0044
Copper	7.0	0.018	0.060	0.0020	0.45	0.30	2.1	1.0	0.015	3.75	1.0	0.017	4.1	35	0.0042	0.00049
Lead	21.1	0.018	0.060	0.0061	0.45	0.63	13	1.0	0.096	3.75	1.0	0.10	1.6	45	0.062	0.0023
Nickel	6.3	0.018	0.060	0.0018	0.45	0.90	5.7	1.0	0.041	3.75	1.0	0.043	6.7	19	0.0064	0.0023
Selenium	*0.31*	0.018	0.060	0.000089	0.45	0.90	0.28	1.0	0.0020	3.75	1.0	0.0021	0.29	0.82	0.0072	0.0026
Thallium	*0.86*	0.018	0.060	0.00025	0.45	0.90	0.77	1.0	0.0056	3.75	1.0	0.0058	0.35	3.5	0.017	0.0017
Vanadium	*24.4*	0.018	0.060	0.0070	0.45	0.0148	0.36	1.0	0.0026	3.75	1.0	0.0096	0.34	1.7	0.028	0.0057
Zinc	70.8	0.018	0.060	0.020	0.45	0.57	40	1.0	0.29	3.75	1.0	0.31	66	171	0.0047	0.0018

NOTES:
(a) - Values and references for these variables are presented in Section 5.5.1 of the Risk Assessment Workplan.
(b) - See table XXX for BSAFs and concentration calculations.
(c) - See Table XXX for TRV derivations.
(d) - Sediment consumption rate was converted from kg wet weight (ww) per day to kg dry weight (dw) per day by using the equation from United States Environmental Protection Agency (USEPA) Exposure Factors Handbook (USEPA, 2011):
IRdw = (IRww * % solids)/100
Where: IR = Ingestion rate
% solids = 100 - average % water makeup of sediment (e.g. 100 - 32.15 = 67.85)
* Calcium, Iron, Magnesium, Potassium and Sodium were not included in the model equations as they are considered to be essential nutrients.
mg/kg - milligrams per kilogram
kg/day - kilograms per day
mg/kg/day - milligrams per kilogram per day
kg - kilograms
$_{ww}$ - wet weight
$_{dw}$ - dry weight
$_{bw}$ - body weight
NOAEL - No Observable Adverse Effects Level.
LOAEL - Lowest Observable Adverse Effects Level.
HQ - Hazard Quotient.

Bolded values indicate a concentration based on 1/2 the maximum detection limit for a non-detected value.
Italicized values indicate a maximum detected concentration with no associated Ecological Screening Value.
Shaded cells indicated HQs equal to or greater than 1.0.

Table 6-16
Hazard Quotients for Ingestion of Fish - Great Blue Heron (Downstream Maximum Concentrations)
Red Bank Landfill Site
Red Bank, New Jersey

Analyte	Maximum Concentration of Contaminant in Sediment (mg/kg_{dw})	Sediment Ingestion Rate (a) (kg_{dw}/day)	Area Use Factor (a)	Dose from Sediment (mg/kg_{bw}/day)	Dietary Ingestion Rate (a) (kg_{ww}/day)	Sediment to Fish Biota-Sediment Accumulation Factors (BSAFs) (b)	Concentration of Contaminant in Fish (mg/kg_{ww}) (b)	Dietary Percentage of Fish (a)	Dose from Fish (mg/kg_{bw}/day)	Average Body Weight (a) (kg)	Seasonal Use Factor (a)	Average Daily Dose (mg/kg_{bw}/day)	Toxicity Reference Values (TRVs) (c)		Hazard Quotient	
SVOCs													NOAEL	LOAEL	NOAEL HQ	LOAEL HQ
2,4-Dinitrophenol	**0.065**	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.072	1.0	0.0000049	2.39	1.0	0.0000049	1.6	16	0.0000031	0.00000031
4-Nitrophenol	**0.020**	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.030	1.0	0.0000021	2.39	1.0	0.0000021	16	159	0.00000013	0.000000013
Acenaphthene	0.0061	0.0	0.00039	0.0	0.42	0.00411	0.000025	1.0	0.0000000017	2.39	1.0	0.0000000017	19	194	0.000000000089	0.0000000000089
Acetophenone	*0.0039*	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.0048	1.0	0.00000033	2.39	1.0	0.00000033	1.6	16	0.00000021	0.000000021
Benzaldehyde	**0.0080**	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.0085	1.0	0.00000058	2.39	1.0	0.00000058	1.6	16	0.00000037	0.000000037
Benzo(g,h,i)perylene	0.079	0.0	0.00039	0.0	0.42	0.0164	0.0013	1.0	0.000000089	2.39	1.0	0.000000089	0.20	2.0	0.00000044	0.000000044
Carbazole	**0.0010**	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.0047	1.0	0.00000032	2.39	1.0	0.00000032	1.6	16	0.00000020	0.000000020
Fluorene	0.011	0.0	0.00039	0.0	0.42	0.0040	0.000044	1.0	0.0000000030	2.39	1.0	0.0000000030	0.20	2.0	0.000000015	0.0000000015
Phenanthrene	0.13	0.0	0.00039	0.0	0.42	0.0039	0.00051	1.0	0.000000035	2.39	1.0	0.000000035	0.20	2.0	0.00000017	0.000000017
Pesticides																
4,4'-DDD	0.00034	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.016	1.0	0.0000011	2.39	1.0	0.0000011	0.23	2.7	0.0000049	0.00000041
4,4'-DDE	0.00038	0.0	0.00039	0.0	0.42	0.95	0.00036	1.0	0.000000025	2.39	1.0	0.000000025	0.23	2.7	0.00000011	0.0000000092
4,4'-DDT	**0.000022**	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.0010	1.0	0.000000069	2.39	1.0	0.000000069	0.23	2.7	0.00000030	0.000000026
Aldrin	**0.000027**	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.0013	1.0	0.000000091	2.39	1.0	0.000000091	0.050	0.50	0.0000018	0.00000018
alpha-Chlordane	*0.00035*	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.020	1.0	0.0000013	2.39	1.0	0.0000013	2.1	11	0.00000063	0.00000013
delta-BHC	**0.000023**	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.00021	1.0	0.000000015	2.39	1.0	0.000000015	0.56	2.3	0.000000026	0.0000000065
Dieldrin	0.00013	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.0031	1.0	0.00000021	2.39	1.0	0.00000021	0.071	0.80	0.0000030	0.00000026
Endosulfan I	**0.000028**	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.00015	1.0	0.000000011	2.39	1.0	0.000000011	10	100	0.0000000011	0.00000000011
Endosulfan II	**0.000026**	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.00016	1.0	0.000000011	2.39	1.0	0.000000011	10	100	0.0000000011	0.00000000011
Endrin	0.00018	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.0031	1.0	0.00000022	2.39	1.0	0.00000022	0.010	0.10	0.000022	0.0000022
Endrin Ketone	**0.000023**	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.00044	1.0	0.000000030	2.39	1.0	0.000000030	0.010	0.10	0.0000030	0.00000030
gamma-Chlordane	*0.00046*	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.026	1.0	0.0000018	2.39	1.0	0.0000018	2.1	11	0.00000083	0.00000017
Hepatachlor	**0.000033**	0.0	0.00039	0.0	0.42	1.67	0.000054	1.0	0.0000000037	2.39	1.0	0.0000000037	65	650	0.000000000057	0.0000000000057
Hepatachlor epoxide	0.000066	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.0010	1.0	0.000000070	2.39	1.0	0.000000070	65	650	0.0000000011	0.00000000011
Toxaphene	**0.0010**	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.029	1.0	0.0000020	2.39	1.0	0.0000020	0.68	6.0	0.0000029	0.00000033
PCBs																
PCB-1254	0.0056	0.0	0.00039	0.0	0.42	0.53	0.0030	1.0	0.00000020	2.39	1.0	0.00000020	0.18	1.8	0.0000011	0.00000011
PCB-1260	**0.00021**	0.0	0.00039	0.0	0.42	log=0.819*log(Kow)-1.146	0.018	1.0	0.0000012	2.39	1.0	0.0000012	0.18	1.8	0.0000067	0.00000067
Total PCBs	0.0056	0.0	0.00039	0.0	0.42	0.0327	0.00018	1.0	0.000000013	2.39	1.0	0.000000013	0.18	1.8	0.000000070	0.0000000070
Metals*																
Antimony	*0.32*	0.0	0.00039	0.0	0.42	0.90	0.29	1.0	0.000020	2.39	1.0	0.000020	490	4,900	0.000000040	0.0000000040
Arsenic	13.8	0.0	0.00039	0.0	0.42	0.90	12	1.0	0.00085	2.39	1.0	0.00085	2.2	4.5	0.00038	0.00019
Barium	*5.5*	0.0	0.00039	0.0	0.42	0.90	5.0	1.0	0.00034	2.39	1.0	0.00034	21	208	0.000016	0.0000016
Beryllium	*0.48*	0.0	0.00039	0.0	0.42	0.90	0.43	1.0	0.000030	2.39	1.0	0.000030	3.9	19	0.0000076	0.0000015
Chromium	22.3	0.0	0.00039	0.0	0.42	0.39	8.7	1.0	0.00060	2.39	1.0	0.00060	2.7	16	0.00022	0.000038
Copper	7.0	0.0	0.00039	0.0	0.42	0.30	2.1	1.0	0.00014	2.39	1.0	0.00014	4.1	35	0.000036	0.0000041
Lead	21.1	0.0	0.00039	0.0	0.42	0.63	13	1.0	0.00091	2.39	1.0	0.00091	1.6	45	0.00056	0.000020
Nickel	6.3	0.0	0.00039	0.0	0.42	0.90	5.7	1.0	0.00039	2.39	1.0	0.00039	6.7	19	0.000058	0.000021
Selenium	*0.31*	0.0	0.00039	0.0	0.42	0.90	0.28	1.0	0.000019	2.39	1.0	0.000019	0.29	0.82	0.000066	0.000023
Thallium	*0.86*	0.0	0.00039	0.0	0.42	0.90	0.77	1.0	0.000053	2.39	1.0	0.000053	0.35	3.5	0.00015	0.000015
Vanadium	*24.4*	0.0	0.00039	0.0	0.42	0.0148	0.36	1.0	0.000025	2.39	1.0	0.000025	0.34	1.7	0.000072	0.000015
Zinc	70.8	0.0	0.00039	0.0	0.42	0.57	40	1.0	0.0028	2.39	1.0	0.0028	66	171	0.000042	0.000016

NOTES:
(a) - Values and references for these variables are presented in Section 5.5.1 of the Risk Assessment Workplan.
(b) - See table XXX for BSAFs and concentration calculations.
(c) - See Table XXX for TRV derivations.
* Calcium, Iron, Magnesium, Potassium and Sodium were not included in the model equations as they are considered to be essential nutrients.
mg/kg - milligrams per kilogram
kg/day - kilograms per day
mg/kg/day - milligrams per kilogram per day
kg - kilograms
$_{ww}$ - wet weight
$_{dw}$ - dry weight
$_{bw}$ - body weight
NOAEL - No Observable Adverse Effects Level.
LOAEL - Lowest Observable Adverse Effects Level.
HQ - Hazard Quotient.

Bolded values indicate a concentration based on 1/2 the maximum detection limit for a non-detected value.
Italicized values indicate a maximum detected concentration with no associated Ecological Screening Value.
Shaded cells indicated HQs equal to or greater than 1.0.

Table 6-17
Hazard Quotients for Ingestion of Benthic Invertebrates - Mallard Duck (Downstream Maximum Concentrations)
Red Bank Landfill Site
Red Bank, New Jersey

Analyte	Maximum Concentration of Contaminant in Sediment (mg/kg_{dw})	Sediment Ingestion Rate (a) (d) (kg_{dw}/day)	Area Use Factor (a)	Dose from Sediment (mg/kg_{bw}/day)	Dietary Ingestion Rate (a) (kg_{ww}/day)	Sediment to Benthic Invertebrate Bioaccumulation Factors (BAFs) (b)	Concentration of Contaminant in Benthic Invertebrates (mg/kg_{ww}) (b)	Dietary Percentage of Benthic Invertebrates (a)	Dose from Benthic Invertebrates (mg/kg_{bw}/day)	Average Body Weight (a) (kg)	Seasonal Use Factor (a)	Average Daily Dose (mg/kg_{bw}/day)	Toxicity Reference Values (TRVs) (c)		Hazard Quotient	
SVOCs													NOAEL	LOAEL	NOAEL HQ	LOAEL HQ
2,4-Dinitrophenol	**0.065**	0.00668	0.0079	0.0000030	0.298	log=0.819*log(Kow)-1.146	0.072	1.0	0.00015	1.162	1.0	0.00015	1.6	16	0.000094	0.0000094
4-Nitrophenol	**0.020**	0.00668	0.0079	0.00000091	0.298	log=0.819*log(Kow)-1.146	0.030	1.0	0.000062	1.162	1.0	0.000062	16	159	0.0000039	0.00000039
Acenaphthene	0.0061	0.00668	0.0079	0.00000028	0.298	0.00411	0.000025	1.0	0.000000051	1.162	1.0	0.00000033	19	194	0.000000017	0.0000000017
Acetophenone	*0.0039*	0.00668	0.0079	0.00000018	0.298	log=0.819*log(Kow)-1.146	0.0048	1.0	0.000010	1.162	1.0	0.000010	1.6	16	0.0000062	0.00000062
Benzaldehyde	**0.0080**	0.00668	0.0079	0.00000036	0.298	log=0.819*log(Kow)-1.146	0.0085	1.0	0.000017	1.162	1.0	0.000018	1.6	16	0.000011	0.0000011
Benzo(g,h,i)perylene	0.079	0.00668	0.0079	0.0000036	0.298	0.0164	0.0013	1.0	0.0000026	1.162	1.0	0.0000062	0.20	2.0	0.000031	0.0000031
Carbazole	**0.0010**	0.00668	0.0079	0.000000045	0.298	log=0.819*log(Kow)-1.146	0.0047	1.0	0.0000095	1.162	1.0	0.000010	1.6	16	0.0000061	0.00000061
Fluorene	0.011	0.00668	0.0079	0.00000050	0.298	0.0040	0.000044	1.0	0.000000089	1.162	1.0	0.00000059	0.20	2.0	0.0000029	0.00000029
Phenanthrene	0.13	0.00668	0.0079	0.0000059	0.298	0.0039	0.00051	1.0	0.0000010	1.162	1.0	0.0000069	0.20	2.0	0.000035	0.0000035
Pesticides																
4,4'-DDD	0.00034	0.00668	0.0079	0.000000015	0.298	log=0.819*log(Kow)-1.146	0.016	1.0	0.000033	1.162	1.0	0.000033	0.23	2.7	0.00015	0.000012
4,4'-DDE	0.00038	0.00668	0.0079	0.000000017	0.298	0.95	0.00036	1.0	0.00000073	1.162	1.0	0.00000075	0.23	2.7	0.0000033	0.00000028
4,4'-DDT	**0.000022**	0.00668	0.0079	0.0000000010	0.298	log=0.819*log(Kow)-1.146	0.0010	1.0	0.0000020	1.162	1.0	0.0000020	0.23	2.7	0.0000090	0.00000076
Aldrin	**0.000027**	0.00668	0.0079	0.0000000012	0.298	log=0.819*log(Kow)-1.146	0.0013	1.0	0.0000027	1.162	1.0	0.0000027	0.050	0.50	0.000054	0.0000054
alpha-Chlordane	*0.00035*	0.00668	0.0079	0.000000016	0.298	log=0.819*log(Kow)-1.146	0.020	1.0	0.000040	1.162	1.0	0.000040	2.1	11	0.000019	0.0000037
delta-BHC	**0.000023**	0.00668	0.0079	0.0000000010	0.298	log=0.819*log(Kow)-1.146	0.00021	1.0	0.00000043	1.162	1.0	0.00000043	0.56	2.3	0.00000077	0.00000019
Dieldrin	0.00013	0.00668	0.0079	0.0000000059	0.298	log=0.819*log(Kow)-1.146	0.0031	1.0	0.0000063	1.162	1.0	0.0000063	0.071	0.80	0.000088	0.0000078
Endosulfan I	**0.000028**	0.00668	0.0079	0.0000000013	0.298	log=0.819*log(Kow)-1.146	0.00015	1.0	0.00000031	1.162	1.0	0.00000031	10	100	0.000000031	0.0000000031
Endosulfan II	**0.000026**	0.00668	0.0079	0.0000000012	0.298	log=0.819*log(Kow)-1.146	0.00016	1.0	0.00000032	1.162	1.0	0.00000033	10	100	0.000000033	0.0000000033
Endrin	0.00018	0.00668	0.0079	0.0000000082	0.298	log=0.819*log(Kow)-1.146	0.0031	1.0	0.0000064	1.162	1.0	0.0000064	0.010	0.10	0.00064	0.000064
Endrin Ketone	**0.000023**	0.00668	0.0079	0.0000000010	0.298	log=0.819*log(Kow)-1.146	0.00044	1.0	0.00000088	1.162	1.0	0.00000088	0.010	0.10	0.000088	0.0000088
gamma-Chlordane	*0.00046*	0.00668	0.0079	0.000000021	0.298	log=0.819*log(Kow)-1.146	0.026	1.0	0.000052	1.162	1.0	0.000052	2.1	11	0.000025	0.0000049
Hepatachlor	**0.000033**	0.00668	0.0079	0.0000000015	0.298	1.67	0.000054	1.0	0.00000011	1.162	1.0	0.00000011	65	650	0.0000000017	0.00000000017
Hepatachlor epoxide	0.000066	0.00668	0.0079	0.0000000030	0.298	log=0.819*log(Kow)-1.146	0.0010	1.0	0.0000021	1.162	1.0	0.0000021	65	650	0.000000032	0.0000000032
Toxaphene	**0.0010**	0.00668	0.0079	0.000000045	0.298	log=0.819*log(Kow)-1.146	0.029	1.0	0.000058	1.162	1.0	0.000058	0.68	6.0	0.000086	0.000010
PCBs																
PCB-1254	0.0056	0.00668	0.0079	0.00000025	0.298	0.53	0.0030	1.0	0.0000060	1.162	1.0	0.0000063	0.18	1.8	0.000035	0.0000035
PCB-1260	**0.00021**	0.00668	0.0079	0.0000000095	0.298	log=0.819*log(Kow)-1.146	0.018	1.0	0.000035	1.162	1.0	0.000035	0.18	1.8	0.00020	0.000020
Total PCBs	0.0056	0.00668	0.0079	0.00000025	0.298	0.0327	0.00018	1.0	0.00000037	1.162	1.0	0.00000063	0.18	1.8	0.0000035	0.00000035
Metals*																
Antimony	*0.32*	0.00668	0.0079	0.000015	0.298	0.90	0.29	1.0	0.00058	1.162	1.0	0.00060	490	4,900	0.0000012	0.00000012
Arsenic	13.8	0.00668	0.0079	0.00063	0.298	0.90	12	1.0	0.025	1.162	1.0	0.026	2.2	4.5	0.012	0.0057
Barium	*5.5*	0.00668	0.0079	0.00025	0.298	0.90	5.0	1.0	0.010	1.162	1.0	0.010	21	208	0.00049	0.000049
Beryllium	*0.48*	0.00668	0.0079	0.000022	0.298	0.90	0.43	1.0	0.00088	1.162	1.0	0.00090	3.9	19	0.00023	0.000047
Chromium	22.3	0.00668	0.0079	0.0010	0.298	0.39	8.7	1.0	0.018	1.162	1.0	0.019	2.7	16	0.0070	0.0012
Copper	7.0	0.00668	0.0079	0.00032	0.298	0.30	2.1	1.0	0.0043	1.162	1.0	0.0046	4.1	35	0.0011	0.00013
Lead	21.1	0.00668	0.0079	0.00096	0.298	0.63	13	1.0	0.027	1.162	1.0	0.028	1.6	45	0.017	0.00062
Nickel	6.3	0.00668	0.0079	0.00029	0.298	0.90	5.7	1.0	0.011	1.162	1.0	0.012	6.7	19	0.0018	0.00063
Selenium	*0.31*	0.00668	0.0079	0.000014	0.298	0.90	0.28	1.0	0.00057	1.162	1.0	0.00058	0.29	0.82	0.0020	0.00071
Thallium	*0.86*	0.00668	0.0079	0.000039	0.298	0.90	0.77	1.0	0.0016	1.162	1.0	0.0016	0.35	3.5	0.0046	0.00046
Vanadium	*24.4*	0.00668	0.0079	0.0011	0.298	0.0148	0.36	1.0	0.00073	1.162	1.0	0.0018	0.34	1.7	0.0053	0.0011
Zinc	70.8	0.00668	0.0079	0.0032	0.298	0.57	40	1.0	0.082	1.162	1.0	0.085	66	171	0.0013	0.00050

NOTES:
(a) - Values and references for these variables are presented in Section 5.5.1 of the Risk Assessment Workplan.
(b) - See table XXX for BAFs and concentration calculations.
(c) - See Table XXX for TRV derivations.
(d) - Sediment consumption rate was converted from kg wet weight (ww) per day to kg dry weight (dw) per day by using the equation from United States Environmental Protection Agency (USEPA) Exposure Factors Handbook (USEPA, 2011):
IRdw = (IRww * % solids)/100
Where: IR = Ingestion rate
% solids = 100 - average % water makeup of sediment (e.g. 100 - 32.15 = 67.85)
* Calcium, Iron, Magnesium, Potassium and Sodium were not included in the model equations as they are considered to be essential nutrients.
mg/kg - milligrams per kilogram
kg/day - kilograms per day
mg/kg/day - milligrams per kilogram per day
kg - kilograms
$_{ww}$ - wet weight
$_{dw}$ - dry weight
$_{bw}$ - body weight
NOAEL - No Observable Adverse Effects Level.
LOAEL - Lowest Observable Adverse Effects Level.
HQ - Hazard Quotient.

Bolded values indicate a concentration based on 1/2 the maximum detection limit for a non-detected value.
Italicized values indicate a maximum detected concentration with no associated Ecological Screening Value.
Shaded cells indicated HQs equal to or greater than 1.0.

Table 6-18
Hazard Quotients for Ingestion of Benthic Invertebrates - Spotted Sandpiper (Downstream Maximum Concentrations)
Red Bank Landfill Site
Red Bank, New Jersey

Analyte	Maximum Concentration of Contaminant in Sediment (mg/kg_{dw})	Sediment Ingestion Rate (a) (kg_{dw}/day)	Area Use Factor (a)	Dose from Sediment (mg/kg_{bw}/day)	Dietary Ingestion Rate (a) (d) (kg_{ww}/day)	Sediment to Benthic Invertebrate Bioaccumulation Factors (BAFs) (b)	Concentration of Contaminant in Benthic Invertebrates (mg/kg_{ww}) (b)	Dietary Percentage of Benthic Invertebrates (a)	Dose from Benthic Invertebrates (mg/kg_{bw}/day)	Average Body Weight (a) (kg)	Seasonal Use Factor (a)	Average Daily Dose (mg/kg_{bw}/day)	Toxicity Reference Values (TRVs) (c)		Hazard Quotient	
													NOAEL	LOAEL	NOAEL HQ	LOAEL HQ
SVOCs																
2,4-Dinitrophenol	**0.065**	0.0085	0.070	0.0010	0.049	log=0.819*log(Kow)-1.146	0.072	1.0	0.0062	0.040	0.66	0.0047	1.6	16	0.0030	0.00030
4-Nitrophenol	**0.020**	0.0085	0.070	0.00030	0.049	log=0.819*log(Kow)-1.146	0.030	1.0	0.0026	0.040	0.66	0.0019	16	159	0.00012	0.000012
Acenaphthene	0.0061	0.0085	0.070	Q	0.049	0.00411	0.000025	1.0	0.0000022	0.040	0.66	#VALUE!	19	194	#VALUE!	#VALUE!
Acetophenone	*0.0039*	0.0085	0.070	0.000058	0.049	log=0.819*log(Kow)-1.146	0.0048	1.0	0.00041	0.040	0.66	0.00031	1.6	16	0.00020	0.000020
Benzaldehyde	**0.0080**	0.0085	0.070	0.00012	0.049	log=0.819*log(Kow)-1.146	0.0085	1.0	0.00074	0.040	0.66	0.00057	1.6	16	0.00036	0.000036
Benzo(g,h,i)perylene	0.079	0.0085	0.070	0.0012	0.049	0.0164	0.0013	1.0	0.00011	0.040	0.66	0.00085	0.20	2.0	0.0042	0.00042
Carbazole	**0.0010**	0.0085	0.070	0.000015	0.049	log=0.819*log(Kow)-1.146	0.0047	1.0	0.00041	0.040	0.66	0.00028	1.6	16	0.00018	0.000018
Fluorene	0.011	0.0085	0.070	0.00016	0.049	0.0040	0.000044	1.0	0.0000038	0.040	0.66	0.00011	0.20	2.0	0.00055	0.000055
Phenanthrene	0.13	0.0085	0.070	0.0019	0.049	0.0039	0.00051	1.0	0.000044	0.040	0.66	0.0013	0.20	2.0	0.0065	0.00065
Pesticides																
4,4'-DDD	0.00034	0.0085	0.070	0.0000051	0.049	log=0.819*log(Kow)-1.146	0.016	1.0	0.0014	0.040	0.66	0.00093	0.23	2.7	0.0041	0.00034
4,4'-DDE	0.00038	0.0085	0.070	0.0000057	0.049	0.95	0.00036	1.0	0.000031	0.040	0.66	0.000024	0.23	2.7	0.00011	0.0000090
4,4'-DDT	**0.000022**	0.0085	0.070	0.00000033	0.049	log=0.819*log(Kow)-1.146	0.0010	1.0	0.000087	0.040	0.66	0.000058	0.23	2.7	0.00025	0.000021
Aldrin	**0.000027**	0.0085	0.070	0.00000039	0.049	log=0.819*log(Kow)-1.146	0.0013	1.0	0.00011	0.040	0.66	0.000076	0.050	0.50	0.0015	0.00015
alpha-Chlordane	*0.00035*	0.0085	0.070	0.0000052	0.049	log=0.819*log(Kow)-1.146	0.020	1.0	0.0017	0.040	0.66	0.0011	2.1	11	0.00053	0.00011
delta-BHC	**0.000023**	0.0085	0.070	0.00000033	0.049	log=0.819*log(Kow)-1.146	0.00021	1.0	0.000018	0.040	0.66	0.000012	0.56	2.3	0.000022	0.0000055
Dieldrin	0.00013	0.0085	0.070	0.0000019	0.049	log=0.819*log(Kow)-1.146	0.0031	1.0	0.00027	0.040	0.66	0.00018	0.071	0.80	0.0025	0.00022
Endosulfan I	**0.000028**	0.0085	0.070	0.00000042	0.049	log=0.819*log(Kow)-1.146	0.00015	1.0	0.000013	0.040	0.66	0.0000091	10	100	0.00000091	0.000000091
Endosulfan II	**0.000026**	0.0085	0.070	0.00000039	0.049	log=0.819*log(Kow)-1.146	0.00016	1.0	0.000014	0.040	0.66	0.0000094	10	100	0.00000094	0.000000094
Endrin	0.00018	0.0085	0.070	0.0000027	0.049	log=0.819*log(Kow)-1.146	0.0031	1.0	0.00027	0.040	0.66	0.00018	0.010	0.10	0.018	0.0018
Endrin Ketone	**0.000023**	0.0085	0.070	0.00000034	0.049	log=0.819*log(Kow)-1.146	0.00044	1.0	0.000038	0.040	0.66	0.000025	0.010	0.10	0.0025	0.00025
gamma-Chlordane	*0.00046*	0.0085	0.070	0.0000068	0.049	log=0.819*log(Kow)-1.146	0.026	1.0	0.0022	0.040	0.66	0.0015	2.1	11	0.00069	0.00014
Hepatachlor	**0.000033**	0.0085	0.070	0.00000048	0.049	1.67	0.000054	1.0	0.0000047	0.040	0.66	0.0000034	65	650	0.000000053	0.0000000053
Hepatachlor epoxide	0.000066	0.0085	0.070	0.00000098	0.049	log=0.819*log(Kow)-1.146	0.0010	1.0	0.000089	0.040	0.66	0.000059	65	650	0.00000091	0.000000091
Toxaphene	**0.0010**	0.0085	0.070	0.000015	0.049	log=0.819*log(Kow)-1.146	0.029	1.0	0.0025	0.040	0.66	0.0017	0.68	6.0	0.0024	0.00027
PCBs																
PCB-1254	0.0056	0.0085	0.070	0.000083	0.049	0.53	0.0030	1.0	0.00026	0.040	0.66	0.00022	0.18	1.8	0.0012	0.00012
PCB-1260	**0.00021**	0.0085	0.070	0.0000031	0.049	log=0.819*log(Kow)-1.146	0.018	1.0	0.0015	0.040	0.66	0.0010	0.18	1.8	0.0056	0.00056
Total PCBs	0.0056	0.0085	0.070	0.000083	0.049	0.0327	0.00018	1.0	0.000016	0.040	0.66	0.000065	0.18	1.8	0.00036	0.000036
Metals*																
Antimony	*0.32*	0.0085	0.070	0.0048	0.049	0.90	0.29	1.0	0.025	0.040	0.66	0.020	490	4,900	0.000040	0.0000040
Arsenic	13.8	0.0085	0.070	0.21	0.049	0.90	12	1.0	1.1	0.040	0.66	0.84	2.2	4.5	0.38	0.19
Barium	*5.5*	0.0085	0.070	0.082	0.049	0.90	5.0	1.0	0.43	0.040	0.66	0.34	21	208	0.016	0.0016
Beryllium	*0.48*	0.0085	0.070	0.0071	0.049	0.90	0.43	1.0	0.037	0.040	0.66	0.029	4	19	0.0076	0.0015
Chromium	22.3	0.0085	0.070	0.33	0.049	0.39	8.7	1.0	0.75	0.040	0.66	0.72	2.7	16	0.27	0.046
Copper	7.0	0.0085	0.070	0.10	0.049	0.30	2.1	1.0	0.18	0.040	0.66	0.19	4.1	35	0.047	0.0054
Lead	21.1	0.0085	0.070	0.31	0.049	0.63	13	1.0	1.2	0.040	0.66	0.97	1.6	45	0.59	0.022
Nickel	6.3	0.0085	0.070	0.094	0.049	0.90	5.7	1.0	0.49	0.040	0.66	0.39	6.7	19	0.057	0.021
Selenium	*0.31*	0.0085	0.070	0.0046	0.049	0.90	0.28	1.0	0.024	0.040	0.66	0.019	0.29	0.82	0.065	0.023
Thallium	*0.86*	0.0085	0.070	0.013	0.049	0.90	0.77	1.0	0.067	0.040	0.66	0.053	0.35	3.5	0.15	0.015
Vanadium	*24.4*	0.0085	0.070	0.36	0.049	0.0148	0.36	1.0	0.031	0.040	0.66	0.26	0.34	1.7	0.76	0.15
Zinc	70.8	0.0085	0.070	1.1	0.049	0.57	40	1.0	3.5	0.040	0.66	3.0	66	171	0.045	0.017

NOTES:
(a) - Values and references for these variables are presented in Section 5.5.1 of the Risk Assessment Workplan.
(b) - See table XXX for BAFs and concentration calculations.
(c) - See Table XXX for TRV derivations.
(d) - Food consumption rate was converted from kg dry weight (dw) per day to kg wet weight (ww) per day by using the equation from United States Environmental Protection Agency (USEPA) Exposure Factors Handbook (USEPA, 2011):
IRww = (IRdw * 100)/% solids
Where: IR = Ingestion rate
% solids = 100 - % water makeup of benthic invertebrates (e.g. 100 - 84 = 16) (USEPA, 2007)
* Calcium, Iron, Magnesium, Potassium and Sodium were not included in the model equations as they are considered to be essential nutrients.
mg/kg - milligrams per kilogram
kg/day - kilograms per day
mg/kg/day - milligrams per kilogram per day
kg - kilograms
$_{ww}$ - wet weight
$_{dw}$ - dry weight
$_{bw}$ - body weight
NOAEL - No Observable Adverse Effects Level.
LOAEL - Lowest Observable Adverse Effects Level.
HQ - Hazard Quotient.

Bolded values indicate a concentration based on 1/2 the maximum detection limit for a non-detected value.
Italicized values indicate a maximum detected concentration with no associated Ecological Screening Value.
Shaded cells indicated HQs equal to or greater than 1.0.

Table 6-19
Hazard Quotients for Ingestion of Fish and Benthic Invertebrates - Raccoon (Downstream Maximum Concentrations)
Red Bank Landfill Site
Red Bank, New Jersey

Analyte	Maximum Concentration of Contaminant in Sediment (mg/kg_{dw})	Sediment Ingestion Rate (a) (d) (kg_{dw}/day)	Area Use Factor (a)	Dose from Sediment (mg/kg_{bw}/day)	Dietary Ingestion Rate (a) (kg_{ww}/day)	Sediment to Benthic Invertebrate Biota-Sediment Accumulation Factors (BSAFs) (b)	Concentration of Contaminant in Benthic Invertebrates (mg/kg_{ww}) (b)	Dietary Percentage of Benthic Invertebrates (a)	Dose from Benthic Invertebrates (mg/kg_{bw}/day)	Sediment to Fish Biota-Sediment Accumulation Factors (BSAFs) (b)	Concentration of Contaminant in Fish (mg/kg_{ww}) (b)	Dietary Percentage of Fish (a)	Dose from Fish (mg/kg_{bw}/day)	Average Body Weight (a) (kg)	Seasonal Use Factor (a)	Average Daily Dose (mg/kg_{bw}/day)	Toxicity Reference Values (TRVs) (c)		Hazard Quotient	
																	NOAEL	LOAEL	NOAEL HQ	LOAEL HQ
SVOCs																				
2,4-Dinitrophenol	**0.065**	0.080	0.0054	0.0000049	1.26	log=0.819*log(Kow)-1.146	0.072	0.50	0.000042	log=0.819*log(Kow)-1.146	0.072	0.50	0.000042	5.78	1.0	0.000089	20	30	0.0000045	0.0000030
4-Nitrophenol	**0.020**	0.080	0.0054	0.0000015	1.26	log=0.819*log(Kow)-1.146	0.030	0.50	0.000018	log=0.819*log(Kow)-1.146	0.030	0.50	0.000018	5.78	1.0	0.000037	12	28	0.0000032	0.0000013
Acenaphthene	0.0061	0.080	0.0054	0.00000046	1.26	0.00411	0.000025	0.50	0.000000015	0.00411	0.000025	0.50	0.000000015	5.78	1.0	0.00000049	66	356	0.0000000074	0.00000000014
Acetophenone	*0.0039*	0.080	0.0054	0.00000029	1.26	log=0.819*log(Kow)-1.146	0.0048	0.50	0.0000028	log=0.819*log(Kow)-1.146	0.0048	0.50	0.0000028	5.78	1.0	0.0000059	42	423	0.00000014	0.000000014
Benzaldehyde	**0.0080**	0.080	0.0054	0.00000060	1.26	log=0.819*log(Kow)-1.146	0.0085	0.50	0.0000050	log=0.819*log(Kow)-1.146	0.0085	0.50	0.0000050	5.78	1.0	0.000011	14	40	0.00000074	0.00000027
Benzo(g,h,i)perylene	0.079	0.080	0.0054	0.0000059	1.26	0.0164	0.0013	0.50	0.00000076	0.0164	0.0013	0.50	0.00000076	5.78	1.0	0.0000075	0.62	38	0.000012	0.00000019
Carbazole	**0.0010**	0.080	0.0054	0.000000075	1.26	log=0.819*log(Kow)-1.146	0.0047	0.50	0.0000028	log=0.819*log(Kow)-1.146	0.0047	0.50	0.0000028	5.78	1.0	0.0000056	5.0	50	0.0000011	0.00000011
Fluorene	0.011	0.080	0.0054	0.00000083	1.26	0.0040	0.000044	0.50	0.000000026	0.0040	0.000044	0.50	0.000000026	5.78	1.0	0.00000088	66	356	0.000000013	0.00000000025
Phenanthrene	0.13	0.080	0.0054	0.0000098	1.26	0.0039	0.00051	0.50	0.00000030	0.0039	0.00051	0.50	0.00000030	5.78	1.0	0.000010	66	356	0.00000016	0.000000029
Pesticides																				
4,4'-DDD	0.00034	0.080	0.0054	0.000000026	1.26	log=0.819*log(Kow)-1.146	0.016	0.50	0.0000096	log=0.819*log(Kow)-1.146	0.016	0.50	0.0000096	5.78	1.0	0.000019	0.15	5.6	0.00013	0.0000034
4,4'-DDE	0.00038	0.080	0.0054	0.000000029	1.26	0.95	0.00036	0.50	0.00000021	0.95	0.00036	0.50	0.00000021	5.78	1.0	0.00000045	0.15	5.6	0.0000031	0.000000082
4,4'-DDT	**0.000022**	0.080	0.0054	0.0000000017	1.26	log=0.819*log(Kow)-1.146	0.0010	0.50	0.00000059	log=0.819*log(Kow)-1.146	0.0010	0.50	0.00000059	5.78	1.0	0.0000012	0.15	5.6	0.0000081	0.00000021
Aldrin	**0.000027**	0.080	0.0054	0.0000000020	1.26	log=0.819*log(Kow)-1.146	0.0013	0.50	0.00000078	log=0.819*log(Kow)-1.146	0.0013	0.50	0.00000078	5.78	1.0	0.0000016	0.20	1.0	0.0000078	0.0000016
alpha-Chlordane	*0.00035*	0.080	0.0054	0.000000026	1.26	log=0.819*log(Kow)-1.146	0.020	0.50	0.000012	log=0.819*log(Kow)-1.146	0.020	0.50	0.000012	5.78	1.0	0.000023	4.6	9.2	0.0000050	0.0000025
delta-BHC	**0.000023**	0.080	0.0054	0.0000000017	1.26	log=0.819*log(Kow)-1.146	0.00021	0.50	0.00000012	log=0.819*log(Kow)-1.146	0.00021	0.50	0.00000012	5.78	1.0	0.00000025	0.15	0.67	0.0000017	0.00000038
Dieldrin	0.00013	0.080	0.0054	0.0000000098	1.26	log=0.819*log(Kow)-1.146	0.0031	0.50	0.0000018	log=0.819*log(Kow)-1.146	0.0031	0.50	0.0000018	5.78	1.0	0.0000037	0.015	1.3	0.00024	0.0000029
Endosulfan I	**0.000028**	0.080	0.0054	0.0000000021	1.26	log=0.819*log(Kow)-1.146	0.00015	0.50	0.000000091	log=0.819*log(Kow)-1.146	0.00015	0.50	0.000000091	5.78	1.0	0.00000018	0.15	1.5	0.0000012	0.00000012
Endosulfan II	**0.000026**	0.080	0.0054	0.0000000020	1.26	log=0.819*log(Kow)-1.146	0.00016	0.50	0.000000094	log=0.819*log(Kow)-1.146	0.00016	0.50	0.000000094	5.78	1.0	0.00000019	0.15	1.5	0.0000013	0.00000013
Endrin	0.00018	0.080	0.0054	0.000000014	1.26	log=0.819*log(Kow)-1.146	0.0031	0.50	0.0000019	log=0.819*log(Kow)-1.146	0.0031	0.50	0.0000019	5.78	1.0	0.0000037	0.092	0.92	0.000040	0.0000040
Endrin Ketone	**0.000023**	0.080	0.0054	0.0000000017	1.26	log=0.819*log(Kow)-1.146	0.00044	0.50	0.00000026	log=0.819*log(Kow)-1.146	0.00044	0.50	0.00000026	5.78	1.0	0.00000051	0.092	0.92	0.0000056	0.00000056
gamma-Chlordane	*0.00046*	0.080	0.0054	0.000000035	1.26	log=0.819*log(Kow)-1.146	0.026	0.50	0.000015	log=0.819*log(Kow)-1.146	0.026	0.50	0.000015	5.78	1.0	0.000031	4.6	9.2	0.0000066	0.0000033
Hepatachlor	**0.000033**	0.080	0.0054	0.0000000024	1.26	1.67	0.000054	0.50	0.000000032	1.67	0.000054	0.50	0.000000032	5.78	1.0	0.000000066	0.10	1.0	0.00000066	0.000000066
Hepatachlor epoxide	0.000066	0.080	0.0054	0.0000000050	1.26	log=0.819*log(Kow)-1.146	0.0010	0.50	0.00000060	log=0.819*log(Kow)-1.146	0.0010	0.50	0.00000060	5.78	1.0	0.0000012	0.10	1.0	0.000012	0.0000012
Toxaphene	**0.0010**	0.080	0.0054	0.000000075	1.26	log=0.819*log(Kow)-1.146	0.029	0.50	0.000017	log=0.819*log(Kow)-1.146	0.029	0.50	0.000017	5.78	1.0	0.000034	8.0	80	0.0000042	0.00000042
PCBs																				
PCB-1254	0.0056	0.080	0.0054	0.00000042	1.26	0.53	0.0030	0.50	0.0000017	0.53	0.0030	0.50	0.0000017	5.78	1.0	0.0000039	0.098	0.68	0.000040	0.0000057
PCB-1260	**0.00021**	0.080	0.0054	0.000000016	1.26	log=0.819*log(Kow)-1.146	0.018	0.50	0.000010	log=0.819*log(Kow)-1.146	0.018	0.50	0.000010	5.78	1.0	0.000021	5.0	50	0.0000042	0.00000042
Total PCBs	0.0056	0.080	0.0054	0.00000042	1.26	0.0327	0.00018	0.50	0.00000011	0.0327	0.00018	0.50	0.00000011	5.78	1.0	0.00000064	0.098	0.68	0.0000065	0.00000093
Metals*																				
Antimony	*0.32*	0.080	0.0054	0.000024	1.26	0.90	0.29	0.50	0.00017	0.90	0.29	0.50	0.00017	5.78	1.0	0.00036	0.059	2.8	0.0062	0.00013
Arsenic	13.8	0.080	0.0054	0.0010	1.26	0.90	12	0.50	0.0073	0.90	12	0.50	0.0073	5.78	1.0	0.016	1.0	5.7	0.015	0.0028
Barium	*5.5*	0.080	0.0054	0.00041	1.26	0.90	5.0	0.50	0.0029	0.90	5.0	0.50	0.0029	5.78	1.0	0.0062	52	83	0.00012	0.000075
Beryllium	*0.48*	0.080	0.0054	0.000036	1.26	0.90	0.43	0.50	0.00025	0.90	0.43	0.50	0.00025	5.78	1.0	0.00054	0.53	0.67	0.0010	0.00081
Chromium	22.3	0.080	0.0054	0.0017	1.26	0.39	8.7	0.50	0.0051	0.39	8.7	0.50	0.0051	5.78	1.0	0.012	2.4	58	0.0050	0.00020
Copper	7.0	0.080	0.0054	0.00053	1.26	0.30	2.1	0.50	0.0012	0.30	2.1	0.50	0.0012	5.78	1.0	0.0030	5.6	83	0.00054	0.000036
Lead	21.1	0.080	0.0054	0.0016	1.26	0.63	13	0.50	0.0078	0.63	13	0.50	0.0078	5.78	1.0	0.017	4.7	186	0.0037	0.000092
Nickel	6.3	0.080	0.0054	0.00047	1.26	0.90	5.7	0.50	0.0033	0.90	5.7	0.50	0.0033	5.78	1.0	0.0071	1.7	15	0.0042	0.00048
Selenium	*0.31*	0.080	0.0054	0.000023	1.26	0.90	0.28	0.50	0.00016	0.90	0.28	0.50	0.00016	5.78	1.0	0.00035	0.14	0.66	0.0025	0.00053
Thallium	*0.86*	0.080	0.0054	0.000065	1.26	0.90	0.77	0.50	0.00046	0.90	0.77	0.50	0.00046	5.78	1.0	0.00098	0.0074	0.074	0.13	0.013
Vanadium	*24.4*	0.080	0.0054	0.0018	1.26	0.0148	0.36	0.50	0.00021	0.0148	0.36	0.50	0.00021	5.78	1.0	0.0023	4.2	9.4	0.00054	0.00024
Zinc	70.8	0.080	0.0054	0.0053	1.26	0.57	40	0.50	0.024	0.57	40	0.50	0.024	5.78	1.0	0.053	75	298	0.00070	0.00018

NOTES:
(a) - Values and references for these variables are presented in Section 5.5.1 of the Risk Assessment Workplan.
(b) - See table XXX for BSAFs and concentration calculations.
(c) - See Table XXX for TRV derivations.
(d) - Sediment consumption rate was converted from kg wet weight (ww) per day to kg dry weight (dw) per day by using the equation from United States Environmental Protection Agency (USEPA) Exposure Factors Handbook (USEPA, 2011):
IRdw = (IRww * % solids)/100
Where: IR = Ingestion rate
% solids = 100 - average % water makeup of sediment (e.g. 100 - 32.15 = 67.85)
* Calcium, Iron, Magnesium, Potassium and Sodium were not included in the model equations as they are considered to be essential nutrients.
mg/kg - milligrams per kilogram
kg/day - kilograms per day
mg/kg/day - milligrams per kilogram per day
kg - kilograms
$_{ww}$ - wet weight
$_{dw}$ - dry weight
$_{bw}$ - body weight
NOAEL - No Observable Adverse Effects Level.
LOAEL - Lowest Observable Adverse Effects Level.
HQ - Hazard Quotient.

Bolded values indicate a concentration based on 1/2 the maximum detection limit for a non-detected value.
Italicized values indicate a maximum detected concentration with no associated Ecological Screening Value.
Shaded cells indicated HQs equal to or greater than 1.0.

Table 6-20
Hazard Quotients for Ingestion of Earthworms - American Robin (Site Maximum Concentrations)
Red Bank Landfill Site
Red Bank, New Jersey

Analyte	Maximum Concentration of Contaminant in Soil (mg/kg_{dw})	Soil Ingestion Rate (a) (kg_{dw}/day)	Area Use Factor (a)	Dose from Soil (mg/kg_{bw}/day)	Dietary Ingestion Rate (a) (kg_{ww}/day)	Soil to Invertebrate Bioaccumulation Factors (BAFs) (b)	Concentration of Contaminant in Earthworms (mg/kg_{ww}) (b)	Dietary Percentage of Earthworms (a)	Dose from Earthworms (mg/kg_{bw}/day)	Average Body Weight (a) (kg)	Seasonal Use Factor (a)	Average Daily Dose (mg/kg_{bw}/day)	Toxicity Reference Values (TRVs) (c)		Hazard Quotient	
SVOCs													NOAEL	LOAEL	NOAEL HQ	LOAEL HQ
2,4-Dimethylphenol	***0.075***	0.0057	1.0	0.006	0.069	1.0	0.075	1.0	0.067	0.0773	1.0	0.072	1.6	16	0.046	0.0046
2,4-Dinitrophenol	***0.55***	0.0057	1.0	0.04	0.069	1.0	0.55	1.0	0.49	0.0773	1.0	0.53	1.6	16	0.34	0.034
Acetophenone	*0.012*	0.0057	1.0	0.0009	0.069	1.0	0.012	1.0	0.011	0.0773	1.0	0.012	1.6	16	0.0073	0.00073
Benzaldehyde	*0.19*	0.0057	1.0	0.014	0.069	1.0	0.19	1.0	0.17	0.0773	1.0	0.18	1.6	16	0.12	0.012
Carbazole	*0.081*	0.0057	1.0	0.006	0.069	1.0	0.081	1.0	0.072	0.0773	1.0	0.078	1.6	16	0.049	0.0049
Dibenzofuran	*0.010*	0.0057	1.0	0.0007	0.069	1.0	0.010	1.0	0.0089	0.0773	1.0	0.0096	6.3	63	0.0015	0.00015
Pesticides																
4,4'-DDT	0.030	0.0057	1.0	0.0022	0.069	ln=0.8689*ln(Cs)+2.1247	0.054	1.0	0.048	0.0773	1.0	0.050	0.23	2.7	0.22	0.019
alpha-Chlordane	*0.037*	0.0057	1.0	0.0027	0.069	1.0	0.037	1.0	0.033	0.0773	1.0	0.036	2.1	11	0.017	0.0033
delta-BHC	*0.00027*	0.0057	1.0	0.000020	0.069	1.0	0.00027	1.0	0.00024	0.0773	1.0	0.00026	0.56	2.3	0.00046	0.00012
Dieldrin	0.019	0.0057	1.0	0.0014	0.069	14.7	0.045	1.0	0.040	0.0773	1.0	0.041	0.071	0.80	0.58	0.051
Endosulfan II	*0.0013*	0.0057	1.0	0.00010	0.069	1.0	0.0013	1.0	0.0012	0.0773	1.0	0.0013	10	100	0.00013	0.000013
Endrin Ketone	*0.00028*	0.0057	1.0	0.000021	0.069	1.0	0.00028	1.0	0.00025	0.0773	1.0	0.00027	0.010	0.10	0.027	0.0027
gamma-Chlordane	*0.051*	0.0057	1.0	0.0038	0.069	1.0	0.051	1.0	0.045	0.0773	1.0	0.049	2.1	11	0.023	0.0046
PCBs																
PCB-1254	*0.11*	0.0057	1.0	0.008	0.069	1.13	0.12	1.0	0.11	0.0773	1.0	0.12	0.18	1.8	0.66	0.066
Total PCBs	0.11	0.0057	1.0	0.008	0.069	1.0	0.11	1.0	0.098	0.0773	1.0	0.11	0.18	1.8	0.59	0.059
Metals*																
Antimony	1.8	0.0057	1.0	0.13	0.069	1.0	0.29	1.0	0.26	0.0773	1.0	0.39	490	4,900	0.00080	0.000080
Arsenic	25	0.0057	1.0	1.9	0.069	ln=0.706*ln(Cs)-1.421	0.38	1.0	0.34	0.0773	1.0	2.2	2.2	4.5	0.98	0.49
Cadmium	1.5	0.0057	1.0	0.11	0.069	ln=0.795*ln(Cs)+2.114	1.8	1.0	1.6	0.0773	1.0	1.7	1.5	6.3	1.2	0.27
Chromium	178	0.0057	1.0	13	0.069	0.306	8.7	1.0	7.8	0.0773	1.0	21	2.7	16	7.9	1.3
Cobalt	10	0.0057	1.0	0.7	0.069	0.122	0.20	1.0	0.18	0.0773	1.0	0.92	7.6	18	0.12	0.050
Copper	48	0.0057	1.0	3.6	0.069	0.515	4.0	1.0	3.5	0.0773	1.0	7.1	4.1	35	1.8	0.20
Lead	209	0.0057	1.0	15	0.069	ln=0.807*ln(Cs)-0.218	9.6	1.0	8.5	0.0773	1.0	24	1.6	45	15	0.54
Manganese	224	0.0057	1.0	17	0.069	ln=0.682*ln(Cs)-0.809	2.9	1.0	2.5	0.0773	1.0	19	179	377	0.11	0.051
Mercury	0.19	0.0057	1.0	0.014	0.069	(8.5*3%Cs) + (0.04*97%Cs)	0.056	1.0	0.050	0.0773	1.0	0.064	0.054	0.24	1.2	0.27
Nickel	25	0.0057	1.0	1.9	0.069	0.020	0.51	1.0	0.45	0.0773	1.0	2.3	6.7	19	0.35	0.13
Selenium	1.4	0.0057	1.0	0.10	0.069	ln=0.733*ln(Cs)-0.075	0.19	1.0	0.17	0.0773	1.0	0.27	0.29	0.82	0.94	0.33
Thallium	4.8	0.0057	1.0	0.36	0.069	0.22	1.1	1.0	0.94	0.0773	1.0	1.3	0.35	3.5	3.7	0.37
Vanadium	334	0.0057	1.0	25	0.069	0.042	2.2	1.0	2.0	0.0773	1.0	27	0.34	1.7	78	16
Zinc	218	0.0057	1.0	16	0.069	ln=0.328*ln(Cs)+4.449	80	1.0	71	0.0773	1.0	87	66	171	1.3	0.51

NOTES:
(a) - Values and references for these variables are presented in Section 5.5.1 of the Risk Assessment Workplan.
(b) - See table XXX for BAFs and concentration calculations.
(c) - See Table XXX for TRV derivations.
(d) - Soil consumption rate was converted from kg wet weight (ww) per day to kg dry weight (dw) per day by using the equation from United States Environmental Protection Agency (USEPA) Exposure Factors Handbook (USEPA, 2011):
IRdw = (IRww * % solids)/100
Where: IR = Ingestion rate
% solids = 100 - average % water makeup of soil (e.g. 100 - 19.96 = 80.04)
* Calcium, Iron, Magnesium, Potassium and Sodium were not included in the model equations as they are considered to be essential nutrients.
mg/kg - milligrams per kilogram
kg/day - kilograms per day
mg/kg/day - milligrams per kilogram per day
kg - kilograms
$_{ww}$ - wet weight
$_{dw}$ - dry weight
$_{bw}$ - body weight
NOAEL - No Observable Adverse Effects Level.
LOAEL - Lowest Observable Adverse Effects Level.
HQ - Hazard Quotient.

Bolded values indicate a concentration based on 1/2 the maximum detection limit for a non-detected value.
Italicized values indicate a maximum detected concentration with no associated Ecological Screening Value.
Shaded cells indicated HQs equal to or greater than 1.0.

Table 6-21
Hazard Quotients for Ingestion of Earthworms and White-Footed Mice - Raccoon (Site Maximum Concentrations)
Red Bank Landfill Site
Red Bank, New Jersey

Analyte	Maximum Concentration of Contaminant in Soil (mg/kg_{dw})	Soil Ingestion Rate (a) (e) (kg_{dw}/day)	Area Use Factor (a)	Dose from Soil (mg/kg_{bw}/day)	Dietary Ingestion Rate (a) (kg_{ww}/day)	Soil to Invertebrate Bioaccumulation Factors (BAFs) (b)	Concentration of Contaminant in Earthworms (mg/kg_{ww}) (b)	Dietary Percentage of Earthworms (a)	Dose from Earthworms (mg/kg_{bw}/day)	Soil to White-Footed Mouse Bioconcentration Factors (BCFs) (c)	Concentration of Contaminant in White-Footed Mouse (mg/kg_{ww}) (c)	Dietary Percentage of MIce (a)	Dose from Mice (mg/kg_{bw}/day)	Average Body Weight (a) (kg)	Seasonal Use Factor (a)	Average Daily Dose (mg/kg_{bw}/day)	Toxicity Reference Values (TRVs) (d)		Hazard Quotient	
SVOCs																	NOAEL	LOAEL	NOAEL HQ	LOAEL HQ
2,4-Dimethylphenol	***0.075***	0.080	0.0054	0.0000056	1.26	1.0	0.075	0.50	0.000044	1.0	0.075	0.50	0.000044	5.78	1.0	0.000094	5.0	25	0.000019	0.0000038
2,4-Dinitrophenol	***0.55***	0.080	0.0054	0.000041	1.26	1.0	0.55	0.50	0.00032	1.0	0.55	0.50	0.00032	5.78	1.0	0.00069	20	30	0.000034	0.000023
Acetophenone	*0.012*	0.080	0.0054	0.00000090	1.26	1.0	0.012	0.50	0.0000071	1.0	0.012	0.50	0.0000071	5.78	1.0	0.000015	42	423	0.00000036	0.000000036
Benzaldehyde	*0.19*	0.080	0.0054	0.000014	1.26	1.0	0.19	0.50	0.00011	1.0	0.19	0.50	0.00011	5.78	1.0	0.00024	14	14	0.000017	0.000017
Carbazole	*0.081*	0.080	0.0054	0.0000061	1.26	1.0	0.081	0.50	0.000048	1.0	0.081	0.50	0.000048	5.78	1.0	0.00010	5.0	50	0.000020	0.0000020
Dibenzofuran	*0.010*	0.080	0.0054	0.00000075	1.26	1.0	0.010	0.50	0.0000059	1.0	0.010	0.50	0.0000059	5.78	1.0	0.000013	2.0	10	0.0000063	0.0000013
Pesticides																				
4,4'-DDT	0.030	0.080	0.0054	0.0000023	1.26	ln=0.8689*ln(Cs)+2.1247	0.054	0.50	0.000032	0.000122	0.0000037	0.50	0.0000000022	5.78	1.0	0.000034	0.15	5.6	0.00023	0.0000061
alpha-Chlordane	*0.037*	0.080	0.0054	0.0000028	1.26	1.0	0.037	0.50	0.000022	1.0	0.037	0.50	0.000022	5.78	1.0	0.000046	4.6	9.2	0.000010	0.0000050
delta-BHC	*0.00027*	0.080	0.0054	0.000000020	1.26	1.0	0.00027	0.50	0.00000016	1.0	0.00027	0.50	0.00000016	5.78	1.0	0.00000034	0.15	0.67	0.0000023	0.00000051
Dieldrin	0.019	0.080	0.0054	0.0000014	1.26	14.7	0.045	0.50	0.000026	1.0	0.019	0.50	0.000011	5.78	1.0	0.000039	0.015	1.3	0.0026	0.000031
Endosulfan II	*0.0013*	0.080	0.0054	0.000000098	1.26	1.0	0.0013	0.50	0.00000077	1.0	0.0013	0.50	0.00000077	5.78	1.0	0.0000016	0.15	1.5	0.000011	0.0000011
Endrin Ketone	*0.00028*	0.080	0.0054	0.000000021	1.26	1.0	0.00028	0.50	0.00000016	1.0	0.00028	0.50	0.00000016	5.78	1.0	0.00000035	0.092	0.92	0.0000038	0.00000038
gamma-Chlordane	*0.051*	0.080	0.0054	0.0000038	1.26	1.0	0.051	0.50	0.000030	1.0	0.051	0.50	0.000030	5.78	1.0	0.000064	4.6	9.2	0.000014	0.0000069
PCBs																				
PCB-1254	*0.11*	0.080	0.0054	0.0000083	1.26	1.13	0.12	0.50	0.000073	0.000109	0.000012	0.50	0.0000000071	5.78	1.0	0.000081	0.098	0.68	0.00083	0.00012
Total PCBs	0.11	0.080	0.0054	0.0000083	1.26	1.0	0.11	0.50	0.000065	0.000109	0.11	0.50	0.000065	5.78	1.0	0.00014	0.098	0.68	0.0014	0.00020
Metals*																				
Antimony	1.8	0.080	0.0054	0.00014	1.26	1.0	0.29	0.50	0.00017	0.0000027	0.0000049	0.50	0.0000000029	5.78	1.0	0.00030	0.059	2.8	0.0052	0.00011
Arsenic	25	0.080	0.0054	0.0019	1.26	ln=0.706*ln(Cs)-1.421	0.38	0.50	0.00022	0.0000054	0.00014	0.50	0.000000080	5.78	1.0	0.0021	1.0	5.7	0.0020	0.00037
Cadmium	1.5	0.080	0.0054	0.00011	1.26	ln=0.795*ln(Cs)+2.114	1.8	0.50	0.0011	0.000000324	0.00000049	0.50	0.00000000029	5.78	1.0	0.0012	0.77	6.9	0.0015	0.00017
Chromium	178	0.080	0.0054	0.013	1.26	0.306	8.7	0.50	0.0051	0.0000149	0.0027	0.50	0.0000016	5.78	1.0	0.018	2.4	58	0.0077	0.00032
Cobalt	10	0.080	0.0054	0.00076	1.26	0.122	0.20	0.50	0.00012	1.0	10	0.50	0.0059	5.78	1.0	0.0068	7.3	19	0.00093	0.00036
Copper	48	0.080	0.0054	0.0036	1.26	0.515	4.0	0.50	0.0023	1.0	48	0.50	0.028	5.78	1.0	0.034	5.6	83	0.0061	0.00041
Lead	209	0.080	0.0054	0.016	1.26	ln=0.807*ln(Cs)-0.218	9.6	0.50	0.0056	0.000000811	0.00017	0.50	0.00000010	5.78	1.0	0.021	4.7	186	0.0045	0.00011
Manganese	224	0.080	0.0054	0.017	1.26	ln=0.682*ln(Cs)-0.809	2.9	0.50	0.0017	1.0	224	0.50	0.13	5.78	1.0	0.15	52	146	0.0029	0.0010
Mercury	0.19	0.080	0.0054	0.000014	1.26	(8.5*3%Cs) + (0.04*97%Cs)	0.056	0.50	0.000033	(0.00000211*3%Cs) + (0.0000141*97%Cs)	0.0000026	0.50	0.0000000015	5.78	1.0	0.000047	0.015	0.16	0.0031	0.00029
Nickel	25	0.080	0.0054	0.0019	1.26	0.020	0.51	0.50	0.00030	0.0000162	0.00041	0.50	0.00000024	5.78	1.0	0.0022	1.7	15	0.0013	0.00015
Selenium	1.4	0.080	0.0054	0.00011	1.26	ln=0.733*ln(Cs)-0.075	0.19	0.50	0.00011	0.00000613	0.0000086	0.50	0.0000000051	5.78	1.0	0.00022	0.14	0.66	0.0015	0.00033
Thallium	4.8	0.080	0.0054	0.00036	1.26	0.22	1.1	0.50	0.00062	0.000108	0.00052	0.50	0.00000031	5.78	1.0	0.0010	0.0074	0.074	0.13	0.013
Vanadium	334	0.080	0.0054	0.025	1.26	0.042	2.2	0.50	0.0013	1.0	334	0.50	0.20	5.78	1.0	0.22	4.2	9.4	0.054	0.024
Zinc	218	0.080	0.0054	0.016	1.26	ln=0.328*ln(Cs)+4.449	80	0.50	0.047	0.000000243	0.000053	0.50	0.000000031	5.78	1.0	0.063	75	298	0.00084	0.00021

NOTES:
(a) - Values and references for these variables are presented in Section 5.5.1 of the Risk Assessment Workplan.
(b) - See table XXX for BAFs and concentration calculations.
(c) - See Table XXX for BCFs and concentration calculations.
(d) - See Table XXX for TRV derivations.
(e) - Sediment consumption rate was converted from kg wet weight (ww) per day to kg dry weight (dw) per day by using the equation from United States Environmental Protection Agency (USEPA) Exposure Factors Handbook (USEPA, 2011):
IRdw = (IRww * % solids)/100
Where: IR = Ingestion rate
% solids = 100 - average % water makeup of sediment (e.g. 100 - 32.15 = 67.85)
* Calcium, Iron, Magnesium, Potassium and Sodium were not included in the model equations as they are considered to be essential nutrients.
mg/kg - milligrams per kilogram
kg/day - kilograms per day
mg/kg/day - milligrams per kilogram per day
kg - kilograms
$_{ww}$ - wet weight
$_{dw}$ - dry weight
$_{bw}$ - body weight
NOAEL - No Observable Adverse Effects Level.
LOAEL - Lowest Observable Adverse Effects Level.
HQ - Hazard Quotient.

Bolded values indicate a concentration based on 1/2 the maximum detection limit for a non-detected value.
Italicized values indicate a maximum detected concentration with no associated Ecological Screening Value.
Shaded cells indicated HQs equal to or greater than 1.0.

Table 6-22
Hazard Quotients for Ingestion of Earthworms - Short-tailed Shrew (Site Maximum Concentrations)
Red Bank Landfill Site
Red Bank, New Jersey

Analyte	Maximum Concentration of Contaminant in Soil (mg/kg_{dw})	Soil Ingestion Rate (e) (kg_{dw}/day)	Area Use Factor (a)	Dose from Soil (mg/kg_{bw}/day)	Dietary Ingestion Rate (d) (e) (kg_{ww}/day)	Soil to Invertebrate Bioaccumulation Factors (BAFs) (b)	Concentration of Contaminant in Earthworms (mg/kg_{ww}) (b)	Dietary Percentage of Earthworms (a)	Dose from Earthworms (mg/kg_{bw}/day)	Average Body Weight (a) (kg)	Seasonal Use Factor (a)	Average Daily Dose (mg/kg_{bw}/day)	Toxicity Reference Values (TRVs) (c)		Hazard Quotient	
SVOCs													NOAEL	LOAEL	NOAEL HQ	LOAEL HQ
2,4-Dimethylphenol	***0.075***	0.000094	1.0	0.00047	0.0196	1.0	0.075	1.0	0.098	0.015	1.0	0.098	5.0	25	0.020	0.0039
2,4-Dinitrophenol	***0.55***	0.000094	1.0	0.0034	0.0196	1.0	0.55	1.0	0.72	0.015	1.0	0.72	20	30	0.036	0.024
Acetophenone	*0.012*	0.000094	1.0	0.000075	0.0196	1.0	0.012	1.0	0.016	0.015	1.0	0.016	42	423	0.00037	0.000037
Benzaldehyde	*0.19*	0.000094	1.0	0.0012	0.0196	1.0	0.19	1.0	0.25	0.015	1.0	0.25	14	40	0.017	0.0062
Carbazole	*0.081*	0.000094	1.0	0.00051	0.0196	1.0	0.081	1.0	0.11	0.015	1.0	0.11	5.0	50	0.021	0.0021
Dibenzofuran	*0.010*	0.000094	1.0	0.000063	0.0196	1.0	0.010	1.0	0.013	0.015	1.0	0.013	2.0	10	0.0066	0.0013
Pesticides																
4,4'-DDT	0.030	0.000094	1.0	0.00019	0.0196	ln=0.8689*ln(Cs)+2.1247	0.054	1.0	0.070	0.015	1.0	0.070	0.15	5.6	0.48	0.013
alpha-Chlordane	*0.037*	0.000094	1.0	0.00023	0.0196	1.0	0.037	1.0	0.048	0.015	1.0	0.049	4.6	9.2	0.011	0.0053
delta-BHC	*0.00027*	0.000094	1.0	0.0000017	0.0196	1.0	0.00027	1.0	0.00035	0.015	1.0	0.00035	0.15	0.67	0.0024	0.00053
Dieldrin	0.019	0.000094	1.0	0.00012	0.0196	14.7	0.045	1.0	0.058	0.015	1.0	0.058	0.015	1.3	3.9	0.046
Endosulfan II	*0.0013*	0.000094	1.0	0.0000082	0.0196	1.0	0.0013	1.0	0.0017	0.015	1.0	0.0017	0.15	1.5	0.011	0.0011
Endrin Ketone	*0.00028*	0.000094	1.0	0.0000018	0.0196	1.0	0.00028	1.0	0.00037	0.015	1.0	0.00037	0.092	0.92	0.0040	0.00040
gamma-Chlordane	*0.051*	0.000094	1.0	0.00032	0.0196	1.0	0.051	1.0	0.067	0.015	1.0	0.067	4.6	9.2	0.015	0.0073
PCBs																
PCB-1254	*0.11*	0.000094	1.0	0.00069	0.0196	1.13	0.12	1.0	0.16	0.015	1.0	0.16	0.098	0.68	1.7	0.24
Total PCBs	0.11	0.000094	1.0	0.00069	0.0196	1.0	0.11	1.0	0.14	0.015	1.0	0.14	0.098	0.68	1.5	0.21
Metals*																
Antimony	1.8	0.000094	1.0	0.011	0.0196	1.0	0.29	1.0	0.38	0.015	1.0	0.39	0.059	2.8	6.6	0.14
Arsenic	25	0.000094	1.0	0.16	0.0196	ln=0.706*ln(Cs)-1.421	0.38	1.0	0.49	0.015	1.0	0.65	1.0	5.7	0.63	0.11
Cadmium	1.5	0.000094	1.0	0.0094	0.0196	ln=0.795*ln(Cs)+2.114	1.8	1.0	2.4	0.015	1.0	2.4	0.77	6.9	3.1	0.35
Chromium	178	0.000094	1.0	1.1	0.0196	0.306	8.7	1.0	11.4	0.015	1.0	12	2.4	58	5.2	0.21
Cobalt	10	0.000094	1.0	0.063	0.0196	0.122	0.20	1.0	0.26	0.015	1.0	0.32	7.3	19	0.044	0.017
Copper	48	0.000094	1.0	0.30	0.0196	0.515	4.0	1.0	5.2	0.015	1.0	5.5	5.6	83	0.98	0.066
Lead	209	0.000094	1.0	1.3	0.0196	ln=0.807*ln(Cs)-0.218	9.6	1.0	12.5	0.015	1.0	14	4.7	186	2.9	0.074
Manganese	224	0.000094	1.0	1.4	0.0196	ln=0.682*ln(Cs)-0.809	2.9	1.0	3.7	0.015	1.0	5.1	52	146	0.10	0.035
Mercury	0.19	0.000094	1.0	0.0012	0.0196	(8.5*3%Cs) + (0.04*97%Cs)	0.056	1.0	0.1	0.015	1.0	0.074	0.015	0.16	4.9	0.46
Nickel	25	0.000094	1.0	0.16	0.0196	0.020	0.51	1.0	0.66	0.015	1.0	0.82	1.7	15	0.48	0.055
Selenium	1.4	0.000094	1.0	0.0088	0.0196	ln=0.733*ln(Cs)-0.075	0.19	1.0	0.25	0.015	1.0	0.26	0.14	0.66	1.8	0.39
Thallium	4.8	0.000094	1.0	0.030	0.0196	0.22	1.1	1.0	1.4	0.015	1.0	1.4	0.0074	0.074	190	19
Vanadium	334	0.000094	1.0	2.1	0.0196	0.042	2.2	1.0	2.9	0.015	1.0	5.0	4.2	9.4	1.2	0.53
Zinc	218	0.000094	1.0	1.4	0.0196	ln=0.328*ln(Cs)+4.449	80	1.0	105	0.015	1.0	106	75	298	1.4	0.36

NOTES:
(a) - Values and references for these variables are presented in Section 5.5.1 of the Risk Assessment Workplan.
(b) - See table XXX for BAFs and concentration calculations.
(c) - See Table XXX for TRV derivations.
(d) - Food consumption rate was converted from kg dry weight (dw) per day to kg wet weight (ww) per day by using the equation from United States Environmental Protection Agency (USEPA) Exposure Factors Handbook (USEPA, 2011):
IRww = (IRdw * 100)/% solids
Where: IR = Ingestion rate
% solids = 100 - % water makeup of benthic invertebrates (e.g. 100 - 84 = 16) (USEPA, 2007)
(e) United States Environmental Protection Agency (USEPA) Ecological Soil Screening Levels (Eco-SSLs). Guidance for Developing EcoSSLs. Attachment 4-1. Exposure Factors and Bioaccumulation Models for Derivation of Wildlife EcoSSLs. USEPA. 2007.
* Calcium, Iron, Magnesium, Potassium and Sodium were not included in the model equations as they are considered to be essential nutrients.
mg/kg - milligrams per kilogram
kg/day - kilograms per day
mg/kg/day - milligrams per kilogram per day
kg - kilograms
$_{ww}$ - wet weight
$_{dw}$ - dry weight
$_{bw}$ - body weight
NOAEL - No Observable Adverse Effects Level.
LOAEL - Lowest Observable Adverse Effects Level.
HQ - Hazard Quotient.

Bolded values indicate a concentration based on 1/2 the maximum detection limit for a non-detected value.
Italicized values indicate a maximum detected concentration with no associated Ecological Screening Value.
Shaded cells indicated HQs equal to or greater than 1.0.

Appendix A

Ecological Risk Assessment Work Plan

ECOLOGICAL RISK ASSESSMENT WORK PLAN

RED BANK LANDFILL SITE
RED BANK, NEW JERSEY

Prepared for:

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1256 North Church Street
Moorestown, New Jersey 08075

Prepared by:

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November 2013

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LIST OF ACRONYMS

ACO	Administrative Consent Order
ADD	Average Daily Dose
AMEC	AMEC Environment & Infrastructure, Inc.
AOCs	Areas of Concern
ARRCS	Administrative Requirements for Remediating Contaminated Sites
AUF	Area Use Factor
CERCLA	Comprehensive Environmental Responsibility, Cleanup, and Liability Act
COPEC	Constituent of Potential Ecological Concern
CSM	Conceptual Site Model
EcoSSL	Ecological Soil Screening Level
EE	Ecological Evaluation
EPCs	Exposure Point Concentrations
ERA	Ecological Risk Assessment
ERAGS	Ecological Risk Assessment Guidance for Superfund
ERAWP	Ecological Risk Assessment Work Plan
ER-L	Effects Range – Low
ER-M	Effects Range - Medium
ESC	Ecological Screening Criteria
ESNR	Environmentally Sensitive Natural Resource
GPS	Global Positioning System
ha	hectares
HQ	Hazard Quotient
kg	kilograms
km	kilometer
K_{oc}	Organic Carbon Partition Coefficient
L	liters
LOAEL	Lowest Observed Adverse Effects Level
mg	milligrams
mg/kg BW-day	milligrams per kilogram body weight per day
NJDEP	New Jersey Department of Environmental Protection
NJSWQS	New Jersey Surface Water Quality Standards
NOAEL	No Observed Adverse Effects Level
NRDCSCC	Non-Residential Direct Contact Soil Cleanup Criteria
NWI	National Wetlands Inventory
OSWER	Office of Solid Waste and Emergency Response
PCB	polychlorinated biphenyls
RDCSCC	Residential Direct Contact Soil Cleanup Criteria
RIR	Remedial Investigation Report
ROI	Receptor of Interest
SLC	Screening Level Concentration

LIST OF ACRONYMS (CONT.)

SRRA	Site Remediation Reform Act
SRP	Site Remediation Program
SUF	Seasonal Use Factor
SVOCs	Semivolatile Organic Compounds
T&M	T&M Associates
TAL	Target Analyte List
TOC	Total Organic Carbon
TRSR	Technical Requirements for Site Remediation
TRV	Toxicity Reference Value
TSS	Total Suspended Solids
UCL	Upper Confidence Level
U.S.	United States
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service

1.0 INTRODUCTION

This ecological risk assessment work plan (ERAWP) outlines the approaches and methodologies to be used in the preparation of an ecological risk assessment (ERA) for the Sunset Avenue Landfill (the Site), located at the end of Sunset Avenue in the Borough of Red Bank, Monmouth County, New Jersey (**Figure 1**). Environmental concerns at the Site are being addressed under the New Jersey Department of Environmental Protection (NJDEP) Site Remediation Program (SRP). Information concerning environmental conditions at the Site was submitted to the NJDEP in a November 2010 Remedial Investigation Report (RIR), which concluded that an Ecological Risk Assessment (ERA) should be performed.

The NJDEP *Technical Requirements for Site Remediation* (TRSR) states that all sites in New Jersey managed under the SRP must be evaluated for potential ecological impacts utilizing a phased approach. As outlined in the TRSR, as modified by the Site Remediation Reform Act (SRRA) and the Administrative Requirements for Remediating Contaminated Sites (ARRCS), the first step is the completion of a qualitative Ecological Evaluation (EE) as part of the Receptor Evaluation (N.J.A.C. 7:26E – 1.16). The EE is then finalized as part of N.J.A.C. 7:26E – 4.8.

The EE should be conducted by experienced biologists familiar with New Jersey natural resources and U.S. Environmental Protection Agency guidance on ecological assessments. The objectives of the EE are to: 1) identify Environmentally Sensitive Natural Resources (ESNRs) and potential ecological receptors on and immediately adjacent to the Site; 2) identify chemical migration pathways to any ESNRs and document observations of potential impact which may be attributable to the presence of chemicals; and 3) evaluate the nature of chemicals detected at the site and identify Constituents of Potential Ecological Concern (COPECs) which may adversely impact ecological receptors.

The EE evaluates the potential for ecological impacts from the presence of COPECs at the Site. The EE is intended to be qualitative in nature and is based on sampling results obtained during the site investigation. The results of the EE are intended to assess the *potential* for ecological

effects from the exposure of ESNRs to COPECs and to focus future investigations, if needed. The EE will identify whether an ERA is necessary. Continued investigations are required (N.J.A.C. 7:26E – 4.8) if, and only if, the EE indicates the co-occurrence of the following conditions:

1. COPECs exist on-site;
2. An ESNR exists on, or immediately adjacent to, the Site; and
3. Potential contaminant migration pathways to ESNRs exist or an impact to these areas is indicated based on visual observation.

All three conditions must be present for an ecological risk assessment to be required.

If an EE indicates that an ERA is necessary, that step of the assessment process is conducted in accordance with N.J.A.C. 7:26E – 4.8. The regulatory objective of the ERA is to reduce uncertainty regarding any exceedances that were defined in the EE. The ERA is to be conducted by experienced biologists familiar with New Jersey natural resources and U.S. Environmental Protection Agency guidance on ecological assessments and is to be conducted in accordance the *Ecological Evaluation Technical Guidance* (Version 1.2, August 2012) for ESNRs associated with the Site. The protocols for conducting an ERA are to be outlined in a work plan that must be approved by the LSRP for the Site, unless the Site is under state oversight. The work plan must define the assessment and measurement endpoints that will be used in the completion of the ERA.

Assessment endpoints are statements of the characteristics or attributes of the environment that are to be protected. Since assessment endpoints generally cannot be measured directly, measurement endpoints (sometimes known as measures of effects) must be identified as a means of indirectly evaluating the assessment endpoints. ERAs are generally completed through the execution of a variety of activities, including biological surveys, supplemental sampling, toxicity testing, bioassays and tissue analaysis, and modeling.

This ERAWP was developed by AMEC Environment & Infrastructure, Inc. (AMEC) on behalf of T&M Associates based on the following guidance material from NJDEP and the United States Environmental Protection Agency (USEPA):

- *Ecological Evaluation Technical Guidance* (NJDEP 2012);
- *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (ERAGS)(USEPA, 1997);
- *Guidelines for Ecological Risk Assessment* (USEPA, 1998);
- *Framework for Ecological Risk Assessment* (USEPA, 1992a);
- *Developing a Work Scope for Ecological Assessments* (USEPA, 1992b);
- *Guidance for Conducting Remedial Investigations and Feasibility Studies under the Comprehensive Environmental Responsibility, Cleanup, and Liability Act (CERCLA)* (USEPA, 1988);
- *Issuance of Final Guidance: Ecological Risk Assessment and Risk Management Principles for Superfund Sites* (USEPA, 1999a);
- *Planning for Ecological Risk Assessment: Developing Management Objectives* (USEPA, 2001a)*;*
- *Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites* (USEPA, 2002a); and
- *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (USEPA. 2002b).*

1.1 SCOPE AND OBJECTIVES

The objective of this ERA is to evaluate potential ecological effects that may exist as a result of the presence of elevated levels of metals, semi-volatile organic compounds (SVOC), pesticides, and polychlorinated biphenyls (PCBs) that have been previously identified within the Site. The ERA will utilize a combination of historic data (provided by T&M), as well as newly generated data (collected by T&M and AMEC), and will be prepared using conservative, but realistic assumptions about potential exposures.

Specifically, the principal functions of the ERA are to:

- Assess whether actual or potential ecological risks currently exist at the Site;
- Define the magnitude and extent of the constituents present at the Site that may pose potential ecological risks;
- Determine if constituents originating from the Site have been transported to on-site wetlands; and
- Generate data and information for risk management and risk reduction decisions, as warranted.

This ERAWP outlines the procedures by which historic data collected from aquatic habitats associated with the Site will be evaluated in order to assess the potential for adverse ecological effects. Additional sample collection and analysis, recommended to close data gaps from the previous sampling efforts, will also be described.

1.2 ORGANIZATION OF THIS ERAWP

The ERAWP begins with a description of the environmental investigation activities that were used to develop an understanding of the environmental conditions at the Site (Section 2.0). The ERAWP then discusses the problem formulation phase (Section 3.0) that characterizes the environmental setting and condition of the receiving environment. The screening-level problem formulation phase presents a conceptual site model that outlines the contaminants known to exist at the Site, describes contaminant fate and transport mechanisms, presents possible mechanisms of toxicity, describes completed exposure pathways associated with the Site, and identifies the endpoints that will be used in the screening process.

Section 4.0 outlines the additional site investigative activities that will be used to support the preparation of the ERA. Section 5.0, the analysis section, summarizes how the relationship between contaminants identified during the remedial investigative sampling and assessment and

measurement endpoints associated with ecological receptors will be developed. Section 6.0 describes how the risk characterization phase of the ERA will be conducted. Risk characterization in an ERA is performed for each assessment endpoint by (1) comparing measured chemical concentrations to ecotoxicological benchmarks, (2) estimating the effects of the COPECs retained by this screening analysis, (3) estimating the effects of exposure on the endpoint biota based on the results of the biological survey data, (4) logically integrating the evidence to characterize risks to the endpoint, and (5) listing and discussing the uncertainties in the assessment.

2.0 SITE HISTORY AND SUMMARY OF PREVIOUS INVESTIGATIONS

The following sections present information regarding historic Site activities and a synopsis of previously conducted Site environmental investigations.

2.1 SITE HISTORY

The Red Bank Landfill Site is at the end of Sunset Avenue, consisting of Block 84, Lot 64, in the Borough of Red Bank, Monmouth County, New Jersey. The property contained an abandoned incinerator building (demolished in 2009-2010). A landfill that was in use from the early 1900's and ceased operation in 1983 remains. The landfill has been closed in accordance with NJDEP requirements. The original incinerator burned coal for the incineration process and was modified and expanded in the 1930's to utilize natural gas. A Borough composting center operated on the western portion of the property from 1983 to 2005. The Borough recycling center is located on the south side of Sunset Avenue for bulk disposal of recyclable materials.

The 8.5 acre property is located north of Newman Springs Road, west of Tilton Avenue, south of James Parker Boulevard, and is situated along approximately 1,000 feet of the eastern shore of the Swimming River. Single and Multifamily residential buildings are located to the east, north, and south of the property, and undeveloped marshlands are located across the Swimming River.

Closure activities included covering the landfill with two feet of cover material as specified in the NJDEP's Administrative Consent Order (ACO) dated August 1984. Four groundwater monitoring wells were installed on the property in accordance with post closure requirements.

2.2 PREVIOUS ENVIRONMENTAL INVESTIGATIONS

T&M conducted a Preliminary Assessment/Site Investigation (PA/SI) in April 2007 in accordance with the NJDEP's TRSR (N.J.A.C. 7:26E). The PA/SI identified five areas of concern (AOCs) on the property.

AOC 1: Landfill – Sanborn Maps from 1922 depict a "Borough Garbage Dump" on the property. The Red Bank Landfill had NJDEP permits for acceptance of specific solid waste types (ID 13 Bulky Waste, ID 23 Vegetative Waste, and ID 27 Dry Industrial Waste). Wastes were incinerated in the incinerator building, and the residue was deposited in the landfill. The Red Bank Landfill is listed as being "closed" as of 1983.

AOC 2: Historic Fill – Review of the NJDEP Historic Fill of the Long Branch Quadrangle indicates historic fill was placed on the western border of the property. Historic fill is defined as non-indigenous material placed in order to raise the topographic elevation.

AOC 3: Incinerator Site – Surface soil samples were collected by T&M Associates on September 21, 2006 in the vicinity of the incinerator building. Soil samples collected from the perimeter of the incinerator building and one sample of the stack residue revealed base / neutral semi-volatile compounds and chlordane (pesticide) in excess of Residential and Non-Residential Direct Contact Soil Cleanup Criteria (RDCSCC and NRDCSCC).

AOC 4: Incinerator Stack – A sample of the incinerator stack residue (sample SB-6) collected by T&M in December, 2006 indicated elevated concentrations of antimony, arsenic, cadmium, lead, mercury, and zinc.

AOC 5: Groundwater – Four monitoring wells are located on the property for groundwater characterization associated with the NJPDES permit and landfill closure plan. Quarterly sampling through 1990 indicated elevated levels of permitted parameters.

A sixth AOC, the Swimming River, was investigated as part of a RIR performed by T&M between 2006 and 2010. This final AOC will be the primary focus of the ERAWP:

AOC 6: Swimming River – Surface water samples were collected from three locations along the shore of the Site, and found to exceed ecological screening values for metals.

The RIR noted that environmental sampling of surface water, sediment, surface water, and groundwater had identified metals, SVOCs, pesticides, and PCBs in excess of NJDEP clean-up criteria. The RIR concluded that an Ecological Risk Assessment should be performed relative to the surface water and sediment sampling.

3.0 PROBLEM FORMULATION

The problem formulation section consists of the description of the relevant Site features and current condition of the environment, a description of the potential sources, the identification of ecological receptors at the Site and surrounding area and the development of the Conceptual Site Model (CSM). The CSM is a conceptual projection of possible source to pathway to receptor scenarios for the COPECs identified at the Site.

3.1 SITE SETTING

The following sections provide the regional ecological conditions and a general understanding of the ecological receptors, communities, and setting found within and adjacent to the Site.

The Site is located at the end of Sunset Avenue, Red Bank, Monmouth County, New Jersey. A Site location map, prepared from the United States Geological Survey New Jersey 7½ minute topographic quadrangle for Long Branch, is included as **Figure 1**. A Site plan showing property boundaries and previously identified AOCs is provided as **Figure 2**.

The surrounding area to the northeast, east, and south of the Site is residential/commercial, and to the northwest (across the Swimming River) is undeveloped marsh land. Sunset Avenue ends at a gate leading to a dirt path into the landfill area (Appendix A, Photo 1). During a June 3, 2013 site visit, the dirt path was highly eroded by stormwater runoff (Photo 2). The middle of the landfill area is a partially open meadow, vegetated with sedges, common reed (*Phragmites*), and low shrubs (Photo 3). The southern end of the landfill, leading to the forested wetland is densely vegetated with *Phragmites*, Japanese knotweed (*Fallopia japonica*), briars, and ruderal species (Photo 4). There is a forested wetland at the southern end of the Site, with steep banks (Photo 5) sloping down to a small drainage that leads to the river (Photo 6). The drainage appeared to be a stormwater conveyance rather than a creek, and the water at the mouth of the drainage appeared to be the river water moving in and out with the tide.

The portion of the landfill Site that borders the river is steeply banked, and vegetated with small trees, vines, and shrubs (Photo 7). Passing the landfill and the salt marsh to the west (Photo 8), the river flows north and joins with the discharge from Shadow Lake to become the Shrewsbury River, approximately 3/4 mile downstream from the Site.

There is a large earthen mound near the entrance to the landfill area. While the mound is at ground level near the Sunset Avenue gate, where it is used as a recycling collection center (Photo 9), the landfill property slopes down toward the river, and the landfill side of the mound is steeply banked, and the slope is approximately 20 feet high (Photo 10). The slope is not vegetated, and the soil has been eroded by storm runoff (Photo 11). There are residential properties adjacent to the landfill, to the southeast of the mound, and at the head of the forested wetland swale (Photo 12).

Wildlife use of the site and the adjacent river includes mammals and birds observed during the June site visit (white-tailed deer, grey squirrel, raccoon, great blue heron, osprey, red-winged blackbird, and numerous passerines). The NJDEP Landscape Project shows the Swimming River to be a potential foraging area for the endangered bald eagle. The Swimming River is anticipated to provide habitat for marine/estuarine fish and invertebrates.

During the course of the field activities supporting the ERA, a more thorough understanding of the characteristics of the terrestrial, wetland, and aquatic ecosystem associated with the Site will be developed. Wetland and aquatic sampling will provide a qualitative assessment of the benthic macroinvertebrate community as well as physical characteristics of, and concentration of constituents within, the sediments and surface water of the river. A description of the surrounding upland and aquatic habitats and dominant vegetative communities of both, including a qualitative determination of community makeup, density, frequency and abundance will be provided in the ERA, based on observations and information collected during implementation of the field sampling program. Evidence of the wildlife in the community, including calls or songs, tracks and scat, will also be documented to further understand the avian and mammalian

populations that utilize the landfill site for various activities including foraging, drinking, or resting.

3.1.1 Topography and Drainage

The Site topography generally slopes toward the river, with a steeper slope from the end of Sunset Avenue down to a relatively flat central plain, and steep slopes around the perimeter of the Site dropping into the forested wetland swale or down to the river. The approximate elevation of the Site is less than 10 feet above mean sea level. Drainage in the area is generally via overland flow and from the wetland swale that discharges into the Swimming River.

3.1.2 Soils

A review of the United States Department of Agriculture (USDA) Soil Conservation Service's soil survey for Monmouth County (USDA, 2013) indicates that the soils surrounding the Site are of several different general soil units. The following soil mapping units were located on and immediately adjacent to the landfill (**Figure 3**):

- Freehold sandy loam, 15-25% slopes, eroded
- Humaquepts, 0-3% slopes, frequently flooded
- Tinton loamy sand, 5-10% slopes

The Freehold sandy loam soil is classified as moderately deep, well drained soil, 35 to 70 inches deep or more to the restrictive feature. The Humaquepts soil is moderately deep, poorly drained, with a depth to the water table of 0-12 inches. The Tinton loamy sand soil is classified as moderately deep, well drained soil, with a depth to the water table of more than 80 inches (USDA 2013).

3.1.3 Geology

The Site is located in the Coastal Plain physiographic province of New Jersey. The Coastal Plain extends from the Delaware Bay in the southwest to the Raritan Bay in the northeast and from the "Fall Line" (boundary line with the Piedmont province) in the northwest to the Atlantic Ocean in the southeast. The Coastal Plain province is approximately 4,667 square miles in area and occupies about three-fifths of the state. The unconsolidated deposits that make up the Coastal Plain range in age from the upper Lower Cretaceous to the Miocene period (90 to 10 million years old) and dip gently to the southeast towards the Atlantic Ocean. The altitude for the Coastal Plain is between sea level and 391 feet above sea level (NJGS, 2003).

3.1.4 Hydrology

The entire property lies in the Navesink River/Lower Shrewsbury River Watershed. The Swimming River borders the Site on the western boundary. A tidal marsh exists across the river from the Site. No ponds or impoundments are present on, or adjacent to the Site. The forested wetland feature on the south of the landfill acts as a large drainage ditch located between the landfill and the residential neighborhood to the south.

3.2 ENVIRONMENTALLY SENSITIVE NATURAL RESOURCES

The following sections discus the natural resources of the Site area and environs encountered on AMEC's site visit on June 3, 2013.

3.2.1 Wetlands and The Swimming River

The Clean Water Act implementing regulations define wetlands as "those areas that are inundated or saturated by surface or groundwater at a frequency or duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for

life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas" (40 CFR 230.3(t)).

According to the New Jersey Wetlands Map, the forested wetland area to the south of the landfill, the marsh along the southern shore upstream of the Site, and the salt marsh across the Swimming River from the Site area described as natural wetlands (**Figure 4**). The U.S. Fish and Wildlife Service's (USFWS) National Wetlands Inventory (NWI) Map describes the open water community of the Swimming River as estuarine, subtidal, unconsolidated bottom. The forested wetland area is listed as a palustrine, forested, broad-leaved deciduous, seasonal-tidal wetland. The shoreline of the Swimming River upstream of the Site is described as an estuarine, intertidal, emergent, *Phragmites australis* wetland. The salt marsh across the Swimming River from the Site is described as estuarine, intertidal, emergent, persistent wetland. (**Figure 5**).

3.2.2 Upland Community

The upland wooded areas located around the perimeter of the Site support a diverse and dense vegetative community. The upland canopy in these sections was dominated by deciduous tree species, such as Norway maple (*Acer platanoides*), silver maple (*Acer saccharinum*), box elder (*Acer negundo*), chestnut oak (*Quercus Montana*), tree-of-heaven (*Ailanthus altissima*), black locust (*Robinia pseudoacacia*), and sycamore (*Platanus occidentalis*).

The herbaceous layer was comprised of species such as mugwort (*Artemisia vulgaris*), Japanese knotweed (*Fallopia japonica*), garlic mustard (*Alliaria petiolata*), white wood aster (*Eurybia divaricata*), curly dock (*Rumex crispus*), bluegrass (*Poa* spp), hawthorn (*Crataegus* spp), vines such as oriental bittersweet (*Celastrus orbiculatus*), Japanese honeysuckle (*Lonicera japonica*), and poison ivy (*Toxicodendron radicans*), and saplings of the above tree species.

The central open area of the landfill supports a mixture of short and tall grassy areas dominated by common reed (*Phragmites australis*).

Photographs of these upland communities are provided in **Appendix A**.

3.2.3 Threatened and Endangered Species

Endangered species are those organisms whose prospects for survival in an area are assumed to be in immediate danger because of a loss or change in habitat, over-exploitation, predation, competition, or disease. Threatened species are those who may become endangered if conditions surrounding the species begin, or continue, to deteriorate. After reviewing the NJDEP Landscape Project files for this property on NJ-GeoWeb (NJDEP, 2013), the emergent marsh area and the riparian corridor adjacent to the Site has been designated by the NJDEP as habitat suitable for foraging by the common tern (*Sterno hirundo*), bald eagle (*Haliaeetus leucocephalus*), and black-crowned night heron (*Nycticorax nycticorax*).

Of the three species listed as being potentially present in and around the Site area, the bald eagle and the black-crowned night heron are state listed endangered species. The common tern is considered a species of special concern.

3.3 CONCEPTUAL SITE MODEL

One of the most critical elements of the ERA scoping process is the development of the CSM. The CSM describes the hypothesized source of COPECs, routes of exposure and transport, and ecological receptors associated with the Site. The CSM serves as the rationale for the development of sampling plans and protocols, the selection of assessment and measurement endpoints, and the identification of receptors of concern. The CSM can be revised as new site-related information becomes available.

The following sections describe in greater detail the CSM for the aquatic pathway associated with the Site. The CSM is graphically described in **Figure 6**.

3.3.1 Aquatic Pathways

The contamination within the landfill portion of the Site is based on historic dumping. Therefore, the primary aquatic pathways would be the mechanisms by which chemicals migrate into sediments and surface water through groundwater migration, surface runoff, physical disturbance, and food chain transport.

In coarse-grained sediments with little organic material, dissolved COPECs will pass directly into the water column. In fine-grained or organic rich sediments, a portion of the constituents may adhere to sediment particles. Whether the constituents remain in the sediment or are dissolved again will depend on their chemical characteristics. Those chemicals with high organic carbon partition coefficient (K_{oc}) values will have a greater affinity for sediment, especially sediment that is high in organic matter. Such constituents would tend to remain sorbed onto sediment particles and migration would occur as a result of sediment movement, not chemical movement.

A physical disturbance of the sediment by anthropogenic activities, like dredging, or natural processes such as erosion, can cause resuspension and/or dissolution of the chemicals within the sediment. This effect may be long- or short-term depending upon the size and solubility of the compound and the size of the sediment particle. While in the water column, pelagic flora and fauna may be directly exposed to the re-suspended chemicals as they are transported to other sites. Mobilized constituents in surface water may then be transported through the food chain to higher order trophic levels (e.g., piscivorous and omnivorous wildlife). Indirect exposure through the food chain occurs when a COPEC is assimilated by a species (e.g., prey/food item) at one trophic level, bioaccumulated by that trophic level, and transferred to the next trophic level through consumption.

Constituents that are dissolved in the surface water may be diffused by the larger volume of the receiving water body. Diffusion is further enhanced by the flow of water within a water body, by increasing the rate of diffusion and moving the diluted chemicals out of the recharge zone.

However, if the water body is low in volume and flow, the settling of suspended constituents back into the sediment is possible.

The aquatic and terrestrial pathways are the primary pathways to be assessed in this ecological evaluation. The sampling that will support this ERA is designed to investigate the magnitude of the potential risk by examining the sediment and surface water in the Swimming River.

3.3.2 Terrestrial Pathways

The contamination within the terrestrial portion of the landfill is based on historic dumping. While the landfill closure included covering the landfill with two feet of soil, the forested wetland ESNR adjacent to the former landfill area provides a potential exposure pathway for Site-related contaminants to impact ecological receptors. Therefore, the primary terrestrial pathway would be the mechanisms by which chemicals migrate into soils through groundwater migration, surface runoff, physical disturbance, and food chain transport.

3.4 SELECTION OF CONSTITUENTS OF POTENTIAL ECOLOGICAL CONCERN

The target parameters or analytes of concern for the Red Bank Landfill Site are metals, SVOCs, pesticides and PCBs identified in the sediments during the initial RIR process. The results of the proposed sampling and analysis of soil, sediment, and surface water will be used to determine where the COPECs are present in the forested wetland and the Swimming River, and if there are potential impacts to ecological receptors from site-specific COPECs.

3.5 IDENTIFICATION OF RECEPTORS AND ENDPOINTS

This section will discuss the identification of receptors of interest (ROIs) and assessment and measurement endpoints used to determine potential impacts to ecological receptors.

3.5.1 Identification of Receptors of Interest

The first step in the assessment of effects is the identification of those ROIs that will be evaluated in the ERA. As it is not feasible to evaluate the relationship of COPECs to every species at the Site, ROIs have been selected to represent the organisms that might be present at the Site most often or are likely to be most sensitive to the effects of the COPECs. Selection criteria for ROIs include the following factors specified in USEPA guidance (1989, 1992a, 1994, 1997, 1998): (1) the occurrence of potentially complete pathways for exposure of ecological resources to chemicals in environmental media; (2) resident communities or species exposed to the highest concentrations of COPECs in environmental media; (3) species or functional groups considered to be essential to, or indicative of, the normal functioning of the affected habitat; and (4) the feasibility of completing a quantitative assessment for the identified pathways and receptors.

Species were selected as ROIs for this assessment using the following criteria:

- Relative abundance and ecological importance within the identified habitats;
- Availability and quality of appropriate ecotoxicological research;
- The sensitivity of the organism to the COPECs;
- Importance of the trophic level in the ecosystem;
- The relative mobility and type of feeding habits; and
- The ability to bioaccumulate COPECs.

The following ROIs have been selected for use in preparing this ERA because they were either observed at the Site or are expected to utilize the habitat in or around the landfill and the Swimming River. In addition, these species are well documented in terms of ecological risk exposure modeling information:

- Benthic invertebrates
- Fish

- Birds
  - Piscivorous birds (bald eagle (*Haliaeetus leucocephalus*) and great blue heron (*Ardea herodias*))
  - Invertivorous birds (American robin (*Turdus migratorius*), spotted sandpiper (*Actitis macularia*) and mallard duck (*Anas platyrhynchos*))
- Mammals
  - Invertivorous mammal (short-tailed shrew (*Blarina brevicauda*))
  - Omnivorous mammal (raccoon (*Procyon lotor*))

Benthic invertebrates were selected as ROIs because they are sensitive to environmental stressors and they are susceptible to localized contamination due to their relative immobility. Because benthic invertebrates form the prey base for higher trophic level organisms, and some of the constituents tend to bioaccumulate or biomagnify up the food chain, higher trophic-level birds (bald eagle, great blue heron, spotted sandpiper, and mallard) and mammals (raccoon) were also selected for the aquatic pathway risk assessment.

Terrestrial ROIs were also chosen because COPECs in soil can be accumulated by soil invertebrates which act as prey for higher trophic level birds (robin) and mammals (raccoon and shrew), which were also selected for the terrestrial pathway risk assessment.

3.5.2 Assessment and Measurement Endpoints

The next step in the ERA process is the identification of those endpoints that will be utilized in the ERA to evaluate the ecological effects associated with the potential exposure of ROIs to COPECs.

3.5.2.1 Assessment Endpoints

Assessment endpoints are statements of the characteristics or attributes of the environment that are to be protected. The following assessment endpoints were developed based on the four selection criteria described in the USEPA ERAGS (USEPA, 1997).

Assessment Endpoint #1: Evaluate the potential for adverse changes in the survival, reproduction, and growth of benthic invertebrate populations utilizing the Swimming River, resulting from potential exposures to COPECs in sediments and/or surface water;

Assessment Endpoint #2: Evaluate the potential for adverse changes in the survival, reproduction, and growth of fish populations utilizing the Swimming River, resulting from potential exposures to COPECs in sediments and/or surface water;

Assessment Endpoint #3: Evaluate the potential for adverse changes in the survival, reproduction, and growth of populations of piscivorous, omnivorous, and invertivorous species potentially utilizing the Swimming River, resulting from exposures to COPECs in sediments, surface water and/or prey.

Assessment Endpoint #4: Evaluate the potential for adverse changes in the survival, reproduction, and growth of populations of omnivorous and invertivorous species potentially utilizing the forested wetland adjacent to the former landfill area, resulting from exposures to COPECs in soil and/or prey.

The assessment will evaluate ecological risks relative to these endpoints from the forested wetland, the Swimming River, and the vicinity of the Site. Data to evaluate these endpoints will be collected during field studies as specified in Section 4 of this ERAWP.

3.5.2.2 Measurement Endpoints

Because the above assessment endpoints generally cannot be measured directly, measurement endpoints have been identified. There are four types of measurement endpoints, or lines of

evidence that will be used to assess the status and potential changes in the attributes of the environment. The lines of evidence are:

- Determination of the potential for ecological effects by the comparison of COPEC concentrations to media-specific ecotoxicological benchmarks derived from the literature, when available;
- Qualitative and semi-qualitative biological survey data of various ROIs which are direct estimates of the assessment endpoint;
- Direct measurement of sediment toxicity using surrogate benthic invertebrates in laboratory exposures; and
- Estimation of the potential for ecological effects on higher trophic level organisms from COPECs based on dietary exposure.

A weight-of-evidence approach will be utilized in evaluating differing lines of evidence collected for each of the measurement endpoints. Each line of evidence used in the weight-of-evidence approach will be correlated in an exposure-response relationship in an attempt to demonstrate a relationship between the magnitude of exposure and the magnitude of effects. A weight-of-evidence approach weighs each of the measurement endpoints by considering:

- The strength of association between the measurement endpoints and the assessment endpoints;
- Data quality; and
- Study design and execution.

The strength of association refers to how well a measurement endpoint represents an assessment endpoint such that the greater the correlation between the measurement and assessment endpoints, the greater the weight given to that measure of effect in the risk analysis.

The weight assigned a measurement endpoint also depends on the quality of the data as well as the overall study design and execution. The sampling program will provide information to

evaluate each measurement endpoint. However, the ERA will also evaluate the variability and uncertainties associated with the results following implementation of the sampling effort. The risk characterization gives higher weight to measurement endpoints that are based on good quality data and are obtained using study designs that account for confounding variables. Nonetheless, there is considerable uncertainty associated with estimating potential ecological risks, because ecological systems are complex and exhibit high natural variability.

Measurement endpoints typically have specific strengths and weaknesses related to the factors discussed above. Therefore, it is common practice to use more than one measurement endpoint to evaluate each assessment endpoint.

Assessment Endpoint #1: Evaluate the potential for adverse changes in the survival, reproduction, and growth of benthic invertebrate populations utilizing the Swimming River, resulting from potential exposures to COPECs in sediments and/or surface water;

Measurement Endpoints for Assessment Endpoint #1

a) The first line of evidence will be the evaluation of COPEC data obtained through the chemical analysis of sediments. The ability of the benthic community to perform its role as a prey base will be evaluated by comparing the concentrations of COPECs in sediments collected from the river to appropriate sediment quality benchmarks based on the protection of benthic macroinvertebrates (*e.g.*, NJDEP Ecological Screening Criteria (ESC); NJDEP, 2009). The comparison will be established in terms of an exposure-response gradient horizontally across all sampling locations.

b) Another line of evidence will be the evaluation of COPEC data obtained through the chemical analysis of surface water. This will be assessed for benthos by comparing concentrations of Site-related COPECs identified in surface water samples collected from within the river to the New Jersey Surface Water Quality Standards (NJSWQS) (NJDEP,

2006) which are based on the protection of aquatic organisms. If appropriate NJSWQS benchmarks are not available, then NJDEP's ESC (NJDEP, 2009) or USEPA Region 4 Freshwater Surface Water Screening Values for Hazardous Waste Sites (USEPA, 2001b), or other appropriate surface water criteria will be used as secondary sources for constituent benchmarks.

c) A qualitative biological survey of the river and surrounding communities will be used as another line of evidence. As part of that, AMEC will utilize appropriate biological indicator metrics to assess the possible presence of gross level changes in the biological community. Visible indicators, such as areas that are devoid of plant material, will be noted.

d) The qualitative evaluation of benthic community structure will also be used as a line of evidence. Evaluations will include a presence/absence determination of benthic invertebrates from each sediment sample collected as well as documenting the dominant species to the lowest practical taxon.

e) A direct measurement of sediment toxicity will also be made through laboratory sediment toxicity studies using the marine amphipod, *Leptocheirus plumulosus*.

Rationale for Measurement Endpoints 1a through 1e

The potential release of COPECs in sufficient concentrations could have an ecological impact on the benthic community. As described above, a number of lines of evidence will be examined to evaluate this potential effect.

The measurement endpoints identified above were selected to evaluate the potential pathways that would result in the exposure of benthos to COPECs. Those endpoints associated with sediment and surface water measurements are intended to provide an assessment of the ability of these matrices to potentially support benthic macroinvertebrates. The sampling area represents

only a small portion of the aquatic system, as such, assumptions will be made based on best professional judgment, regarding the potential exposure-response relationship for the Swimming River.

While the analysis of sediments and surface water will provide an estimate of potential exposure, the biological survey will provide a qualitative visual assessment of the effects, if any, of sediment and surface water COPECs on the flora and faunal communities. It will also assess habitat suitability of the Swimming River for various wildlife species activities, such as breeding and foraging.

The qualitative evaluation of the benthic macroinvertebrate community provides evidence of its ability to function as a prey base. By examining the benthic community, the ERA will be able to correlate chemical concentrations in sediments to possible benthic community effects. The benthic community assessment will provide evidence of the habitat suitability of the river sediments for macroinvertebrates while the chemical analyses will help identify which of the COPECs may be responsible for any observed effect.

The direct measure of sediment toxicity to marine amphipods provides quantitative and qualitative evidence of the sediment's suitability as habitat. By examining the sediment toxicity, the ERA will be able to correlate COPEC concentrations in the sediment to observed toxic effects.

Assessment Endpoint #2: Evaluate the potential for adverse changes in the survival, reproduction, and growth of fish populations utilizing the Swimming River, resulting from potential exposures to COPECs in sediments and/or surface water;

Measurement Endpoints for Assessment Endpoint #2

a) The first line of evidence will be the evaluation of COPEC data obtained through the chemical analysis of sediments. The ability of the river to support fish will be evaluated

by comparing the concentrations of COPECs in sediments collected from the river to appropriate sediment quality benchmarks based on the protection of fish and/or aquatic biota (*e.g.*, NJDEP ESCs). The comparison will be established in terms of an exposure-response gradient horizontally across all sampling locations.

b) Another line of evidence will be the evaluation of COPEC data obtained through the chemical analysis of surface water. This will be assessed for fish by comparing concentrations of Site-related COPECs identified in surface water samples collected from within the river to the NJSWQS (NJDEP, 2006) which are based on the protection of aquatic organisms. If appropriate NJSWQS benchmarks are not available, then NJDEP's ESC or USEPA Region 4 Freshwater Surface Water Screening Values for Hazardous Waste Sites (USEPA, 2001b), or other appropriate surface water criteria will be used as secondary sources for constituent benchmarks.

Rationale for Measurement Endpoints 2a and 2b

The potential release of COPECs in sufficient concentrations could have an ecological impact on the fish community. As described above, two lines of evidence will be examined to evaluate this potential effect.

The measurement endpoints identified above were selected to evaluate the potential pathways that would result in the exposure of fish to COPECs. Those endpoints associated with sediment and surface water measurements are intended to provide an assessment of the ability of these matrices to potentially support fish. The sampling area represents only a small portion of the aquatic system, as such, assumptions will be made based on best professional judgment, regarding the potential exposure-response relationship for the entire Swimming River.

Assessment Endpoint #3: Evaluate the potential for adverse changes in the survival, reproduction, and growth of populations of piscivorous, omnivorous and

invertivorous species potentially utilizing the Swimming River, resulting from exposures to COPECs in sediments, surface water and/or prey.

Measurement Endpoints for Assessment Endpoint #3

a) Potential ecological risks to piscivorous birds (bald eagle and great-blue heron), invertivorous birds (spotted sandpiper and mallard), and an omnivorous mammal (raccoon) will be measured using a dietary exposure based on body burden concentrations of COPECs in sediments and surface water collected at the Site, compared to associated toxicity reference values (TRVs) identified in the literature. Exposure concentrations to ROIs will be estimated using food chain models and the dose calculations described in Section 5.5.

Rationale for Measurement Endpoint #3a

Measured concentrations of COPECs in the sediment and surface water may not produce direct ecotoxicological effects. However, if the constituents are bioavailable and bioaccumulative, they may have the potential to produce effects at higher trophic levels. This may result in indirect impacts to more wide-ranging species, to species that are especially sensitive to particular COPECs, or to species that have special status because of population levels or habitat requirements. For that reason, dietary exposure will be employed to assess the potential exposure of upper level aquatic species to COPECs in sediments and surface water. Using empirical data, the potential for ecological risks to these ROIs feeding at the Site will be calculated through an average daily dose (ADD) then compared to COPEC-specific TRVs.

Assessment Endpoint #4: Evaluate the potential for adverse changes in the survival, reproduction, and growth of populations of omnivorous and invertivorous species potentially utilizing the forested wetland adjacent to the former landfill area, resulting from exposures to COPECs in soil and/or prey.

Measurement Endpoints for Assessment Endpoint #4

a) Potential ecological risks to invertivorous birds (American robin), omnivorous mammals (raccoon), and invertivorous mammals (short-tailed shrew) will be measured using a dietary exposure based on body burden concentrations of COPECs in soil collected at the Site, compared to associated TRVs identified in the literature. Exposure concentrations to ROIs will be estimated using food chain models and the dose calculations described in Section 5.5.

Rationale for Measurement Endpoint #4a

Measured concentrations of COPECs in the soil may not produce direct ecotoxicological effects. However, if the constituents are bioavailable and bioaccumulative, they may have the potential to produce effects at higher trophic levels. This may result in indirect impacts to more wide-ranging species, to species that are especially sensitive to particular COPECs, or to species that have special status because of population levels or habitat requirements. For that reason, dietary exposure will be employed to assess the potential exposure of upper level terrestrial species to COPECs in soil. Using empirical data, the potential for ecological risks to these ROIs feeding at the Site will be calculated through an ADD then compared to COPEC-specific TRVs.

Methodologies for collecting the data required to measure the effects are described in Section 4 of this work plan.

4.0 SUPPLEMENTAL SITE INVESTIGATION

The analysis portion of the ERA includes the estimation of potential exposures of biological receptors to COPECs and the determination of the potential effects associated with those exposures. The assessment of effects is the determination of the relationship between the concentrations of potential COPECs identified in various matrices in the Swimming River at the Site and the potential responses of ecological receptors to these concentrations. Additional sampling is required within the river to support the completion of the ERA and to fill certain data gaps. This section outlines the supplemental data collection activities that will be used to prepare the ERA.

4.1 SAMPLING OVERVIEW

Twenty-three sediment samples will be collected from the river: two samples will be collected near-shore from each of the five historical sediment sampling locations; one sample will be collected mid-stream between each of the five existing locations; three samples will be collected in the far-shore environment (one each across from historical locations #1, #3, and #5); three background location samples will be collected upstream of the Site; and two samples will be collected from downstream of the Site. Proposed sample locations are provided in **Figure 2**.

Eleven surface water samples will be collected from locations co-located with 11 of the sediment samples.

Five surface soil samples will be collected in the forested wetland area. Soil collection locations will be chosen based on the terrain, and will include potential locations where soil runoff may have deposited site-related contaminants. Proposed sample locations are provided in **Figure 2**.

Detailed procedures for collection, handling, and shipping of additional soil, sediment, surface water, and biota samples are described in the following sections. Procedures are included for the following items:

- Sample locations and sample types;
- Sampling and decontamination procedures; and
- Documentation.

4.1.1 Surface Water/Sediments

A total of 11 surface water samples will be collected from the river (co-located with 11 of the proposed sediment sample locations), if possible, by submerging the laboratory-supplied bottle into the water at the zero to six-inch interval above the sediment, or, if the bottle contains a preservative, by submerging a non-preserved lab-supplied bottle into the water and decanting the water from the non-preserved bottle into the preserved bottle. These samples will be analyzed for total and dissolved target analyte list (TAL) metals and mercury, SVOCs, PCBs, pesticides, and total suspended solids (TSS).

Water quality parameters such as dissolved oxygen, temperature, pH, salinity, and conductivity will be recorded prior to sample collection using a HORIBA U-10 monitor (or equivalent) calibrated in accordance with the equipment manufacturer's specifications. Additionally, qualitative observations of water conditions (color, turbidity, and odors) will also be made at each location. The sample locations will be noted using a hand-held global positioning system (GPS) unit.

The 23 sediment samples will be collected using a field decontaminated, stainless steel hand auger, trowel, and or other sampling device (*e.g.* petite ponar dredge). Samples will be collected from the 0 to 6-inch interval. These samples will be analyzed for the same metals, SVOCs, PCBs, and pesticides as the water samples, as well as total organic carbon (TOC), and grain size. The collected sediment will first be placed directly into a decontaminated stainless steel bowl for homogenization. Sediments will be observed for the presence or absence of benthic macroinvertebrates and will be noted as such. If benthic macroinvertebrates are observed, the

dominant species will be identified to the lowest practical taxon in the field. Sediment will then be placed into the laboratory-supplied glass containers using a field-decontaminated steel trowel.

Five of the sediment samples will be submitted for 10-day laboratory toxicity testing using the marine amphipod, *Leptocheirus plumulosus*. The toxicity study will be performed in accordance with American Society for Testing and Materials guidance (ASTM, 2008). A summary of procedures can be found in Appendix B.

All sample bottles will be stored in a cooler at 4°C until shipped to the analytical laboratory under a chain-of-custody. Quality assurance/quality control samples will include one equipment blank and one duplicate sample collected for every ten samples. The positions of the aquatic samples will be such that they maximize the spatial coverage of the river and will be biased towards inflow areas or areas where Site-related sediments are expected to accumulate. The proposed aquatic sampling locations have been selected to reassess and complement the five samples that have been collected to date.

The sequence of sample collection will be arranged to maximize efficiency while minimizing potential cross-sample contamination.

4.1.2 Soil

The five soil samples will be collected using a field decontaminated, stainless steel hand auger, trowel, and or other sampling device. Samples will be collected from the 0 to 6-inch interval. These samples will be analyzed for the same metals, SVOCs, PCBs, and pesticides as the surface water and sediment samples. The collected soil will first be placed directly into a decontaminated stainless steel bowl for homogenization. Soils will be observed for the presence or absence of macroinvertebrates and will be noted as such. Soil will then be placed into the laboratory-supplied glass containers using a field-decontaminated steel trowel.

4.2 DECONTAMINATION

All re-usable sampling equipment will be decontaminated between each use to ensure the integrity of each of the representative sediment samples. The decontamination procedure shall consist of the following:

1) Wash with a non-phosphate detergent (alconox or other suitable detergent) and potable water solution,
2) Rinse with potable water,
3) Rinse with 10% nitric acid (trace metal grade or higher),
4) Rinse with potable water,
5) Rinse with methanol, and
6) Rinse with distilled or deionized water.

Isopropyl alcohol may also be used, only when necessary, to aid in decontaminating sampling devices that cannot be rendered visibly clean with the detergent wash and rinse sequence. The rinse sequence must be repeated if additional decontamination is required.

Equipment for measuring field parameters such as pH, temperature, dissolved oxygen, salinity, and turbidity shall be rinsed per manufacturer specifications between sampling locations.

Personnel responsible for equipment decontamination must wear the proper personal protective equipment specified in the site-specific Health and Safety Plan.

4.3 DOCUMENTATION

For samples intended for chemical analysis, sample custody procedures shall be followed through collection, transfer, analysis, and disposal to ensure the integrity of the samples. Custody of samples shall be maintained in accordance with USEPA chain-of-custody guidelines as prescribed in USEPA Policies and Procedures, National Enforcement Investigations Center,

Denver, Colorado, revised May 1986; USEPA's Resource Conservation and Recovery Act Ground Water Monitoring Technical Enforcement Guidance Document, Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (USEPA Office of Solid Waste and Emergency Response (OSWER) Directive 9355 3-01), Appendix 2 of the Technical Guidance Manual for Solid Waste Water Quality Assessment Test Proposals and Reports, and Test Methods for Evaluating Solid Waste (USEPA SW-846).

The integrity of each sample from the time of collection to the point of data reporting must be maintained throughout the study. Proper record-keeping and chain-of-custody procedures will be implemented to allow samples to be traced from collection to final disposition. Various logs and forms required to adequately identify station and sample information include the following:

- **Field Logbook -** Work conducted during the course of the sampling program will be documented so as to provide a concise, permanent record of field activities. A daily field logbook will be kept as the primary record for documenting all investigative activities. Field logbooks will be bound and will have numbered water-resistant pages. Pertinent information regarding the areas of investigation and sampling procedures will be documented, with notations made in logbook fashion, noting the time and date of entries. Information recorded in the logbook will include, but not be limited to, the following information:

    1. Date and time of on-Site arrival/departure;
    2. Name of person keeping the logbook;
    3. Names of personnel present and associated with the daily field activities;
    4. Daily objective;
    5. Sketch of sampling locations in relation to landmarks;
    6. Samples collected;
    7. Methods used in sample collection;
    8. Media sampled and parameters to be analyzed for;
    9. GPS location and visual bearings from sampling locations;

10. Qualitative observations of biota and biological conditions;
11. Weather conditions;
12. Description of photographs taken;

- **Chain-of-Custody Form -** The sample and tag numbers of each sample container will be recorded on a chain-of-custody form. This form will also identify the sample collection date and time, the type of sample, the project, and the person responsible for sample handling. The chain-of-custody form will be sent to the laboratory along with the sample. Chain-of-custody forms will be completed in at least duplicate with the field team leader retaining one copy.

- **Sample Label and Custody Seal -** A sample label will be completed for each sample. Sample containers will be labeled at the time of sampling with the following information: sample number, site name, sampling date and time, sampling personnel, and preservative (if appropriate).

  At the end of each day, chain-of-custody entries will be made for all samples. Finally, information on the labels will be checked against station/sample log entries, and samples will be re-counted. A custody seal will then be placed across the lid of the cooler prior to shipment or release to the lab.

The field team leader is responsible for properly completing all forms. Chain-of-custody forms will be signed at each point of transfer between the field and the laboratory and within the laboratory. The field team leader will retain copies of all forms. Any changes in the sampling procedures described in this work plan will be documented in the field notebook.

Laboratory personnel will be responsible for the care and custody of samples from the time of their receipt at the laboratory through their exhaustion or disposal. Samples should be logged in and out on internal laboratory chain-of-custody forms each time they are removed from storage for extraction or analysis.

5.0 ANALYSIS

The analysis portion of the ERA includes the estimation of potential exposures of biological receptors to COPECs and the determination of the potential effects associated with those exposures. The assessment of effects is the determination of the relationship between the concentrations of COPECs potentially identified in various matrices in the Swimming River at the Site, and the potential responses of ecological receptors to these concentrations. This section outlines those components that will be utilized in the assessment of the potential ecological effects associated with the exposure of ecological receptors to Site-related constituents.

As described in the previous section, some of the measurement endpoints to be used in the assessment of potential risks to ecological receptors in the aquatic environment include the comparison of ecotoxicological benchmarks to COPEC data for various media. These benchmarks are risk-based screening concentrations that will be used to evaluate the COPEC concentrations detected in sediments and surface water in the river. The benchmarks are compound-specific and represent COPEC concentrations below which adverse effects will not likely occur.

5.1 SEDIMENT SCREENING BENCHMARKS

Benthic invertebrates are a food source for higher trophic levels. Thus, the NJDEP ESC (NJDEP 2009) will be used to initially screen sediments for COPECs. The NJDEP marine sediment ESC are made up of an Effects Range Low (ER-L) and an Effects Range Medium (ER-M). The ER-L is a screening value and represents a concentration at which adverse benthic impacts are found in approximately 10% of the studies. The ER-M is a value indicating potential impacts to the benthic community in 50% of the cases studied (NJDEP, 2009). Concentrations of COPECs detected in sediment at each location will be compared to both the ER-L and ER-M to determine the magnitude or probability of the potential for ecological risks on the benthic macroinvertebrate community at that location.

ER-Ls and ER-Ms are screening values used for the identification of potential ecological risks in sediments and considerable uncertainty is associated with these values. The screening values do not take into account site-specific attributes such as bioavailability, bioaccumulation, or the acclimation of organisms to the presence of COPECs; therefore, the values must be used in conjunction with other sediment screening tools, such as field observations (Jones *et al.*, 1997). Secondary screening values will be used if NJDEP values are not available.

Because chemical concentrations in sediments are not accurate predictors of biological and ecological effects, sediment toxicity benchmarks will not be used as the sole measure of toxicity. Rather, they will be used in conjunction with field tests (qualitative benthos survey), laboratory toxicity study results, and a habitat characterization to allow for a more accurate evaluation of potential risks to benthos.

5.2 SURFACE WATER SCREENING BENCHMARKS

Concentrations of COPECs identified in surface water at the Site will be compared to the NJDEP ESC or other secondary benchmarks for the protection of aquatic organisms. These comparisons will provide an initial basis for evaluating potential impacts to ecological receptors.

5.3 SOIL SCREENING BENCHMARKS

Soil invertebrates are a food source for higher trophic levels. Thus, the ESC (NJDEP 2009) will be used to initially screen soils for COPECs. The USEPA's Ecological Soil Screening Levels (EcoSSLs) will be used to screen all soil COPECs that are not addressed by the NJDEP ESCs.

5.4 WILDLIFE SCREENING BENCHMARKS

Potential ecological risks to wildlife ROIs will be assessed by comparing exposures to ROIs (calculated using dietary exposure with empirical data) to wildlife benchmarks that are derived from available toxicological data in the literature (TRVs). Two TRVs will be derived for each

COPEC and wildlife ROI – one will be based on the no-observed-adverse-effect-level (NOAEL) (TRV_{NOAEL}) and the other will be based on the lowest-observed-adverse-effect-level (LOAEL) (TRV_{LOAEL}). The NOAEL corresponds to the highest dose at which no adverse effects on growth, reproduction, or survival have been observed. The LOAEL corresponds to the lowest dose at which adverse effects on growth, reproduction or survival have been observed.

The ERA will indicate whether the NOAEL and LOAELs are bounded or unbounded. Bounded values are those data sets where a NOAEL and LOAEL have been determined for a certain chemical. An unbounded data set is an NOAEL for which there are no LOAELs, thereby adding uncertainty because the point at which a chemical may first elicit an effect has not been identified. Unbounded TRVs will be identified as a source of uncertainty. TRVs for wildlife ROIs will be reported in milligrams of COPEC exposure per kilogram of body weight per day (mg/kg BW-day) for a specified effect to the receptor. For the ERA, TRVs for wildlife ROIs will be derived from literature values by following the methodology of Sample *et al.* (1996). The following literature sources will be used in the selection of the TRVs; others will be included as necessary:

- USFWS biological reports prepared by Eisler (2000);
- Toxicological studies cited in Sample *et al.* (1996);
- Ecotox database–(Jorgensen *et al.*, 2000);
- Computer online databases, such as Toxline, Biosis, Wildlife Fisheries Review, Pollution Abstracts, and Environmental Abstracts;
- USEPA Ecotox database; and
- Other readily available literature.

When reviewing the toxicological literature and selecting the most appropriate study for TRV development, several factors will be considered, including:

- Taxonomic relationship between the test animal and the indicator species;
- Use of laboratory animals or domesticated species;

- Toxicological studies in which the chemical was administered through the diet of the test species will be preferred over studies using other dosing methods, such as oral gavage or intraperitoneal injection;
- Ecological relevance of the study endpoints; studies with toxicity endpoints, such as reproduction, growth, behavior and developmental endpoints will be targeted. Sensitive endpoints such as reproductive or developmental toxicity will be preferentially selected because they are closely related to the selected assessment endpoints; and
- Long-term studies representing chronic exposure will be preferentially selected.

Generally, for chemicals without chronic dose-response-based NOAELs, but for which other toxicity values are available, uncertainty factors will be applied to extrapolate these other toxicity values to chronic NOAELs. These other toxicity values include less than chronic NOAELs (*e.g.*, subchronic NOAELs), LOAELs, and the lethal dose for 50 percent of a study population (LD_{50}). Specifically, an uncertainty factor of 10 (as cited in Sample *et al.*, 1996) will be used to adjust TRV_{LOAEL} to TRV_{NOAEL}, and an uncertainty factor of 10 (as cited in Sample *et al.*, 1996) will be used to adjust TRVs derived from subchronic studies to chronic TRVs. An uncertainty factor of 100 will be used to adjust LD_{50} values to chronic NOAEL equivalent values.

Species-specific toxicity studies may not be available for all COPECs and extrapolation from other species may be necessary. For mammalian species, smaller animals have higher metabolic rates and are usually more resistant to toxic chemicals than larger animals because of more rapid rates of detoxification. Allometric scaling is one commonly employed extrapolation approach. It is based on the observation that many biological properties vary with body weight or a power of body weight such that:

$$A = a(BW)^b$$

Where:

A = biological attribute

a = intercept,

BW = body weight,

b = allometric scaling factor

The assumption is that the effective dose per body surface area for species "a" and "b" would be equivalent. Therefore, knowing the body weights of two species and the dose (d_b) producing a given effect in species "b," the dose (d_a) producing the same effect in species "a" can be determined. Using this approach, if a NOAEL is available for a test species ($NOAEL_t$), the equivalent NOAEL for a wildlife species ($NOAEL_w$) will be calculated using the adjustment scaling factor for differences in body size:

$$NOAEL_w = NOAEL_t \left(\frac{bw_t}{bw_w} \right)^{1-b}$$

This methodology is equivalent to the process that USEPA uses in their carcinogenicity assessments and Reportable Quantity documents for adjusting mammalian data to an equivalent human dose. Sample and Arenal (1999) report some allometric scaling factors for individual chemical constituents based on mammalian and/or avian receptors. However, they list the default scaling factors of 1.2 and 0.94 for birds and mammals, respectively, for those constituents with no associated scaling factor.

5.5 WILDLIFE EXPOSURE MODELS

For the wildlife ROIs, a generalized exposure model will be utilized to estimate COPEC contact to the selected wildlife species. Exposure to COPECs will be estimated by calculating an ADD using (1) exposure media-specific concentrations, (2) measured exposure point concentrations (EPCs) for prey, and (3) receptor-specific exposure parameters. The ADD represents the amount of a chemical that an individual member of a receptor population would ingest (*i.e.*, diet and ambient contact) if the individual foraged at least a portion of the time within the area used to develop EPCs.

To be conservative, EPCs for wildlife receptors will be expressed as either the maximum COPEC concentration in prey, sediment and surface water within the receptors' foraging area, or as a 95% upper confidence level (95% UCL) if analytical results for more than eight samples are available. Air is not considered a pathway of concern for this ERA (USEPA, 2000). ADDs for ROIs will be developed based on procedures outlined in Sample *et al.* (1996) and USEPA (1993). For this ERA, it is assumed that food items are obtained from a particular area and environmental medium as a function of an Area Use Factor (AUF) and a Seasonal Use Factor (SUF). The AUF accounts for relative foraging times based on the ratio of the proportion of habitat containing COPECs from a particular on-site location to the species-specific foraging area. The SUF accounts for the portion of the year that an ROI may be exposed to Site-related COPECs. The evaluation will be conducted using AUFs and SUFs derived from the Wildlife Exposure Factors Handbook (USEPA, 1993) and other relevant sources (*e.g.*, Sample and Suter, 1994). The total ADD is the sum of ADDs for each of the pathways (*i.e.,* food, surface water and sediment), adjusted for the seasonal duration of exposure and normalized to body weight (mg/kg BW-day).

The formula for calculating the ADD for this ERA will be as follows:

$$ADD = (Dose_{food} + Dose_{sediment} + Dose_{water}) * SUF$$

Where:

ADD	=	Average daily dose of Site-related COPECs (mg/kg BW-day);
$Dose_{food}$	=	Dose of Site-related COPECs in food (mg/kg BW-day);
$Dose_{sediment}$	=	Dose of Site-related COPECs in sediment (mg/kg BW-day);
$Dose_{water}$	=	Dose of Site-related COPECs in water (mg/kg BW-day); and
SUF	=	Seasonal Use Factor (unitless).

The individual terms of the equation are calculated as:

$$Dose_x = IR_x \text{ x } C_x \text{ x } AUF$$

Where:

$Dose_x$	=	Dose of the particular medium in mg/kg BW-day;
IR_x	=	Ingestion rate of medium in kg/kg BW-day or Liters (L)/kg BW-day;
C_x	=	Concentration of Site-related COPECs in particular medium in mg/kg or mg/L;
AUF	=	Area Use Factor (unitless).

Exposure estimates will be developed for each of the wildlife ROIs. Data from each relevant sample location will be included in the exposure estimation for that particular site.

5.5.1 Exposure Model Input Parameters

Receptor-specific exposure parameters from the scientific literature will be used to estimate the ADD for each ROI. Receptor-specific exposure parameters will include body weight, food ingestion rate, incidental sediment ingestion rate, and water ingestion rate. An additional exposure parameter, foraging habitat and range will be used to determine the size and type of areas for assessment. Prey (*i.e.*, fish, insects) used in the dietary exposure model will be assessed at 100% to provide a conservative risk estimate. Discrepancies between the modeled prey and actual prey base will be discussed qualitatively in the uncertainty analysis. The species-specific life history parameters used to calculate exposure for various ROIs are listed below. Most of the exposure parameters are obtained from Sample and Suter (1994). The primary citation is indicated adjacent to the parameter.

5.5.1.1 Great-Blue Heron

To estimate COPEC exposure concentrations potentially experienced by the great-blue heron feeding on fish in the Swimming River, the following assumptions will be made:

- Body weight = 2.39 kilograms (kg) – (Sample and Suter, 1994);
- Food ingestion rate = 0.42 kg wet weight/d (Sample and Suter, 1994);
- Sediment consumption rate = assumed to be negligible (Sample and Suter, 1994);
- Surface water consumption rate = 0.1058 L/d (Sample and Suter, 1994);
- Diet consists predominantly of fish but may include crustaceans, insects, snails, amphibians, reptiles, birds and mammals (Sample and Suter, 1994), however, for this project, it will be conservatively assumed that fish makes up 100% of the heron's diet;
- Home range = 8,825 hectares (ha) (mean foraging distance from colony) (USEPA, 1993);
- SUF = An SUF of 100% will be used as the great-blue heron is a year-round resident of New Jersey (Sibley, 2000);
- AUF = 0.00039 (based on 3.43 ha Site); and
- Habitat of the great-blue heron is in coastal and inland water-associated habitats. The forage along shallow shores and most nest in trees (Sample and Suter, 1994).

5.5.1.2 Bald Eagle

To estimate COPEC exposure concentrations potentially experienced by the bald eagle feeding on fish in the Swimming River, the following assumptions will be made:

- Body weight = 3.75 kg – (USEPA, 1993);
- Food ingestion rate = 0.45 kg wet weight/d (USEPA, 1993);
- Sediment consumption rate = 0.026 kg/d (calculated as 5.9% of diet; USEPA, 1999b);
- Surface water consumption rate = 0.135 L/d (USEPA, 1993);
- Diet consists predominantly of fish but may include birds and mammals (USEPA, 1993), however, for this project, it will be conservatively assumed that fish makes up 100% of the eagle's diet;
- Home range = 15.8 kilometers (km; length along river, for breeding pair) (USEPA, 1993);
- SUF = An SUF of 100% will be used as the bald eagle can be a year-round resident of New Jersey (Sibley, 2000);

- AUF = 0.06 (based on 1.0 km frontage along river); and
- Habitat of the bald eagle is near lakes, rivers, marshes, coasts, and water-associated habitats. The forage along shallow shores and most nest in trees in forests nearby foraging areas (Cornell Lab of Ornithology, 2013).

5.5.1.3 Spotted Sandpiper

To estimate COPEC exposure concentrations potentially experienced by the spotted sandpiper feeding on invertebrates in the Swimming River, the following assumptions will be made:

- Body weight = 0.04 kg – (USEPA, 1999b);
- Food ingestion rate = 0.082 kg dry weight/d (USEPA, 1999b);
- Sediment consumption rate = 0.0085 kg/d (10.4% of total diet) (USEPA, 1999b);
- Surface water consumption rate = 0.0071 L/d (USEPA, 1999b);
- Diet consists predominantly of benthic invertebrates, but may include small fish (USEPA, 1999b), however, for this project, it will be conservatively assumed that benthic invertebrates make up 100% of the sandpiper's diet;
- Home range = 0.25 ha (USEPA, 1999b);
- SUF = An SUF of 66% will be used as the spotted sandpiper migrates to the southern United States and Mexico during the winter months (Sibley, 2000);
- AUF = 0.07; and
- Habitat of the spotted sandpiper is along edges of open water bodies. They require open water for bathing and drinking, semi-open habitat for nesting, and dense vegetation for breeding (USEPA, 1993).

5.5.1.4 Mallard Duck

To estimate COPEC exposure concentrations potentially experienced by the mallard duck feeding on aquatic invertebrates in the Swimming River, the following assumptions will be made:

- Body weight = 1.162 kg (average mean adult body weight) (USEPA, 1993);
- Food ingestion rate = 0.298 kg wet weight /d - estimated using food ingestion equations (Sample and Suter, 1994);
- Sediment consumption rate = 0.00985 kg/d (3.3% of diet; Beyer *et. al*, 1994);
- Surface water consumption rate = 0.0652 L/d – estimated using a water ingestion calculation (USEPA, 1993);
- The mallard's diet varies during different seasons, from a more herbivorous diet in the winter (feeding primarily on seeds), to eating mainly invertebrates in the spring, including gastropods, crustacean, annelids, and misc. animals (USEPA, 1993). However, for this project, it will be conservatively assumed that aquatic invertebrates make up 100% of the mallard's diet;
- Home range = 434 ha (average mean adult home range) (USEPA, 1993);
- SUF = An SUF of 100% will be used as the mallard is a year-round resident of New Jersey (Sibley, 2000);
- AUF = 0.0079; and
- Habitat of the mallard varies from season to season but they tend to prefer habitat that provides concealment from predators. In winter they prefer natural bottomland wetlands and rivers. Water depths of 20 to 40 centimeters are optimum for foraging mallards (USEPA, 1993).

5.5.1.5 Raccoon

To estimate COPEC exposure concentrations potentially experienced by the raccoon foraging along the shores of the river, the following assumptions will be made:

- Body weight = 5.78 kg (average mean adult body weight) (USEPA, 1993);
- Food ingestion rate = 1.26 kg wet weight/d - estimated using food ingestion equations (Sample and Suter, 1994);

- Sediment consumption rate = 0.118 kg/d - calculated as 9.4% of the diet (Beyer et.al, 1994);
- Surface water consumption rate = 0.48 L/d – estimated using a water ingestion calculation (USEPA, 1993);
- The raccoon is an omnivorous and opportunistic feeder. Raccoons will feed on virtually any animal or vegetable matter (USEPA, 1993), however, for this project, it will be conservatively assumed that aquatic invertebrates make up 50% of the raccoon's diet and fish make up the other 50%;
- Home range = 630 ha (average mean adult home range) (USEPA, 1993);
- SUF = 100%;
- AUF = 0.0054
- Habitat = Raccoons are found near almost every aquatic habitat, particularly in hardwood swamps, mangroves, floodplain forests, and freshwater or saltwater marshes (USEPA, 1993).

5.5.1.6 Short-tailed shrew

To estimate COPEC exposure concentrations potentially experienced by the short-tailed shrew foraging within the Site, the following assumptions will be made:

- Body weight = 0.015 kg (Schlessinger and Potter, 1974);
- Food ingestion rate = 0.009 kg/d; Barrett and Stuek, 1976);
- Soil consumption = 0.00117 kg/d (Talmage and Walton, 1993);
- Water consumption = 0.033 L/d (Chew, 1951);
- Diet consists of 31.4% earthworms (the remainder is reported as being insects and plants, Whitaker and Ferraro, 1963). Chemical residue data from the earthworms will be calculated from soil COPEC concentrations, and the diet will be conservatively assumed to be 100% earthworms;
- Home range = 0.39 ha (Buckner, 1966);
- SUF = 100%;

- AUF = 100% (This is a conservative assessment that assumes that the shrew will spend it entire life within an area containing elevated COPEC concentrations and that the limited number of soil samples that will be collected are representative of soil conditions throughout a given area); and,
- Habitat = U.S. EPA (1993) notes that short-tailed shrews inhabit a variety of habitats and are common in areas with abundant vegetative cover, though they require cool, moist habitats because of their high metabolic rates and water-loss rates.

5.5.1.7 American robin

To estimate COPEC exposure concentrations potentially experienced by the robin foraging within the Site, the following assumptions will be made:

- Body weight = 0.0773 kg (USEPA, 1993);
- Food ingestion rate = 0.89 kg/d; (USEPA, 1993);
- Soil consumption = 0.014 kg/d (USEPA, 1993);
- Water consumption = 0.0108 L/d (USEPA, 1993);
- Diet consists primarily of invertebrates in spring and summer, and primarily fruit and berries in autumn and winter (USEPA, 1993). Chemical residue data from the earthworms will be calculated from soil COPEC concentrations, and the diet will be conservatively assumed to be 100% earthworms;
- Home range = 0.81 ha (USEPA, 1993);
- SUF = 100%;
- AUF = 100%; and,
- Habitat = U.S. EPA (1993) notes that the robin inhabits moist forests, swamps, open woodlands, orchards, parks, and lawns. The robin requires access to fresh water, protected nest sites, and productive foraging areas.

6.0 RISK CHARACTERIZATION

Risk characterization combines potential Site-related exposures and the potential for ecotoxicological effects to estimate the likelihood of ecological risks. The risk characterization is conducted for each line of evidence and then a weight-of-evidence approach is used to evaluate potential effects for each assessment endpoint. For the ideal risk assessment, there are three lines of evidence: literature-derived single chemical toxicity data which indicates the potential effects of the COPEC concentrations measured in site media, biological surveys of the potentially affected system which indicate the actual state of the potentially affected environment, and toxicity tests with ambient media which indicate the potential effects of COPEC concentrations measured in site media, if warranted or conducted.

Procedurally, the risk characterization is performed for each assessment endpoint by (1) comparing all measured COPECs against toxicological benchmarks (where possible, exposure-response gradients will be developed to help ascertain a more precise understanding of the potential for impacts to receptors); (2) estimating the potential effects of the COPECs identified at the Site; (3) estimating the effects of ambient media based on the media toxicity test results; (4) logically integrating the lines of evidence to characterize risks to the endpoint, and (5) listing and discussing the uncertainties in the assessment.

The screening of measured COPECs in the environmental media or estimated biological body burdens is conducted by the mathematical comparison of a constituent concentration to an ecotoxicological benchmark. The resulting value is identified as a Hazard Quotient (HQ). HQs are calculated using the following equation:

$$HQ = \frac{\text{Media-Specific Constituent Concentration or Total Estimate of Exposure}}{\text{Ecotoxicological Benchmark (in comparable units)}}$$

If the HQ is less than 1.0, then it is concluded that the potential for impacts to ecological receptors is absent or minimal. If the HQ is greater than or equal to 1.0, then it is concluded that a potential for impacts to ecological receptors exists.

It is again cautioned that an HQ greater than or equal to 1.0 is not confirmation that an ecological risk is occurring, only an indication of the potential for a risk and the need to examine other lines of evidence. The magnitude of the exceedance over 1.0 may be related to the magnitude of the potential for risk. The level of conservatism in the benchmark, however, must be taken into consideration. Comparison of chemical data to strongly conservative benchmarks may be overprotective of the resource and exaggerate the potential for an ecological risk. As part of the comparison process, the spatial distribution of exceedances will be examined. Exceedances at a large number of sampling points will indicate the potential for more widespread risks as opposed to the exceedance at a single point which would suggest localized impacts. Calculations of HQs will take into account spatial and temporal factors.

As the exceedance of a HQ indicates the potential for an ecological risk to an individual receptor at a specific location, it is the focus of this ERA to determine the potential for ecological risks to the population. USEPA (1999a) guidance states, "… remedial actions generally should not be designed to protect organisms on an individual basis (the exception being designated protected status resources, such as listed or candidate threatened and endangered species or treaty-protected species that could be exposed to site releases), but to protect local populations and communities of biota". To assess that potential, estimations will be made of the population wildlife receptors at the Site, based on habitat availability, home range of the organisms and relative size of the Site compared to suitable habitats in the area.

7.0 ASSUMPTIONS AND UNCERTAINTIES

Following the characterization of risks, sources of uncertainty and variability within the ERA will be identified. The impact associated with these uncertainties will be qualitatively addressed through sensitivity analyses (biased high or biased low) for the more important exposure parameters that are used in the wildlife exposure models and for the TRVs that are used to estimate risks to the representative wildlife species. Despite these uncertainties, HQs will not be excluded due to these factors.

Uncertainty includes both real variation (reflecting actual, mechanistic biological response ranges and variability in ecosystem conditions) and error (USEPA, 1997). Thus, because biological systems are inherently uncertain and variable, some component of variability in risk estimation is due to a realistic reflection of ecological conditions, while another component is due to error or uncertainty introduced by the overall analytical process. Error is the component to be minimized, because this encompasses undesirable uncertainty that has been introduced by the assessment process. However, it is critically important to understand ecosystem variability because this represents an important component of the ecosystem within which risk management decisions must be made. Substantial differences exist between observations and conclusions made at the individual, population, and community levels of biological organization. For example, effects not manifested at the population or community levels (*e.g.,* mortality of only a few individuals) may not be observable with the type of studies implemented. The ramifications of this also include an understanding that, because the assessment level endpoints are protective of populations and communities and not individuals, the projected loss of a few individuals may not cause impacts that are important at the levels of assessment where risk management decisions are made.

8.0 ECOLOGICAL RISK ASSESSMENT REPORT

The results of the field collection activities will be compiled and documented in a comprehensive Ecological Risk Assessment Report for submittal to NJDEP. This report will include the following:

- Executive Summary: providing a summary description of the basis and background of the project, as well as the findings of field investigation activities;
- Objectives of the ERA: including a description of the work plan, and any deviations realized as a result of project implementation;
- Problem formulation: including a comprehensive Site history and descriptions of the natural resources located on the property;
- Description of field activities: including discussion of equipment utilized, test protocols, tabular descriptions of sample locations and depth;
- Results of the chemical analyses and risk calculations;
- Uncertainties analysis; and
- Appendices, containing laboratory analytical data and field logs.

9.0 REFERENCES

ASTM (American Society for Testing and Materials). 2008. Standard Test Method for Measuring the Toxicity of Sediment-Associated Contaminants with Estuarine and Marine Invertebrates. E1367-03(2008). ASTM, West Conshohocken, PA

Barrett, GW and KL Stueck. 1976. Caloric ingestion rate and assimilation efficiency of the short-tailed shrew, *Blarina brevicauda*. *Ohio J. Sci*. 76:25-26.

Beyer, W. N., E. E. Conner, and S. Gerould, 1994. Estimates of Soil Ingestion by Wildlife. *J. Wildl. Manage.* 58(2):1994.

Buckner, CH. 1966. Populations and ecological relationships of shrews in Tamarack bogs of southeastern Manitoba. *Journal of Mammalogy* 47: 181 – 194.

Chew, RM. 1951. The water exchanges of some small mammals. *Ecological Monographs* 1: 215 – 224.

Cornell Lab of Ornithology. 2013. All About Birds: Bald Eagle. http://www.allaboutbirds.org/guide/Bald_Eagle/lifehistory.

Eisler, R., 2000. Handbook of Chemical Risk Assessment, Health Hazards to Humans, Plants, and Animals. Volume 2: Organics. Lewis Publishers. Boca Raton, FL.

Jones, D.S., G.W. Suter II, and R.N. Hull, 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota. ES/ER/TM-95/R4.

Jorgensen, L.A., S.E. Jorgensen, S.N. Nielsen, 2000. Ecological Modeling and Ecotoxicology Database. Elsevier Publishers.

Neff, J.M., B.W. Cornaby, R.M. Vaga, T.C. Gulbransen, J.A. Scanlon, and D.J. Bean, 1988. An Evaluation of the Screening Level Concentration Approach for Validation of Sediment Quality Criteria for Freshwater and Saltwater Ecosystems. *in Aquatic Toxicology and Hazard Assessment:* 10th Volume, ASTM STP 971. Adams, W.J., G.A. Chapman, and W.G. Landis (eds.). American Society for Testing and Materials, PA.

NJDEP (New Jersey Department of Environmental Protection), 1998. Guidance for Sediment Quality Evaluations, November 1998.

NJDEP, 2006. Surface Water Quality Standards. N.J.A.C. 7:9B.

NJDEP, 2009. NJDEP Ecological Screening Criteria. Available at: http://www.state.nj.us/dep/srp/guidance/ecoscreening/.

NJDEP. 2012. Ecological Evaluation Technical Guidance, Version 1.2, 8/29/12

NJDEP. 2013. NJ-GeoWeb Map Viewer, http://njwebmap.state.nj.us/NJGeoWeb/WebPages/Map/MapViewer.aspx.

NJGS (New Jersey Geological Survey), 2003. Physiographic Provinces of New Jersey. Information Circular.

Persaud, D., R. Jaagumagi and A. Hayton, 1990. The Provincial Sediment Quality Guidelines. Ontario Ministry of the Environment.

Persaud, D., R. Jaagumagi and A. Hayton, 1993. Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario. Ontario Ministry of the Environment, Water Resources Branch, Watershed Management Section, Ontario, Canada.

Sample, B.E. and C.A. Arenal, 1999. Allometric Models for Interspecies Extrapolation of Wildlife Toxicity Data. *Bull. Environ. Contam. Toxicol.* 62:653-663.

Sample, B.E., D.M. Opresko and G.W. Suter II, 1996. Toxicological Benchmarks for Wildlife 1996 Revision. ES/ER/TM-86/R3.

Sample, B.E. and G.W. Suter, 1994. Estimating Exposure of Terrestrial Wildlife to Contaminants. ES/ER/TM-125.

Schlessinger, WH and GL Potter. 1974. Lead, copper, and cadmium concentrations in small mammals in the Hubbard Brook experimental forest. *Oikos* 25: 148 – 152.

Sibley, D. A., 2000. The Sibley Guide to Birds. Alfred A. Knopf, Inc. New York, Publishers.

Talmage, SS and BT Walton. 1993. Food chain transfer and potential renal toxicity to small mammals at a contaminated terrestrial field site. *Ecotoxicology* 2: 243 – 256.

USDA (United States Department of Agriculture), 2013. Custom Soil Resource Report for Monmouth County, New Jersey. Obtained from the USDA Web Soil Survey website: http://websoilsurvey.nrcs.usda.gov/app/.

USEPA (United States Environmental Protection Agency), 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA. EPA 540G-80004.

USEPA, 1989. Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual, Interim Final. EPA/540/1-89/001. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC.

USEPA, 1992a. Framework for Ecological Risk Assessment. Risk Assessment Forum. EPA 630/R-92-001. Washington, D.C.

USEPA, 1992b. Developing a Work Scope for Ecological Assessment. Eco Update 1(4).

USEPA, 1993. Wildlife Exposure Factors Handbook. EPA/600/R-93/187a. Office of Research and Development. Washington, D.C.

USEPA, 1994. Interim Draft Ecological Risk Assessment Guidance for RCRA Corrective Action. U.S. Environmental Protection Agency, Chicago, IL.

USEPA, 1997. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. EPA 540-R-97-006. Washington, D.C.

USEPA, 1998. Guidelines for Ecological Risk Assessment. EPA/630/R-95/002F. Washington, D.C.

USEPA, 1999a. Issuance of Final Guidance: Ecological Risk Assessment and Risk Management Principles for Superfund Sites. Office of Solid Waste and Emergency Response. OSWER Directive 9285.7-28 P. Washington, D.C.

USEPA, 1999b. Data Collection for the Hazardous Waste Identification Rule; Section 12.0 Ecological Exposure Factors. Office of Solid Waste, Washington, DC

USEPA, 2000. Draft Ecological Soil Screening Level Guidance. Office of Emergency and Remedial Response, Washington, D.C.

USEPA, 2001a. Planning for Ecological Risk Assessment: Developing Management Objectives. Office of Research and Development. EPA/630/R-01/001A.

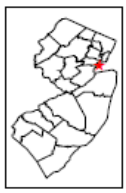
USEPA, 2001b. Supplemental Guidance to RAGS: Region 4 Bulletins, Ecological Risk Assessment. Originally published November 1995. Website version last updated November 30, 2001: http://www.epa.gov/region4/waste/ots/ecolbul.htm.

USEPA, 2002a. Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites. Office of Solid Waste and Emergency Response. OSWER Directive 9285.6-08, 11p.

USEPA, 2002b. Contaminated Sediment Remediation Guidance for Hazardous Waste Sites. Office of Solid Waste and Emergency Response. OSWER 9355.0-85.

Whitaker, JO and MG Ferraro. 1963. Summer food of 220 short-tailed shrews from Ithaca, New York. *Journal of Mammalogy* 44:419.

FIGURES



Site Location

Imagery Source: United States Geological Survey Quadrangles: NJ Long Branch West 2011

amec

Figure 1
Site Location Map
Sunset Landfill Site
Red Bank, New Jersey

Legend

Approximate site boundary

Sample locations

N
W E
S

IMAGE SOURCE:
ESRI, National Geographic Society, i-cubed, 2013

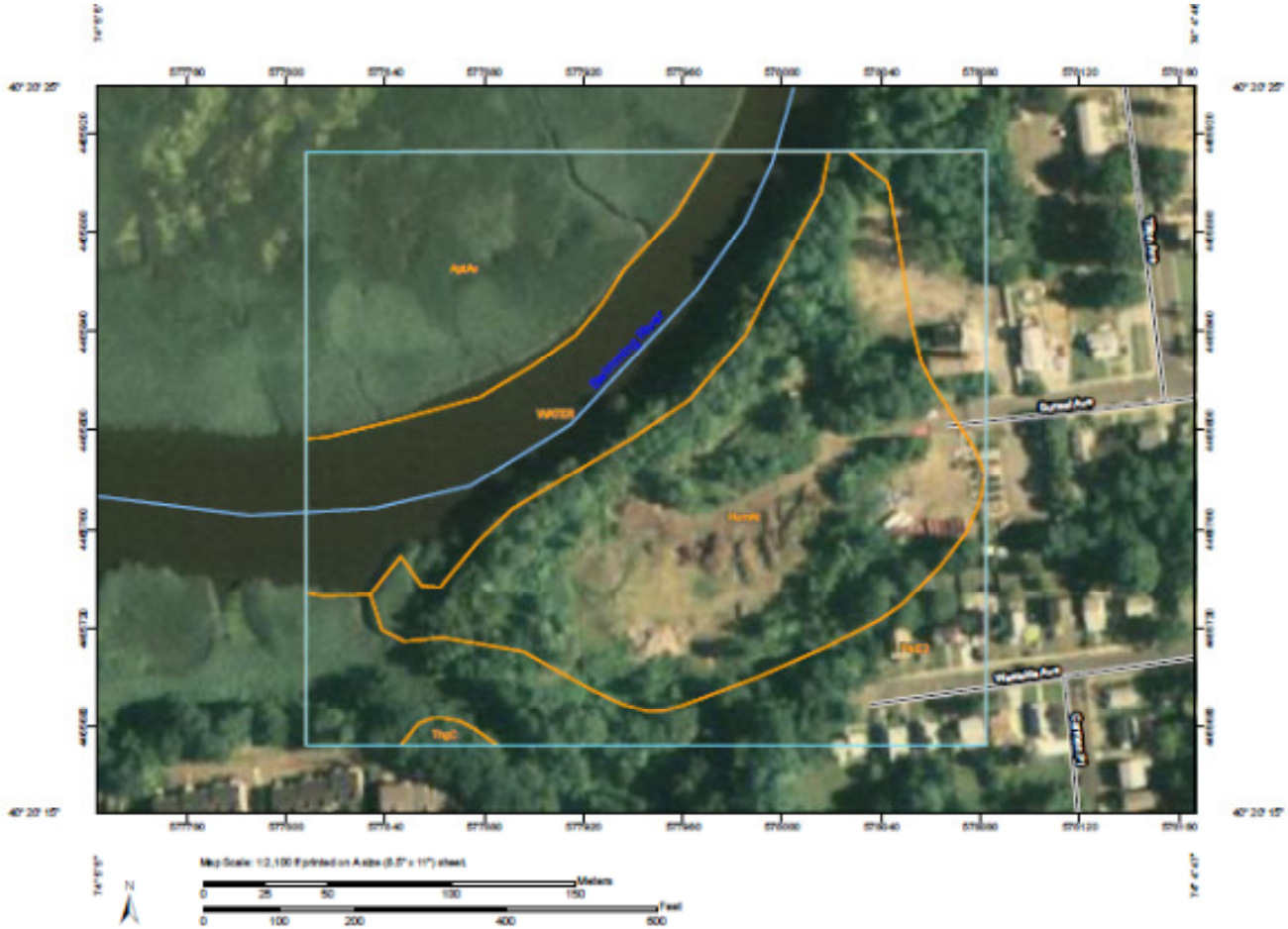
amec *Environment & Infrastructure*

Figure 2

Proposed Surface Water, Sediment and Soil Sample Locations
Sunset Avenue Landfill Site
Red Bank, New Jersey

Rev. By: DC	Contract No.: 3481130017	10/29/2013

Figure 3. Monmouth County Soil Map
Red Bank Landfill
Sunset Avenue, Red Bank, NJ



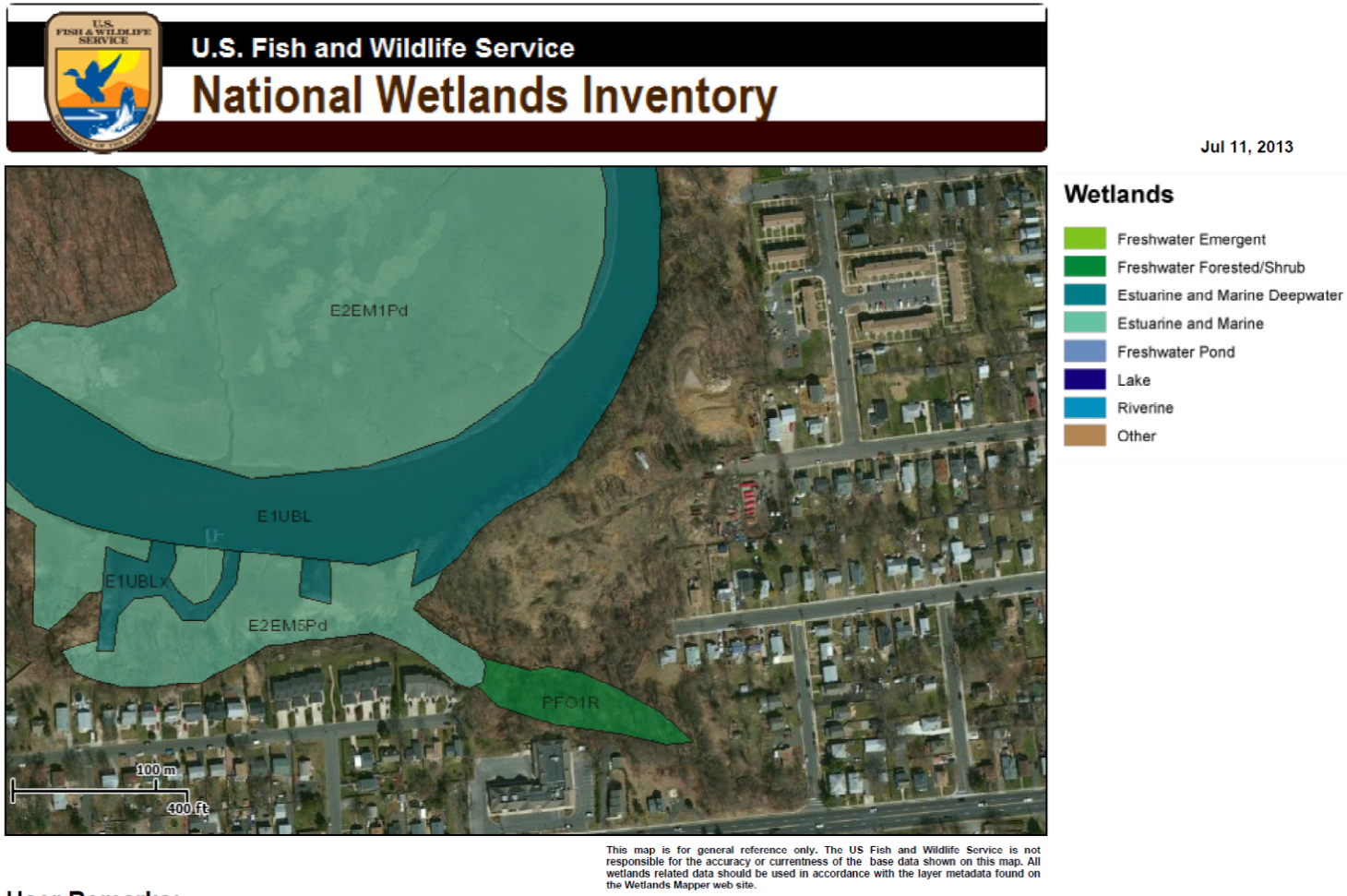
Monmouth County, New Jersey (NJ025)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
AptAv	Appoquinimink-Transquaking-Mispillion complex, 0 to 1 percent slopes, very frequently flooded	3.2	19.9%
FrkE2	Freehold sandy loam, 15 to 25 percent slopes, eroded	3.6	22.3%
HumAt	Humaquepts, 0 to 3 percent slopes, frequently flooded	6.1	37.5%
ThgC	Tinton loamy sand, 5 to 10 percent slopes	0.1	0.4%
WATER	Water	3.2	19.9%
Totals for Area of Interest		**16.3**	**100.0%**

From: USDA Custom Soil Resource Report for Monmouth County, New Jersey. Obtained from the USDA Web Soil Survey website: http://websoilsurvey.nrcs.usda.gov/app/

Figure 4. New Jersey Wetlands Map
Red Bank Landfill
Red Bank, New Jersey

From: NJDEP's NJ-GeoWeb Map Viewer: http://njwebmap.state.nj.us/NJGeoWeb/WebPages/Map/MapViewer.aspx

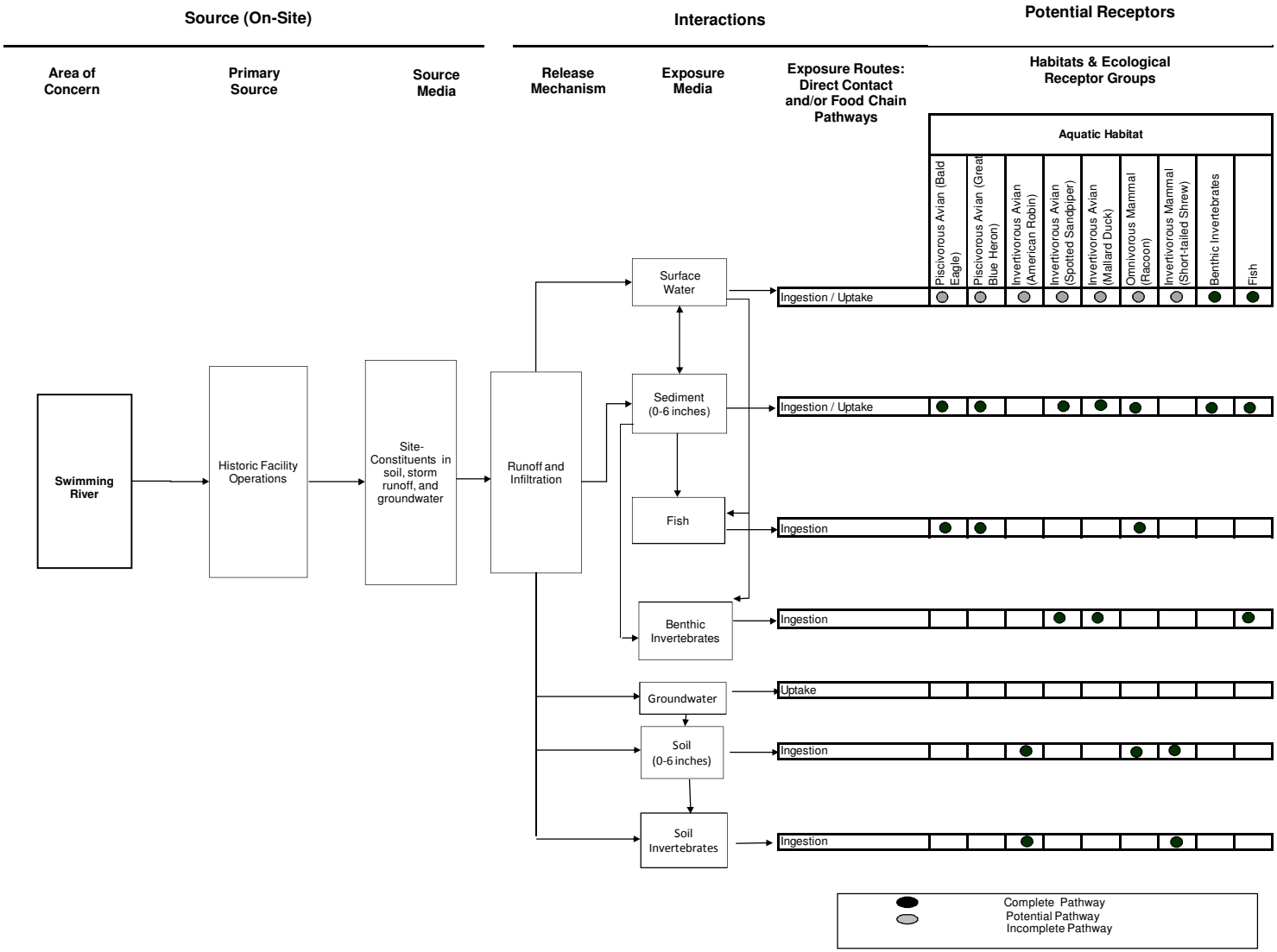
Figure 5. National Wetlands Inventory Map
Red Bank Landfill Site
Red Bank, Linden, New Jersey



User Remarks:

From: US Fish & Wildlife Service National Wetlands Inventory Mapper web site: http://www.fws.gov/wetlands/Wetlands-Mapper.html

Figure 6
Conceptual Site Model - Red Bank Landfill
Sunset Avenue, Red Bank, New Jersey



TABLES

TABLE 1

LIST OF FLORA FOUND AT THE FORMER RED BANK LANDFILL SITE

FLORA

Common Name	Scientific Name
Trees/Shrubs	
Sycamore	*Platanus occidentalis*
Norway Maple	*Acer platanoides*
Silver Maple	*Acer saccharinum*
Box Elder	*Acer negundo*
Chestnut Oak	*Quercus montana*
Tree-of-Heaven	*Ailanthus altissima*
Black Locust	*Robinia pseudoacacia*
Vines	
Oriental Bittersweet	*Celastrus orbiculatus*
Japanese Honeysuckle	*Lonicera japonica*
Poison Ivy	*Toxicodendron radicans*
Grasses/Sedges/Rushes	
Common Reed	*Phragmites australis*
Bluegrass	*Poa* spp.
Indian Grass	*Sorghastrum nutans*
Herbaceous Plants	
Common Mugwort	*Artemisia vulgaris*
Japanese Knotweed	*Fallopia japonica*
Garlic Mustard	*Alliaria petiolata*
White Wood Aster	*Eurybia divaricata*
Curly Dock	*Rumex crispus*
Hawthorn	*Crataegus* spp.

APPENDIX A

PHOTOGRAPH LOG

Photo 1: Path into landfill area, facing Sunset Avenue gate

Photo 2: Storm runoff erosion leading from Sunset Avenue gate into landfill area

Photo 3: Partially open meadow in south-central portion of the landfill area

Photo 4: Vegetation leading into forested wetland swale

Photo 5: Steep slope leading to wetland swale

Photo 6: Wetland swale discharge to Swimming River

Photo 7: River bank from landfill site

Photo 8: Salt marsh across the Swimming River

Photo 9: Red Bank recycling collection center on top of earthen mound

Photo 10: Earthen mound near landfill entrance

Photo 11: Earthen mound soil erosion

Photo 12: Houses adjacent to the landfill, at the head of the wetland swale

APPENDIX B

TOXICITY TESTING SUMMARY OF PROCEDURES

AQUATIC TOXICITY TESTING

The laboratory will perform marine sediment toxicity evaluations following the attached procedure summary (based on ASTM guidance). The contaminants of potential ecological concern (COPECs) are metals, SVOCs, pesticides, and PCBs. Technical questions can be addressed by contacting Dan Cooke at 732-302-9500 ext. 131, or by email at daniel.cooke@amec.com.

A total of 5 (4 Site sediments and 1 upstream reference sediment) will be shipped to the laboratory via overnight carrier. Testing must begin within 7 days of sample receipt.

Toxicity Test	**Endpoints**	**Matrix**	**Sample #**
10 day *Leptocheirus plumulosus* bioassay	Survival	Sediment	5

Special Requirements:

1. The attached procedure summary follows ASTM guidance. However, it may differ slightly from the laboratory's standard operating procedures. The laboratory is strongly advised to ensure that all personnel participating in this study are familiar with the required procedures. All deviations from the test protocol must be discussed with AMEC prior to test initiation and listed in the final report, along with justification for the deviation.

2. A standard reference toxicant (SRT) test is required. The SRT must be initiated on the same day, with the same batch of organisms used for testing samples. If the SRT falls outside of the acceptable range of the lab's SRT control chart, testing will be considered suspect, and must be repeated at the lab's expense.

3. Note the requirement for 'sacrifice replicates'. For each test treatment, two additional replicates must be prepared. Sacrifice replicates will be evaluated on days 1 and 4. If there is significant mortality in the laboratory control, the laboratory should notify AMEC immediately and the entire study should be terminated and re-initiated with a new batch of test organisms as soon as possible (within 5 days). Mortality in site and reference samples should be recorded on the laboratory data sheets.

4. Note the requirement to sieve the sediment samples only if necessary. Testing should be performed using whole sediment samples. If sieving is required, the laboratory will be responsible for sieving test samples, and sending an aliquot of each sieved sample, and an aliquot of the laboratory control sediment to a designated lab for analysis of TOC, grain size, and COPECs (at AMEC's expense).

5. Toxicity testing must be initiated within 7 days of sample receipt. A draft report is required within 10 business days of test completion. A final report is required within 5 business days of receipt of AMEC comments to the draft report.

6. The laboratory is required to submit one unbound hard (paper) copy of the final report, and one electronic copy (CD or email). The electronic copy should be submitted in PDF format, and should be an exact duplicate of the paper report (including scanned copies of all laboratory raw data sheets and QA information).

SUMMARY OF PROCEDURE: 10 Day Acute Toxicity Study with Marine Amphipods (*Leptocheirus plumulosus*)

References: ASTM. 2008. Standard Test Method for Measuring the Toxicity of Sediment-Associated Contaminants with Estuarine and Marine Invertebrates. E1367-03(2008). American Society for Testing and Materials, West Conshohocken, PA.

Test sample storage: 4 ± 1°C, in the dark, in original, sealed container, with no headspace, when not in use for testing.

Sediment prep: Prior to use, homogenize each sediment sample and remove debris, rocks, vegetation, and/or organisms. Guidance suggests that sediment should be press-sieved through a 0.25 mm screen before use. But because removal of the coarser fraction of the sediment could potentially expose test organisms to the higher COPEC concentrations associated with the fine fraction of the sediment, sieving should only be performed if necessary (e.g., when potentially predatory organisms are observed, or when amphipods are present in the sample that may confound final survival counts). If one sample requires sieving, all samples should be sieved. If the lab sieves the samples, an aliquot of each sieved sample should be sent to a designated lab (at AMEC's expense) for analysis of TOC, grain size, and COPECs.

Test type: Whole sediment toxicity test, with no renewal of overlying water.

Test duration: 10 days

Organism source: Laboratory stock culture, or commercial source (must be identified)

Organism history: Hatch date and culture sediment/water source should be recorded

Organism age: 2-4 mm, uniform size (<1 mm difference), no mature males or females at test initiation

Test temperature: 25 ± 2°C

Illumination: Continuous illumination, wide-spectrum fluorescent, 500 to 1000 lux

Test vessels: 1 L glass beakers, with 10 cm inner diameter, covered. All test chambers must be identical.

Sediment volume: 175 mL (about 2 cm depth)

Overlying water vol: 775 mL (fill beaker to 950 mL total)

Water renewal: None

SUMMARY OF PROCEDURE (cont.): 10 Day Acute Toxicity Study with Marine Amphipods (*Leptocheirus plumulosus*)

Replication: 20 amphipods per replicate, 9 replicates per treatment (5 exposure replicates + 2 sacrifice replicates + 2 ammonia replicates)

Sacrifice Replicates: Each exposure, including the reference and laboratory control, should have 2 sacrifice replicates. The first sacrifice replicate for each treatment should be broken down on Day 1, and assessed for survival. The second sacrifice replicate should be broken down on Day 4. If there is significant mortality in the laboratory control, the laboratory should notify AMEC immediately and the entire study should be terminated and re-initiated with a new batch of test organisms as soon as possible. Mortality in site and reference samples should be recorded on the lab data sheets.

If potentially predatory organisms are found in the sacrifice replicates, the laboratory should notify AMEC immediately for guidance.

Ammonia Replicates: Each exposure, including the reference and laboratory control, should have 2 pore water ammonia replicates. One should be measured for pore water ammonia at Day 0, and the other at Day 10.

If ammonia in any treatment exceeds 60 mg/L on Day 0, the laboratory should notify AMEC immediately for guidance before proceeding.

Feeding regime: No feeding during test

Aeration: Aerate all test chambers constantly, at about 3 bubbles per second, through a glass pipet. Aeration should not disturb the sediment surface. Dissolved oxygen should average greater than 4.4 mg/L for the duration of the study, and should not drop below 3.6 mg/L.

Lab control water: Natural seawater from a source known to be uncontaminated, or synthetic seawater prepared no less than 24 hours, and no more than two weeks prior to use.

Salinity should be measured in the test sediment pore water prior to test initiation. If all Site and reference samples have the same pore-water salinity (±1 ppt), testing should be performed at that salinity.

Alternately, test water salinity should be maintained at 5 ppt if the sediment pore water is between 1 ppt and 10 ppt. If the sediment pore water is >10 ppt, test water salinity should be maintained at 20 ppt. If sediment samples require both 5 ppt and 20 ppt salinity, a laboratory control must be set up for each salinity.

SUMMARY OF PROCEDURE (cont.): 10 Day Acute Toxicity Study with Marine Amphipods (*Leptocheirus plumulosus*)

Test concentrations: 100% site sediment and a laboratory control sediment

Lab control sediment: Natural sediment from an area believed to be free of contamination (must be identified), which the laboratory has used successfully in multiple 10-day *Leptocheirus* studies. The laboratory control sediment should have the same pore water salinity as the test samples.

Responses: Record observations of mortality, appearance, and behavior daily. Observations of survival at test termination.

Physical/Chemical: Sediment pore water salinity, pH, and ammonia in ammonia replicates at test initiation and at test termination.

Temperature, dissolved oxygen (DO), pH, and salinity of overlying water initially, and at test termination.

DO measured in ammonia replicate daily. Do not put water quality probes in test sample exposure chambers.

A sample of the lab control sediment must be submitted for total organic carbon, grain size, and COPECs, as specified by AMEC.

Test acceptability: ≥90% control survival (with no single replicate having ≤60% survival)

A standard reference toxicant (SRT) test must be performed concurrent with each test of site samples, using the same batch of test organisms. The SRT results must fall within the acceptable range of the laboratory generated control chart.

Data analysis: Compare survival of amphipods in each test exposure to the laboratory control using ANOVA.

Compare survival in each test exposure to the reference location sample using ANOVA. When performing statistical analyses versus reference locations, do not include the lab control data.

Appendix B

Photograph Log

Photo 1: Path into landfill area, facing Sunset Avenue gate

Photo 2: Storm runoff erosion leading from Sunset Avenue gate into landfill area

Photo 3: Partially open meadow in south-central portion of the landfill area

Photo 4: Vegetation leading into forested wetland swale

Photo 5: Steep slope leading to wetland swale

Photo 6: Wetland swale discharge to Swimming River

Photo 7: River bank from landfill site

Photo 8: Salt marsh across the Swimming River

Photo 9: Red Bank recycling collection center on top of earthen mound

Photo 10: Earthen mound near landfill entrance

Photo 11: Earthen mound soil erosion

Photo 12: Houses adjacent to the landfill, at the head of the wetland swale

Photo 13: Soil sampling location FW-SO-1, near head of Forested Wetland swale

Photo 14: Soil sampling location FW-SO-4, near mouth of Forested Wetland swale

Photo 15: Marsh side of Swimming River, at low tide, across from upstream end of Site

Photo 16: Landfill side of Swimming River, at high tide, at Location SED-2

Photo 17: Landfill side of Swimming River, at low tide, at Location SED-4

Photo 18: Landfill side of Swimming River, at low tide, at Location SED-5

Appendix C

Sediment Toxicity Study Report

Client: T&M Associated Inc.
CBI Project ID: TMAS1301
Client Project ID: Red Bank Landfill Site
Sample Period: 11/19/13 to 11/21/13

Coastal Bioanalysts, Inc.

Report of Analysis - Whole Sediment Toxicity: *Leptocheirus plumulosus* 10-day survival test

Submitted To:	**Prepared By:**
Toni Sapio T&M Associates Inc. 1256 North Church Street Moorestown, NJ 08075 ASapio@tandmassociates.com	Coastal Bioanalysts, Inc. 6400 Enterprise Court Gloucester, VA 23061 (804) 694-8285 www.coastalbio.com Technical Contact: Peter F. De Lisle, Ph.D.

Summary Results

Table 1. Summary Biological Data

Sample ID	Field ID	Mean Survival	Mean Control-Correct Survival	Statistically Significant (< Lab Control)? (p = 0.05)	Biologically Significant? (< 80% Control Survival)*
TMAS1301-B	SED-5C	76	77.6	Y	Y
TMAS1301-C	SED-3C	98	100.0	N	N
TMAS1301-A	DNREF-SED2	95	96.9	N	N
TMAS1301-E	UPREF-SED2	92	93.9	N	N
TMAS1301-D	SED-1C	99	101.0	N	N
OHC110313	LAB CONTROL	98	100.0	NA	NA

*EPA criterion most programs

NOTE: SED-5C survival was also significantly (p = 0.05) less than that of both DNREF-SED2 and UPREF-SED2 (see attached statistical printouts).

VELAP ID: 460030
EPA Laboratory ID: VA01116

Methods

Tests were 10-day static survival tests using the euryhaline amphipod *Leptocheirus plumulosus.* Tests were conducted in accordance with the ERA Work Plan Toxicity Testing Appendix (attached), a modification of ASTM method E1367-03. Detailed procedures are also described in the attached Coastal Bioanalysts' standard operating procedure STS003D. Copies of all bench sheets associated with the conduct of the tests and summary sediment, water quality and biological data are provided in attached appendices

Control sediments were collected from Old House Creek-Ware River-Chesapeake Bay (37°21'25.20" N, 76°26'51.16" W; depth ~ 1 m) using a stainless steel Ekman grab sampler. This sediment source has been used successfully as a laboratory control for the past 20+ years. All sediments were stored refrigerated until used. Prior to processing, all sediments were homogenized in glass pans. Because control sediments are used to evaluate lab procedure and the health of organisms, control sediments were press sieved using a 500 μm mesh nylon sieve prior to testing to insure removal of any indigenous organisms. Test sediments were not press sieved (per the ERA Plan) because potential indigenous organisms that may interfere with the test were not observed during sediment homogenization.

Per the ERA Plan separate sacrificial replicates were set up to evaluate survival on test days 1 and 4. Survival in the sacrificial replicates was communicated via email immediately to T&M associates. Also, separate ammonia replicates were set up for measurement of pore water ammonia, pH, and salinity on test days 0 and 10. These ammonia replicates were also used for daily measurements of overlying water. Water quality measurements were reduced in nature from those recommended in ASTM E1367-03 as described in the ERA Plan.

Overlying water for the sediment toxicity tests and corresponding dilution water for the reference toxicant tests consisted of artificial seawater adjusted to 20 g/kg salinity. Water was prepared in 20 L Nalgene® carboys using high-purity deionized water and Wiegandt hw-Marinemix® sea salts; water was vigorously aerated prior to use. Water was prepared at least 24 hours prior to use and used for no more than 14 days after preparation.

Laboratory-reared amphipods, 2-4 mm in length, were obtained from Chesapeake Culture, Hayes, VA. All test organisms were hand delivered to the laboratory within a few hours of removal from culture sediments. Sediments and overlying water were added to test chambers (1-L glass beakers) the day prior to addition of animals. Test organisms were not fed during the 10-day static test. All test chambers were covered and continuously aerated, using glass Pasteur pipettes, at a rate of ca. 100 bubbles/min. Tests were ended by wet sieving the entire contents of each test chamber through a 410 µm mesh stainless steel sieve and enumerating the number of live amphipods.

Statistical analyses were conducted using the ToxCalc (vers. 5.0.23) software package. ToxCalc was used to compare animal response (survival) within each site sediment against the laboratory control group and (without the lab control group included) against the UPREF and DNREF groups . Survival data were transformed using the arc sine transformation prior to hypothesis testing. All data sets were evaluated for homogeneity of variance and normality to determine whether a one-tailed parametric or non-parametric hypothesis test was appropriate. Details of statistical analyses are provided in the attached printouts.

Coastal Bioanalysts, Inc.

Quality Assurance/Quality Control

Table 2. 96-h Reference Toxicant QA/QC Test
(same batch of organisms as used in tests)

96-h Acute Test QA/QC Reference Toxicant: $CdCl_2$ Units: µg/l						
Sediment Test ID (Ref. Test Date)	**Data Source**	**Animal Source/Lot**	**% Control Survival**	**96-h LC50**	**95% C.L./A.L. for LC50**	**RTT In Control?**
TMAS1301	RTT	CC 112613	100	794	655-1016	Yes
(11/26/13-11/30/13)	CC	N/A	99	689	442-937	

Note: RTT = Reference Toxicant Test, CC = Control Chart.

Overall assessment of data validity of the testing responses:

1. Tests were started with animals of appropriate age and from the same source.
2. Negative lab control survival was acceptable for all tests.
3. Testing parameters (e.g., D.O, temperature) were within prescribed limits.
4. Sample handling was within specified limits. Samples were stored properly (dark, 4° C).
5. No significant deviations from protocols occurred in the conduct of the tests.
6. Reference toxicant tests conducted with the same batches of organisms used in tests were within control chart acceptance limits.

The overall assessment of the toxicity data reported for these samples indicates that the organisms used were responding to toxic stress in a typical fashion such that the data presented meet the project requirements and are considered usable for the intended purpose.

The results of analysis contained within this report relate only to the samples as received in the laboratory. This report shall not be reproduced except in full without written approval from the laboratory.

APPROVED:

Peter F. De Lisle, Ph.D.
Technical Director

12/11/13
Date

GLOSSARY OF TERMS AND ABBREVIATIONS

A.L. (Acceptance Limits): The results of a given reference toxicant test are compared to the control chart mean value ± 2 standard deviations. These limits approximate the 95% probability limits for the "true" reference toxicant value.

C.L. (Confidence Limits): These are the probability limits, based on the data set and statistical model employed, that the "true value" lies within the limits specified. Typically limits are based on 95% or 99% probabilities.

Control chart: A cumulative summary chart of results from QC tests with reference toxicants. The results of a given reference toxicant test are compared to the control chart mean value and 95% Acceptance Limits (A.L.) (mean ± 2 standard deviations).

LC50: The concentration of sample or chemical, calculated from the data set using statistical models, causing a 50% reduction in test organism survival. The lower the LC50, the more toxic the chemical or sample. Units are same as test concentration units. Note: The LC50 value must always be associated with the duration of exposure. Thus 48-h LC50, 96-h LC50, etc. are calculated.

N/A: Not applicable.

Coastal Bioanalysts, Inc.

N/D: Not determined or measured.

Q.L.: Quantitation Limit. Level, concentration, or quantity of a target variable (analyte) that can be reported at a specified degree of confidence.

Appendix 1

Bench sheets
& statistical printouts

Leptocheirus plumulosus test set up bench sheet (EPA METHOD 100.4) Template version LP10D 070913

TEST CHAMBER:	1000 ml Beaker	✓	AERATION:	Continuous
	Other:		ILLUMINATION/PHOTOPERIOD:	50-100 ft-c 24L:0D
SEDIMENT VOLUME:	200 ml:		NO. REPLICATES/TREATMENT:	5
	Other (ml):	175	NO. ANIMALS/REPLICATE:	20
OVERLYING WATER VOLUME:	800 ml:			
	Other (ml):	775	OVERLYING WATER:	Wiegandt hwM Artificial Seawater

WATER QUALITY OVERLYING WATER USED FOR SET UP:	Temperature (C)	pH (S.U.)	Diss. Oxygen (mg/l)	Salinity (g/kg)
	25	7.89	7.3	20

LAB CONTROL SEDIMENT I.D.:	OHC110313	CONTROL SEDIMENT COLLECTION DATE:	11/3/13
CONTROL SEDIMENT SOURCE:	Old House Cr-Ware R-Ches Bay 37o21'25.20"N 76o26'51.16" W		

SPECIES:	Leptocheirus plumulosus	
SOURCE:	Chesapeake Cultures Inc.	
ARRIVAL DATE:	11/26/13	
ARRIVAL CONDITION:	Good	
ACCLIMATION WATER:	Wiegandt hwM Artificial Seawater 20 g/kg	
ACCLIMATION TEMP (o C):	25	
AGE/SIZE RANGE mm (MIN-MAX):	2.4	3.4
FEEDING DURING TEST:	None	
DATE/TIME SEDIMENT & WATER ADDED:	11/25/13 15:30	
DATE/TIME ANIMALS ADDED:	11/26/13 14:23	
TEST SET UP BY:	GB. PB	

INITIAL LENGTHS (mm; SUBSET OF 20 PRESERVED ANIMALS):

2.8	2.8	2.9	2.8	2.6
2.4	2.9	3.0	2.5	2.4
2.7	3.1	2.4	2.5	3.1
2.4	3.0	2.4	3.4	3.4

MEAN (mm):	2.8	STD DEV (mm):	0.3
MEASURED BY:	GB	DATE:	11/26/13

CONCURRENT SRT 96-h LC50 (Cd ug/l):	794		
CONTROL CHART LIMITS:	442-937	IN CONTROL?	YES

CHANGES & NOTES (INITIALS, DATE, SPECIFIC CHANGE MADE:	Note: sacrificial replicates set up for examination on test days 1 and 4. Ammonia replicates set up for porewater ammonia days 0 and 10 plus daily water quality measurements. Test performed in accordance with Red Bank Landfill ERA work plan.

TEST ID:	TMAS1301	PEER REVIEW BY (Initial/Date):	PB GB	12/11/13

Leptocheirus plumulosus Overlying water quality sheet (EPA METHOD 100.4) Template version LP10D 070913

	SAMPLE ID	FIELD ID	TRTMNT ID	Daily Water Quality											SUMMARY WATER QUALITY DATA			
				Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	MEAN	S.D.	MIN.	MAX.
pH (S.U.)	TMAS1301-B	SED-5C	1	7.79										7.71	7.75	0.06	7.71	7.79
	TMAS1301-C	SED-3C	2	7.79										7.68	7.74	0.08	7.68	7.79
	TMAS1301-A	DNREF-SED2	3	7.85										7.85	7.85	0.00	7.85	7.85
	TMAS1301-E	UPREF-SED2	4	7.93										7.92	7.93	0.01	7.92	7.93
	TMAS1301-D	SED-1C	5	7.86										7.91	7.89	0.04	7.86	7.91
	OHC110313	LAB CONTROL	6	7.80										7.96	7.88	0.11	7.80	7.96
Temp. (o C)	TMAS1301-B	SED-5C	1	24	25	25	25	25	25	25	25	25	26	25	25	0.4	24	26
	TMAS1301-C	SED-3C	2	24	25	25	25	25	25	25	25	25	26	25	25	0.4	24	26
	TMAS1301-A	DNREF-SED2	3	24	25	25	25	25	25	25	25	25	26	25	25	0.4	24	26
	TMAS1301-E	UPREF-SED2	4	24	25	25	25	25	25	25	25	25	26	25	25	0.4	24	26
	TMAS1301-D	SED-1C	5	24	25	25	25	25	25	25	25	25	26	25	25	0.4	24	26
	OHC110313	LAB CONTROL	6	24	25	25	25	25	25	25	25	25	26	25	25	0.4	24	26
Diss. Oxygen (mg/l)	TMAS1301-B	SED-5C	1	6.9	6.3	6.6	6.5	6.1	6.1	6.5	6.4	6.6	6.7	6.6	6.5	0.2	6.1	6.9
	TMAS1301-C	SED-3C	2	6.8	6.5	6.6	6.6	6.5	6.1	6.6	6.4	6.7	6.8	6.6	6.6	0.2	6.1	6.8
	TMAS1301-A	DNREF-SED2	3	7.0	6.4	6.5	6.6	6.3	6.0	6.5	6.4	6.6	6.7	6.8	6.5	0.3	6.0	7.0
	TMAS1301-E	UPREF-SED2	4	6.4	6.2	6.5	6.5	6.2	5.8	6.5	6.3	6.6	6.7	6.7	6.4	0.3	5.8	6.7
	TMAS1301-D	SED-1C	5	6.5	6.4	6.5	6.5	6.6	6.0	6.5	6.4	6.5	6.7	6.7	6.5	0.2	6.0	6.7
	OHC110313	LAB CONTROL	6	6.5	6.5	6.6	6.7	6.5	6.2	6.6	6.5	6.7	6.8	6.0	6.5	0.2	6.0	6.8
Salinity (g/kg)	TMAS1301-B	SED-5C	1	20										20	20	0.0	20	20
	TMAS1301-C	SED-3C	2	20										20	20	0.0	20	20
	TMAS1301-A	DNREF-SED2	3	20										20	20	0.0	20	20
	TMAS1301-E	UPREF-SED2	4	20										20	20	0.0	20	20
	TMAS1301-D	SED-1C	5	20										20	20	0.0	20	20
	OHC110313	LAB CONTROL	6	20										20	20	0.0	20	20
NH3-N (mg/l)	TMAS1301-B	SED-5C	1	<0.1										<0.1				
	TMAS1301-C	SED-3C	2	<0.1										<0.1				
	TMAS1301-A	DNREF-SED2	3	<0.1										<0.1				
	TMAS1301-E	UPREF-SED2	4	<0.1										<0.1				
	TMAS1301-D	SED-1C	5	<0.1										<0.1				
	OHC110313	LAB CONTROL	6	0.7										<0.1				
Replicate measured				F	F	F	F	F	F	F	F	F	F	F				
Initials				GB	GB	RCD	RCD	GB	BJA	AG	PB	AG	AG	PB				
Changes & Notes (Initials, date, specific change or notes):					All water quality measurements from ammonia replicates (F). No probes placed in test chambers.													
TMAS1301																		

Leptocheirus plumulosus biological observations bench sheet (EPA METHOD 100.4) Template version LP10D 070913

Treatment ID Sample ID Field ID	Rep	No. LIVE Day 0	Number Dead Observed (Test Days 1-9) Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	No. LIVE Day 10	Proportion Live Day 10	Mean Survival	Standard Deviation	Control-corrected Survival	Statistically Significant*	Biologically Significant*
	A	20	0	0	0	0	0	0	0	0	0	13	0.65	76.0	11.4	77.6	Yes	Yes
1	B	20	0	0	0	0	0	0	0	0	0	14	0.70					
	C	20	0	0	0	0	0	0	0	0	0	19	0.95					
TMAS1301-B	D	20	0	0	0	0	0	0	0	0	0	15	0.75					
SED-5C	E	20	0	0	0	0	0	0	0	0	0	15	0.75					
	A	20	0	0	0	0	0	0	0	0	0	19	0.95	98.0	2.7	100.0	No	No
2	B	20	0	0	0	0	0	0	0	0	0	19	0.95					
	C	20	0	0	0	0	0	0	0	0	0	20	1.00					
TMAS1301-C	D	20	0	0	0	0	0	0	0	0	0	20	1.00					
SED-3C	E	20	0	0	0	0	0	0	0	0	0	20	1.00					
	A	20	0	0	0	0	0	0	0	0	0	20	1.00	95.0	7.1	96.9	No	No
3	B	20	0	0	0	0	0	0	0	0	0	17	0.85					
	C	20	0	0	0	0	0	0	0	0	0	20	1.00					
TMAS1301-A	D	20	0	0	0	0	0	0	0	0	0	20	1.00					
DNREF-SED2	E	20	0	0	0	0	0	0	0	0	0	18	0.90					
	A	20	0	0	0	0	0	0	0	0	0	18	0.90	92.0	5.7	93.9	No	No
4	B	20	0	0	0	0	0	0	0	0	0	19	0.95					
	C	20	0	0	0	0	0	0	0	0	0	20	1.00					
TMAS1301-E	D	20	0	0	0	0	0	0	0	0	0	18	0.90					
UPREF-SED2	E	20	0	0	0	0	0	0	0	0	0	17	0.85					
	A	20	0	0	0	0	0	0	0	0	0	20	1.00	99.0	2.2	101.0	No	No
5	B	20	0	0	0	0	0	0	0	0	0	20	1.00					
	C	20	0	0	0	0	0	0	0	0	0	20	1.00					
TMAS1301-D	D	20	0	0	0	0	0	0	0	0	0	20	1.00					
SED-1C	E	20	0	0	0	0	0	0	0	0	0	19	0.95					
	A	20	0	0	0	0	0	0	0	0	0	19	0.95	98.0	2.7	100.0	No	No
6	B	20	0	0	0	0	0	0	0	0	0	20	1.00					
	C	20	0	0	0	0	0	0	0	0	0	20	1.00					
OHC110313	D	20	0	0	0	0	0	0	0	0	0	20	1.00					
LAB CONTROL	E	20	0	0	0	0	0	0	0	0	0	19	0.95					
Immergent animals (trtmnt ID-rep-number) and observations:																		
INITIALS:		GB. PB	GB	RCD	RCD	GB	BJA	AG	PB	AG	AG	PB. PD						
DATE & TIME:		11/26/13 14:23	11/27/13 8:39	11/28/13 13:52	11/29/13 10:57	11/30/13 16:15	12/1/13 10:10	12/2/13 9:55	12/3/13 8:34	12/4/13 9:04	12/5/13 9:38	12/6/13 10:38						

*See separate printout for statistical hypothesis tests of data. Statistical significance is one-tailed, p=0.05 reduction in survival compared with lab control. Biological significance is < 80% of lab control survival (EPA standard criterion).

CHANGES & NOTES (INITIALS, DATE, SPECIFIC CHANGE MADE:	#live in sacrificial replicate day 1: trt 1=20,trt 2=20,trt 3=13,trt 4=20,trt 5=20,trt 6=20. Polychaete in trt 3,4,5 (1/beaker). GB. #live in sacrificial replicate day 4: trt 1=20, trt 2=19, trt 3=20, trt 4=18, trt 5=20, trt 6=20. 1 polychaete in trt 5. GB. INDIGENOUS ORGANISMS FOUND IN SEDIMENT TREATMENTS ON DAY 10: 1b, 1c and 1e small isopod; 1d small polychaete; 3b and 3c large amphipod (not L. Plumulosus); 5b small isopod PB PD	% CONTROL SURVIVAL:	98
TMAS1301			

Leptocheirus plumulosus test sediment characterization bench sheet (EPA METHOD 100.4) Template version LP10D 070913

TRTMNT ID	SAMPLE ID	FIELD ID	Sediment Appearance & Texture	Check for Interfering Organisms		Pore Water Chemistry Day 0				%Water Measurement			
				Sieve Size (um)	Organism Types Present	pH (S.U.)	Salinity (g/kg)	NH3-N (mg/l)	Un-ionized NH3-N (mg/l)	Pan Tare Weight (g)	Total Wet Weight (g)	Total dry Weight (g)	Percent Water
1	TMAS1301-B	SED-5C	Dark brown coarse sand,pebbles,sticks			6.90	20	<2	ND	1.3	61.8	48.9	21.3
2	TMAS1301-C	SED-3C	Brown coarse sand,pebbles,sticks			7.01	21	<2	ND	1.3	50.4	38.9	23.4
3	TMAS1301-A	DNREF-SED2	Dark brown fine sand			6.91	22	<2	ND	1.3	55.0	40.4	27.2
4	TMAS1301-E	UPREF-SED2	Brown coarse sand		Isopod (removed)	6.97	14	<2	ND	1.3	19.7	14.4	28.8
5	TMAS1301-D	SED-1C	Brown coarse sand		Small red nematode, crab(removed)	6.69	21	<2	ND	1.3	31.0	23.6	24.9
6	OHC110313	LAB CONTROL	Gray soft mud	500		7.07	20	7.9	0.033	1.3	16.3	8.4	52.7
		Initials:	GB. PB			GB. PB				GB	GB. PB	PB	
		Date:	11/25/13			11/25/13				11/22/13	11/25/13	11/27/13	
	CHANGES & NOTES (INITIALS, DATE, SPECIFIC CHANGE MADE:		Pore water ammonia, salinity and pH from ammonia replicates. 5 ml pore water samples from site sediments diluted for analysis by ISE				Balance Calib. Check	Standard ref. weight (g):		10.0	100.0	100.0	
								Measured weight (g):		10.0	100.0	100.0	
TMAS1301			Ammonia samples collected and preserved at time of pore water pH and salinity measurement. Un-ionized ammonia calculated from total ammonia, salinity and pH (at 25 C) using NMFS spreadsheet.										

TRTMNT ID	SAMPLE ID	FIELD ID	Pore Water Chemistry Day 10			
			pH (S.U.)	Salinity (g/kg)	NH3-N (mg/l)	Un-ionized NH3-N (mg/l)
1	TMAS1301-B	SED-5C	6.96	20	4.4	0.014
2	TMAS1301-C	SED-3C	6.93	21	<2	ND
3	TMAS1301-A	DNREF-SED2	6.93	22	<2	ND
4	TMAS1301-E	UPREF-SED2	6.96	20	<2	ND
5	TMAS1301-D	SED-1C	6.88	21	<2	ND
6	OHC110313	LAB CONTROL	7.02	20	3.0	0.011
		Initials:	PB. PD			
		Date:	12/6/13			
	CHANGES & NOTES (INITIALS, DATE, SPECIFIC CHANGE MADE:			Balance Calib. Check	Standard ref. weight (g):	
					Measured weight (g):	
TMAS1301			Ammonia samples collected and preserved at time of pore water pH and salinity measurement. Un-ionized ammonia calculated from total ammonia, salinity and pH (at 25 C) using NMFS spreadsheet.			

L. plumulosus Sediment Survival Test-10 Day Survival

Start Date:		Test ID:	TMAS1301	Sample ID:	COMPARISON WITH LAB CONTROL
End Date:		Lab ID:	CBI	Sample Type:	
Sample Date:		Protocol:	EPA	Test Species:	L. plumulosus
Comments:	DATA ENTERED BY PB				

SEDIMENT ID	1	2	3	4	5
6-CONTROL	0.9500	1.0000	1.0000	1.0000	0.9500
1-SED-5C	0.6500	0.7000	0.9500	0.7500	0.7500
2-SED-3C	0.9500	0.9500	1.0000	1.0000	1.0000
3-DNREF	1.0000	0.8500	1.0000	1.0000	0.9000
4-UPREF	0.9000	0.9500	1.0000	0.9000	0.8500
5-SED 10	1.0000	1.0000	1.0000	1.0000	0.9500

			Transform: Arcsin Square Root						1-Tailed	
SEDIMENT ID	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD
6-CONTROL	0.9800	1.0000	1.4134	1.3453	1.4588	4.398	5			
*1-SED-5C	0.7600	0.7755	1.0737	0.9377	1.3453	14.760	5	5.095	2.360	0.1573
2-SED-3C	0.9800	1.0000	1.4134	1.3453	1.4588	4.398	5	0.000	2.360	0.1573
3-DNREF	0.9500	0.9694	1.3597	1.1731	1.4588	10.171	5	0.805	2.360	0.1573
4-UPREF	0.9200	0.9388	1.2950	1.1731	1.4588	8.496	5	1.775	2.360	0.1573
5-SED 10	0.9900	1.0102	1.4361	1.3453	1.4588	3.534	5	-0.340	2.360	0.1573

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)	0.96033	0.9	0.54846	0.98653
Bartlett's Test indicates equal variances (p = 0.17)	7.76112	15.0863		

Hypothesis Test (1-tail, 0.05)	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test indicates significant differences	0.07125	0.07305	0.09291	0.01111	1.1E-04	5, 24

L. plumulosus Sediment Survival Test-10 Day Survival

Start Date:		Test ID:	TMAS1301A	Sample ID:	COMPARISON WITH DNREF
End Date:		Lab ID:	CBI	Sample Type:	
Sample Date:		Protocol:	EPA	Test Species:	L. plumulosus
Comments:	DATA ENTERED BY PB				

SEDIMENT ID	1	2	3	4	5
3-DNREF	1.0000	0.8500	1.0000	1.0000	0.9000
1-SED-5C	0.6500	0.7000	0.9500	0.7500	0.7500
2-SED-3C	0.9500	0.9500	1.0000	1.0000	1.0000
4-UPREF	0.9000	0.9500	1.0000	0.9000	0.8500
5-SED-10	1.0000	1.0000	1.0000	1.0000	0.9500

			Transform: Arcsin Square Root						1-Tailed	
SEDIMENT ID	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD
3-DNREF	0.9500	1.0000	1.3597	1.1731	1.4588	10.171	5			
*1-SED-5C	0.7600	0.8000	1.0737	0.9377	1.3453	14.760	5	4.035	2.300	0.1630
2-SED-3C	0.9800	1.0316	1.4134	1.3453	1.4588	4.398	5	-0.757	2.300	0.1630
4-UPREF	0.9200	0.9684	1.2950	1.1731	1.4588	8.496	5	0.912	2.300	0.1630
5-SED-10	0.9900	1.0421	1.4361	1.3453	1.4588	3.534	5	-1.078	2.300	0.1630

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)	0.96871	0.888	0.56843	0.76836
Bartlett's Test indicates equal variances (p = 0.19)	6.13001	13.2767		

Hypothesis Test (1-tail, 0.05)	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test indicates significant differences	0.08965	0.09376	0.10618	0.01256	3.7E-04	4, 20

L.plumulosus Sediment Survival Test-10 Day Survival

Start Date:		Test ID:	TMAS1301B	Sample ID:	COMPARISON WITH UPREF
End Date:		Lab ID:	CBI	Sample Type:	
Sample Date:		Protocol:	EPA	Test Species:	L. plumulosus
Comments:	DATA ENTERED BY PB				

SEDIMENT ID	1	2	3	4	5
4-UPREF	0.9000	0.9500	1.0000	0.9000	0.8500
1-SED-5C	0.6500	0.7000	0.9500	0.7500	0.7500
2-SED-3C	0.9500	0.9500	1.0000	1.0000	1.0000
3-DNREF	1.0000	0.8500	1.0000	1.0000	0.9000
5-SED-10	1.0000	1.0000	1.0000	1.0000	0.9500

			Transform: Arcsin Square Root						1-Tailed	
SEDIMENT ID	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD
4-UPREF	0.9200	1.0000	1.2950	1.1731	1.4588	8.496	5			
*1-SED-5C	0.7600	0.8261	1.0737	0.9377	1.3453	14.760	5	3.123	2.300	0.1630
2-SED-3C	0.9800	1.0652	1.4134	1.3453	1.4588	4.398	5	-1.670	2.300	0.1630
3-DNREF	0.9500	1.0326	1.3597	1.1731	1.4588	10.171	5	-0.912	2.300	0.1630
5-SED-10	0.9900	1.0761	1.4361	1.3453	1.4588	3.534	5	-1.990	2.300	0.1630

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.01)	0.96871	0.888	0.56843	0.76836
Bartlett's Test indicates equal variances (p = 0.19)	6.13001	13.2767		

Hypothesis Test (1-tail, 0.05)	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test indicates significant differences	0.10634	0.11485	0.10618	0.01256	3.7E-04	4, 20

Appendix 2

Custody forms, air bills, packing slips

Coastal Bioanalysts
6400 Enterprise Court, Gloucester, VA 23061
PH: 804-694-8285, FAX: 804-695-1129
www.coastalbio.com

ENVIRONMENTAL SAMPLE CHAIN-OF-CUSTODY FORM (SPLF2021D 10/8/10)

PROJECT NAME: Red Bank LF Ecological Risk Assessment
CONTACT NAME: Toni Sapio
SAMPLERS: T. Sapio
CONTACT PH#: 856 722-6700, 856 381-5297 cell
CONTACT EMAIL: asapio@tandmassociates.com
ANALYSES REQUESTED: TOX

BILL TO: Toni Sapio
T&M Associates
1256 North Church St., Moorestown, NJ 08057

PO #: RBNK02018

AUTHORIZED BY: (PRINT & SIGN)[1] Toni Sapio Toni Sapio 11/21/13

CBI ID #	SAMPLE ID	LOGIN NUMBER	DATE & TIME	SAMPLE LOCATION/DESCRIPTION	NO. BTLS	MATRIX	CONT. TYPE	CBI Log-in number
TMAS1301-A	DNREF-SED2		11/19/13 10:40	1 tidal water/sediment of swimming River	1	Sed	2L	13-09466
TMAS1301-B	SED-5C		11/19/13 13:26	2	1			13-09467
TMAS1301-C	SED-3C		11/20/13 10:00	3	1			13-09468
TMAS1301-D	SED-1C		11/20/13 14:00	4	1			13-09469
TMAS1301-E	UPREF-SED2		11/21/13 9:15	5	1			13-09470
				6				
				7				
				8				
				9				
				10				

[1]Authorization for payment by a valid purchase order or established account required for processing of samples
Matrix: SW = surface water S = soil SD = sediment P = product O = Other:
Container type: G = glass HDPE = high density polyethylene O = Other:

Print and Sign Names:

1. Relinquished by: Toni Sapio / T&M Assoc. Date/time: 11/21/13 16:40E
   Received by: B. Bir / CBI Date/time: 11/22/13 1110
2. Relinquished by: _____ Date/time: _____
   Received by: _____ Date/time: _____
3. Relinquished by: _____ Date/time: _____
   Received by: _____ Date/time: _____

Cooler temperature upon arrival: 4 °C Arrival condition: Acceptable ✓ Other _____

Delivered by: UPS X FedEx ___ Hand ___ Other _____

Page 1 of 1

UPS CampusShip: View/Print Label

1. **Ensure there are no other shipping or tracking labels attached to your package.** Select the Print button on the print dialog box that appears. Note: If your browser does not support this function select Print from the File menu to print the label.

2. **Fold the printed sheet containing the label at the line so that the entire shipping label is visible. Place the label on a single side of the package and cover it completely with clear plastic shipping tape. Do not cover any seams or closures on the package with the label.** Place the label in a UPS Shipping Pouch. If you do not have a pouch, affix the folded label using clear plastic shipping tape over the entire label.

3. **GETTING YOUR SHIPMENT TO UPS**
   UPS locations include the UPS Store®, UPS drop boxes, UPS customer centers, authorized retail outlets and UPS drivers.
   Schedule a same day or future day Pickup to have a UPS driver pickup all your CampusShip packages.
   Hand the package to any UPS driver in your area.
   Take your package to any location of The UPS Store®, UPS Drop Box, UPS Customer Center, UPS Alliances (Office Depot® or Staples®) or Authorized Shipping Outlet near you. Items sent via UPS Return Services(SM) (including via Ground) are also accepted at Drop Boxes. To find the location nearest you, please visit the Resources area of CampusShip and select UPS Locations.

   Customers with a Daily Pickup
   Your driver will pickup your shipment(s) as usual.

FOLD HERE

T & M MOORESTOWN
856-722-6700
T&M ASSOCIATES
1256 NORTH CHURCH STREET
MOORESTOWN NJ 08057

50 LBS

1 OF 1

SHIP TO:
COASTAL BIOANALYSTS
804-695-1129
6400 ENTERPRISE COURT
GLOUCESTER VA 23061-3769

VA 236 9-04

UPS NEXT DAY AIR

1

TRACKING #: 1Z V31 18V 01 9285 4507

BILLING: P/P

Reference: RBNK02018

GS 15.6.12. WNTIE90 45.0A 10/2013

UPS CampusShip: View/Print Label

1. **Ensure there are no other shipping or tracking labels attached to your package.** Select the Print button on the print dialog box that appears. Note: If your browser does not support this function select Print from the File menu to print the label.

2. **Fold the printed sheet containing the label at the line so that the entire shipping label is visible. Place the label on a single side of the package and cover it completely with clear plastic shipping tape. Do not cover any seams or closures on the package with the label.** Place the label in a UPS Shipping Pouch. If you do not have a pouch, affix the folded label using clear plastic shipping tape over the entire label.

3. **GETTING YOUR SHIPMENT TO UPS**
   UPS locations include the UPS Store®, UPS drop boxes, UPS customer centers, authorized retail outlets and UPS drivers.
   Schedule a same day or future day Pickup to have a UPS driver pickup all your CampusShip packages.
   Hand the package to any UPS driver in your area.
   Take your package to any location of The UPS Store®, UPS Drop Box, UPS Customer Center, UPS Alliances (Office Depot® or Staples®) or Authorized Shipping Outlet near you. Items sent via UPS Return Services(SM) (including via Ground) are also accepted at Drop Boxes. To find the location nearest you, please visit the Resources area of CampusShip and select UPS Locations.

   Customers with a Daily Pickup
   Your driver will pickup your shipment(s) as usual.

FOLD HERE

T & M MOORESTOWN
856-722-6700
T&M ASSOCIATES
1256 NORTH CHURCH STREET
MOORESTOWN NJ 08057

50 LBS

1 OF 1

SHIP TO:
COASTAL BIOANALYSTS
804-694-8285
6400 ENTERPRISE COURT
GLOUCESTER VA 23061-3769

VA 236 9-04

UPS NEXT DAY AIR 1

TRACKING #: 1Z V31 18V 01 9279 6893

BILLING: P/P

Reference: RBNK02018

CS 15.6.12. WNTE90 45.0A 10/2013

CHESAPEAKE CULTURES, INC.
P.O. BOX 507
HAYES, VA 23072 USA
(804) 693-4046 Phone
(804) 694-4704 Fax
growfish@c-cultures.com

Packing Slip

DATE	INVOICE #
11/26/2013	8191

BILL TO:

Pete DeLisle
Coastal Bioanalysts
6400 Enterprise Ct.
Gloucester, VA 23061

SHIP TO:

P.O. NUMBER	TERMS	REP	SHIP	VIA	F.O.B.	PROJECT
verbal	net 30 days		11/26/2013			

QUANTITY	ITEM CODE	DESCRIPTION	PRICE EACH	AMOUNT
980	ll	Leptocheirus plumulosus 2-4mm VA Sales Tax	[redacted]	[redacted]

R 11/26/13
at GR

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637421 (12/12)

Appendix 3

Relevant correspondence

From: pfd@coastalbio.com <pfd@coastalbio.com>

To: Toni Sapio <ASapio@tandmassociates.com>
Cc:

Date: Monday, November 25, 2013 04:42 pm
Subject: Re: Aquatic Toxicity Testing
Attachments:

Thanks Toni.

We will be shipping the lab control sediment only. We did not need to sieve the samples because all that was found was an isopod in one sample and a large crab (easily removed without sieving) in another; i.e. no predators or indigenous amphipods observed that would require sieving.

It is too late for UPS but we will ship tomorrow for Wednesday delivery.

Pete

-----Original Message-----
From: Toni Sapio [mailto:ASapio@tandmassociates.com]
Sent: Monday, November 25, 2013 04:26 PM
To: pfd@coastalbio.com
Subject: RE: Aquatic Toxicity Testing

Hi Pete,
Sorry for the delay, here are your answers to the following:

1. Test America, 777 New Durham Road, Edison, NJ 08817 (see the attached chain for additional info)
2. See attached, I left the dates and the times blank?I wasn?t sure to uses your info from today or the info from the original Chain I sent to you on 11/21/13
3. FED EX ? 1357-2849-7, or UPS V3118V, whichever is best for you.

I was waiting to hear back from Test America on shipping details, sorry again.

Thanks, Toni

From: pfd@coastalbio.com [mailto:pfd@coastalbio.com]
Sent: Monday, November 25, 2013 1:27 PM
To: Toni Sapio
Subject: Re: Aquatic Toxicity Testing

Hi Toni,

Can you provide?

1. Test America Edison shipping address
2. Test America Chain of custody (there was not one in the cooler)
3. UPS shipper number

Thanks,
Pete

-----Original Message-----
From: Toni Sapio [mailto:ASapio@tandmassociates.com]
Sent: Monday, November 25, 2013 12:08 PM
To: pfd@coastalbio.com
Subject: RE: Aquatic Toxicity Testing

Thanks Pete.

From: pfd@coastalbio.com [mailto:pfd@coastalbio.com]
Sent: Monday, November 25, 2013 9:01 AM
To: Toni Sapio
Subject: Re: Aquatic Toxicity Testing

Hi Toni,

Just wanted to give you the heads up regarding sediment pore water salinity. The sample pore water salinity values (ppt) are:

SED-1C: 21
DNREF-SED2: 22
UPREF-SED2: 14
SED-3C: 21
SED-5C: 20
LAB CONTROL: 20

Per the protocol, since the values vary more than +/- 1 ppt but all are >10 ppt, tests will be run at 20 ppt using our standard lab control sediment (pore water 20 ppt).

I will let you know later in the day if we need to sieve samples. We will need to get your UPS number for shipping the lab control sediment for analyses as well as the sieved samples (if needed).

Thanks,

Pete

Peter F. De Lisle, Ph.D.
Coastal Bioanalysts, Inc.
6400 Enterprise Court
Gloucester, VA 23061
804-694-8285
804-695-1129 (Fax)

-----Original Message-----
From: Toni Sapio [mailto:ASapio@tandmassociates.com]
Sent: Friday, November 22, 2013 10:04 AM
To: pfd@coastalbio.com
Subject: RE: Aquatic Toxicity Testing

Hi Pete,
I sent all the samples (5 total) in one cooler. I sent them overnight mail UPS. I also sent another cooler with empty sample bottles, in case you need to sieve the samples. Also, I did not specifically state on the COC, but we would like the samples to be tested based on the attached (as presented in my earlier email):

I have attached a copy of a portion of the Ecological Risk Assessment Workplan for the project, which also includes Appendix B (page 4 of the *pdf) TOXICITY TESTING SUMMARY OF PROCEDURES. Hopefully this information is helpful, and may provide a better explanation the testing procedures I am requesting. The project is the investigation and closure of a former municipal landfill located along the Swimming River, Red Bank, NJ (tidal water draining to Raritan Bay/Atlantic ocean).

Please advise if this is acceptable.

Lastly, if we must send sieved soil for analysis, I?m using TestAmerica in Edison. Let me know and I can review the bottles for submission to them. I can also provide our UPS# for mailing back to them.

And again, thanks for your help,
Toni

Toni Sapio
Environmental Scientist | T&M Associates | 1256 North Church Street | Moorestown, New Jersey 08057
phone: 856.722.6700 | fax: 856.722.0175
ASapio@tandmassociates.com

From: pfd@coastalbio.com [mailto:pfd@coastalbio.com]
Sent: Monday, November 18, 2013 10:21 AM
To: Toni Sapio; pfd@coastalbio.com
Cc: Christine Ballard
Subject: Re: Aquatic Toxicity Testing

Hi Toni,

We only need 2 L of sediment so the 2 gal pails would be overkill and expensive to ship. We are overnighting a cooler with 5 2-L plastic bottles. I thought I had instructed my staff to send the kit last week but I guess I didn't; I don't usually work from home so that is my lame excuse. If they do not arrive until after you head out to the field tomorrow you can always transfer the sediment into the smaller containers.

Pete

From: pfd@coastalbio.com <pfd@coastalbio.com>

To: Sapio, Toni <ASapio@tandmassociates.com>
Cc:

Date: Wednesday, November 27, 2013 05:12 pm
Subject: Sacrificial Replicate counts day 1
Attachments:

Toni,

Per the ERA Study Plan we counted the animals in one of the sacrificial replicates today (Test Day 1). All treatments except sediment DNREF-SED2 had 100% survival. Sediment DNREF-SED2 had 13/20 alive. Small polychaetes were observed in treatments UPREF-SED2, SED-3C, and DNREF-SED2. These polychaetes were small enough that they could not be seen in the unsieved sediment which was examined for predators when compositing in large glass pans during test set up.

Hope you have a great Thanksgiving.

Pete

Peter F. De Lisle, Ph.D.
Coastal Bioanalysts, Inc.
6400 Enterprise Court
Gloucester, VA 23061
804-694-8285
804-695-1129 (Fax)

From: pfd@coastalbio.com <pfd@coastalbio.com>

To: Sapio, Toni <ASapio@tandmassociates.com>
Cc:

Date: Monday, December 02, 2013 07:58 am
Subject: Sacrificial replicate counts test day 4
Attachments:

Hi Toni,

The second set of sacrificial replicates were counted Saturday afternoon (test day 4). Number live (out of 20) were a follows:
SED-5C: 20
SED-3C: 19
DNREF-SED2: 20
UPREF-SED2: 18
SED-1C: 20
LAB CONTROL: 20

A small polychaete was found in treatment SED-1C

Pete

Peter F. De Lisle, Ph.D.
Coastal Bioanalysts, Inc.
6400 Enterprise Court
Gloucester, VA 23061
804-694-8285
804-695-1129 (Fax)

Appendix 4

Test Methods:

ERA Work Plan Toxicity Testing Appendix
and
Coastal Bioanalysts' SOP STS003D

(10-D SEDIMENT TOX. TEST – Estuarine Amphipods)

ECOLOGICAL RISK ASSESSMENT WORK PLAN

RED BANK LANDFILL SITE
RED BANK, NEW JERSEY

Prepared for:

T&M Associates, Inc.
1256 North Church Street
Moorestown, New Jersey 08075

Prepared by:

AMEC Environment & Infrastructure, Inc.
285 Davidson Avenue
Suite 405
Somerset, New Jersey 08873

November 2013

- Sample locations and sample types;
- Sampling and decontamination procedures; and
- Documentation.

4.1.1 Surface Water/Sediments

A total of 11 surface water samples will be collected from the river (co-located with 11 of the proposed sediment sample locations), if possible, by submerging the laboratory-supplied bottle into the water at the zero to six-inch interval above the sediment, or, if the bottle contains a preservative, by submerging a non-preserved lab-supplied bottle into the water and decanting the water from the non-preserved bottle into the preserved bottle. These samples will be analyzed for total and dissolved target analyte list (TAL) metals and mercury, SVOCs, PCBs, pesticides, and total suspended solids (TSS).

Water quality parameters such as dissolved oxygen, temperature, pH, salinity, and conductivity will be recorded prior to sample collection using a HORIBA U-10 monitor (or equivalent) calibrated in accordance with the equipment manufacturer's specifications. Additionally, qualitative observations of water conditions (color, turbidity, and odors) will also be made at each location. The sample locations will be noted using a hand-held global positioning system (GPS) unit.

The 23 sediment samples will be collected using a field decontaminated, stainless steel hand auger, trowel, and or other sampling device (*e.g.* petite ponar dredge). Samples will be collected from the 0 to 6-inch interval. These samples will be analyzed for the same metals, SVOCs, PCBs, and pesticides as the water samples, as well as total organic carbon (TOC), and grain size. The collected sediment will first be placed directly into a decontaminated stainless steel bowl for homogenization. Sediments will be observed for the presence or absence of benthic macroinvertebrates and will be noted as such. If benthic macroinvertebrates are observed, the

dominant species will be identified to the lowest practical taxon in the field. Sediment will then be placed into the laboratory-supplied glass containers using a field-decontaminated steel trowel.

Five of the sediment samples will be submitted for 10-day laboratory toxicity testing using the marine amphipod, *Leptocheirus plumulosus*. The toxicity study will be performed in accordance with American Society for Testing and Materials guidance (ASTM, 2008). A summary of procedures can be found in Appendix B.

All sample bottles will be stored in a cooler at 4°C until shipped to the analytical laboratory under a chain-of-custody. Quality assurance/quality control samples will include one equipment blank and one duplicate sample collected for every ten samples. The positions of the aquatic samples will be such that they maximize the spatial coverage of the river and will be biased towards inflow areas or areas where Site-related sediments are expected to accumulate. The proposed aquatic sampling locations have been selected to reassess and complement the five samples that have been collected to date.

The sequence of sample collection will be arranged to maximize efficiency while minimizing potential cross-sample contamination.

4.1.2 Soil

The five soil samples will be collected using a field decontaminated, stainless steel hand auger, trowel, and or other sampling device. Samples will be collected from the 0 to 6-inch interval. These samples will be analyzed for the same metals, SVOCs, PCBs, and pesticides as the surface water and sediment samples. The collected soil will first be placed directly into a decontaminated stainless steel bowl for homogenization. Soils will be observed for the presence or absence of macroinvertebrates and will be noted as such. Soil will then be placed into the laboratory-supplied glass containers using a field-decontaminated steel trowel.

APPENDIX B

TOXICITY TESTING SUMMARY OF PROCEDURES

AQUATIC TOXICITY TESTING

The laboratory will perform marine sediment toxicity evaluations following the attached procedure summary (based on ASTM guidance). The contaminants of potential ecological concern (COPECs) are metals, SVOCs, pesticides, and PCBs. Technical questions can be addressed by contacting Dan Cooke at 732-302-9500 ext. 131, or by email at daniel.cooke@amec.com.

A total of 5 (4 Site sediments and 1 upstream reference sediment) will be shipped to the laboratory via overnight carrier. Testing must begin within 7 days of sample receipt.

Toxicity Test	Endpoints	Matrix	Sample #
10 day *Leptocheirus plumulosus* bioassay	Survival	Sediment	5

Special Requirements:

1. The attached procedure summary follows ASTM guidance. However, it may differ slightly from the laboratory's standard operating procedures. The laboratory is strongly advised to ensure that all personnel participating in this study are familiar with the required procedures. All deviations from the test protocol must be discussed with AMEC prior to test initiation and listed in the final report, along with justification for the deviation.

2. A standard reference toxicant (SRT) test is required. The SRT must be initiated on the same day, with the same batch of organisms used for testing samples. If the SRT falls outside of the acceptable range of the lab's SRT control chart, testing will be considered suspect, and must be repeated at the lab's expense.

3. Note the requirement for 'sacrifice replicates'. For each test treatment, two additional replicates must be prepared. Sacrifice replicates will be evaluated on days 1 and 4. If there is significant mortality in the laboratory control, the laboratory should notify AMEC immediately and the entire study should be terminated and re-initiated with a new batch of test organisms as soon as possible (within 5 days). Mortality in site and reference samples should be recorded on the laboratory data sheets.

4. Note the requirement to sieve the sediment samples only if necessary. Testing should be performed using whole sediment samples. If sieving is required, the laboratory will be responsible for sieving test samples, and sending an aliquot of each sieved sample, and an aliquot of the laboratory control sediment to a designated lab for analysis of TOC, grain size, and COPECs (at AMEC's expense).

5. Toxicity testing must be initiated within 7 days of sample receipt. A draft report is required within 10 business days of test completion. A final report is required within 5 business days of receipt of AMEC comments to the draft report.

6. The laboratory is required to submit one unbound hard (paper) copy of the final report, and one electronic copy (CD or email). The electronic copy should be submitted in PDF format, and should be an exact duplicate of the paper report (including scanned copies of all laboratory raw data sheets and QA information).

SUMMARY OF PROCEDURE: 10 Day Acute Toxicity Study with Marine Amphipods (*Leptocheirus plumulosus*)

References: ASTM. 2008. Standard Test Method for Measuring the Toxicity of Sediment-Associated Contaminants with Estuarine and Marine Invertebrates. E1367-03(2008). American Society for Testing and Materials, West Conshohocken, PA.

Test sample storage: 4 ± 1°C, in the dark, in original, sealed container, with no headspace, when not in use for testing.

Sediment prep: Prior to use, homogenize each sediment sample and remove debris, rocks, vegetation, and/or organisms. Guidance suggests that sediment should be press-sieved through a 0.25 mm screen before use. But because removal of the coarser fraction of the sediment could potentially expose test organisms to the higher COPEC concentrations associated with the fine fraction of the sediment, sieving should only be performed if necessary (e.g., when potentially predatory organisms are observed, or when amphipods are present in the sample that may confound final survival counts). If one sample requires sieving, all samples should be sieved. If the lab sieves the samples, an aliquot of each sieved sample should be sent to a designated lab (at AMEC's expense) for analysis of TOC, grain size, and COPECs.

Test type: Whole sediment toxicity test, with no renewal of overlying water.

Test duration: 10 days

Organism source: Laboratory stock culture, or commercial source (must be identified)

Organism history: Hatch date and culture sediment/water source should be recorded

Organism age: 2-4 mm, uniform size (<1 mm difference), no mature males or females at test initiation

Test temperature: 25 ± 2°C

Illumination: Continuous illumination, wide-spectrum fluorescent, 500 to 1000 lux

Test vessels: 1 L glass beakers, with 10 cm inner diameter, covered. All test chambers must be identical.

Sediment volume: 175 mL (about 2 cm depth)

Overlying water vol: 775 mL (fill beaker to 950 mL total)

Water renewal: None

SUMMARY OF PROCEDURE (cont.): 10 Day Acute Toxicity Study with Marine Amphipods (*Leptocheirus plumulosus*)

Replication: 20 amphipods per replicate, 9 replicates per treatment (5 exposure replicates + 2 sacrifice replicates + 2 ammonia replicates)

Sacrifice Replicates: Each exposure, including the reference and laboratory control, should have 2 sacrifice replicates. The first sacrifice replicate for each treatment should be broken down on Day 1, and assessed for survival. The second sacrifice replicate should be broken down on Day 4. If there is significant mortality in the laboratory control, the laboratory should notify AMEC immediately and the entire study should be terminated and re-initiated with a new batch of test organisms as soon as possible. Mortality in site and reference samples should be recorded on the lab data sheets.

If potentially predatory organisms are found in the sacrifice replicates, the laboratory should notify AMEC immediately for guidance.

Ammonia Replicates: Each exposure, including the reference and laboratory control, should have 2 pore water ammonia replicates. One should be measured for pore water ammonia at Day 0, and the other at Day 10.

If ammonia in any treatment exceeds 60 mg/L on Day 0, the laboratory should notify AMEC immediately for guidance before proceeding.

Feeding regime: No feeding during test

Aeration: Aerate all test chambers constantly, at about 3 bubbles per second, through a glass pipet. Aeration should not disturb the sediment surface. Dissolved oxygen should average greater than 4.4 mg/L for the duration of the study, and should not drop below 3.6 mg/L.

Lab control water: Natural seawater from a source known to be uncontaminated, or synthetic seawater prepared no less than 24 hours, and no more than two weeks prior to use.

Salinity should be measured in the test sediment pore water prior to test initiation. If all Site and reference samples have the same pore-water salinity (±1 ppt), testing should be performed at that salinity.

Alternately, test water salinity should be maintained at 5 ppt if the sediment pore water is between 1 ppt and 10 ppt. If the sediment pore water is >10 ppt, test water salinity should be maintained at 20 ppt. If sediment samples require both 5 ppt and 20 ppt salinity, a laboratory control must be set up for each salinity.

SUMMARY OF PROCEDURE (cont.): 10 Day Acute Toxicity Study with Marine Amphipods (*Leptocheirus plumulosus*)

Test concentrations: 100% site sediment and a laboratory control sediment

Lab control sediment: Natural sediment from an area believed to be free of contamination (must be identified), which the laboratory has used successfully in multiple 10-day *Leptocheirus* studies. The laboratory control sediment should have the same pore water salinity as the test samples.

Responses: Record observations of mortality, appearance, and behavior daily. Observations of survival at test termination.

Physical/Chemical: Sediment pore water salinity, pH, and ammonia in ammonia replicates at test initiation and at test termination.

Temperature, dissolved oxygen (DO), pH, and salinity of overlying water initially, and at test termination.

DO measured in ammonia replicate daily. Do not put water quality probes in test sample exposure chambers.

A sample of the lab control sediment must be submitted for total organic carbon, grain size, and COPECs, as specified by AMEC.

Test acceptability: ≥90% control survival (with no single replicate having ≤60% survival)

A standard reference toxicant (SRT) test must be performed concurrent with each test of site samples, using the same batch of test organisms. The SRT results must fall within the acceptable range of the laboratory generated control chart.

Data analysis: Compare survival of amphipods in each test exposure to the laboratory control using ANOVA.

Compare survival in each test exposure to the reference location sample using ANOVA. When performing statistical analyses versus reference locations, do not include the lab control data.

APPROVED:
Peter F. De Lisle, Ph.D., Technical Director 5/9/07

NOTE: This Standard Operating Procedure contains proprietary information and was developed for the sole use of Coastal Bioanalysts, Inc. and shall not be used by other organizations, or distributed to other parties, without written approval from Coastal Bioanalysts, Inc.

Distribution:

1. Quality Assurance office file (Original hardcopy with records of review and distribution)
2. Controlled copies to appropriate personnel/laboratories.

Distribution records (Original copy only):

Copy #	To: Name/Location	Distrib. Date	QAO Init.	Return Date	QAO Init.
1	Lab	12/15/08			

Records of review* (Original copy only):

(Reviewed by)	(Date)	(Reviewed by)	(Date)
	10/1/08		5/21/09
	3/3/10		2/15/11
	4/16/12		3/11/13

Date removed from laboratory use:
(All controlled copies returned/destroyed by this date) _____ (Technical Director) _____ (Date)

*Methods must be reviewed at least annually by the quality assurance officer as part of the annual audit and managerial review. All affected staff reading a method for the first time should certify such in their personnel file.

Uncontrolled Copy

TEST METHOD

1. EPA Method 100.4 (EPA 1994). WARNING: This method number has also been used by EPA for another test method (i.e. the *Hyalella azteca* 42-d chronic tests, SOP STS009).
2. This procedure is also compatible with the following methods. Specific modifications required for these methods are highlighted in the procedure.
   a) Army Corps of Engineers methods described in the "Green Book" (COE/EPA 1991) and the "Inland Testing Manual" (COE/EPA 1994)
   b) ASTM method E 1367-03 (ASTM 2006)
   c) EPA EMAP Lab Manual (EPA 1995 with additional QC requirements in EPA 2001b)

APPLICABLE MATRICES

Sediment

DETECTION LIMIT & METHOD PERFORMANCE

Detection limits are not applicable to toxicity. The method has been validated by EPA (see references).

SCOPE AND APPLICATION

1. This test method measures the acute toxicity of sediments to the estuarine amphipods, *Leptochierus plumulosus, Eohaustorius estuarius, Rheopoxynius abronius* or *Ampelisca abdita* during a 10-day static exposure.
2. These procedures are applicable to sediments collected for conducting tests in accordance with the Army Corps of Engineers testing manuals for the evaluation of dredged materials proposed for ocean, near coastal and inland disposal (see references below).
3. Applicable Federal programs which may require assessment of sediment toxicity using these procedures are described in Table 1.2 of EPA 1994.
4. This test is generally used as a definitive test consisting 100% concentration only of test site(s), reference site(s) and a laboratory control sediment.
5. This version of this SOP incorporates the changes listed below; however, the basic conduct of the test method is unchanged from the previous version of the SOP.
   a) NELAP-required elements
   b) Specific modifications for tests conducted according to EMAP protocols (e.g. SDS reference toxicant)
   c) Updated ASTM references

DEFINITIONS

1. Sediment: Used, for the sake of convenience, throughout this document to refer to clean, contaminated or spiked natural sediments, dredge spoils or concocted sediments.
2. See also DRS801 for additional definitions and terms.

SUMMARY OF TEST METHOD

Amphipods are exposed to laboratory control, reference and test site sediments for a period of 10 days in a static test system. Water quality is monitored daily during the tests. The number of dead amphipods which have emerged from their burrows and any sediment avoidance behaviors are recorded daily. The test endpoint is survival. Valid tests must have a minimum of 90% control survival. Refer to the references below for additional information.

Uncontrolled Copy

1.	**Day -2: Receive/collect amphipods:** Acclimate amphipods to test-specific conditions (salinity, temperature, photoperiod, etc.). Remove from collection sediment using a 0.5 mm sieve, if applicable. Feed and measure water quality daily.
2.	**Day -1: Add sediment and water to chambers; start aeration:** Mix samples thoroughly, press sieve if necessary (see STS002 and table below). Press sieve (0.5 mm) lab control sediment. Add sediment aliquots to each test chamber, smoothing surface by tapping and/or spreading with spatula. Add water using a plastic disk to prevent unnecessary disturbance of sediments. Randomly place chambers on test table, cover and begin gentle aeration
3.	**Day 0: Obtain "total water quality" measurements.** Measure sediment percent water and pore water salinity, pH and ammonia using a reserved aliquot of sediment (see STS002; sediment parameters may be measured on days 0 or -1). Measure in one replicate of each treatment overlying water ammonia and in all replicates pH, salinity, dissolved oxygen and temperature.
4.	**Day 0: Sieve amphipods to collect correct size class and add to test.** Wet sieve amphipods on Nitex sieve. For *L plumulosus* collect 2-4 mm size by washing through 0.71 mm and 0.5 mm screens, tests use those retained on 0.5 mm screen. For A*. abdita* collect 3-5 mm animals by washing through 1 mm and 0.71 mm screens, tests use those retained on 0.71 mm screen. For *E. estuarius* and *R. abronius* use those retained on a 1 mm screen. Randomly assign active animals to plastic Solo cups with a small amount of dilution water until each cup has 20 animals. Transfer animals to test; replace animals that do not burrow within 10 min. (1 hr. for *A. abdita*). Retain an extra cup of 20 animals for length measurement (preserve in buffered formalin if can't be measured immediately)
5.	**Days 1-9: Measure salinity, dissolved oxygen, temperature and pH in one replicate of each treatment.** Also measure dissolved oxygen in any chambers in which airflow has ceased. Check chambers for dead/emergent animals.
6.	**Day 10: Collect "total water quality" measurements (see 3 above; note that sediment/pore water measurements not taken).**
7.	**Day 10: End test.** Sieve animals using 0.41 mm sieve (0.5 mm *A. abdita*) and record number of survivors.

REQUIRED TEST CONDITIONS

PARAMETER	EPA 1994	COE, EMAP, ASTM Modifications
TEMPERATURE	*A. abdita*: 20 ± 1 °C avg, ± °3 instantaneous *L. plumulosus*: 25 ± 1 °C avg, ± °3 instant. *E. estuarius* 15 ± 1 °C avg, ± °3 instantaneous *R. abronius* 15 ± 1 °C avg, ± °3 instantaneous	EMAP ± 1 °C avg, 3 °C max range ± 2 °C instantaneous range ASTM ± 2 °C avg, ± 3 °C instantaneous range
SALINITY	*A. abdita* and *R. abronius*: 28 g/kg *L. plumulosus* and *E. estuarius:* 20 g/kg	ITM site water salinity 28-35 g/kg EMAP (*A. abdita*) 30 ± 2 g/kg ITM site water salinity 2-32 g/kg
PHOTOPERIOD	24L:0D	ITM 16L:8D *L. plumulosus* ITM
ILUMINANCE/QUALITY	500-1000 lux, wide-spectrum fluorescent	EMAP 100 lux min. at sed. surface
TEST CHAMBERS	1000 ml glass beakers or canning jars	
SEDIMENT SIEVING	Typically 1mm to remove indigenous organisms (Program/contract specific)*	EMAP does not specify EPA 1994 & ITM recommend 1 mm sieve ASTM optional, with warning
SEDIMENT VOLUME	175 ml (2 cm)	EMAP 3-4 cm 200 ml ITM 2 cm *L. plumulosus* ITM 4 cm *A. abdita*
OVERLYING WATER VOL	800 ml	EMAP 600 ml ITM, ASTM to 950 ml
OVERLYING WATER	Artificial seawater	Natural seawater option for all
WATER RENEWAL	None	
AMPHIPOD LIFE STAGE	*A. abdita* 3-5 mm, no mature males, females *L. plumulosa* 2-4 mm no mature males, females *E. estuarius* 3-5 mm *R. abronius* 3-5 mm	ITM immature ITM-- 3-5 mm
NO. ANIMALS/BEAKER	20	
NO. REPLICATES	5	
FEEDING	None	
AERATION	Continuous trickle maintains ≥ 90% saturation (must be ≥ 60% saturation)	
TEST DURATION	10 days	
SAMPLE HOLD TIME	2 weeks max recommended*	EMAP 30 days max ASTM 8 weeks max ITM prefer ≤ 2 weeks, 8 weeks max
ENDPOINTS	Survival	EPA, ASTM: reburial optional for *E. estuarius, R. abronius* and *L. plumulosus*
TEST ACCEPTABILITY	≥ 90% mean control survival	EMAP Control surv ≥ 85%/beaker

*Methods manuals are not specific on sample hold time (2-8 weeks) or sieving to remove indigenous species. Sample hold time and whether or not to sieve samples should be determined *a priori* in contract or work order. Because control sediments are used to evaluate lab procedure and health of organisms, laboratory control sediments are always press sieved (e.g. good laboratory control survival and poor reference site survival may be due to indigenous predators in the field samples). Typically we advise clients we will press sieve all marine sediments with a 1 mm sieve prior to testing.

INTERFERENCES (See also sect. 4.1 of EPA Method 100.4)

1. Indigenous organisms present in samples can interfere with tests (see press sieving below)
2. Natural sediment characteristics (grain size, NH3, TOC, presence of food) may affect survival and growth of the test species. Additional controls for unusual sediment characteristics is recommended (NOTE: Advise client, additional costs associated with these controls)
3. Pore water salinity must be within the tolerance range of the organism.
4. Large amounts of detritus in samples may make it difficult to recover animals at the end of the test.

SAFETY, WASTE MANAGEMENT AND POLLUTION PREVENTION

1. Collection and use of samples in toxicity tests may pose risks to personal safety and health. Standard laboratory safety procedures must be adhered to at all times. Gloves must be worn at all times when handling samples, organisms, dilution waters, glassware, etc.
2. Generally, field samples may be discarded as normal solid waste. Except for pH adjustment (> 5), all reagents used in this test and supporting analyses (e.g. ammonia, alkalinity, etc.) do not require any pre-treatment prior to discharge to the sanitary sewer. Hazardous samples remaining after testing are stored in the chemical storage until appropriate disposal can be arranged.
3. All test animals must be destroyed (drying oven or bleach @ 100 ppm) prior to disposal.
4. Ground-fault interrupters are installed in all electrical circuits supplying wet labs. Do not run extension cords into laboratories from areas not ground-fault protected (e.g. offices).

Notes on Control of contamination:

Samples may contain bacteria and fungi which are pathogenic to the laboratory cultures as well as toxicants and opportunistic organisms which can be harmful to cultures and/or interfere with other tests. To decrease the possibility of contamination:

- Gloves must be worn whenever hands come in contact with samples, dilution water, test vessels, etc.
- Do not prepare, store or use samples in culture areas or refrigerators.
- Use dedicated glassware, siphons, etc. for sample handling and processing.
- Rinse probes well between measurements and after final use.
- Clean up all spills.

EQUIPMENT AND SUPPLIES

1. Amphipods (Note: AA may not be available mid May-early June from NE sites)
   a) Chesapeake Cultures (Elizabeth Wilkins 804-693-4046) (LP)
   b) Aquatic BioSystems (Scott Kellman 800-331-5916) (LP)
   c) Aquatic Research Organisms (800-927-1650) (AA, LP)
   d) Northwest Aquatic Sciences (541-265-7225) - Pacific Coast Species
   e) Nautilus Northwest (253-922-4296 Karen Bergman) - Pacific Coast Species
   f) Kim Siewers (831-425-1391) - Pacific Coast Species
   g) Parametrics (541-791-1667) - Pacific Coast Species
2. Forceps
3. Temperature controlled test area (15±1, 20±1 or 25±1° C)
4. Light table
5. Sieves, Nitex (culture) or stainless steel (samples) 1.0, 0.71, 0.50, 0.41 mm
6. Wash bottles containing DI H2O
7. Wash bottles containing dilution water
8. Beakers, borosilicate 1-L (5 per treatment)
9. Tape, markers

10. Data sheets
11. Large glass bowls or sorting pans/plastic bins
12. Small solo cups
13. Airline tubing
14. Pipettes-Pasteur (borosilicate glass)
15. Stereomicroscope with ocular micrometer
16. Light table
17. Tetramin
18. Pipettes, wide bore
19. Pipette bulbs
20. Carboys

REAGENTS AND STANDARDS

1. Water, deionized
2. Reference toxicants:
   a) KCl (Sigma Ultrapure P-9333, or equivalent)
   b) Sodium dodecly sulfate (a.k.a. sodium lauryl sulfate; Sigma Ultra grade L-6026, or equivalent))
3. Dilution water (synthetic seawater of appropriate salinity; site-specific qualities may apply)
4. Lab control sediment (e.g. Oldhouse Creek-Ware R.-Ches. Bay OR amphipod collection site), 0.5 mm sieved

SAMPLE COLLECTION, PRESERVATION, SHIPMENT AND STORAGE

See STS001 and STS002

PROCEDURE

Test Set Up

Test should be set up as soon as practical within sample holding time. However, refrigerated holding of sediments for 2 weeks may reduce interference from indigenous organisms (ASTM 2006a,b) in lieu of sieving.

1. Receive/collect and hold/acclimate amphipods.
   a) Acclimate amphipods for 48 hr minimum to test-specific conditions (salinity, temperature, photoperiod). Do not adjust temperature more than 3°C/day or salinity more than 5 g/kg/day.
   b) Remove from collection sediment (if applicable) by wet sieving using a 0.5 mm sieve.
   c) Holding density is 480 amphipods per 11-L bin with a ca. 1 cm (control or culture) sediment layer and vigorous aeration.
   d) Feed (0.5 g dry wt. Tetramin as slurry/bin) and measure water quality daily.
   e) Animal quality: If greater than 20% emmerge or appear unhealthy during the 48 hr preceding the test, or greater than 10% die during the holding period, discard the lot and do not use in testing.
   f) Animals should be active with full guts and be opalescent pink (*A. abdita*) or bownish- oranish-gray (*L. plumulosus*).
2. <u>The day before the test is to begin:</u>
   a) Check dilution water to ensure acceptable temperature, pH, D.O., and salinity. Adjust if necessary and record measurements on Dilution Water bench sheet.
   b) Assign sediment test-specific treatment I.D. values and label (e.g. 1-A, 1-B… 2-A etc.) beakers. Identify test I.D. with label on test table where beakers are to be placed.
   c) Prepare and sieve test sediments (if approved *a priori;* see SOP STS002).

Typically sediments are 1 mm press-sieved. Because control sediments are used to evaluate lab procedure and health of organisms, laboratory control sediments are always sieved (0.5 mm).

d) Add sediment and water to chambers and start aeration (see table above for method-specific volumes).
   i) Mix sample thoroughly and add 200 ml aliquots (2 cm depth in 1-L beaker) to each test chamber, smoothing surface by tapping and/or spreading with spatula.
   ii) Add water using a polyethylene disc attached to a cable tie that just fits inside the beaker. Position just above the sediment layer and move up as more water is added. Disc is removed after filling. Wash disc thoroughly between sediments (one disk/treatment). Add 800 ml/beaker.

e) Randomly place chambers on test table (DRS601), cover and begin gentle aeration (ca. 100 bubbles/min)

3. On test day 0 (start date) obtain "total water quality" measurements. Measure sediment percent water and pore water salinity, pH and ammonia using a reserved aliquot of sediment (see SOP STS002; these parameters may be measured on days 0 or -1). Measure in one replicate of each treatment: overlying water ammonia and in all replicates pH, salinity, dissolved oxygen and temperature.

4. Collect amphipods of correct size class and add to test.
   a) Wet sieve amphipods on Nitex sieve. Sieving should be conducted using water with the same temperature and salinity as the holding and test water.
      i) For *L plumulosus* collect 2-4 mm animals by washing through 0.71 mm and 0.5 mm screens, tests use those retained on 0.5 mm screen.
      ii) For A*. abdita* collect 3-5 mm animals by washing through 1 mm and 0.71 mm screens, tests use those retained on 0.71 mm screen.
   b) Randomly assign active animals to plastic Solo cups with a small amount of dilution water until each cup has 20 animals.
   c) After obtaining enough amphipods recount the animals in each cup to verify the number and randomly distribute the cups to the test beakers
   d) Transfer animals to test; replace animals that do not burrow within 10 min. (allow 1 hr. for *A. abdita* which builds tubes).
   e) Retain an extra cup of 20 animals for standard length measurement ("stretched out" base of first antenna to base of telson). These may be measured immediately or preserved in 10 buffered formalin for later measurement. Calculate mean and S.D.

Daily Tasks

1. Count and record the number of dead or live emergent amphipods.
   a) Remove dead amphipods.
   b) Record time and initials.
   c) Gently push down any amphipods caught in the air-water interface using a glass pipette to "bombard" with water droplets.
   d) Any pertinent observations on the appearance of the sediment (such as color, presence of non-test organisms, growth of mold or algae, or depth of oxidized layer) or organisms should be recorded.
2. Measure and record temperature, pH, D.O., and salinity in one replicate of each concentration. Check that values make sense with respect to previous day's values, concentrations, saturation values, required conditions, etc. Unusual values may indicate instrument drift since last calibration, interruption of aeration, measurement error, etc.
3. If air flow to the beakers is interrupted for more than an hour, DO should be measured to determine whether DO concentration dropped to less than 60 % of saturation (ITM: 40% for warm water species).

4. Test day 10: Measure "total water quality" (see step 3 under set up)

Termination of Test (10 days)

1. The test is terminated by wet sieving sediments using a 0.41mm mesh (0.5 mm *Ampelisca*) and counting the number of live amphipods. *Ampelisca* require rather forceful spraying using a spray bottle containing test water to break up tubes. Once sprayed and tubes have been broken up, rinse material from sieve into a plastic bin and begin counting live amphipods. As counting, remove amphipods and place in 30 ml cups. Record final counts, time, and initials.
2. Discard all test organisms after destroying (oven or 100 ppm bleach).
3. Remove all test glassware to wash area.

CALCULATIONS AND DATA ANALYSIS

1. For all treatments and controls calculate the percent total survival.
2. The TAC are determined using performance of animals in the laboratory control; the purpose of the laboratory control is to evaluate the health of the organisms and the performance of the method by the lab.
3. Typically, performance of animals exposed to sediments from various stations are compared against a reference site (i.e. not lab control) to evaluate toxicity.
4. Refer to SOPs DRS101, DRS102 and DRS103 and the cited references for the test method for calculation and data analysis procedures.

QUALITY CONTROL

1. Test acceptability criteria (TAC):
   a) A negative-control sediment must be included in the test.
   b) Minimum average control survival of 90%. (EMAP: $\geq$ 85% in any single control beaker)
   c) The test must be conducted in accordance with specified test conditions (temperature, test organism age, acclimation conditions and procedures, etc.). DO must be greater than 60% saturation (ITM: 40%) See Table 11.3 of EPA Test Method 100.4
   d) All test organisms must appear healthy, be from the same source. If greater than 20% appear unhealthy or die during the 48 hr preceding the test, the animals are not acceptable for testing.
   e) All test chambers must be identical and contain the same amount of sediment and water.
   f) The time-weighted temperature must be within 1°C of the specified temperature and the instantaneous temperature must always be within 3°C of the specified temperature (See table above).
   g) All supporting activities, such as preparation of dilution water, balance use and calibration, etc., must be performed in strict accordance with laboratory SOPs.
   h) A test may be deemed conditionally acceptable if there are minor deviations from specified conditions; determination of conditional acceptance shall be made by the laboratory technical director and deviations flagged in the test report.
2. Reference toxicant tests:
   a) Reference toxicant tests ($\geq$5) are conducted to construct a control chart (established)
   b) If animals are purchased from an outside source a concurrent reference toxicant test must be conducted with the same batch of animals used in the sediment test to evaluate the health of the batch of animals. NOTE: Field-collected species (e.g. *A. abdita*) must always be tested with a reference toxicant concurrent with sediment test.
   c) Reference tests should be within control chart limits and have an acceptance rate $\geq$ 95% (see SOP QSS301).
   d) These tests are conducted using water-only exposure and a standard dilution series. Tests are 96-h in duration using static exposure.
   e) A frequency of 6 tests over a three year period is recommended. If sediment tests are not conducted monthly or this frequency then SRT tests should be conducted concurrently with sediment tests.

3. An initial demonstration of laboratory capability, consisting of a) two or more 10-day tests using control sediment only, and b) 5 or more SRT tests, should also be conducted (established). The purpose of these tests is to determine that control sediment and dilution water quality are sufficient to meet test acceptability and performance criteria.
4. Technicians terminating tests for the first time must demonstrate they can recover at least 90% of the organisms added to a control sediment ca. 1 hr prior to collecting/counting. The other work cell components (e.g. water quality measurements, weighing, etc.) are identical to those of other salt toxicity tests (e.g. EPA 1007.0) for the purposes of demonstrating technician capability.

NOTE: Although reference toxicant tests are conducted in ambient laboratory light, the chambers are covered with opaque plastic sheeting.

Reference Toxicant Test Procedure (*A. abdita, L. plumulosus* $CdCl_2$):

1. **NOTE:** Cadmium is required for some monitoring programs.
2. Prepare stock solution by dissolving 40.77 mg $CdCl_2$ in 25 ml of deionized water using a volumetric flask. Stock solution concentration (as Cd) = 1000 mg/l.
3. Prepare highest test concentration (500 ug/l) by adding 1000 ul of stock solution to a calibrated 2 L flask. Bring up to a final volume of 2 L using test dilution water. Concentration = 500 ug/l. NOTE: For *A. abdita* prepare highest concentration of 400 ug/l (800 ul stock in 2 L). Use dilution water of 20 g/kg salinity for *A. abdita* and 5 g/kg salinity for *L. plumulosus.*
4. Serially dilute highest concentration to prepare two replicates each of the following test concentrations: 500, 250, 125 62.5 and 31.3 ug/l for *L. plumulosus* or 400, 200, 100, 50 and 25 ug/l for *A. abdita*. Use 1000 ml beakers as exposure chambers and fill with 500 ml of solution.
5. Conduct test as standard static acute test with 10 animals/replicate. Test duration is 96-h without renewals. Animal size is as described above and animals are not fed during the test. NOTE: Add a small piece (~2 cm x 2cm) of 500 um mesh Nitex® to each beaker to serve as an artificial substrate for the animals.
6. Test acceptability criterion: 90% control survival.
7. Data analysis: see SOP QSS301.

Reference Toxicant Test Procedure (SDS/SLS – required for EMAP):

1. Use standard dilution water (i.e. synthetic seawater). Use dilution water of 30 g/kg salinity for *A. abdita.*
2. Prepare highest test concentration (10 mg/l = "100%") by adding 80 mg SDS to a calibrated (to 4000 ml) flask. Bring up to a final volume of 4 L using test dilution water. Concentration = 20 mg/l.
3. Use a calibrated (1000 ml) flask and cylinder to dilute highest concentration ("100%") to prepare two replicates each of the following test concentrations: 20, 12, 7.2, 4.3, 2.6, 1.6, 1.0 mg/l (see table below). Use 1000 ml beakers as exposure chambers and fill each with 500 ml of solution.
4. Place a small (1-2 cm x 1-2 cm) square of 110 um mesh Nitex in each beaker and add 10 amphipods (same age as sediment test) to each beaker.
5. In one replicate of each treatment measure pH, D.O., salinity and temperature daily.
6. Conduct test as standard static acute test. Test duration is 96-h without renewals.
7. Test acceptability criterion: 90% control survival.
8. Data analysis: see SOP QSS301.

Toxicant Conc. (mg/l)	**20**	**12**	**7.2**	**4.3**	**2.6**	**1.6**	**1.0**
Vol. (ml) of 100% in 1000 ml	**1000**	**600**	**360**	**215**	**130**	**80**	**50**

Reference Toxicant Test Procedure (KCl):

1. Use standard dilution water (i.e. synthetic seawater). Use dilution water of 20 g/kg salinity for *L. plumulosus.*

2. Prepare highest test concentration (2800 mg/l) by adding 5.6 g KCl in a calibrated (to 2000 ml) flask. Bring up to a final volume of 2 L using test dilution water. Concentration = 2.8 g/l.
3. Dilute highest concentration to prepare two replicates each of the following test concentrations: 2800, 1400, 700, 350 and 175 mg/l. Use 1000 ml beakers as exposure chambers and fill with 500 ml of solution.
4. Place a small (1-2 cm x 1-2 cm) square of 110 um mesh Nitex in each beaker and add 10 amphipods (same age as sediment test) to each beaker.
5. In one replicate of each treatment measure pH, D.O., salinity and temperature daily.
6. Conduct test as standard static acute test. Test duration is 96-h without renewals.
7. Test acceptability criterion: 90% control survival.
8. Data analysis: see SOP QSS301.

OUT-OF-CONTROL/UNACCEPTABLE DATA: CORRECTIVE ACTIONS AND CONTINGENCIES

Immediately notify the QA officer if data are out of control limits or unacceptable. SOP QSS201 details procedures dealing with out-of-control/unacceptable tests.

CALIBRATION AND STANDARDIZATION

Calibration is not applicable to toxicity testing. See QSS301 and QSS302 for precision estimation and standardization using reference toxicants and PT samples.

REFERENCES

ASTM 2006a. Standard Guide for Collection, Storage, Characterization, and Manipulation of Sediments for Toxicological Testing and for Selection of Samplers Used to Collect Benthic Invertebrates. E 1391-03. In: *Annual Book of Standards. Vol. 11.05 Biological Effects and Environmental Fate; Biotechnology; Pesticides.* American Society for Testing and Materials, West Conshohocken, PA

ASTM 2006b. Standard Test Method for Measuring the Toxicity of Sediment-Associated Contaminants with Estuarine and Marine Invertebrates. E 1367-03. In: *Annual Book of Standards. Vol. 11.05 Biological Effects and Environmental Fate; Biotechnology; Pesticides.* American Society for Testing and Materials, West Conshohocken, PA

ASTM 2006c. Standard Guide for Designing Biological Tests with Sediments. E 1525-02 In: *Annual Book of Standards. Vol. 11.05 Biological Effects and Environmental Fate; Biotechnology; Pesticides.* American Society for Testing and Materials, West Conshohocken, PA

COE/EPA 1991. *Evaluation of Dredged Material Proposed for Ocean Disposal: Testing Manual* ("Green Book") EPA-503/8-91/001, Office of Water-Washington, DC

COE/EPA 1994. *Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S. - Inland Testing Manual* EPA-823-B-94-002, Office of Water-Washington, DC.

EPA 1994. *Methods for Assessing the Toxicity of Sediment-associated Contaminants with Estuarine and Marine Amphipods.* EPA/600/R-94/025, Office of Research and Development, Washington, DC.

EPA 1995. *Environmental Monitoring and Assessment Program (EMAP) Laboratory Methods Manual. Estuaries. Volume 1. Biological and Physical Analyses.* August 1995. EPA/620/R-95/008.

EPA 2001a. *Methods for Collection, Storage and Manipulation of Sediments for Chemical and Toxicological Analyses: Technical Manual.* October 2001. EPA-823-B-01-002.

Uncontrolled Copy

EPA 2001b. *National Coastal Assessment. Quality Assurance Project Plan 2001-2004*. May 2001. EPA/620/R-01/002.

See also Quality Manual

Appendix D

NJDEP Freshwater Wetlands Letter of Interpretation: Line Verification

RECEIVED
NOV 12 2013
T & M ASSOCIATES
MOORESTOWN, NJ

State of New Jersey

DEPARTMENT OF ENVIRONMENTAL PROTECTION
Division of Land Use Regulation
Mail Code 501-02A, P. O. Box 420
Trenton, New Jersey 08625-0420
www.state.nj.us/dep/landuse

CHRIS CHRISTIE
Governor

KIM GUADAGNO
Lt. Governor

BOB MARTIN
Commissioner

Stanley J. Sickels
Office of the Administrator
Borough of Red Bank
90 Monmouth Street
Red Bank, NJ 07701

NOV 0 6 2013

RE: Freshwater Wetlands Letter of Interpretation: Line Verification
File No.: 1340-03-0002.2
Activity Number: FWW130002
Applicant: Borough of Red Bank
Block(s) and Lot(s): [84, 64]
Red Bank Borough, Monmouth County

Dear Mr. Sickels:

This letter is in response to your request for a Letter of Interpretation to have Division of Land Use Regulation (Division) staff verify the boundary of the freshwater wetlands and/or State open waters on the referenced property.

In accordance with agreements between the State of New Jersey Department of Environmental Protection, the U.S. Army Corps of Engineers Philadelphia and New York Districts, and the U.S. Environmental Protection Agency, the NJDEP, the Division is the lead agency for establishing the extent of State and Federally regulated wetlands and waters. The USEPA and/or USACOE retain the right to reevaluate and modify the jurisdictional determination at any time should the information prove to be incomplete or inaccurate.

Based upon the information submitted, and upon a site inspection conducted by Division staff on September 18, 2013, the Division has determined that the wetlands and waters boundary line(s) as shown on the plan map entitled: "WETLANDS LOCATION PLAN, BLOCK 84, LOTS 63 & 64, BOROUGH OF RED BANK, RED BANK LANDFILL REMEDIAL INVESTIGATION, BOROUGH OF RED BANK, MONMOUTH COUNTY, NEW JERSEY", consisting of one sheet, dated 10/15/13, unrevised, and prepared by T&M Associates, is accurate as shown.

Wetlands Resource Value Classification ("RVC")

Exceptional: Flag points A8 through A14. [150 foot wetland buffer]

Ordinary: Flag points A1 through A8; A1 to A1A; and A1A through A7A. [No wetland buffer]

State Open Water: Flag points A14 through A30. [No wetland buffer]

In addition, there are mapped coastal wetlands adjacent to the site, as shown on Coastal Wetlands Map #546-2160, and as such is regulated pursuant to the Coastal Wetlands Act of 1970 (N.J.S.A. 13:9A-1 et seq.). Please be advised that if the proposed project is regulated under the Rules for Coastal Zone Management (N.J.A.C. 7:7E), then a buffer of up to 300 feet may be imposed adjacent to coastal wetlands.

RVC may affect requirements for wetland and/or transition area permitting. This classification may affect the requirements for an Individual Wetlands Permit (see N.J.A.C. 7:7A-7), the types of Statewide General Permits available for the property (see N.J.A.C. 7:7A-4) and any modification available through a transition area waiver (see N.J.A.C. 7:7A-6). Please refer to the Freshwater Wetlands Protection Act (N.J.S.A. 13:9B-1 et seq.) and implementing rules for additional information.

Wetlands resource value classification is based on the best information available to the Department. The classification is subject to reevaluation at any time if additional or updated information is made available, including, but not limited to, information supplied by the applicant.

Under N.J.S.A. 13:9B-7a(2), if the Division has classified a wetland as exceptional resource value, based on a finding that the wetland is documented habitat for threatened and endangered species that remains suitable for use for breeding, resting or feeding by such species, an applicant may request a change in this classification. Such requests for a classification change must demonstrate that the habitat is no longer suitable for the documented species because there has been a change in the suitability of this habitat. Requests for resource value classification changes and associated documentation should be submitted to the Division at the address at the top of this letter.

General Information

Pursuant to the Freshwater Wetlands Protection Act Rules, you are entitled to rely upon this jurisdictional determination for a period of five years from the date of this letter unless it is determined that the letter is based on inaccurate or incomplete information. Should additional information be disclosed or discovered, the Division reserves the right to void the original letter of interpretation and issue a revised letter of interpretation.

Regulated activities proposed within a wetland, wetland transition area or water area, as defined by N.J.A.C. 7:7A-2.2 and 2.6 of the Freshwater Wetlands Protection Act rules, require a

permit from this office unless specifically exempted at N.J.A.C. 7:7A-2.8. The approved plan and supporting jurisdictional limit information are now part of the Division's public records.

This letter in no way legalizes any fill which may have been placed, or other regulated activities which may have occurred on-site. This determination of jurisdiction extent or presence does not make a finding that wetlands or water areas are "isolated" or part of a surface water tributary system unless specifically called out in this letter as such. Furthermore, obtaining this determination does not affect your responsibility to obtain any local, State, or Federal permits which may be required.

Appeal Process

In accordance with N.J.A.C. 7:7A-1.7, any person who is aggrieved by this decision may request a hearing within 30 days of the date the decision is published in the DEP Bulletin by writing to: New Jersey Department of Environmental Protection, Office of Legal Affairs, Attention: Adjudicatory Hearing Requests, P.O. Box 402, Trenton, NJ 08625-0402. This request must include a completed copy of the Administrative Hearing Request Checklist found at www.state.nj.us/dep/landuse/forms. Hearing requests received after 30 days of publication notice may be denied. The DEP Bulletin is available on the Department's website at www.state.nj.us/dep/bulletin. In addition to your hearing request, you may file a request with the Office of Dispute Resolution to engage in alternative dispute resolution. Please see the website www.nj.gov/dep/odr for more information on this process.

Please contact Ryan Anderson of our staff by e-mail at ryan.anderson@dep.state.nj.us or by phone at (609) 633-2289 should you have any questions regarding this letter. Be sure to indicate the Department's file number in all communication.

Sincerely,

Bruce Stonebark
for Ryan J. Anderson, Supervisor
Division of Land Use Regulation

c: Municipal Clerk
Municipal Construction Official
Agent (original)

LOCATION MAP
SCALE: 1"=2000'

PROPERTY NOTES:

1. TOTAL AREA OF PROPERTY, BLOCK 84, LOT 64 = 8.55 ACRES
2. THE MEAN HIGH WATER LINE IS CALCULATED AS 2.09 FEET NAVD 88 BASED ON NOAA STATION 8531680.
3. 100 YR. FLOOD ELEVATION BASED ON FIRM FOR MONMOUTH COUNTY, PANEL 179 OF 457, MAP #34025C0179F, EFFECTIVE SEPTEMBER 25, 2009. THE 100 YR. FLOOD ELEVATION IS 9.0' NAVD 88.
4. TOPOGRAPHY WAS TAKEN FROM 2007 MONMOUTH COUNTY GIS DATA.

LAND AREA

DESCRIPTION	AREA
UPLAND	8.11 ACRES
WETLANDS	0.13 ACRES
WATER	0.31 ACRES
TOTAL AREA	8.55 ACRES

ENVIRONMENTAL BOUNDARY NOTES:

1. THE LIMITS OF WETLANDS WERE FIELD DELINEATED BY T&M ASSOCIATES, APRIL 2009.
2. 1970 MAPPED COASTAL WETLAND BOUNDARY SHOWN ON/ADJACENT TO SITE WERE GEOREFERENCED FROM HTTP://NJWEBMAP.STATE.NJ.US/NJIMAGERY
3. WETLAND BOUNDARY POINT, A1 THROUGHT A14, A1 TO B1 AND B1 THROUGH B13 ARE FRESHWATER WETLANDS.
4. OPEN WATER BOUNDARY POINT A14 THROUGH A30 AREA OPEN WATER AREAS.

APPROVED
1340-03-0002.2
FNJ130002
LOI
Department of Environmental Protection
Land Use Regulation Program

LEGEND

	CONTOUR LINE
	PROPERTY LINE
	WETLANDS LINE
• A5 or B8	WETLANDS\OPEN WATER POINT
	TREE LINE
	1970 MAPPED COASTAL WETLAND BOUNDARY
MW-A	MONITORING WELL
⊗	SOIL BORING / SEDIMENT SAMPLE LOCATION
	2012 SHORE LINE

GRAPHIC SCALE
100 0 50 100 200
(IN FEET)
1 inch = 100 ft.

PROJ. No.:	DATE:
PROJECT DATUM	
H	V
■ NAD 83	■ NAVD 88
□ NAD 27	□ NGVD 29
□ LOCAL H	□ LOCAL V
SOURCE/LOCATION:	

NO.	DATE	REVISIONS	BY	CHECKED

BOROUGH OF RED BANK

RED BANK LANDFILL REMEDIAL INVESTIGATION

BOROUGH OF RED BANK, MONMOUTH COUNTY, NEW JERSEY

WETLANDS LOCATION PLAN

BLOCK 84, LOTS 63 & 64

T&M ASSOCIATES
1256 NORTH CHURCH ST.
MOORESTOWN, NJ 08057
TEL 856-722-9700
FAX 856-722-0175
NEW JERSEY BOARD OF PROFESSIONAL ENGINEERS AND LAND SURVEYORS CERTIFICATE OF AUTHORIZATION: GA 276807

WILLIAM E. ALBURGER, P.L.S., P.P.
LICENSED PROFESSIONAL LAND SURVEYOR
STATE OF NEW JERSEY LICENSE No. 32106

10-15-13
DATE

DESIGNED BY	DRAWN BY	CHECKED BY
TS	JDH	
PROJECT NO. RBNK02018	CADD FILE CC-4327B	FIELD BK: #

DRAWING C1
SHEET

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Appendix E

ProUCL Statistical Output

	A	B	C	D	E	F	G	H	I	J	K	L
1	**UCL Statistics for Data Sets with Non-Detects**											
2												
3	User Selected Options											
4	Date/Time of Computation			2/21/2014 1:41:26 PM								
5	From File			ProUCL.xls								
6	Full Precision			OFF								
7	Confidence Coefficient			95%								
8	Number of Bootstrap Operations			2000								
9												
10												
11	**Arsenic**											
12												
13	**General Statistics**											
14	Total Number of Observations					20	Number of Distinct Observations					18
15							Number of Missing Observations					0
16	Minimum					10.4	Mean					19.57
17	Maximum					49.1	Median					13.5
18	SD					10.52	Std. Error of Mean					2.352
19	Coefficient of Variation					0.538	Skewness					1.405
20												
21	**Normal GOF Test**											
22	Shapiro Wilk Test Statistic					0.803	**Shapiro Wilk GOF Test**					
23	5% Shapiro Wilk Critical Value					0.905	Data Not Normal at 5% Significance Level					
24	Lilliefors Test Statistic					0.265	**Lilliefors GOF Test**					
25	5% Lilliefors Critical Value					0.198	Data Not Normal at 5% Significance Level					
26	**Data Not Normal at 5% Significance Level**											
27												
28	**Assuming Normal Distribution**											
29	**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**					
30	95% Student's-t UCL					23.63	95% Adjusted-CLT UCL (Chen-1995)					24.22
31							95% Modified-t UCL (Johnson-1978)					23.76
32												
33	**Gamma GOF Test**											
34	A-D Test Statistic					1.273	**Anderson-Darling Gamma GOF Test**					
35	5% A-D Critical Value					0.745	Data Not Gamma Distributed at 5% Significance Level					
36	K-S Test Statistic					0.265	**Kolmogrov-Smirnoff Gamma GOF Test**					
37	5% K-S Critical Value					0.195	Data Not Gamma Distributed at 5% Significance Level					
38	**Data Not Gamma Distributed at 5% Significance Level**											
39												
40	**Gamma Statistics**											
41	k hat (MLE)					4.525	k star (bias corrected MLE)					3.879
42	Theta hat (MLE)					4.324	Theta star (bias corrected MLE)					5.043
43	nu hat (MLE)					181	nu star (bias corrected)					155.2
44	MLE Mean (bias corrected)					19.57	MLE Sd (bias corrected)					9.933
45							Approximate Chi Square Value (0.05)					127.4
46	Adjusted Level of Significance					0.038	Adjusted Chi Square Value					125.4
47												

	A	B	C	D	E	F	G	H	I	J	K	L
48	**Assuming Gamma Distribution**											
49	95% Approximate Gamma UCL (use when n>=50))					23.83	95% Adjusted Gamma UCL (use when n<50)					24.21
50												
51	**Lognormal GOF Test**											
52	Shapiro Wilk Test Statistic					0.87	**Shapiro Wilk Lognormal GOF Test**					
53	5% Shapiro Wilk Critical Value					0.905	Data Not Lognormal at 5% Significance Level					
54	Lilliefors Test Statistic					0.252	**Lilliefors Lognormal GOF Test**					
55	5% Lilliefors Critical Value					0.198	Data Not Lognormal at 5% Significance Level					
56	**Data Not Lognormal at 5% Significance Level**											
57												
58	**Lognormal Statistics**											
59	Minimum of Logged Data					2.342	Mean of logged Data					2.859
60	Maximum of Logged Data					3.894	SD of logged Data					0.471
61												
62	**Assuming Lognormal Distribution**											
63	95% H-UCL					24.18	90% Chebyshev (MVUE) UCL					25.7
64	95% Chebyshev (MVUE) UCL					28.56	97.5% Chebyshev (MVUE) UCL					32.54
65	99% Chebyshev (MVUE) UCL					40.35						
66												
67	**Nonparametric Distribution Free UCL Statistics**											
68	**Data do not follow a Discernible Distribution (0.05)**											
69												
70	**Nonparametric Distribution Free UCLs**											
71	95% CLT UCL					23.43	95% Jackknife UCL					23.63
72	95% Standard Bootstrap UCL					23.36	95% Bootstrap-t UCL					24.53
73	95% Hall's Bootstrap UCL					24.66	95% Percentile Bootstrap UCL					23.68
74	95% BCA Bootstrap UCL					23.87						
75	90% Chebyshev(Mean, Sd) UCL					26.62	95% Chebyshev(Mean, Sd) UCL					29.82
76	97.5% Chebyshev(Mean, Sd) UCL					34.26	99% Chebyshev(Mean, Sd) UCL					42.97
77												
78	**Suggested UCL to Use**											
79	95% Student's-t UCL					23.63				or 95% Modified-t UCL		23.76
80												
81	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
82	These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)											
83	and Singh and Singh (2003). However, simulations results will not cover all Real World data sets.											
84	For additional insight the user may want to consult a statistician.											
85												
86												

	A	B	C	D	E	F	G	H	I	J	K	L
87	**Chromium**											
88												
89						**General Statistics**						
90					Total Number of Observations	20				Number of Distinct Observations		20
91										Number of Missing Observations		0
92					Minimum	15.5				Mean		36.38
93					Maximum	125				Median		25.1
94					SD	26.32				Std. Error of Mean		5.885
95					Coefficient of Variation	0.724				Skewness		2.262
96												
97						**Normal GOF Test**						
98					Shapiro Wilk Test Statistic	0.738				**Shapiro Wilk GOF Test**		
99					5% Shapiro Wilk Critical Value	0.905				Data Not Normal at 5% Significance Level		
100					Lilliefors Test Statistic	0.214				**Lilliefors GOF Test**		
101					5% Lilliefors Critical Value	0.198				Data Not Normal at 5% Significance Level		
102						**Data Not Normal at 5% Significance Level**						
103												
104						**Assuming Normal Distribution**						
105					**95% Normal UCL**					**95% UCLs (Adjusted for Skewness)**		
106					95% Student's-t UCL	46.55				95% Adjusted-CLT UCL (Chen-1995)		49.24
107										95% Modified-t UCL (Johnson-1978)		47.05
108												
109						**Gamma GOF Test**						
110					A-D Test Statistic	0.969				**Anderson-Darling Gamma GOF Test**		
111					5% A-D Critical Value	0.748				Data Not Gamma Distributed at 5% Significance Level		
112					K-S Test Statistic	0.209				**Kolmogrov-Smirnoff Gamma GOF Test**		
113					5% K-S Critical Value	0.195				Data Not Gamma Distributed at 5% Significance Level		
114						**Data Not Gamma Distributed at 5% Significance Level**						
115												
116						**Gamma Statistics**						
117					k hat (MLE)	2.995				k star (bias corrected MLE)		2.579
118					Theta hat (MLE)	12.15				Theta star (bias corrected MLE)		14.11
119					nu hat (MLE)	119.8				nu star (bias corrected)		103.2
120					MLE Mean (bias corrected)	36.38				MLE Sd (bias corrected)		22.65
121										Approximate Chi Square Value (0.05)		80.72
122					Adjusted Level of Significance	0.038				Adjusted Chi Square Value		79.15
123												

	A	B	C	D	E	F	G	H	I	J	K	L
124	**Assuming Gamma Distribution**											
125	95% Approximate Gamma UCL (use when n>=50))					46.49	95% Adjusted Gamma UCL (use when n<50)					47.41
126												
127	**Lognormal GOF Test**											
128	Shapiro Wilk Test Statistic					0.901	**Shapiro Wilk Lognormal GOF Test**					
129	5% Shapiro Wilk Critical Value					0.905	Data Not Lognormal at 5% Significance Level					
130	Lilliefors Test Statistic					0.195	**Lilliefors Lognormal GOF Test**					
131	5% Lilliefors Critical Value					0.198	Data appear Lognormal at 5% Significance Level					
132	**Data appear Approximate Lognormal at 5% Significance Level**											
133												
134	**Lognormal Statistics**											
135	Minimum of Logged Data					2.741	Mean of logged Data					3.418
136	Maximum of Logged Data					4.828	SD of logged Data					0.569
137												
138	**Assuming Lognormal Distribution**											
139	95% H-UCL					47.1	90% Chebyshev (MVUE) UCL					49.72
140	95% Chebyshev (MVUE) UCL					56.15	97.5% Chebyshev (MVUE) UCL					65.07
141	99% Chebyshev (MVUE) UCL					82.6						
142												
143	**Nonparametric Distribution Free UCL Statistics**											
144	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
145												
146	**Nonparametric Distribution Free UCLs**											
147	95% CLT UCL					46.06	95% Jackknife UCL					46.55
148	95% Standard Bootstrap UCL					46.11	95% Bootstrap-t UCL					53.09
149	95% Hall's Bootstrap UCL					61.41	95% Percentile Bootstrap UCL					46.47
150	95% BCA Bootstrap UCL					49.35						
151	90% Chebyshev(Mean, Sd) UCL					54.03	95% Chebyshev(Mean, Sd) UCL					62.03
152	97.5% Chebyshev(Mean, Sd) UCL					73.13	99% Chebyshev(Mean, Sd) UCL					94.93
153												
154	**Suggested UCL to Use**											
155	95% Chebyshev (Mean, Sd) UCL					62.03						
156												
157	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
158	These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)											
159	and Singh and Singh (2003). However, simulations results will not cover all Real World data sets.											
160	For additional insight the user may want to consult a statistician.											
161												
162												

	A	B	C	D	E	F	G	H	I	J	K	L
163	**Lead**											
164												
165					**General Statistics**							
166					Total Number of Observations	20			Number of Distinct Observations			19
167									Number of Missing Observations			0
168					Minimum	7.1			Mean			132.9
169					Maximum	1960			Median			18.75
170					SD	434.3			Std. Error of Mean			97.11
171					Coefficient of Variation	3.267			Skewness			4.339
172												
173					**Normal GOF Test**							
174					Shapiro Wilk Test Statistic	0.307			**Shapiro Wilk GOF Test**			
175					5% Shapiro Wilk Critical Value	0.905			Data Not Normal at 5% Significance Level			
176					Lilliefors Test Statistic	0.469			**Lilliefors GOF Test**			
177					5% Lilliefors Critical Value	0.198			Data Not Normal at 5% Significance Level			
178					**Data Not Normal at 5% Significance Level**							
179												
180					**Assuming Normal Distribution**							
181					**95% Normal UCL**				**95% UCLs (Adjusted for Skewness)**			
182					95% Student's-t UCL	300.8			95% Adjusted-CLT UCL (Chen-1995)			393.3
183									95% Modified-t UCL (Johnson-1978)			316.5
184												
185					**Gamma GOF Test**							
186					A-D Test Statistic	3.402			**Anderson-Darling Gamma GOF Test**			
187					5% A-D Critical Value	0.823			Data Not Gamma Distributed at 5% Significance Level			
188					K-S Test Statistic	0.369			**Kolmogrov-Smirnoff Gamma GOF Test**			
189					5% K-S Critical Value	0.208			Data Not Gamma Distributed at 5% Significance Level			
190					**Data Not Gamma Distributed at 5% Significance Level**							
191												
192					**Gamma Statistics**							
193					k hat (MLE)	0.401			k star (bias corrected MLE)			0.374
194					Theta hat (MLE)	331.7			Theta star (bias corrected MLE)			355.5
195					nu hat (MLE)	16.03			nu star (bias corrected)			14.96
196					MLE Mean (bias corrected)	132.9			MLE Sd (bias corrected)			217.4
197									Approximate Chi Square Value (0.05)			7.231
198					Adjusted Level of Significance	0.038			Adjusted Chi Square Value			6.809
199												

	A	B	C	D	E	F	G	H	I	J	K	L
200	**Assuming Gamma Distribution**											
201	95% Approximate Gamma UCL (use when n>=50))					274.9	95% Adjusted Gamma UCL (use when n<50)					291.9
202												
203	**Lognormal GOF Test**											
204	Shapiro Wilk Test Statistic					0.787	**Shapiro Wilk Lognormal GOF Test**					
205	5% Shapiro Wilk Critical Value					0.905	Data Not Lognormal at 5% Significance Level					
206	Lilliefors Test Statistic					0.213	**Lilliefors Lognormal GOF Test**					
207	5% Lilliefors Critical Value					0.198	Data Not Lognormal at 5% Significance Level					
208	**Data Not Lognormal at 5% Significance Level**											
209												
210	**Lognormal Statistics**											
211	Minimum of Logged Data					1.96	Mean of logged Data					3.248
212	Maximum of Logged Data					7.581	SD of logged Data					1.385
213												
214	**Assuming Lognormal Distribution**											
215	95% H-UCL					187.8	90% Chebyshev (MVUE) UCL					129.6
216	95% Chebyshev (MVUE) UCL					160.3	97.5% Chebyshev (MVUE) UCL					202.9
217	99% Chebyshev (MVUE) UCL					286.6						
218												
219	**Nonparametric Distribution Free UCL Statistics**											
220	**Data do not follow a Discernible Distribution (0.05)**											
221												
222	**Nonparametric Distribution Free UCLs**											
223	95% CLT UCL					292.6	95% Jackknife UCL					300.8
224	95% Standard Bootstrap UCL					289.6	95% Bootstrap-t UCL					3122
225	95% Hall's Bootstrap UCL					1155	95% Percentile Bootstrap UCL					321.9
226	95% BCA Bootstrap UCL					424.4						
227	90% Chebyshev(Mean, Sd) UCL					424.2	95% Chebyshev(Mean, Sd) UCL					556.2
228	97.5% Chebyshev(Mean, Sd) UCL					739.3	99% Chebyshev(Mean, Sd) UCL					1099
229												
230	**Suggested UCL to Use**											
231	95% Chebyshev (Mean, Sd) UCL					556.2						
232												
233	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
234	These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)											
235	and Singh and Singh (2003). However, simulations results will not cover all Real World data sets.											
236	For additional insight the user may want to consult a statistician.											
237												
238												

	A	B	C	D	E	F	G	H	I	J	K	L
239	**Vanadium**											
240												
241						**General Statistics**						
242					Total Number of Observations	20			Number of Distinct Observations			20
243									Number of Missing Observations			0
244					Minimum	20.2			Mean			35.6
245					Maximum	84.4			Median			26.25
246					SD	17.5			Std. Error of Mean			3.913
247					Coefficient of Variation	0.492			Skewness			1.34
248												
249						**Normal GOF Test**						
250					Shapiro Wilk Test Statistic	0.815			**Shapiro Wilk GOF Test**			
251					5% Shapiro Wilk Critical Value	0.905			Data Not Normal at 5% Significance Level			
252					Lilliefors Test Statistic	0.244			**Lilliefors GOF Test**			
253					5% Lilliefors Critical Value	0.198			Data Not Normal at 5% Significance Level			
254						**Data Not Normal at 5% Significance Level**						
255												
256						**Assuming Normal Distribution**						
257					**95% Normal UCL**				**95% UCLs (Adjusted for Skewness)**			
258					95% Student's-t UCL	42.37			95% Adjusted-CLT UCL (Chen-1995)			43.29
259									95% Modified-t UCL (Johnson-1978)			42.56
260												
261						**Gamma GOF Test**						
262					A-D Test Statistic	1.167			**Anderson-Darling Gamma GOF Test**			
263					5% A-D Critical Value	0.745			Data Not Gamma Distributed at 5% Significance Level			
264					K-S Test Statistic	0.235			**Kolmogrov-Smirnoff Gamma GOF Test**			
265					5% K-S Critical Value	0.194			Data Not Gamma Distributed at 5% Significance Level			
266						**Data Not Gamma Distributed at 5% Significance Level**						
267												
268						**Gamma Statistics**						
269					k hat (MLE)	5.29			k star (bias corrected MLE)			4.53
270					Theta hat (MLE)	6.73			Theta star (bias corrected MLE)			7.859
271					nu hat (MLE)	211.6			nu star (bias corrected)			181.2
272					MLE Mean (bias corrected)	35.6			MLE Sd (bias corrected)			16.73
273									Approximate Chi Square Value (0.05)			151.1
274					Adjusted Level of Significance	0.038			Adjusted Chi Square Value			148.9
275												

	A	B	C	D	E	F	G	H	I	J	K	L
276	**Assuming Gamma Distribution**											
277	95% Approximate Gamma UCL (use when n>=50))					42.7	95% Adjusted Gamma UCL (use when n<50)					43.32
278												
279	**Lognormal GOF Test**											
280	Shapiro Wilk Test Statistic					0.874	**Shapiro Wilk Lognormal GOF Test**					
281	5% Shapiro Wilk Critical Value					0.905	Data Not Lognormal at 5% Significance Level					
282	Lilliefors Test Statistic					0.218	**Lilliefors Lognormal GOF Test**					
283	5% Lilliefors Critical Value					0.198	Data Not Lognormal at 5% Significance Level					
284	**Data Not Lognormal at 5% Significance Level**											
285												
286	**Lognormal Statistics**											
287	Minimum of Logged Data					3.006	Mean of logged Data					3.475
288	Maximum of Logged Data					4.436	SD of logged Data					0.437
289												
290	**Assuming Lognormal Distribution**											
291	95% H-UCL					43.23	90% Chebyshev (MVUE) UCL					45.98
292	95% Chebyshev (MVUE) UCL					50.8	97.5% Chebyshev (MVUE) UCL					57.49
293	99% Chebyshev (MVUE) UCL					70.64						
294												
295	**Nonparametric Distribution Free UCL Statistics**											
296	**Data do not follow a Discernible Distribution (0.05)**											
297												
298	**Nonparametric Distribution Free UCLs**											
299	95% CLT UCL					42.04	95% Jackknife UCL					42.37
300	95% Standard Bootstrap UCL					41.98	95% Bootstrap-t UCL					43.64
301	95% Hall's Bootstrap UCL					43.91	95% Percentile Bootstrap UCL					42.39
302	95% BCA Bootstrap UCL					43.09						
303	90% Chebyshev(Mean, Sd) UCL					47.34	95% Chebyshev(Mean, Sd) UCL					52.66
304	97.5% Chebyshev(Mean, Sd) UCL					60.04	99% Chebyshev(Mean, Sd) UCL					74.54
305												
306	**Suggested UCL to Use**											
307	95% Student's-t UCL					42.37					or 95% Modified-t UCL	42.56
308												
309	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
310	These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)											
311	and Singh and Singh (2003). However, simulations results will not cover all Real World data sets.											
312	For additional insight the user may want to consult a statistician.											
313												

	A	B	C	D	E	F	G	H	I	J	K	L
314	**Endrin**											
315												
316						**General Statistics**						
317					Total Number of Observations	20			Number of Distinct Observations			17
318					Number of Detects	13			Number of Non-Detects			7
319					Number of Distinct Detects	13			Number of Distinct Non-Detects			5
320					Minimum Detect	5.1000E-5			Minimum Non-Detect			4.9000E-5
321					Maximum Detect	0.035			Maximum Non-Detect			5.6000E-5
322					Variance Detects	9.1770E-5			Percent Non-Detects			35%
323					Mean Detects	0.00316			SD Detects			0.00958
324					Median Detects	4.1000E-4			CV Detects			3.031
325					Skewness Detects	3.588			Kurtosis Detects			12.91
326					Mean of Logged Detects	-7.675			SD of Logged Detects			1.641
327												
328						**Normal GOF Test on Detects Only**						
329					Shapiro Wilk Test Statistic	0.35			**Shapiro Wilk GOF Test**			
330					5% Shapiro Wilk Critical Value	0.866			Detected Data Not Normal at 5% Significance Level			
331					Lilliefors Test Statistic	0.471			**Lilliefors GOF Test**			
332					5% Lilliefors Critical Value	0.246			Detected Data Not Normal at 5% Significance Level			
333						**Detected Data Not Normal at 5% Significance Level**						
334												
335						**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**						
336					Mean	0.00207			Standard Error of Mean			0.00176
337					SD	0.00757			95% KM (BCA) UCL			0.00554
338					95% KM (t) UCL	0.00512			95% KM (Percentile Bootstrap) UCL			0.00548
339					95% KM (z) UCL	0.00497			95% KM Bootstrap t UCL			0.0604
340					90% KM Chebyshev UCL	0.00736			95% KM Chebyshev UCL			0.00975
341					97.5% KM Chebyshev UCL	0.0131			99% KM Chebyshev UCL			0.0196
342												
343						**Gamma GOF Tests on Detected Observations Only**						
344					A-D Test Statistic	2.084			**Anderson-Darling GOF Test**			
345					5% A-D Critical Value	0.82			Detected Data Not Gamma Distributed at 5% Significance Level			
346					K-S Test Statistic	0.387			**Kolmogrov-Smirnoff GOF**			
347					5% K-S Critical Value	0.255			Detected Data Not Gamma Distributed at 5% Significance Level			
348						**Detected Data Not Gamma Distributed at 5% Significance Level**						
349												
350						**Gamma Statistics on Detected Data Only**						
351					k hat (MLE)	0.351			k star (bias corrected MLE)			0.321
352					Theta hat (MLE)	0.00902			Theta star (bias corrected MLE)			0.00985
353					nu hat (MLE)	9.114			nu star (bias corrected)			8.344
354					MLE Mean (bias corrected)	0.00316			MLE Sd (bias corrected)			0.00558
355												
356						**Gamma Kaplan-Meier (KM) Statistics**						
357					k hat (KM)	0.075			nu hat (KM)			2.998
358					Approximate Chi Square Value (3.00, α)	0.372			Adjusted Chi Square Value (3.00, β)			0.314
359					95% Gamma Approximate KM-UCL (use when n>=50)	0.0167			95% Gamma Adjusted KM-UCL (use when n<50)			0.0198
360						Gamma (KM) may not be used when k hat (KM) is < 0.1						
361												

	A	B	C	D	E	F	G	H	I	J	K	L
362	**Gamma ROS Statistics using Imputed Non-Detects**											
363	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
364	GROS may not be used when kstar of detected data is small such as < 0.1											
365	For such situations, GROS method tends to yield inflated values of UCLs and BTVs											
366	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
367					Minimum	5.1000E-5				Mean		0.00555
368					Maximum	0.035				Median		7.4000E-4
369					SD	0.00832				CV		1.497
370					k hat (MLE)	0.458				k star (bias corrected MLE)		0.422
371					Theta hat (MLE)	0.0121				Theta star (bias corrected MLE)		0.0132
372					nu hat (MLE)	18.31				nu star (bias corrected)		16.89
373					MLE Mean (bias corrected)	0.00555				MLE Sd (bias corrected)		0.00855
374										Adjusted Level of Significance (β)		0.038
375					Approximate Chi Square Value (16.89, α)	8.597				Adjusted Chi Square Value (16.89, β)		8.131
376					95% Gamma Approximate UCL (use when n>=50)	0.0109				95% Gamma Adjusted UCL (use when n<50)		0.0115
377												
378	**Lognormal GOF Test on Detected Observations Only**											
379					Shapiro Wilk Test Statistic	0.875				**Shapiro Wilk GOF Test**		
380					5% Shapiro Wilk Critical Value	0.866				Detected Data appear Lognormal at 5% Significance Level		
381					Lilliefors Test Statistic	0.231				**Lilliefors GOF Test**		
382					5% Lilliefors Critical Value	0.246				Detected Data appear Lognormal at 5% Significance Level		
383	**Detected Data appear Lognormal at 5% Significance Level**											
384												
385	**Lognormal ROS Statistics Using Imputed Non-Detects**											
386					Mean in Original Scale	0.00206				Mean in Log Scale		-9.004
387					SD in Original Scale	0.00777				SD in Log Scale		2.288
388					95% t UCL (assumes normality of ROS data)	0.00506				95% Percentile Bootstrap UCL		0.00548
389					95% BCA Bootstrap UCL	0.00746				95% Bootstrap t UCL		0.06
390					95% H-UCL (Log ROS)	0.0213						
391												
392	**UCLs using Lognormal Distribution and KM Estimates when Detected data are Lognormally Distributed**											
393					KM Mean (logged)	-8.461				95% H-UCL (KM -Log)		0.00346
394					KM SD (logged)	1.663				95% Critical H Value (KM-Log)		3.705
395					KM Standard Error of Mean (logged)	0.387						
396												
397	**DL/2 Statistics**											
398					**DL/2 Normal**					**DL/2 Log-Transformed**		
399					Mean in Original Scale	0.00206				Mean in Log Scale		-8.689
400					SD in Original Scale	0.00777				SD in Log Scale		1.927
401					95% t UCL (Assumes normality)	0.00507				95% H-Stat UCL		0.00681
402	**DL/2 is not a recommended method, provided for comparisons and historical reasons**											
403												
404	**Nonparametric Distribution Free UCL Statistics**											
405	**Detected Data appear Lognormal Distributed at 5% Significance Level**											
406												
407	**Suggested UCL to Use**											
408					99% KM (Chebyshev) UCL	0.0196						
409												
410	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
411	Recommendations are based upon data size, data distribution, and skewness.											
412	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
413	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											